Зміст

Danfoss-DDC 28
1 Contents 30
2 General Description 32
2.1 Design 32
2.2 Key Features 32
2.3 Typical Applications 32
2.4 System Diagram 33
2.5 Schematic Diagram 34
3 Technical Specifications 35
3.1 Design Specifications 35
3.2 Performance Specifications 35
3.3 Operating Parameters 36
3.4 Fluid Specifications 36
4 Operation 37
4.1 High Pressure Relief / Check Valve (HPRV) 37
4.1.1 High pressure relief / check valve with orifice 37
4.2 Bypass Function 38
4.3 Charge Pressure Relief Valve (CPRV) 39
4.4 Loop flushing valve 40
4.5 Control 41
4.5.1 Direct Displacement Control 41
4.5.2 Control Handle Requirements 41
5 Operating Parameters 42
5.1 Overview 42
5.2 Input speed 42
5.3 System pressure 42
5.4 Charge pressure 42
5.5 Charge pump inlet pressure 43
5.6 Case pressure 43
5.7 Temperature 43
5.8 Viscosity 43
6 System Design Parameters 44
6.1 Filtration system 44
6.2 Filtration 45
6.2.1 Suction filtration 45
6.2.2 Charge pressure filtration 45
6.2.3 External Pressure Filtration 46
6.3 Independent braking system 46
6.4 Fluid Selection 46
6.5 Reservoir 46
6.6 Case Drain 46
6.7 Charge Pump 47
6.7.1 Charge Pump Sizing/Selection 47

6.8 Charge Pump Output Flow 47
6.9 Implement Pump 48
6.10 Bearing Loads and Life 50
6.10.1 Applications with External Shaft Loads 50
6.10.2 Input Shaft 50
6.11 Shaft Torque 51
6.12 Mounting Flange Loads 52
6.12.1 Estimating Overhung Load Moments 52
6.13 Understanding and minimizing system noise 53
6.14 Size Equations 54
7 Model Code 55
7.1 Model Code: A, B, R, C, E, G, M 55
7.2 Model Code: H, K, F 56
7.3 Model Code: J, S, L 57
7.4 Model Code: N, P, Y, Z 58
8 Installation Drawings 59
8.1 With Aux-Pad, No Charge Pump, Left Trunnion, SAE A Flange Configuration 59
8.2 With Aux-Pad, No Charge Pump, Left Trunnion, SAE B Flange Configuration 61
8.3 With Charge Pump, No Aux-Pad, Left Trunnion, SAE A Flange Configuration 63
8.4 With Charge Pump, No Aux-Pad, Left Trunnion, SAE B Flange Configuration 65
8.5 With Implement Pump, No Aux-Pad, Left Trunnion, SAE A Flange Configuration 67
8.6 With Implement Pump, No Aux-Pad, Left Trunnion, SAE B Flange Configuration 69
8.7 Option: Detent 71
8.8 Input Shafts: AA, BA, DA 72
8.9 Input Shafts: AB, BB, DB 73
8.10 Input Shafts: AC, BC, DC 74
8.11 Auxiliary Mounting Pads 75
9 Reference Literature 77
9.1 Literature 77
Danfoss-MP1 79
1 Contents 81
2 General description 84
2.1 Overview 84
2.2 Features 84
2.3 System diagram 85
2.4 Schematic 86
3 Technical specifications 87
3.1 Design specifications 87
3.2 Technical data 87
3.3 Operating parameters 88
3.4 Fluid specifications 88
4 Operation 89
4.1 High Pressure Relief Valve (HPRV) and charge checkHPRV and charge check 89
4.2 Bypass function 89
4.3 Charge Pressure Relief Valve (CPRV)CPRV function 90

4.4 Loop flushing valve 91
4.5 Electrical displacement control (EDC) 91
4.5.1 EDC principle 91
4.5.2 EDC operation 92
4.5.3 Control signal requirements, EDC MP1 92
4.5.4 EDC solenoid data 93
4.5.5 Control response 93
4.5.5.1 EDC response time 93
4.5.6 Manual override (MOR) 93
4.6 Hydraulic displacement control (HDC) 95
4.6.1 HDC principle 95
4.6.2 HDC operation 95
4.6.3 Hydraulic signal pressure range 96
4.6.4 Pump output flow direction vs. control pressure 96
4.6.5 Control response 96
4.6.6 Response time, HDC 97
4.7 Swashplate angle sensor for EDC controls 98
4.7.1 Swash plate angle sensor parameters (EDC) 98
4.7.2 Swash plate angle sensor connector 99
4.7.3 Interface with ECU (EDC) 99
4.8 Manual displacement control 99
4.8.1 MDC principle 99
4.8.2 MDC operation 101
4.8.3 MDC shaft rotation 101
4.8.4 Control response 102
4.8.4.1 MDC response time 102
4.8.5 Neutral start switch (NSS) 102
4.8.6 Case gauge port M14 103
4.8.7 Lever 103
4.9 Forward-neutral-reverse (FNR) electic control 104
4.9.1 FNR principle 104
4.9.2 Control response 106
4.9.2.1 Response time, FNR 106
4.10 Non feedback proportional electric control (NFPE) 106
4.10.1 Control signal requirements 107
4.10.2 Control response 108
4.10.2.1 Response time 109
4.11 Non-feedback, proportional hydraulic (NFPH) control 109
4.11.1 Control response 110
4.11.1.1 Response time 110
4.12 Automotive control (AC) 111
4.13 Control-cut-off valve (CCO valve) 113
4.13.1 CCO solenoid data 114
4.13.2 Brake gauge port with MDC 115
4.14 Displacement limiter 115

4.14.1 Displacement change (approximate) 115
4.15 Speed sensor 116
4.15.1 Temperature range 116
4.15.2 Output pulses 116
4.15.3 Mating connectors 116
4.15.4 Speed sensor 4.5 – 8 V technical data 116
4.16 Temperature sensor data 117
5 Operating parameters 118
5.1 Input speed 118
5.2 System pressure 118
5.3 Charge pressure 119
5.4 Charge pump inlet pressure 119
5.5 Case pressure 119
5.6 Temperature 119
5.7 Viscosity 120
6 System design parameters 121
6.1 Filtration system 121
6.2 Filtration 121
6.2.1 Suction filtration 121
6.2.2 Charge pressure filtration 122
6.3 Independent braking system 123
6.4 Fluid selection 123
6.5 Reservoir 123
6.6 Case drain 123
6.7 Charge pump 123
6.7.1 Charge pump sizing/selection 124
6.8 Charge pump output flow 125
6.9 Bearing life and external shaft loading 125
6.10 Hydraulic unit life 127
6.11 Mounting flange loads 127
6.12 Shaft torques 129
6.12.1 Shaft selection 129
6.12.2 Shaft torque and splines lubrication 129
6.12.3 Shaft torque for tapered shafts 129
6.13 Shaft availability and torque ratings 130
6.14 Understanding and minimizing system noise 130
6.15 Sizing equations 132
7 Model code 133
7.1 Model code (A - B - C) 133
7.2 Model code (D) 134
7.3 Model code (F) 135
7.4 Model code (H - J - T) 136
7.5 Model code (K) 137
7.6 Model code (E - M - N - Z - L) 138
7.7 Model code (V - G - W) 139

7.8 Model code (X - Y) 141
8 Installation drawings 142
8.1 28/32 ports 142
8.2 38/45 ports 143
8.3 28/32 dimensions 144
8.4 28/32 dimensions with speed sensor 146
8.5 38/45 dimensions 147
8.6 38/45 dimensions with speed sensor 150
8.7 Input shafts: option G4, F6 (SAE B, 13 teeth) 151
8.8 Input shafts: option G1, F1 (SAE B, 14 teeth) 152
8.9 Input shafts: option G5, F5 (SAE B, 15 teeth) 153
8.10 Input shafts: option A7, A9 (SAE B, straight key shaft) 154
8.11 Input shafts: option G6, G7 (SAE B, 19 teeth) 155
8.12 Input shafts: option A6, A8 (SAE B, straight key shaft) 156
8.13 Input shafts: option F2, F3 (SAE B, taper key shaft) 157
8.13.1 Tapered shaft customer acknowledgement 157
8.14 Auxiliary mounting: option A16, B16, C16, D16, E16, F16 (SAE A, 9 teeth) 158
8.15 Auxiliary mounting: option A19, B19, C19, D19, E19, F19 (SAE A, 11 teeth) 159
8.16 Auxiliary mounting: option A22, B22, C22, D22, E22, F22 (SAE B, 13 teeth) 160
8.17 Auxiliary mounting: option A25, B25, C25, D25, E25, F25 (SAE B-B 15 teeth) 161
9 Controls 162
9.1 Electric displacement control (EDC) 162
9.2 Electric displacement control with CCO (EDC+CCO) 163
9.2.1 EDC with ASNSR 164
9.3 Hydraulic displacement control (HDC) 165
9.4 Manual displacement control (MDC) 166
9.4.1 MDC with NSS option M2 167
9.4.2 MDC with CCO options M3, M4 168
9.4.3 MDC with NSS and CCO options M5, M6 169
9.5 Forward-neutral-reverse (FNR) 170
9.6 Non-feedback proportional electric (NFPE) 171
9.7 Non-feedback proportional hydraulic (NFPH) 172
9.8 Automotive control (AC) 173
9.8.1 AC connectors dimensions 174
10 Filtration 175
10.1 Suction filtration: option S 175
10.2 Remote full flow charge pressure filtration: option R 176
10.3 External full flow charge pressure filtration: option E 177
H1_Size_040-053 179
1 Contents 181
2 Technical Specifications 184
2.1 H1 Pumps General Specification 184
2.2 H1P 045/053 Technical Data 184
2.3 H1P 045/053 Operating Parameters 185
2.4 Fluid Specification 186

2.5 H1P 045/053 Mounting Flange Loads 187
2.6 Bearing Life and External Radial Shaft Loads 188
2.7 Charge pump 189
2.7.1 Charge Pump Selection 189
2.7.2 12 cm³ Charge Pump – Flow and Power Curves 189
3 Master Model Code 190
3.1 Displacement, A—Rotation, B—Product Version, Z—Port Configuration 190
3.2 D—Controls 191
3.2.1 Electronic Displacement Controls 191
3.2.2 Fan Drive Controls 191
3.2.3 Forward-Neutral-Reverse (FNR) Controls 191
3.2.4 Non-Feedback Proportional Electric (NFPE) Controls 191
3.2.5 Automotive Controls 192
3.2.6 Manual Displacement Control 192
3.2.7 Hydraulic Displacement Control 192
3.3 F—Orifices, E—Displacement Limiters 193
3.4 G—Endcap 194
3.5 H—Mounting Flange, J—Input Shaft, K—Aux Pad 195
3.6 M, N—Overpressure Protection Settings 196
3.7 S—Charge Pump, T—Filtration, V—Charge Pressure Relief 198
3.8 W—Special Hardware, X—Paint, Y—Special Features 199
4 Control Options 200
4.1 Electrical Displacement Control (EDC) 200
4.1.1 Control signal requirements, EDC 045/053 200
4.1.2 Control Solenoid Data 201
4.1.3 Single Pump Output Flow Direction 201
4.1.4 Connector 201
4.1.5 Control response 202
4.1.6 Response Time, EDC 045/053 202
4.2 Manual Displacement Control (MDC) 203
4.2.1 MDC operation 203
4.2.2 MDC shaft rotation 204
4.2.3 MDC Torque 204
4.2.4 Control response 205
4.2.5 Response time, MDC 045/053 205
4.2.6 Connector 205
4.2.7 Neutral start switch (NSS) 206
4.2.8 Case Gauge Port M14 206
4.2.9 Lever 206
4.3 Hydraulic Displacement Control (HDC) 207
4.3.1 HDC principle 207
4.3.2 HDC operation 207
4.3.3 Hydraulic signal pressure range 208
4.3.4 Pump output flow direction vs. control pressure 208
4.3.5 Control response 208

4.3.6 Response Time, HDC 045/053 209
4.4 Forward-Neutral-Reverse Control (FNR) 210
4.4.1 Single Pump Output Flow Direction 210
4.4.2 FNR Solenoid Data 211
4.4.3 Control response 211
4.4.4 Connector 211
4.4.5 Response Time, FNR 045/053 211
4.5 Non feedback proportional electric control (NFPE) 212
4.5.1 Control Signal Requirements, NFPE 045/053 212
4.5.2 Control Solenoid Data 213
4.5.3 Single Pump Output Flow Direction 213
4.5.4 Connector 213
4.5.5 Control response 214
4.5.6 Response Time, NFPE 045/053 214
4.6 Automotive Control (AC) 215
4.6.1 Mode types 215
4.6.2 Basic functions 215
4.6.3 Performance functions 216
4.6.4 Protection and safety functions 216
4.6.5 Engine control and protection 216
4.6.6 Installation features 216
4.7 Fan Drive Control (FDC) 217
4.7.1 Control Signal Requirements, FDC 045/053 218
4.7.2 Control Solenoid Data 218
4.7.3 Single Pump Output Flow Direction 219
4.7.4 Connector 219
4.7.5 Control response 219
4.7.6 Response Time, FDC 045/053 219
4.8 Manual Override (MOR) 220
4.9 Swashplate angle sensor for EDC controls 221
4.9.1 Swash plate angle sensor parameters (EDC) 221
4.9.2 Swashplate Angle Sensor Connector 222
4.9.3 Interface with ECU (EDC) 222
4.10 Swash Plate Angle Sensor for NFPE and AC2 Controls 223
4.10.1 Swash Plate Angle Characteristic 223
4.10.2 Swash Plate Angle Sensor Parameters (NFPE/AC) 224
4.10.3 Swash Plate Angle Sensor Connector (NFPE) 224
4.10.4 Interface with ECU (NFPE) 224
4.11 Control Cut Off Valve (CCO) 225
4.11.1 Brake gauge port with MDC 225
4.11.2 CCO Connector (MDC) 226
4.11.3 H1P CCO Connector (EDC, NFPE) 226
4.11.4 CCO solenoid data 226
4.12 Displacement Limiter 227
4.12.1 H1P 045/053 Displacement Change (approximately) 227

5 Dimensions and Data 228
5.1 H1P 045/053 Input Shaft Option G1 (SAE C, 14 teeth) 228
5.2 H1P 045/053 Input Shaft Option G4 (SAE B, 13 teeth) 229
5.3 H1P 045/053 Input Shaft Option G5 (SAE B-B, 15 teeth) 230
5.4 H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth) 231
5.5 H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth) 232
5.6 H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth) 233
5.7 H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth) 234
5.8 H1P Displacement Limiter, Option B and D 235
5.9 H1P 045/053 End Cap, Options D6, D8, F2, F3 235
5.10 Speed and temperature sensor, option H (for mounting flange option K) 236
5.11 Single Pump Ports 237
5.12 H1P Dimensions 238
5.13 Controls 241
5.13.1 EDC Options A2 and A3 (12/24 V) 241
5.13.2 EDC with MOR, Options A4 and A5 (12/24 V) 242
5.13.3 EDC with CCO (key C), Options E7 and E8 (12/24 V) 243
5.13.4 EDC with ASNSR, Options: H2 and H3 (12/24 V) 244
5.13.5 EDC with MOR and ASNSR, Options H6 and H7 (12/24 V) 245
5.13.6 EDC with CCO and ASNSR, Options H8 and H9 (12/24 V) 246
5.13.7 MDC Option: M1 247
5.13.8 MDC with Neutral Start Switch Option: M2 248
5.13.9 MDC with CCO, Options: M3, M4 249
5.13.10 MDC with NSS and CCO Options: M5, M6 250
5.13.11 HDC, Options: T1, T2 251
5.13.12 NFPE with MOR, Options: N1, N2 (12/24 V) 252
5.13.13 NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V) 253
5.13.14 NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V) 254
5.13.15 NFPE with MOR and CCO, Options: N7, N8 (12/24 V) 255
5.13.16 Automotive control (AC) 256
5.13.16.1 AC connectors dimensions 257
5.14 Filtration 258
5.14.1 Suction Filtration Option L 258
5.14.2 Full Flow Charge Pressure Filtration Option P 259
5.14.3 External Full Flow Charge Pressure Filtration, Option E 260
H1_Size_060-068 262
1 Contents 264
2 Technical Specifications 267
2.1 H1 Pumps General Specification 267
2.2 H1P 060/068 Technical Data 267
2.3 H1P 060/068 Operating Parameters 268
2.4 Fluid Specification 269
2.5 H1P 060/068 Mounting Flange Loads 269
2.6 Bearing Life and External Radial Shaft Loads 270
2.7 Charge pump 271

2.7.1 Charge Pump Selection 271
2.7.2 14/17 cm³ Charge Pump – Flow and Power Curves 271
3 Master Model Code 272
3.1 Displacement, A—Rotation, B—Product Version, Z—Port Configuration 272
3.2 D—Controls 273
3.2.1 Electronic Displacement Controls 273
3.2.2 Fan Drive Controls 273
3.2.3 Forward-Neutral-Reverse (FNR) Controls 273
3.2.4 Non-Feedback Proportional Electric (NFPE) Controls 273
3.2.5 Automotive Controls 274
3.2.6 Manual Displacement Control 274
3.2.7 Hydraulic Displacement Control 274
3.3 F—Orifices, E—Displacement Limiters 275
3.4 G—Endcap 276
3.5 H—Mounting Flange, J—Input Shaft, K—Aux Pad 277
3.6 M, N—Overpressure Protection Settings 278
3.7 S—Charge Pump, T—Filtration, V—Charge Pressure Relief 279
3.8 W—Special Hardware, X—Paint, Y—Special Features 280
4 Control Options 281
4.1 Electrical Displacement Control (EDC) 281
4.1.1 Control signal requirements, EDC 060/068 281
4.1.2 Control Solenoid Data 282
4.1.3 Single Pump Output Flow Direction 282
4.1.4 Connector 282
4.1.5 Control response 283
4.1.6 Response Time, EDC 060/068 283
4.2 Manual Displacement Control (MDC) 284
4.2.1 MDC operation 284
4.2.2 MDC shaft rotation 285
4.2.3 MDC Torque 285
4.2.4 Control response 286
4.2.5 Response time, MDC 060/068 286
4.2.6 Connector 286
4.2.7 Neutral start switch (NSS) 286
4.2.8 Case Gauge Port M14 287
4.2.9 Lever 287
4.3 Hydraulic Displacement Control (HDC) 288
4.3.1 HDC principle 288
4.3.2 HDC operation 288
4.3.3 Hydraulic signal pressure range 289
4.3.4 Pump output flow direction vs. control pressure 289
4.3.5 Control response 289
4.3.6 Response time, HDC 069/078 290
4.4 Forward-Neutral-Reverse Control (FNR) 291
4.4.1 Single Pump Output Flow Direction 291

4.4.2 FNR Solenoid Data 292
4.4.3 Control response 292
4.4.4 Connector 292
4.4.5 Response Time, FNR 060/068 292
4.5 Non feedback proportional electric control (NFPE) 293
4.5.1 Control Signal Requirements, NFPE 060/068 293
4.5.2 Control Solenoid Data 294
4.5.3 Single Pump Output Flow Direction 294
4.5.4 Control response 295
4.5.5 Connector 295
4.5.6 Response Time, NFPE 060/068 295
4.6 Automotive Control (AC) 296
4.6.1 Mode types 296
4.6.2 Basic functions 296
4.6.3 Performance functions 297
4.6.4 Protection and safety functions 297
4.6.5 Engine control and protection 297
4.6.6 Installation features 297
4.7 Fan Drive Control (FDC) 298
4.7.1 Control Signal Requirements, FDC 060/068 299
4.7.2 Control Solenoid Data 299
4.7.3 Single Pump Output Flow Direction 300
4.7.4 Control response 300
4.7.5 Connector 300
4.7.6 Response Time, FDC 060/068 300
4.8 Manual Override (MOR) 301
4.9 Swashplate angle sensor for EDC controls 302
4.9.1 Swash plate angle sensor parameters (EDC) 302
4.9.2 Swashplate Angle Sensor Connector 303
4.9.3 Interface with ECU (EDC) 303
4.10 Swash Plate Angle Sensor for NFPE and AC2 Controls 304
4.10.1 Swash Plate Angle Characteristic 304
4.10.2 Swash Plate Angle Sensor Parameters (NFPE/AC) 305
4.10.3 Swash Plate Angle Sensor Connector (NFPE) 305
4.10.4 Interface with ECU (NFPE) 305
4.11 Control Cut Off Valve (CCO) 306
4.11.1 Brake gauge port with MDC 306
4.11.2 CCO Connector (MDC) 306
4.11.3 H1P CCO Connector (EDC, NFPE) 307
4.11.4 CCO solenoid data 307
4.12 Displacement Limiter 308
4.12.1 H1P 060/068 Displacement Change (approximately) 308
5 Dimensions and Data 309
5.1 H1P 060/068 Input Shaft Option G1 (SAE C, 14 teeth) 309
5.2 H1P 060/068 Input Shaft Option F1 (SAE C, 21 teeth) 310

5.3 H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth) 311
5.4 H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth) 312
5.5 H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth) 313
5.6 H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth) 314
5.7 H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth) 315
5.8 H1P Displacement Limiter, Option B 316
5.9 Single Pump Ports 317
5.10 H1P Dimensions 318
5.11 Controls 321
5.11.1 EDC Options A2 and A3 (12/24 V) 321
5.11.2 EDC with MOR, Options A4 and A5 (12/24 V) 322
5.11.3 EDC with CCO (key C), Options E7 and E8 (12/24 V) 323
5.11.4 EDC with ASNSR, Options: H2 and H3 (12/24 V) 324
5.11.5 EDC with MOR and ASNSR, Options H6 and H7 (12/24 V) 325
5.11.6 EDC with CCO and ASNSR, Options H8 and H9 (12/24 V) 326
5.11.7 MDC Option: M1 327
5.11.8 MDC with Neutral Start Switch Option: M2 328
5.11.9 MDC with CCO, Options: M3, M4 329
5.11.10 MDC with NSS and CCO Options: M5, M6 330
5.11.11 HDC, Options: T1, T2 331
5.11.12 NFPE with MOR, Options: N1, N2 (12/24 V) 332
5.11.13 NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V) 333
5.11.14 NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V) 334
5.11.15 NFPE with MOR and CCO, Options: N7, N8 (12/24 V) 335
5.11.16 Automotive control (AC) 336
5.11.16.1 AC connectors dimensions 337
5.12 Filtration 338
5.12.1 Suction Filtration Option L 338
5.12.2 Remote Full Charge Pressure Filtration Option P 339
5.12.3 Internal Filtration Option M (End Cap Option: D3) 340
5.12.4 Internal Filtration Option M (End Cap Option: F4) 341
5.12.5 External Filtration Option E (End Cap Option: D8) 342
5.12.6 External Filtration Option E (End Cap Option: F5) 343
H1_Size_040-068 tandem 345
1 Contents 347
2 Technical Specifications 349
2.1 H1 Pumps General Specification 349
2.2 Technical Data for H1 Tandem Pumps 349
2.3 Operating parameters for H1 Tandem Pumps 350
2.4 Fluid Specification 351
2.5 External radial shaft loads H1 Tandem 351
2.6 Bearing Life 352
2.7 Mounting flange loads H1T 045/053 352
2.8 Mounting flange loads H1T 060/068 353
2.9 Case drain 353

3 Master Model Code 354
3.1 H1T rotation, ports, and second pump options 354
3.2 H1T Controls Options 354
3.3 H1T Orifice and Displacement Limiter Options 355
3.4 H1T Endcap and Mounting Options 355
3.5 H1T Input Shaft and Aux Mounting Options 356
3.6 H1T High Pressure Relief Valve Options 356
3.7 H1T Pressure Limiter, Charge Pump, and Filtration Options 357
3.8 H1T Charge Pressure Relief, Special Hardware and Settings 358
4 Control Options 359
4.1 Electrical Displacement Control (EDC) 359
4.1.1 Control Solenoid Data 360
4.2 Manual Displacement Control (MDC) 361
4.3 Hydraulic Displacement Control (HDC) 365
4.3.1 HDC principle 365
4.3.2 HDC operation 365
4.3.3 Hydraulic signal pressure range 366
4.3.4 Pump output flow direction vs. control pressure 366
4.3.5 Control response 366
4.3.6 Response time, HDC 047/053, 060/068 367
4.4 Forward-Neutral-Reverse Control (FNR) 368
4.4.1 Control response 369
4.5 Non feedback proportional electric control (NFPE) 370
4.6 Manual Override (MOR) 372
4.7 Swashplate angle sensor for EDC controls 373
4.7.1 Swash plate angle sensor parameters (EDC) 373
4.7.2 Swash plate angle sensor connector 374
4.7.3 Interface with ECU (EDC) 374
4.8 Swash Plate Angle Sensor for NFPE and AC2 Controls 375
4.8.1 Swash Plate Angle Sensor Parameters (NFPE/AC) 375
4.8.2 Swash-plate Angle Sensor Connector (NFPE/AC2) 376
4.8.3 Interface with ECU (NFPE) 376
4.9 Control-Cut-Off (CCO) and Brake Release Valves 377
4.10 Displacement Limiter 379
5 Port Locations 380
5.1 Port Locations H1T 045/053 Tandem 380
5.2 Port Locations H1T 060/068 Tandem 382
6 Dimensions 383
6.1 Dimensions H1T 045/053 Tandem 383
6.2 Dimensions H1T 060/068 Tandem 386
6.3 Input shaft, option G1 (SAE C, 14 teeth) (045/053/060/068) 387
6.4 Input shaft, option G5 (SAE B-B, 15 teeth) (045/053 only) 388
6.5 Input shaft, option G6, (19 teeth-long) (045/053 only) 389
6.6 Input shaft, option F1, (060/068 only) 390
6.7 Auxiliary mounting pads 391

6.8 060/068 Control dimensions 397
6.9 045/053 Control dimensions 400
6.10 Hydraulic Displacement Control (HDC), options T1, T2 406
6.11 Center section coupling, torque rating 407
6.12 Control Cut Off (CCO) 408
6.12.1 045/053 CCO 408
6.12.2 060/068 CCO 409
6.13 Displacement limiter, H1 Tandem, option B 410
H1_Size_069-078 412
1 Contents 414
2 Technical Specifications 417
2.1 H1 Pumps General Specification 417
2.2 H1P 069/078 Technical Data 417
2.3 H1P 069/078 Operating Parameters 418
2.4 Fluid Specification 419
2.5 H1P 069/078 Mounting Flange Loads 419
2.6 Bearing Life and External Radial Shaft Loads 420
2.7 Charge pump 421
2.7.1 Charge Pump Selection 421
2.7.2 14/17 cm³ Charge Pump – Flow and Power Curves 421
3 Master Model Code 422
3.1 Displacement, A—Rotation, B—Product Version, Z—Port Configuration 422
3.2 D—Controls 423
3.2.1 Electronic Displacement Controls 423
3.2.2 Fan Drive Controls 423
3.2.3 Forward-Neutral-Reverse (FNR) Controls 423
3.2.4 Non-Feedback Proportional Electric (NFPE) Controls 423
3.2.5 Automotive Controls 424
3.2.6 Manual Displacement Control 424
3.2.7 Hydraulic Displacement Control 424
3.3 F—Orifices, E—Displacement Limiters 425
3.4 G—Endcap 426
3.5 H—Mounting Flange, J—Input Shaft, K—Aux Pad 427
3.6 M, N—Overpressure Protection Settings 428
3.7 S—Charge Pump, T—Filtration, V—Charge Pressure Relief 429
3.8 W—Special Hardware, X—Paint, Y—Special Features 430
4 Control Options 431
4.1 Electrical Displacement Control (EDC) 431
4.1.1 EDC Operation 431
4.1.2 Control signal requirements, EDC 069/078 432
4.1.3 Control Solenoid Data 432
4.1.4 Single Pump Output Flow Direction 432
4.1.5 Connector 433
4.1.6 Control response 433
4.1.7 Response Time, EDC 069/078 433

4.2 Manual Displacement Control (MDC) 434
4.2.1 MDC operation 434
4.2.2 MDC shaft rotation 435
4.2.3 MDC Torque 435
4.2.4 Control response 435
4.2.5 Response time, MDC 069/078 436
4.2.6 Neutral start switch (NSS) 436
4.2.7 Connector 436
4.2.8 Case Gauge Port M14 437
4.2.9 Lever 437
4.3 Hydraulic Displacement Control (HDC) 438
4.3.1 HDC principle 438
4.3.2 HDC operation 438
4.3.3 Hydraulic signal pressure range 439
4.3.4 Pump output flow direction vs. control pressure 439
4.3.5 Control response 439
4.3.6 Response time, HDC 069/078 440
4.4 Forward-Neutral-Reverse Control (FNR) 441
4.4.1 FNR Solenoid Data 441
4.4.2 Single Pump Output Flow Direction 442
4.4.3 Connector 442
4.4.4 Control response 442
4.4.5 Response Time, FNR 069/078 442
4.5 Non feedback proportional electric control (NFPE) 443
4.5.1 Control Signal Requirements, NFPE 069/078 443
4.5.2 Control Solenoid Data 444
4.5.3 Single Pump Output Flow Direction 444
4.5.4 Connector 444
4.5.5 Control response 445
4.5.6 Response Time, NFPE 069/078 445
4.6 Automotive Control (AC) 445
4.6.1 Mode types 445
4.6.2 Basic functions 446
4.6.3 Performance functions 446
4.6.4 Protection and safety functions 446
4.6.5 Engine control and protection 446
4.6.6 Installation features 447
4.7 Fan Drive Control (FDC) 448
4.7.1 Control Signal Requirements, FDC 069/078 449
4.7.2 Control Solenoid Data 449
4.7.3 Single Pump Output Flow Direction 450
4.7.4 Connector 450
4.7.5 Control response 450
4.7.6 Response Time, FDC 069/078 450
4.8 Manual Override (MOR) 451

4.9 Swashplate angle sensor for EDC controls 452
4.9.1 Swash plate angle sensor parameters (EDC) 452
4.9.2 Swashplate Angle Sensor Connector 453
4.9.3 Interface with ECU (EDC) 453
4.10 Swash Plate Angle Sensor for NFPE and AC2 Controls 454
4.10.1 Swash Plate Angle Characteristic 454
4.10.2 Swash Plate Angle Sensor Parameters (NFPE/AC) 455
4.10.3 Swash Plate Angle Sensor Connector (NFPE) 455
4.10.4 Interface with ECU (NFPE) 455
4.11 Control Cut Off Valve (CCO) 456
4.11.1 Brake gauge port with MDC 456
4.11.2 CCO Connector (MDC) 457
4.11.3 H1P CCO Connector (EDC, NFPE) 457
4.11.4 CCO solenoid data 457
4.12 Displacement Limiter 458
4.12.1 H1P 069/078 Displacement Change (approximately) 458
5 Dimensions and Data 459
5.1 H1P 069/078 Input Shaft Option G1 (SAE C, 14 teeth) 459
5.2 H1P 069/078 Input Shaft Option G9 (SAE C-C, 23 teeth) 460
5.3 H1P 069/078 Input Shaft Option F1 (SAE C, 21 teeth) 461
5.4 H1P 069/078 Input Shaft Option F4, Code 38–3 462
5.4.1 Tapered shaft customer acknowledgement 462
5.5 H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth) 463
5.6 H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth) 464
5.7 H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth) 465
5.8 H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth) 466
5.9 H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth) 467
5.10 H1P Displacement Limiter, Option B 468
5.11 Single Pump Ports 469
5.12 H1P Dimensions 470
5.13 Controls 473
5.13.1 EDC Options A2 and A3 (12/24 V) 473
5.13.2 EDC with MOR, Options A4 and A5 (12/24 V) 474
5.13.3 EDC with CCO (key C), Options E7 and E8 (12/24 V) 475
5.13.4 EDC with ASNSR, Options: H2 and H3 (12/24 V) 476
5.13.5 EDC with MOR and ASNSR, Options H6 and H7 (12/24 V) 477
5.13.6 EDC with CCO and ASNSR, Options H8 and H9 (12/24 V) 478
5.13.7 MDC Option: M1 479
5.13.8 MDC with Neutral Start Switch Option: M2 480
5.13.9 MDC with CCO, Options: M3, M4 481
5.13.10 MDC with NSS and CCO Options: M5, M6 482
5.13.11 HDC, Options: T1, T2 483
5.13.12 NFPE with MOR, Options: N1, N2 (12/24 V) 484
5.13.13 NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V) 485
5.13.14 NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V) 486

5.13.15 NFPE with MOR and CCO, Options: N7, N8 (12/24 V) 487
5.13.16 Automotive control (AC) 488
5.13.16.1 AC connectors dimensions 489
5.14 Filtration 490
5.14.1 Suction Filtration Option L 490
5.14.2 Remote Full Charge Pressure Filtration Option P 490
5.14.3 Integral Full Flow Charge Pressure Filtration, Option M 491
5.14.4 External Full Flow Charge Pressure Filtration, Option S 492
H1_Size_089-100 494
1 Contents 496
2 Technical Specifications 499
2.1 H1 Pumps General Specification 499
2.2 H1P 089/100 Technical Data 499
2.3 H1P 089/100 Operating Parameters 500
2.4 Fluid Specification 501
2.5 H1P 089/100 Mounting Flange Loads 501
2.6 Bearing Life and External Radial Shaft Loads 502
2.7 Charge pump 503
2.7.1 Charge Pump Selection 503
2.7.2 20/24 cm³ Charge Pump – Flow and Power Curves 503
3 Master Model Code 504
3.1 Displacement, A—Rotation, B—Product Version, Z—Port Configuration 504
3.2 D—Controls 505
3.2.1 Electronic Displacement Controls 505
3.2.2 Fan Drive Controls 505
3.2.3 Forward-Neutral-Reverse (FNR) Controls 505
3.2.4 Non-Feedback Proportional Electric (NFPE) Controls 505
3.2.5 Automotive Controls 506
3.2.6 Manual Displacement Control 506
3.2.7 Hydraulic Displacement Control 506
3.3 F—Orifices, E—Displacement Limiters 507
3.4 G—Endcap 508
3.5 H—Mounting Flange, J—Input Shaft, K—Aux Pad 509
3.6 M, N—Overpressure Protection Settings 510
3.7 S—Charge Pump, T—Filtration, V—Charge Pressure Relief 511
3.8 W—Special Hardware, X—Paint, Y—Special Features 512
4 Control Options 513
4.1 Electrical Displacement Control (EDC) 513
4.1.1 EDC Operation 513
4.1.2 Control signal requirements, EDC 089/100 514
4.1.3 Control Solenoid Data 514
4.1.4 Single Pump Output Flow Direction 514
4.1.5 Connector 515
4.1.6 Control response 515
4.1.7 Response Time, EDC 089/100 515

4.2 Manual Displacement Control (MDC) 516
4.2.1 MDC operation 517
4.2.2 MDC shaft rotation 517
4.2.3 MDC Torque 518
4.2.4 Control response 518
4.2.5 Response time, MDC 089/100 518
4.2.6 Neutral start switch (NSS) 519
4.2.7 Connector 519
4.2.8 Case Gauge Port M14 519
4.2.9 Lever 519
4.3 Hydraulic Displacement Control (HDC) 520
4.3.1 HDC principle 520
4.3.2 HDC operation 520
4.3.3 Hydraulic signal pressure range 521
4.3.4 Pump output flow direction vs. control pressure 521
4.3.5 Control response 521
4.3.6 Response time, HDC 089/100 522
4.4 Forward-Neutral-Reverse Control (FNR) 523
4.4.1 FNR Solenoid Data 524
4.4.2 Single Pump Output Flow Direction 524
4.4.3 Connector 524
4.4.4 Control response 525
4.4.5 Response Time, FNR 089/100 525
4.5 Non feedback proportional electric control (NFPE) 526
4.5.1 Control Signal Requirements, NFPE 089/100 526
4.5.2 Control Solenoid Data 527
4.5.3 Single Pump Output Flow Direction 527
4.5.4 Connector 527
4.5.5 Control response 528
4.5.6 Response Time, NFPE 089/100 528
4.6 Automotive Control (AC) 529
4.6.1 Mode types 529
4.6.2 Basic functions 529
4.6.3 Performance functions 530
4.6.4 Protection and safety functions 530
4.6.5 Engine control and protection 530
4.6.6 Installation features 530
4.7 Fan Drive Control (FDC) 531
4.7.1 Control Signal Requirements, FDC 089/100 532
4.7.2 Control Solenoid Data 532
4.7.3 Single Pump Output Flow Direction 533
4.7.4 Connector 533
4.7.5 Control response 533
4.7.6 Response Time, FDC 089/100 533
4.8 Manual Override (MOR) 534

4.9 Swashplate angle sensor for EDC controls 535
4.9.1 Swash plate angle sensor parameters (EDC) 535
4.9.2 Swashplate Angle Sensor Connector 536
4.9.3 Interface with ECU (EDC) 536
4.10 Swash Plate Angle Sensor for NFPE and AC2 Controls 537
4.10.1 Swash Plate Angle Characteristic 537
4.10.2 Swash Plate Angle Sensor Parameters (NFPE/AC) 538
4.10.3 Swash Plate Angle Sensor Connector (NFPE) 538
4.10.4 Interface with ECU (NFPE) 539
4.11 Control Cut Off Valve (CCO) 539
4.11.1 Brake gauge port with MDC 540
4.11.2 CCO Connector (MDC) 541
4.11.3 H1P CCO Connector (EDC, NFPE) 541
4.11.4 CCO solenoid data 541
4.12 Displacement Limiter 542
4.12.1 H1P 089/100 Displacement Change (approximately) 542
5 Dimensions and Data 543
5.1 H1P 089/100 Input Shaft Option G1 (SAE C, 14 teeth) 543
5.2 H1P Input Shaft Option G3 (SAE C, 13 teeth) 544
5.3 H1P 089/100 Input Shaft Option G9 (SAE C-C, 23 teeth) 545
5.4 H1P 089/100 Input Shaft Option F1 (SAE C, 21 teeth) 546
5.5 H1P 089/100 Input Shaft Option F4, Code 38–3 547
5.5.1 Tapered shaft customer acknowledgement 547
5.6 H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth) 548
5.7 H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth) 549
5.8 H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth) 550
5.9 H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth) 551
5.10 H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth) 552
5.11 H1P 089/100 Auxiliary Mounting, Option S1 (SAE B-B, 14 teeth) 553
5.12 H1P Displacement Limiter, Option B 554
5.13 Single Pump Ports 555
5.14 H1P Dimensions 556
5.15 Controls 559
5.15.1 EDC Options A2 and A3 (12/24 V) 559
5.15.2 EDC with MOR, Options A4 and A5 (12/24 V) 560
5.15.3 EDC with CCO (key C), Options E7 and E8 (12/24 V) 561
5.15.4 EDC with ASNSR, Options: H2 and H3 (12/24 V) 562
5.15.5 EDC with MOR and ASNSR, Options H6 and H7 (12/24 V) 563
5.15.6 EDC with CCO and ASNSR, Options H8 and H9 (12/24 V) 564
5.15.7 MDC Option: M1 565
5.15.8 MDC with Neutral Start Switch Option: M2 566
5.15.9 MDC with CCO, Options: M3, M4 567
5.15.10 MDC with NSS and CCO Options: M5, M6 568
5.15.11 HDC, Options: T1, T2 569
5.15.12 NFPE with MOR, Options: N1, N2 (12/24 V) 570

5.15.13 NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V) 571
5.15.14 NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V) 572
5.15.15 NFPE with MOR and CCO, Options: N7, N8 (12/24 V) 573
5.15.16 FDC Options: F1, F2 (12/24V) 574
5.15.17 Automotive control (AC) 575
5.15.17.1 AC connectors dimensions 576
5.16 Filtration 577
5.16.1 Suction Filtration Option L 577
5.16.2 Remote Full Flow Charge Pressure Filtration Option P 578
5.16.3 Integral Full Flow Charge Pressure Filtration, Option M 579
5.16.4 External Full Flow Charge Pressure Filtration, Option S 580
H1_Size_115-130 582
1 Contents 584
2 Technical Specifications 587
2.1 H1 Pumps General Specification 587
2.2 H1P 115/130 Technical Data 587
2.3 H1P 115/130 Operating Parameters 588
2.4 Fluid Specification 589
2.5 H1P 115/130 Mounting Flange Loads 589
2.6 Bearing Life and External Radial Shaft Loads 590
2.7 Charge pump 591
2.7.1 Charge Pump Selection 591
2.7.2 26/34 cm³ Charge Pump – Flow and Power Curves 591
3 Master Model Code 592
3.1 Displacement, A—Rotation, B—Product Version, Z—Port Configuration 592
3.2 D—Controls 593
3.2.1 Electronic Displacement Controls 593
3.2.2 Fan Drive Controls 593
3.2.3 Forward-Neutral-Reverse (FNR) Controls 593
3.2.4 Non-Feedback Proportional Electric (NFPE) Controls 593
3.2.5 Automotive Controls 594
3.2.6 Manual Displacement Control 594
3.2.7 Manual Displacement Control 594
3.2.8 Hydraulic Displacement Control 595
3.3 F—Orifices, E—Displacement Limiters 596
3.4 G—Endcap 597
3.5 H—Mounting Flange, J—Input Shaft, K—Aux Pad 598
3.6 M, N—Overpressure Protection Settings 599
3.7 S—Charge Pump, T—Filtration, V—Charge Pressure Relief 600
3.8 W—Special Hardware, X—Paint, Y—Special Features 601
4 Control Options 602
4.1 Electrical Displacement Control (EDC) 602
4.1.1 EDC Operation 602
4.1.2 Control signal requirements, EDC 115/130 603
4.1.3 Control Solenoid Data 603

4.1.4 Single Pump Output Flow Direction 603
4.1.5 Connector 604
4.1.6 Control response 604
4.1.7 Response Time, EDC 115/130 604
4.2 Manual Displacement Control (MDC) 605
4.2.1 MDC operation 605
4.2.2 MDC shaft rotation 606
4.2.3 MDC Torque 606
4.2.4 Control response 606
4.2.5 Response time, MDC 115/130 607
4.2.6 Neutral start switch (NSS) 607
4.2.7 Connector 607
4.2.8 Case Gauge Port M14 608
4.2.9 Lever 608
4.3 Hydraulic Displacement Control (HDC) 609
4.3.1 HDC principle 609
4.3.2 HDC operation 609
4.3.3 Hydraulic signal pressure range 610
4.3.4 Pump output flow direction vs. control pressure 610
4.3.5 Control response 610
4.3.6 Response time, HDC 115/130 611
4.4 Forward-Neutral-Reverse Control (FNR) 612
4.4.1 FNR Solenoid Data 613
4.4.2 Single Pump Output Flow Direction 613
4.4.3 Connector 613
4.4.4 Control response 613
4.4.5 Response Time, FNR 115/130 614
4.5 Non feedback proportional electric control (NFPE) 615
4.5.1 Control Signal Requirements, NFPE 115/130 615
4.5.2 Control Solenoid Data 616
4.5.3 Single Pump Output Flow Direction 616
4.5.4 Connector 616
4.5.5 Control response 617
4.5.6 Response Time, NFPE 115/130 617
4.6 Automotive Control (AC) 618
4.6.1 Mode types 618
4.6.2 Basic functions 618
4.6.3 Performance functions 619
4.6.4 Protection and safety functions 619
4.6.5 Engine control and protection 619
4.6.6 Installation features 619
4.7 Fan Drive Control (FDC) 620
4.7.1 Control Signal Requirements, FDC 115/130 621
4.7.2 Control Solenoid Data 621
4.7.3 Single Pump Output Flow Direction 622

4.7.4 Connector 622
4.7.5 Control response 622
4.8 Manual Override (MOR) 623
4.9 Swashplate angle sensor for EDC controls 624
4.9.1 Swash plate angle sensor parameters (EDC) 624
4.9.2 Swashplate Angle Sensor Connector 625
4.9.3 Interface with ECU (EDC) 625
4.10 Swash Plate Angle Sensor for NFPE and AC2 Controls 626
4.10.1 Swash Plate Angle Characteristic 626
4.10.2 Swash Plate Angle Sensor Parameters (NFPE/AC) 627
4.10.3 Swash Plate Angle Sensor Connector (NFPE) 627
4.10.4 Interface with ECU (NFPE) 627
4.11 Control Cut Off Valve (CCO) 628
4.11.1 CCO Connector (MDC) 628
4.11.2 H1P CCO Connector (EDC, NFPE) 629
4.11.3 CCO solenoid data 629
4.12 Displacement Limiter 630
4.12.1 H1P 115/130 Displacement Change (approximately) 630
5 Dimensions and Data 631
5.1 H1P Input Shaft Option G2 (SAE D, 27 teeth) 631
5.2 H1P Input Shaft Option G3 (SAE D, 13 teeth) 632
5.3 H1P 115/130 Input Shaft Option F3, Code 44–3 633
5.3.1 Tapered shaft customer acknowledgement 633
5.4 H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth) 634
5.5 H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth) 635
5.6 H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth) 636
5.7 H1P Auxiliary Mounting, Option H4 (SAE D, 13 teeth) 637
5.8 H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth) 638
5.9 H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth) 639
5.10 H1P 115/130 Auxiliary Mounting, Option S1 (SAE B-B, 14 teeth) 640
5.11 H1P Displacement Limiter, Option B and D 641
5.12 Single Pump Ports 642
5.13 H1P Dimensions 643
5.14 Controls 646
5.14.1 EDC Options A2 and A3 (12/24 V) 646
5.14.2 EDC with MOR, Options A4 and A5 (12/24 V) 647
5.14.3 EDC with CCO (key C), Options E7 and E8 (12/24 V) 648
5.14.4 EDC with ASNSR, Options: H2 and H3 (12/24 V) 649
5.14.5 EDC with MOR and ASNSR, Options H6 and H7 (12/24 V) 650
5.14.6 EDC with CCO and ASNSR, Options H8 and H9 (12/24 V) 651
5.14.7 MDC Option: M1 652
5.14.8 MDC with Neutral Start Switch Option: M2 653
5.14.9 MDC with CCO, Options: M3, M4 654
5.14.10 MDC with NSS and CCO Options: M5, M6 655
5.14.11 HDC, Options: T1, T2 656

5.14.12 NFPE with MOR, Options: N1, N2 (12/24 V) 657
5.14.13 NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V) 658
5.14.14 NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V) 659
5.14.15 NFPE with MOR and CCO, Options: N7, N8 (12/24 V) 660
5.14.16 FDC Options: F1, F2 (12/24V) 661
5.14.17 Automotive control (AC) 662
5.14.18 AC connectors dimensions 663
5.15 Filtration 664
5.15.1 Suction Filtration Option L 664
5.15.2 Integral Full Flow Charge Pressure Filtration, Option M 665
H1_Size_147-160 667
1 Contents 669
2 Technical Specifications 672
2.1 H1 Pumps General Specification 672
2.2 H1P 147/165 Technical Data 672
2.3 H1P 147/165 Operating Parameters 673
2.4 Fluid Specification 674
2.5 H1P 147/165 Mounting Flange Loads 674
2.6 Bearing Life and External Radial Shaft Loads 675
2.7 Charge pump 676
2.7.1 Charge Pump Selection 676
2.7.2 26/34 cm³ Charge Pump – Flow and Power Curves 676
3 Master Model Code 677
3.1 Displacement, A—Rotation, B—Product Version, Z—Port Configuration 677
3.2 D—Controls 678
3.2.1 Electronic Displacement Controls 678
3.2.2 Fan Drive Controls 678
3.2.3 Non-Feedback Proportional Electric (NFPE) Controls 678
3.2.4 Automotive Controls 679
3.2.5 Manual Displacement Control 679
3.2.6 Hydraulic Displacement Control 679
3.3 F—Orifices, E—Displacement Limiters 680
3.4 G—Endcap 681
3.5 H—Mounting Flange, J—Input Shaft, K—Aux Pad 682
3.6 M, N—Overpressure Protection Settings 683
3.7 S—Charge Pump, T—Filtration, V—Charge Pressure Relief 684
3.8 W—Special Hardware, X—Paint, Y—Special Features 685
4 Control Options 686
4.1 Electrical Displacement Control (EDC) 686
4.1.1 EDC Operation 686
4.1.2 Control signal requirements, EDC 147/165 687
4.1.3 Control Solenoid Data 687
4.1.4 Single Pump Output Flow Direction 687
4.1.5 Connector 688
4.1.6 Control response 688

4.1.7 Response Time, EDC 147/165 688
4.2 Manual Displacement Control (MDC) 689
4.2.1 MDC operation 689
4.2.2 MDC shaft rotation 690
4.2.3 MDC Torque 690
4.2.4 Control response 691
4.2.5 Response time, MDC 147/165 691
4.2.6 Neutral start switch (NSS) 691
4.2.6.1 Connector 692
4.2.7 Case Gauge Port M14 692
4.2.8 Lever 692
4.3 Hydraulic Displacement Control (HDC) 693
4.3.1 HDC principle 693
4.3.2 HDC operation 693
4.3.3 Hydraulic signal pressure range 694
4.3.4 Pump output flow direction vs. control pressure 694
4.3.5 Control response 694
4.3.6 Response time, HDC 147/165 695
4.4 Forward-Neutral-Reverse Control (FNR) 696
4.4.1 FNR Solenoid Data 697
4.4.2 Single Pump Output Flow Direction 697
4.4.3 Connector 697
4.4.4 Control response 698
4.4.5 Response Time, FNR 147/165 698
4.5 Non feedback proportional electric control (NFPE) 699
4.5.1 Control Signal Requirements, NFPE 147/165 699
4.5.2 Control Solenoid Data 700
4.5.3 Single Pump Output Flow Direction 700
4.5.4 Connector 700
4.5.5 Control response 701
4.5.6 Response Time, NFPE 147/165 701
4.6 Automotive Control (AC) 702
4.6.1 Mode types 702
4.6.2 Basic functions 702
4.6.3 Performance functions 703
4.6.4 Protection and safety functions 703
4.6.5 Engine control and protection 703
4.6.6 Installation features 703
4.7 Fan Drive Control (FDC) 704
4.7.1 Control Signal Requirements, FDC 147/165 705
4.7.2 Control Solenoid Data 705
4.7.3 Single Pump Output Flow Direction 706
4.7.4 Connector 706
4.7.5 Control response 706
4.7.6 Response Time, FDC 147/165 706

4.8 Manual Override (MOR) 707
4.9 Swashplate angle sensor for EDC controls 708
4.9.1 Swash plate angle sensor parameters (EDC) 708
4.9.2 Swashplate Angle Sensor Connector 709
4.9.3 Interface with ECU (EDC) 709
4.10 Swash Plate Angle Sensor for NFPE and AC2 Controls 710
4.10.1 Swash Plate Angle Characteristic 710
4.10.2 Swash Plate Angle Sensor Parameters (NFPE/AC) 711
4.10.3 Swash Plate Angle Sensor Connector (NFPE) 711
4.10.4 Interface with ECU (NFPE) 711
4.11 Control Cut Off Valve (CCO) 712
4.11.1 Brake gauge port with MDC 712
4.11.2 CCO Connector (MDC) 713
4.11.3 H1P CCO Connector (EDC, NFPE) 713
4.11.4 CCO solenoid data 713
4.12 Displacement Limiter 714
4.12.1 H1P 147/165 Displacement Change (approximately) 714
5 Dimensions and Data 715
5.1 H1P Input Shaft Option G2 (SAE D, 27 teeth) 715
5.2 H1P Input Shaft Option G3 (SAE D, 13 teeth) 716
5.3 H1P 147/165 Input Shaft Option F3, Code 44–3 717
5.3.1 Tapered shaft customer acknowledgement 717
5.4 H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth) 718
5.5 H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth) 719
5.6 H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth) 720
5.7 H1P Auxiliary Mounting, Option H4 (SAE D, 13 teeth) 721
5.8 H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth) 722
5.9 H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth) 723
5.10 H1P Displacement Limiter, Option B 724
5.11 Single Pump Ports 725
5.12 H1P Dimensions 726
5.13 Controls 729
5.13.1 EDC Options A2 and A3 (12/24 V) 729
5.13.2 EDC with MOR, Options A4 and A5 (12/24 V) 730
5.13.3 EDC with CCO (key C), Options E7 and E8 (12/24 V) 731
5.13.4 EDC with ASNSR, Options: H2 and H3 (12/24 V) 732
5.13.5 EDC with MOR and ASNSR, Options H6 and H7 (12/24 V) 733
5.13.6 EDC with CCO and ASNSR, Options H8 and H9 (12/24 V) 734
5.13.7 MDC Option: M1 735
5.13.8 MDC with Neutral Start Switch Option: M2 736
5.13.9 MDC with CCO, Options: M3, M4 737
5.13.10 MDC with NSS and CCO Options: M5, M6 738
5.13.11 HDC, Options: T1, T2 739
5.13.12 NFPE with MOR, Options: N1, N2 (12/24 V) 740
5.13.13 NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V) 741

5.13.14 NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V) 742
5.13.15 NFPE with MOR and CCO, Options: N7, N8 (12/24 V) 743
5.13.16 Automotive control (AC) 744
5.13.16.1 AC connectors dimensions 745
5.14 Filtration 746
5.14.1 Suction Filtration Option L 746
5.14.2 Integral Full Flow Charge Pressure Filtration, Option M 746
H1_Size_210-280 748
1 Contents 750
2 Technical Specifications 753
2.1 H1 Pumps General Specification 753
2.2 Technical Data 753
2.3 Operating Parameters 754
2.4 Fluid Specification 755
2.5 Bearing Life and External Radial Shaft Loads 755
2.6 H1P 210/250/280 Mounting Flange Loads 757
2.7 Charge pump 758
2.7.1 Charge Pump Selection 758
2.7.2 52/60 cm³ Charge Pump – Flow and Power Curves 758
3 Master Model Code 759
3.1 Displacement, A—Rotation, B—Product Version, Z—Port Configuration 759
3.2 D—Controls 760
3.2.1 Electronic Displacement Controls 760
3.2.2 Fan Drive Controls 760
3.2.3 Non-Feedback Proportional Electric (NFPE) Controls 760
3.2.4 Automotive Controls 761
3.2.5 Manual Displacement Control 761
3.2.6 Hydraulic Displacement Control 761
3.3 F—Orifices, E—Displacement Limiters 762
3.4 G—Endcap 763
3.5 H—Mounting Flange, J—Input Shaft, K—Aux Pad 764
3.6 M, N—Overpressure Protection Settings 765
3.7 S—Charge Pump, T—Filtration, V—Charge Pressure Relief 766
3.8 W—Special Hardware, X—Paint, Y—Special Features 767
4 Control Options 768
4.1 Electrical Displacement Control (EDC) 768
4.1.1 EDC Operation 768
4.1.2 Control signal requirements, EDC 210/250/280 769
4.1.3 Control Solenoid Data 769
4.1.4 Single Pump Output Flow Direction 769
4.1.5 Connector 770
4.1.6 Control response 770
4.1.7 Response Time, EDC 210/250/280 770
4.2 Manual Displacement Control (MDC) 771
4.2.1 MDC operation 771

4.2.2 MDC shaft rotation 772
4.2.3 MDC Torque 772
4.2.4 Control response 772
4.2.5 Response time, MDC 210/250/280 773
4.2.6 Neutral start switch (NSS) 773
4.2.7 Connector 774
4.2.8 Case Gauge Port M14 774
4.2.9 Lever 774
4.3 Hydraulic Displacement Control (HDC) 775
4.3.1 HDC principle 775
4.3.2 HDC operation 775
4.3.3 Hydraulic signal pressure range 776
4.3.4 Pump output flow direction vs. control pressure 776
4.3.5 Control response 776
4.3.6 Response time, HDC 210/250/280 777
4.4 Non feedback proportional electric control (NFPE) 778
4.4.1 Control Signal Requirements, NFPE 210/250/280 778
4.4.2 Control Solenoid Data 779
4.4.3 Single Pump Output Flow Direction 779
4.4.4 Connector 779
4.4.5 Control response 779
4.4.6 Response Time, NFPE 210/250/280 780
4.5 Automotive Control (AC) 781
4.5.1 Mode types 781
4.5.2 Basic functions 781
4.5.3 Performance functions 782
4.5.4 Protection and safety functions 782
4.5.5 Engine control and protection 782
4.5.6 Installation features 782
4.6 Fan Drive Control (FDC) 783
4.6.1 Control Signal Requirements, FDC 210/250/280 784
4.6.2 Control Solenoid Data 784
4.6.3 Single Pump Output Flow Direction 785
4.6.4 Connector 785
4.6.5 Control response 785
4.6.6 Response Time, FDC 210/250/280 785
4.7 Manual Override (MOR) 786
4.8 Swashplate angle sensor for EDC controls 787
4.8.1 Swash plate angle sensor parameters (EDC) 787
4.8.2 Swashplate Angle Sensor Connector 788
4.8.3 Interface with ECU (EDC) 788
4.9 Swash Plate Angle Sensor for NFPE and AC2 Controls 789
4.9.1 Swash Plate Angle Characteristic 789
4.9.2 Swash Plate Angle Sensor Parameters (NFPE/AC) 790
4.9.3 Swash Plate Angle Sensor Connector (NFPE) 790

4.9.4 Interface with ECU (NFPE) 790
4.10 Control Cut Off Valve (CCO) 791
4.10.1 Brake gauge port with MDC 791
4.10.2 CCO Connector (MDC) 791
4.10.3 H1P CCO Connector (EDC, NFPE) 792
4.10.4 CCO solenoid data 792
4.11 Displacement Limiter 793
4.11.1 Displacement Change (approximately) 793
5 Dimensions and Data 794
5.1 H1P Input Shaft Option G2 (SAE E, 27 teeth) 794
5.2 H1P Input Shaft Option G3 (SAE E, 13 teeth) 795
5.3 H1P Input Shaft Option F8 (SAE E, 17 teeth) 796
5.4 H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth) 797
5.5 H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth) 798
5.6 H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth) 799
5.7 H1P Auxiliary Mounting, Option H4 (SAE D, 13 teeth) 800
5.8 H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth) 801
5.9 H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth) 802
5.10 H1P Auxiliary Mounting, Option E1 (SAE E, 13 teeth) 803
5.11 H1P Auxiliary Mounting, Option E2 (SAE E, 27 teeth) 804
5.12 H1P Displacement Limiter, Option B 805
5.13 Single Pump Ports 806
5.14 H1P Dimensions 807
5.15 Suction Filtration Option L 809
5.16 Controls 810
5.16.1 EDC Options A2 and A3 (12/24 V) 810
5.16.2 EDC with MOR, Options A4 and A5 (12/24 V) 811
5.16.3 EDC with CCO (key C), Options E7 and E8 (12/24 V) 812
5.16.4 EDC with ASNSR, Options: H2 and H3 (12/24 V) 813
5.16.5 EDC with MOR and ASNSR, Options H6 and H7 (12/24 V) 814
5.16.6 EDC with CCO and ASNSR, Options H8 and H9 (12/24 V) 815
5.16.7 MDC Option: M1 816
5.16.8 MDC with Neutral Start Switch Option: M2 817
5.16.9 MDC with CCO, Options: M3, M4 818
5.16.10 MDC with NSS and CCO Options: M5, M6 819
5.16.11 HDC, Options: T1, T2 820
5.16.12 NFPE with MOR, Options: N1, N2 (12/24 V) 821
5.16.13 NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V) 822
5.16.14 NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V) 823
5.16.15 NFPE with MOR and CCO, Options: N7, N8 (12/24 V) 824
5.16.16 Automotive control (AC) 825
5.16.17 AC connectors dimensions 826

Technical Information

DDC Axial Piston Pumps
Size 20/24

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Revision history

Table of revisions

Date	Changed	Rev
February 2022	Added Option: Detent	0309
December 2021	Minor fix on Design Specifications	0308
November 2021	Added notes at Diagrams and LFV.	0307
October 2021	Added table on CPRV	0306
September 2021	Added to CPRV and Model Code: L.	0305
March 2021	Minor update in Input Shafts AB, BB, DB	0304
January 2021	Minor update in Performance Specifications	0303
November 2020	Minor update in Fluid selection	0302
August 2020	Update CPRV setting	0301
June 2020	Changed document number and version from 'BC00000191' and 'L1104976' to 'BC152886484876'	0201
August 2019	Minor typo	0105
June 2019	Added Size 24	0104
December 2018	Corrected rounding error in performance specifications	0103
February 2017	Change charge pump housing	0102
January 2016	Add SAE-A, 13T Auxiliary Pad Option	0101
April 2015	Minor update in Model Code	BB
March 2015	Add Implement Pump and SAE A Mounting Flange Options, and Converted to Danfoss layout - DITA CMS	BA
March 2013	Paint and Tag	AC
November 2011	Minor edits	AB
October 2011	First edition	AA

Contents

General Description

Design....5
Key Features....5
Typical Applications....5
System Diagram....6
Schematic Diagram....7

Technical Specifications

Design Specifications....8
Performance Specifications....8
Operating Parameters....9
Fluid Specifications....9

Operation

High Pressure Relief / Check Valve (HPRV)....10
  High pressure relief / check valve with orifice....10
Bypass Function....11
Charge Pressure Relief Valve (CPRV)....12
Loop flushing valve....13
Control....14
  Direct Displacement Control....14
  Control Handle Requirements....14

Operating Parameters

Overview....15
Input speed....15
System pressure....15
Charge pressure....15
Charge pump inlet pressure....16
Case pressure....16
Temperature....16
Viscosity....16

System Design Parameters

Filtration system....17
Filtration....18
  Suction filtration....18
  Charge pressure filtration....18
  External Pressure Filtration....19
Independent braking system....19
Fluid Selection....19
Reservoir....19
Case Drain....19
Charge Pump....20
  Charge Pump Sizing/Selection....20
Charge Pump Output Flow....20
Implement Pump....21
Bearing Loads and Life....23
  Applications with External Shaft Loads....23
  Input Shaft....23
Shaft Torque....24
Mounting Flange Loads....25
  Estimating Overhung Load Moments....25
Understanding and minimizing system noise....26
Size Equations....27

Model Code

Model Code: A, B, R, C, E, G, M....28
Model Code: H, K, F....29
Model Code: J, S, L....30
Model Code: N, P, Y, Z....31

Contents

Installation Drawings

With Aux-Pad, No Charge Pump, Left Trunnion, SAE A Flange Configuration....32
With Aux-Pad, No Charge Pump, Left Trunnion, SAE B Flange Configuration....34
With Charge Pump, No Aux-Pad, Left Trunnion, SAE A Flange Configuration....36
With Charge Pump, No Aux-Pad, Left Trunnion, SAE B Flange Configuration....38
With Implement Pump, No Aux-Pad, Left Trunnion, SAE A Flange Configuration....40
With Implement Pump, No Aux-Pad, Left Trunnion, SAE B Flange Configuration....42
Option: Detent....44
Input Shafts: AA, BA, DA....45
Input Shafts: AB, BB, DB....46
Input Shafts: AC, BC, DC....47
Auxiliary Mounting Pads....48

Reference Literature

Literature....50

General Description

Design

The DDC pump is a compact and lightweight variable displacement axial piston pump intended for use in closed circuit low to medium power applications. DDC pump is a direct displacement control pump utilizing an advanced slipper piston design. The flow rate is infinitely variable between zero and maximum. The direction of flow is commanded by tilting the swashplate in one direction or the other from the neutral (zero flow) position. Reversing the direction of flow reverses the direction of motor rotation.

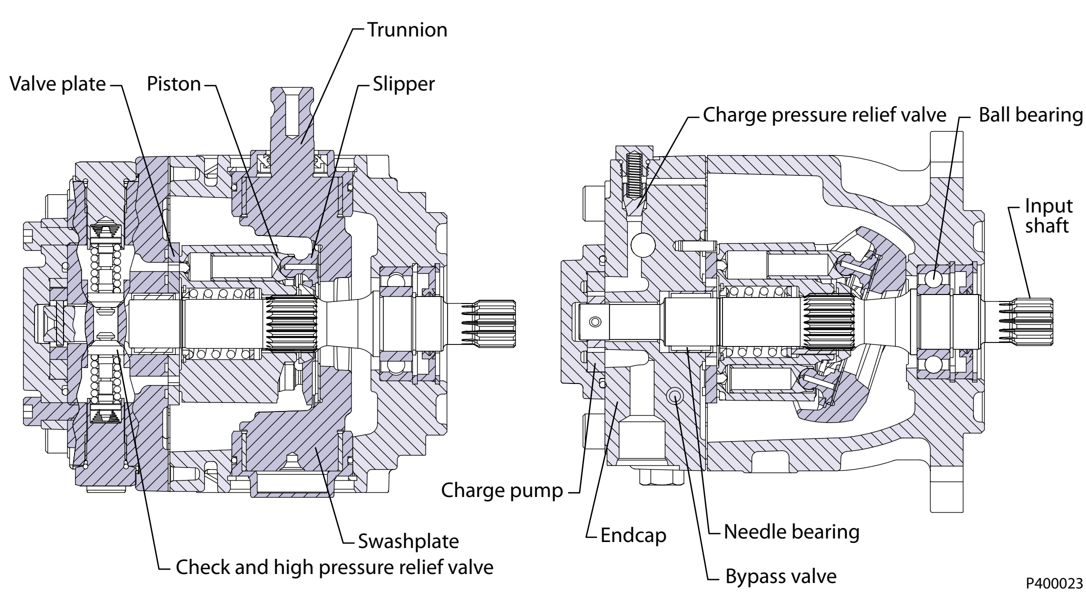
Key Features

- Displacement 20/24 cm^3/rev [1.22/1.46 in^3/rev]
- Optional bypass valve and loop flushing valve
- Optional integral charge pump / Implement pump
- Compact design with best in class pressure ratings and durability
- Low noise
- Backed by a global network of Danfoss service provider
- Mounting flange (SAE-A / B)

Typical Applications

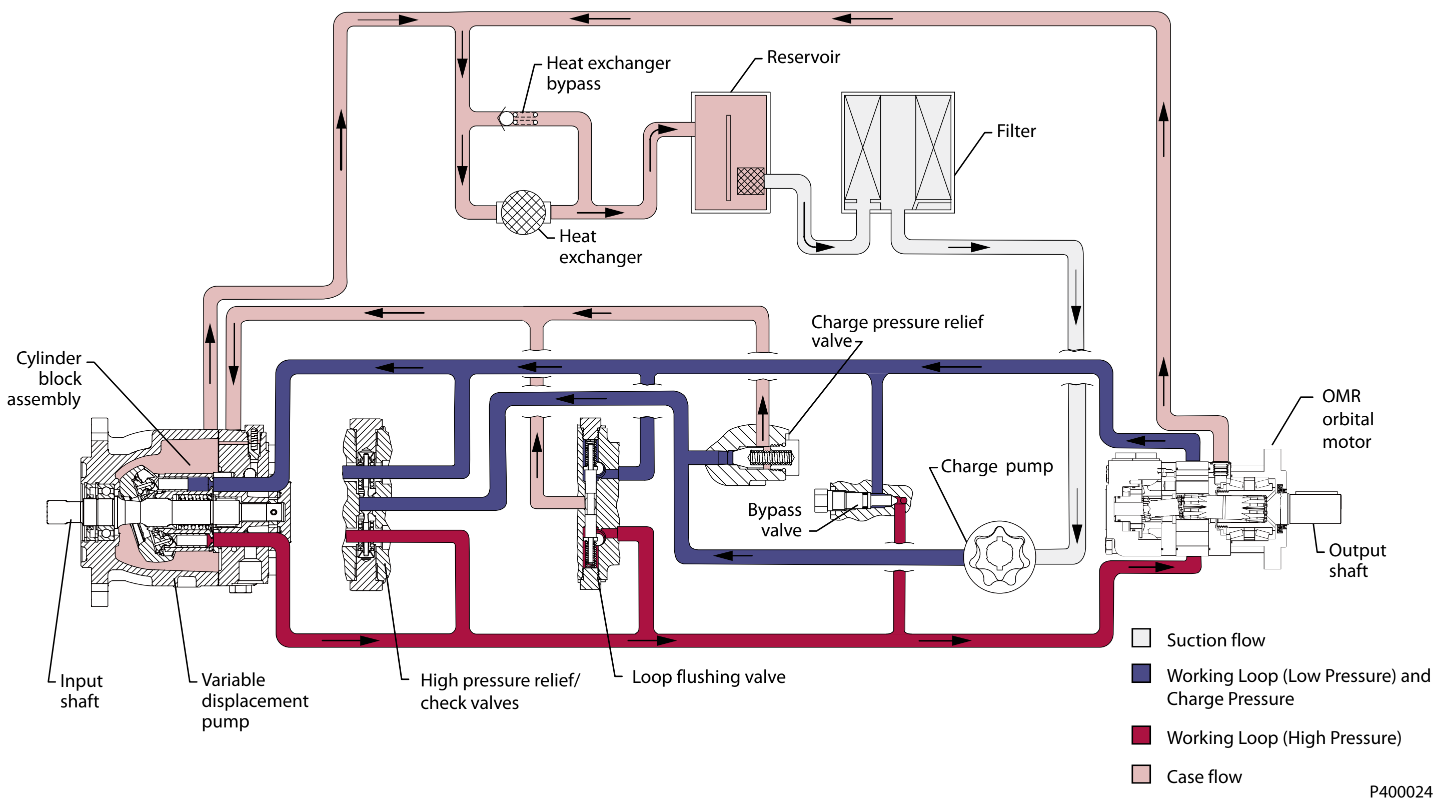
- Turf Care
  - Greens Mower
  - Zero Turn Radius Mower
  - Loaders
- Utility Vehicles
- Compact Agricultural Machinery
- Small Compactors
- Compact Construction Equipment

DDC Pump Cross-Sectional View



General Description

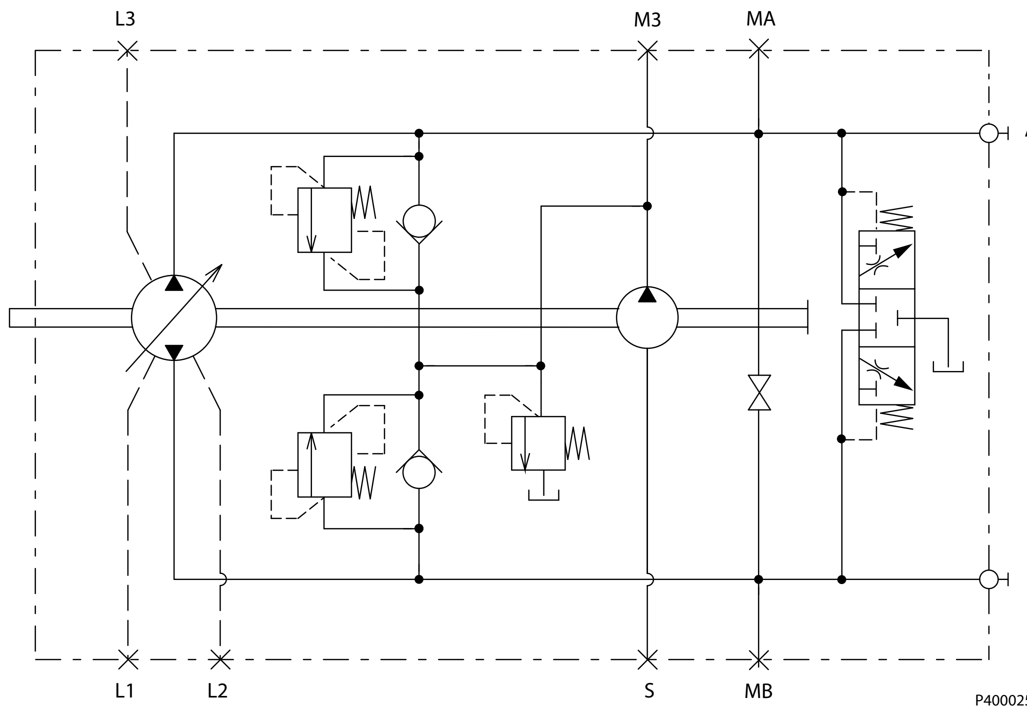
System Diagram



Loop flushing valve and Charge pump cannot be used together in one pump.

General Description

Schematic Diagram



Loop flushing valve and Charge pump cannot be used together in one pump.

Technical Specifications

Design Specifications

Features	DDC pump
Design	Axial piston pump of journal trunnion design with variable displacement
Direction of input rotation	Clockwise or counterclockwise
Recommended installation position	Pump installation position is discretionary, however the recommended trunnion position is on the side or at the bottom. If mounted with trunnion shaft position upward, water and dust tend to collect around the shaft, which may accelerate the deterioration of the shaft seal. Vertical input shaft installation is acceptable. The housing must always be filled with hydraulic fluid. Recommended mounting for a multiple pump stack is to arrange the highest power flow towards the input source. Consult Danfoss for nonconformance to these guidelines.
Filtration configuration	Suction or charge pressure filtration
Other system requirements	Independent braking system, suitable reservoir and heat exchanger
Control type	Direct displacement control

Performance Specifications

Features		Units	DDC20	DDC24
Displacement[1]		cm^3/rev [in^3/rev]	0-20.0 [0-1.22]	0-24.0 [0-1.46]
Mass moment of inertia of rotating components		kg•m^2 [slug•ft^2]	0.0009 [0.0006]	
Weight dry	With charge pump	kg [lb]	10 [22.1]	
	With implement pump		11 [24.3]	
	With auxiliary pad		12 [26.4]	
Oil volume	Case only	liter [US gal]	0.7 [0.1]	
Mounting flange		ISO3019-1 flange 101-2 (SAE B), 2 bolt ISO3019-1 flange 82-2 (SAE A), 2 bolt		
Input shaft outer diameter, Splines, key shafts[2]		ISO 3019-1, outer dia 22mm-4 (SAE B, 13 teeth) ISO 3019-1, outer dia 22mm-1 (Straight Key, Ls) ISO 3019-1, outer dia 22mm-1 (Straight Key, Special length)		
Auxiliary mounting flange with metric fasteners, shaft outer diameter and splines		ISO 3019-1, flange 82 - 2, outer dia 16 mm - 4 (SAE A, 9 teeth) ISO 3019-1, flange 82 - 2, outer dia 19 mm - 4 (SAE A, 11 teeth)		
Suction ports			ISO 11926-1, 7/8 -14 (SAE O-ring boss)	
Main port configuration			ISO 11926-1, 7/8 -14 (SAE O-ring boss) Twin port, radial	
Case drain ports L1, L2 , L3			ISO 11926-1, 3/4 -16 (SAE O-ring boss)	
Other ports			See *Installation Drawings* on page 32	
Customer interface threads			Metric fasteners	

[1] Max Swashplate angle is 18 degrees.

[2] See *Installation Drawings* on page 32 for mounting flange SAE A.

Technical Specifications

Operating Parameters

For definitions of the following specifications, see *Operating Parameters* on page 15

Features		Units	DDC pump
Input speed	Minimum for internal charge supply[1]	min^{-1} (rpm)	500
	Minimum for external charge supply		500
	Rated		4000
	Maximum		4500
System pressure	Maximum working pressure	bar [psi]	300 [4350]
	Maximum pressure		345 [5004]
	Minimum low loop (above case)		4 [58]
Charge pressure (minimum)		bar@15 lpm [psi/USG]	7 [101]
Charge pump inlet pressure	Minimum (continuous)	bar (absolute) [in Hg vacuum]	0.8 [6]
	Minimum (cold start)		0.2 [24]
	Maximum		2.0
Case pressure	Rated	bar [psi]	1.5 [21.7]
	Maximum		3 [43.5]

[1] No load condition. Refer to System Design Parameters/*Charge Pump* on page 20 for details.

Fluid Specifications

Features		Units	DDC pump
Viscosity	intermittent[1]	mm^2/sec. [SUS]	5 [42]
	Minimum		7 [49]
	Recommended range		12 - 80 [66 - 370]
	Maximum (cold start)[2]		1600 [7500]
Temperature range[3]	Maximum (cold start)	°C	-20
	Recommended range		60 - 85
	Maximum continuous		104
	Maximum intermittent		115
Filtration (recommended minimum)	Cleanliness per ISO 4406		22/18/13
	Efficiency (charge pressure filtration)	β-ratio	β15-20=75(β10≥10)
	Efficiency (suction filtration)		β35-45=75(β10≥2)
	Rercommended inlet screen mesh size	µm	100 - 125

[1] Intermittent=Short term t <1 min per incident and not exceeding 2 % of duty cycle based load-life.

[2] Cold start = Short term t < 3 min, p < 50 bar [725 psi], n < 1000 min^{-1} (rpm)

[3] At the hottest point, normally case drain port.

Operation

High Pressure Relief / Check Valve (HPRV)

The DDC pump is equipped with a combination high pressure relief and charge check valve. The high pressure relief valve (HPRV) function is a dissipative (with heat generation) direct acting pressure control valve for the purpose of limiting excessive system pressures. Each side of the transmission loop has a non-adjustable HPRV valve. When system pressure exceeds the factory setting of the valve, oil flows into the charge gallery. The valve is a differential pressure device working with system and charge pressure. The charge check function acts to replenish the low-side working loop with oil any time the low loop pressure falls below charge pressure.

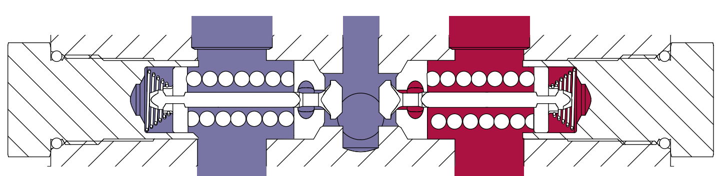
Different pressure relief settings may be used at each system port. The order code specifies HPRV pressure setting availability.

High pressure relief / check valve with orifice

A HPRV valve with an orifice is available as an option. In some applications, it is desirable to use a HPRV/ Check with an orifice to allow for easier neutral adjustment. The orifice connects the working loop to the charge gallery. It allows a small amount of loop leakage which expands the dead band around the neutral position of the swashplate. Most applications find it suitable to configure only one side of the system loop with an orificed HPRV. An orifice referenced to the high pressure side of the loop will decrease effective efficiency of the system and increase heat into the system. By locating an orifice only on the reverse drive side of the loop, system efficiency losses are minimized. Increased downhill creep may also be present.

The HPRV are set at the following flow rates

Check/HPRV without orifice	5 l/min [1.3 US gal/min]
Check/HPRV with orifice	17 l/min [4.5 US gal/min]



Caution

HPRV´s are factory set at a low flow condition. Any application or operating condition which leads to elevated HPRV flow will cause a pressure rise above the factory setting. Contact your Danfoss representative for an application review. Using an HPRV with an orifice may increase downhill creep.

Warning

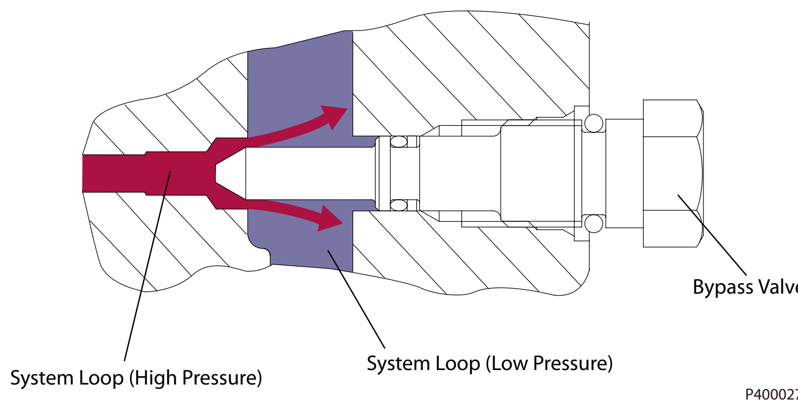
Unintended vehicle or machine movement hazard.

The vehicle must include a braking system redundant to the hydrostatic transmission, sufficient to stop and hold the vehicle or machine in the event of hydrostatic drive power loss.

Operation

Bypass Function

In some applications it is desirable to bypass the hydraulic fluid around the pump so the machine/load can be moved without rotating the pump shaft or prime mover. An optional bypass valve mechanically connects both A & B sides of the system pressure together. The bypass is fully opened when the valve is turned (opened) counterclockwise 3 revolutions. The valve must be fully closed for normal operation. Refer to the DDC pump outline drawings for location of the bypass valve.



Bypass valve wrench size and torque

Wrench size	Torque N•m [lbf•ft]
17 mm external	12.0 [9.0]

Caution

Excessive speed or extended movement will damage the pump and motor(s)

Avoid excessive speeds and extended load/vehicle movement when using the bypass function. Damage to the drive motor is possible if the load or vehicle is moved at a speed greater than 20% of maximum or for a duration exceeding 3 minutes..

Operation

Charge Pressure Relief Valve (CPRV)

An internal charge pressure relief valve (CPRV) regulates charge pressure within the hydraulic circuit. The CPRV is a direct acting poppet valve that regulates charge pressure at a designated level above case pressure.

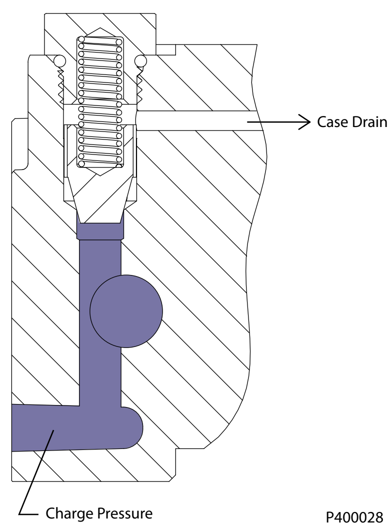
The charge pressure relief valve setting is specified within the model code of the pump. DDC pumps with charge pump have the CPRV set at 1800 rpm while DDC pumps without charge pump have the CPRV set with below external charge supply.

Charge pressure setting in MMC [bar]	External charge flow [L/min]
7	8.6
11, 14, 18, 21	13.5

The 7 bar charge pressure rise rate, with flow, is approximately 0.8 bar/10 liter [4.4 psi/US gal].

The 11 and 14 bar charge pressure rise rate, with flow, is approximately 1.4 bar /10 liter [7.7 psi/US gal].

The 18 and 21 bar charge pressure rise rate, with flow, is approximately 1.6 bar/10 liter [8.8 psi/US gal] .



Caution

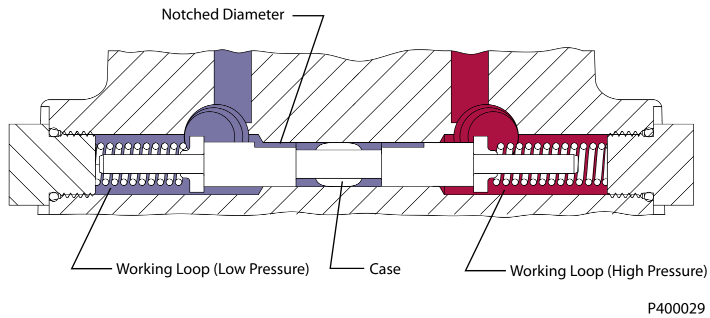
When a DDC pump is used with a variable motor, ensure the available charge pressure matches the required motor shift pressure. Contact your Danfoss representative for the availability of additional charge relief settings.

Operation

Loop flushing valve

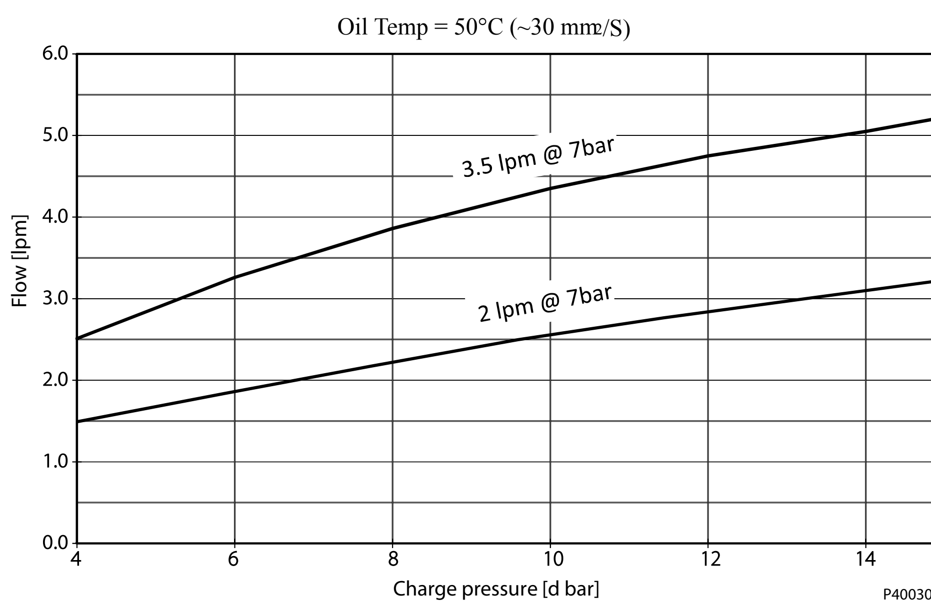
DDC pumps are available with an optional integral loop flushing. A loop flushing valve will remove heat and contaminants from the main loop at a rate faster than otherwise possible.

The DDC loop flushing design is a simple spring centered shuttle spool with an orifice plug. The shuttle shifts at approximately 8 bar [115 psi]. The flushing flow is a function of the low loop system pressure (charge) and the size of the plug.



Loop flushing valve is not available with charge pump combination.

Loop flushing performance



When a DDC pump is used with an external loop flushing shuttle valve, ensure that the charge setting of the pump matches the setting of the loop flushing shuttle valve. Contact your Danfoss representative for the availability of additional charge relief settings.

Operation

Control

Direct Displacement Control

The DDC pump features direct displacement control (DDC) .The swashplate angle is set directly by a linkage attached to the swashplate trunnion. Moving the control lever changes the displacement and direction of flow.

The input shaft is configurable to the left or right side of the pump.

Control Handle Requirements

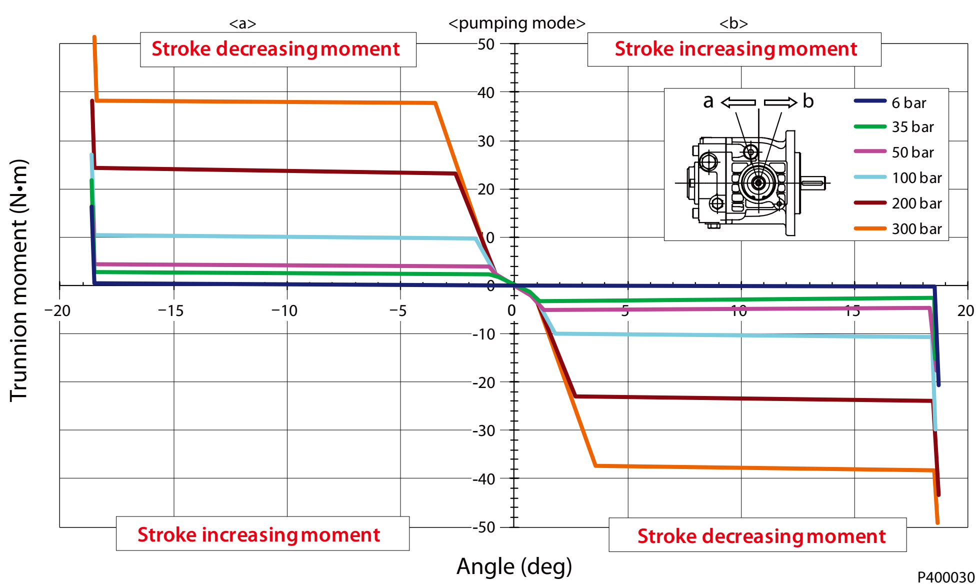
All DDC pumps will transfer hydraulic forces from within the transmission into the pump control arm where these forces are seen as a control arm torque. The nature and magnitude of the control arm torque is a function of transmission operating conditions (pump speed, pressure and displacement) and design of the DDC valve plate. During normal operation the control arm torque will be stroke reducing, whereas dynamic braking and downhill operation likely will result in stroke increasing control arm feedback. The driver and/or the mechanical linkage must be able to return the pump to neutral under all conditions. Contact Danfoss for additional application support regarding lower control arm torque options.

Maximum allowable control arm torque, applied from the customer linkage, is 79.1 Nm (700 in-lbs). Linkage stops may be required to limit input torque to the control arm. Maximum swashplate angle is +/-18 degrees.

DDC Pumps Control Moment

Input=2000 rpm, Temp=50°C, Shell Tellus 46 Viscosity=30m ^{2}/s

Stroking Speed=1deg/sec, Standard HPRV



P400030

Operating Parameters

Overview

This section defines the operating parameters and limitations with regard to input speeds and pressures.

Input speed

Minimum speed is the lowest input speed recommended during engine idle condition. Operating below minimum speed limits pump's ability to maintain adequate flow for lubrication and power transmission.

Rated speed is the highest input speed recommended at full power condition. Operating at or below this speed should yield satisfactory product life.

Maximum speed is the highest operating speed permitted. Exceeding maximum speed reduces product life and can cause loss of hydrostatic power and braking capacity. Never exceed the maximum speed limit under any operating conditions.

Operating conditions between Rated speed and Maximum speed should be restricted to less than full power and to limited periods of time. For most drive systems, maximum unit speed occurs during downhill braking or negative power conditions.

During hydraulic braking and downhill conditions, the prime mover must be capable of providing sufficient braking torque in order to avoid pump over speed. This is especially important to consider for turbocharged and Tier 4 engines.

Warning

Unintended vehicle or machine movement hazard.

Exceeding maximum speed may cause a loss of hydrostatic drive line power and braking capacity. You must provide a braking system, redundant to the hydrostatic transmission, sufficient to stop and hold the vehicle or machine in the event of hydrostatic drive power loss.

System pressure

System pressure is the differential pressure between system ports A and B. It is the dominant operating variable affecting hydraulic unit life. High system pressure, which results from high load, reduces expected life. Hydraulic unit life depends on the speed and normal operating, or weighted average, pressure that can only be determined from a duty cycle analysis.

Application pressure is the high pressure relief setting normally defined within the order code of the pump. This is the applied system pressure at which the driveline generates the maximum calculated pull or torque in the application.

Maximum working pressure is the highest recommended Application pressure. Maximum working pressure is not intended to be a continuous pressure. Propel systems with Application pressures at, or below, this pressure should yield satisfactory unit life given proper component sizing.

Maximum pressure is the highest allowable Application pressure under any circumstance. Application pressures above Maximum Working Pressure will only be considered with duty cycle analysis and factory approval. Pressure spikes are normal and must be considered when reviewing maximum working pressure.

All pressure limits are differential pressures referenced to low loop (charge) pressure. Subtract low loop pressure from gauge readings to compute the differential.

Minimum low loop pressure (above case pressure) is the lowest pressure allowed to maintain a safe working condition in the low side of the loop.

Charge pressure

An internal charge relief valve regulates charge pressure. Charge pressure maintains a minimum pressure in the low side of the transmission loop.

The charge pressure setting listed in the order code is the set pressure of the charge relief valve with the pump in neutral, operating at 1800 min^{-1} [rpm], and with a fluid viscosity of 32 mm^2/s [150 SUS]. Pumps

Operating Parameters

configured with no charge pump (external charge supply) are set with a charge flow of 18.9 l/min [5.0 US gal/min] and a fluid viscosity of 32 mm^2/s [150 SUS].

The charge pressure setting is referenced to case pressure.

Charge pump inlet pressure

At normal operating temperature charge inlet pressure must not fall below rated charge inlet pressure (vacuum).

Minimum charge inlet pressure is only allowed at cold start conditions. In some applications it is recommended to warm up the fluid (e.g. in the tank) before starting the engine and then run the engine at limited speed until the fluid warms up.

Maximum charge pump inlet pressure may be applied continuously.

Case pressure

Under normal operating conditions, the rated case pressure must not be exceeded. During cold start case pressure must be kept below **maximum intermittent case pressure**. Size drain plumbing accordingly.

Caution

Possible component damage or leakage

Operation with case pressure in excess of stated limits may damage seals, gaskets, and/or housings, causing external leakage. Performance may also be affected since charge and system pressure are additive to case pressure.

Temperature

The high temperature limits apply at the hottest point in the transmission, which is normally the motor case drain. The system should generally be run at or below the rated temperature.

The **maximum intermittent temperature** is based on material properties and should never be exceeded.

Cold oil will not affect the durability of the transmission components, but it may affect the ability of oil to flow and transmit power; therefore temperatures should remain 16 °C [30 °F] above the pour point of the hydraulic fluid.

The **minimum temperature** relates to the physical properties of component materials. Size heat exchangers to keep the fluid within these limits. Danfoss recommends testing to verify that these temperature limits are not exceeded.

Ensure fluid temperature and viscosity limits are concurrently satisfied.

Viscosity

Viscosity For maximum efficiency and bearing life, ensure the fluid viscosity remains in the recommended range.

The **minimum viscosity** should be encountered only during brief occasions of maximum ambient temperature and severe duty cycle operation.

The **maximum viscosity** should be encountered only at cold start.

System Design Parameters

Filtration system

To prevent premature wear, ensure that only clean fluid enters the hydrostatic transmission circuit. A filter capable of controlling the fluid cleanliness to ISO 4406, class 22/18/13 (SAE J1165) or better, under normal operating conditions, is recommended.These cleanliness levels cannot be applied for hydraulic fluid residing in the component housing/case or any other cavity after transport.

Filtration strategies include suction or pressure filtration. The selection of a filter depends on a number of factors including the contaminant ingression rate, the generation of contaminants in the system, the required fluid cleanliness, and the desired maintenance interval. Filters are selected to meet the above requirements using rating parameters of efficiency and capacity.

Filter efficiency can be measured with a Beta ratio (β_X). For simple suction-filtered closed circuit transmissions and open circuit transmissions with return line filtration, a filter with a β-ratio within the range of $\beta_{35-45} = 75$ ($\beta_{10} \geq 2$) or better has been found to be satisfactory. For some open circuit systems, and closed circuits with cylinders being supplied from the same reservoir, a higher filter efficiency is recommended. This also applies to systems with gears or clutches using a common reservoir. For these systems, a charge pressure or return filtration system with a filter β-ratio in the range of $\beta_{15-20} = 75$ ($\beta_{10} \geq 10$) or better is typically required.

Because each system is unique, only a thorough testing and evaluation program can fully validate the filtration system. Please see *Design Guidelines for Hydraulic Fluid Cleanliness Technical Information,* **BC152886482150** for more information.

Cleanliness level and β_x-ratio[1]			
Filtration (recommended minimum)	Cleanliness per ISO 4406		22/18/13
	Efficiency (charge pressure filtration)	β-ratio	$\beta_{15-20} = 75$ ($\beta_{10} \geq 10$)
	Efficiency (suction and return line filtration)		$\beta_{35-45} = 75$ ($\beta_{10} \geq 2$)
	Recommended inlet screen mesh size	µm	100 – 125

[1] Filter β_x-ratio is a measure of filter efficiency defined by ISO 4572. It is defined as the ratio of the number of particles greater than a given diameter (“x” in microns) upstream of the filter to the number of these particles downstream of the filter.

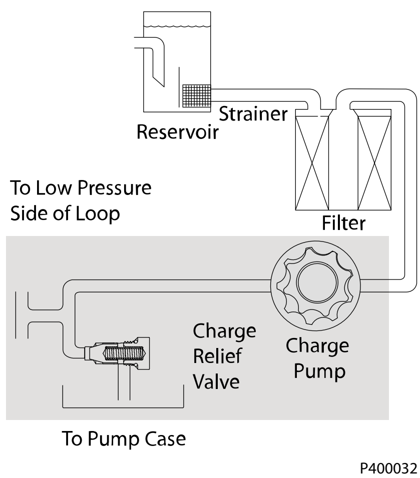
System Design Parameters

Filtration

Suction filtration

A suction circuit uses an internal charge pump. The filter is placed between the reservoir and the charge pump inlet. Do not exceed the inlet vacuum limits during cold start conditions.

Suction filtration

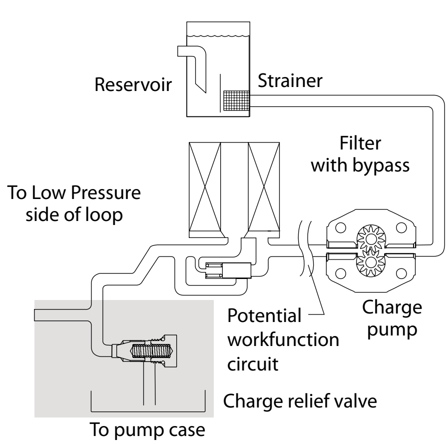


Charge pressure filtration

In a pressure filtration system the pressure filter is remotely mounted in the circuit, downstream of the charge supply. Pressure filtration is possible with, and without, an internal charge pump. Filters used in charge pressure filtration circuits should be rated to at least 35 bar [508 psi] pressure. Danfoss recommends locating a 100 – 125 micron screen in the reservoir or in the charge inlet when using charge pressure filtration.

A filter bypass valve is necessary to prevent damage to the hydrostatic system. In the event of high pressure drop associated with a blocked filter or cold start-up conditions, fluid may bypass the filter temporarily. Avoid working with an open bypass for an extended period. A visual or electrical bypass indicator is preferred. Proper filter maintenance is mandatory.

Charge pressure filtration



System Design Parameters

External Pressure Filtration

Charge supply is provided to the DDC pump from an auxiliary work function or dedicated gear pump circuit. After passing thru a remote filter, the flow enters the pump through the external charge supply port.

Independent braking system

Warning

Unintended vehicle or machine movement hazard.

The loss of hydrostatic drive line power, in any mode of operation (forward, neutral, or reverse) may cause the system to lose hydrostatic braking capacity. You must provide a braking system, redundant to the hydrostatic transmission, sufficient to stop and hold the vehicle or machine in the event of hydrostatic drive power loss.

Fluid Selection

Ratings and performance data are based on operating with hydraulic fluids containing oxidation, rust and foam inhibitors. These fluids must possess good thermal and hydrolytic stability to prevent wear, erosion, and corrosion of pump components.

Caution

Never mix hydraulic fluids of different types.

Reservoir

The hydrostatic system reservoir should accommodate maximum volume changes during all system operating modes and promote de-aeration of the fluid as it passes through the tank.

A suggested minimum total reservoir volume is 5/8 of the maximum charge pump flow per minute with a minimum fluid volume equal to 1/2 of the maximum charge pump flow per minute. This allows 30 seconds fluid dwell for removing entrained air at the maximum return flow. This is usually adequate to allow for a closed reservoir (no breather) in most applications.

Locate the reservoir outlet (charge pump inlet) above the bottom of the reservoir to take advantage of gravity separation and prevent large foreign particles from entering the charge inlet line. A 100-125 µm screen over the outlet port is recommended.

Position the reservoir inlet (fluid return) to discharge below the normal fluid level, toward the interior of the tank. A baffle (or baffles) will further promote de-aeration and reduce surging of the fluid.

Case Drain

The pump housing must remain full of oil at all times. The DDC pump is equipped with three case drain ports to provide flexibility for hose routing and pump installation. Connect a line from one of the case drain ports to the reservoir. Case drain fluid is typically the hottest fluid in the system.

System Design Parameters

Charge Pump

Charge flow is required on DDC pumps. The charge pump provides flow to make up for system leakage, maintain a positive pressure in the main circuit, and provide flow for cooling and filtration.

Many factors influence the charge flow requirements and the resulting charge pump size selection. These factors include system pressure, pump speed, pump swashplate angle, type of fluid, temperature, size of heat exchanger, length and size of hydraulic lines, auxiliary flow requirements, hydrostatic motor type, etc. When initially sizing and selecting hydrostatic units for an application, it is frequently not possible to have all the information necessary to accurately evaluate all aspects of charge pump size selection.

Unusual application conditions may require a more detailed review of charge pump sizing. Charge pressure must be maintained at a specified level under all operating conditions to prevent damage to the transmission. Danfoss recommends testing under actual operating conditions to verify this.

Charge Pump Sizing/Selection

In most applications a general guideline is that the charge pump displacement should be at least 10 % of the total displacement of all components in the system. Unusual application conditions may require a more detailed review of charge flow requirements. Please refer to *Selection of Drive line Components*, **BC157786484430** for a detailed procedure.

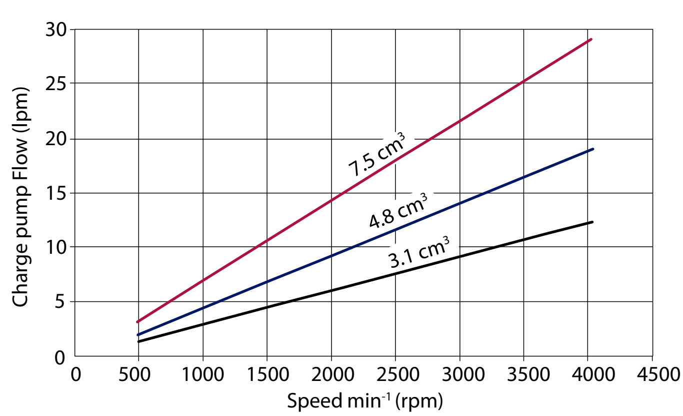
System features and conditions which may invalidate the 10 % guideline include (but are not limited to):

- Continuous operation at low input speeds {< 1500 min^{-1} (rpm)}
- High shock loading
- High input shaft speeds
- LSHT motors with large displacement

Contact your Danfoss representative for application assistance if your application includes any of these conditions.

Charge Pump Output Flow

Flow at 7 bar [100 psi] charge relief setting, 30mm^2/s [140SUS] , 50 °C [122 °F]



System Design Parameters

Implement Pump

Implement pump is an integrated charge pump that can be used for the lightly-loaded external work function. Since implement pump has both external gear pump and charge pump functions, it allows customers to apply more compact sizing than existing system using external gear pump.

The implement circuit must be of the "open center" type that allows oil from the charge pump circulating through the control valve to return to the transmission.

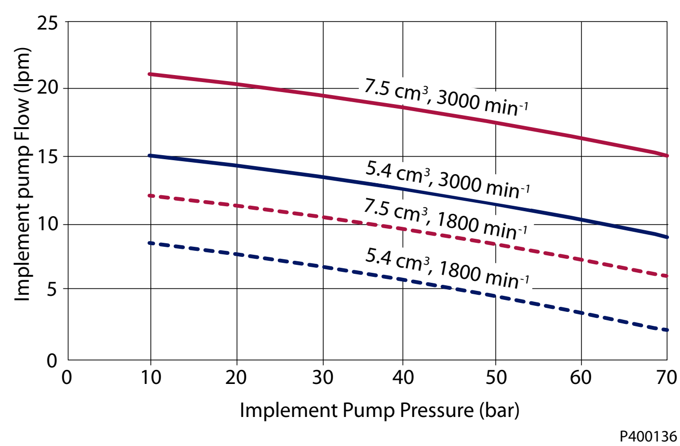
In the DDC implement circuit, flow from the charge (implement) pump flows first to the implement circuit control valve, then to the charge relief and charge check valves. The implement circuit must be designed to return the implement flow to the transmission. The customer must provide an implement circuit relief valve in addition to the implement control valve. It is also recommended that the customer provide a charge pressure filter between the implement control valve and the transmission to prevent any contaminants created in the implement circuit actuator(s) from entering the charge circuit.

Implement Pump Pressure Specifications

Implement Pump Maximum Pressure	bar [psi]	85 [1230]
Implement Pump Maximum working pressure (Implement circuit relief pressure setting)[1]		70 [1015]

[1] Continuous operation at implement pump relief pressure = Short term t <30sec

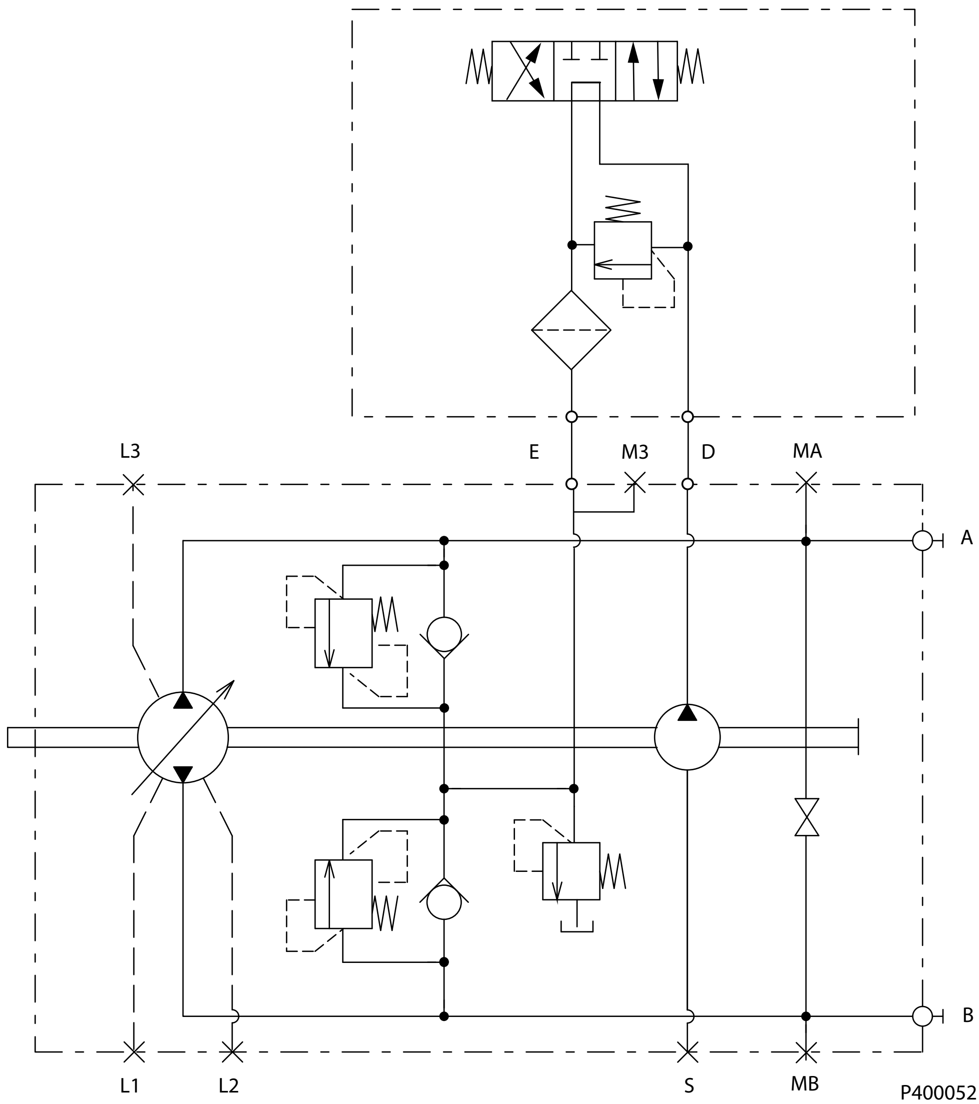
Flow at 11mm²/s [63SUS], 80°C [176°F]



Low input speed with high pressure and high temperature may cause the flow shortage.

System Design Parameters

Implement Circuit - Schematic Diagram



System Design Parameters

Bearing Loads and Life

Bearing life is a function of speed, system pressure, charge pressure, and swashplate angle, plus any external side or thrust loads. The influence of swashplate angle includes displacement as well as direction. External loads are found in applications where the pump is driven with a side/thrust load (belt or gear) as well as in installations with misalignment and improper concentricity between the pump and drive coupling. All external side loads will act to reduce the normal bearing life of a pump. Other life factors include oil type, viscosity and cleanliness.

In vehicle **propel** drives with no external shaft loads and where the system pressure and swashplate angle are changing direction and magnitude regularly, the normal B_{10} bearing life (90 % survival) will exceed the hydraulic load-life of the unit.

Bearing B_{10} Life

Bearing Life (max. swashplate angle)	At 140 bar system pressure 7 bar charge pressure 1800 rpm	B_{10} hours	10000

Applications with External Shaft Loads

DDC pump is designed with bearings that can accept some external radial load. When external loads are present, the allowable radial shaft loads are a function of the load position relative to the mounting flange, the load orientation relative to the internal loads, and the operating pressures of the hydraulic unit. In applications where external shaft loads cannot be avoided, the impact on bearing life can be minimized by proper orientation of the load. Optimum pump orientation is a consideration of the net loading on the shaft from the external load, the pump rotating group and the charge pump load.

- In applications where the pump is operated such that nearly equal amounts of forward vs. reverse swashplate operation is experienced; bearing life can be optimized by orientating the external side load at 90° or 270° such that the external side load acts 90° to the rotating group load (for details see drawing below).
- In applications where the pump is operated such that the swashplate is predominantly (> 75 %) on one side of neutral (ie vibratory, conveyor, typical propel); bearing life can be optimized by orientating the external side load generally opposite of the internal rotating group load. The direction of internal loading is a function of rotation and which system port has flow out.
- DDC pump is designed with bearings that can accept some thrust load such that incidental thrust loads are of no consequence. When thrust loads are anticipated, the allowable load will depend on many factors and it is recommended that an application review be conducted.

Contact Danfoss for a bearing life review if external side loads are present.

Thrust loads should be avoided. If thrust loads are anticipated, contact your Danfossrepresentative.

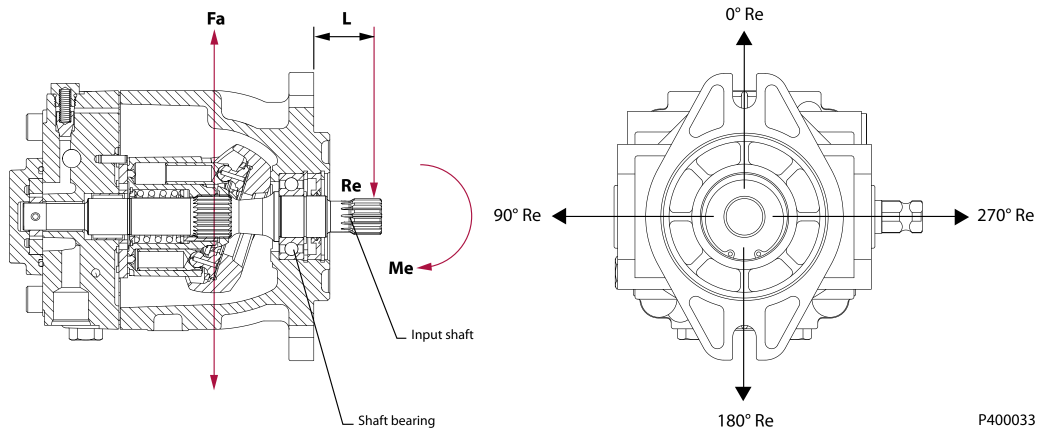
Input Shaft

The **maximum allowable radial load (Re)** is based on the maximum external moment (Me) and the distance (L) from the mounting flange to the load.

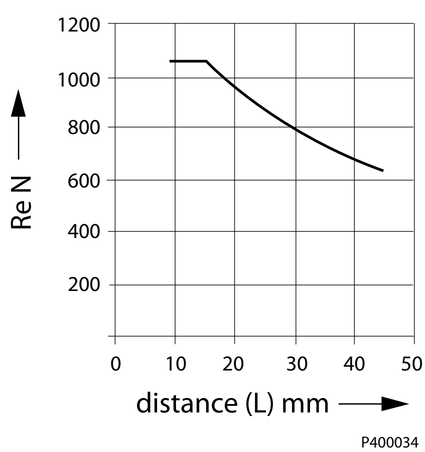
Re = Me / L

Me	Shaft moment
L	Flange distance
Re	External force to the shaft
Fa	Internal rotating group load (changes with direction of flow)

System Design Parameters



Maximum allowable radial load (Re)



Danfoss recommends clamp-type couplings for applications with radial shaft loads

Contact your Danfoss representative for an evaluation of unit bearing life if you have continuously applied external loads exceeding 25 % of the maximum allowable radial load (Re) or the pump swashplate is positioned on one side of center all or most of the time.

Shaft Torque

The **rated torque** is a measure of tooth wear and is the torque level at which a normal spline life of 2 x 10^9 shaft revolutions can be expected. The rated torque presumes a regularly maintained minimum level of lubrication via a moly- disulfide grease in order to reduce the coefficient of friction and to restrict the presence of oxygen at the spline interface. It is also assumed that the mating spline has a minimum hardness of Rc 55 and full spline depth.

Maximum torque ratings are based on torsional fatigue strength considering 100.000 full load reversing cycles. However, a spline running in oil-flooded environment provides superior oxygen restriction in addition to contaminant flushing. The rated torque of a flooded spline can increase to that of the maximum published rating. A flooded spline would be indicative of a pump driven by a pump drive or plugged into an auxiliary pad of a pump.

Maintaining a spline engagement at least equal to the Pitch Diameter will also maximize spline life. Spline engagements of less than ¾ Pitch Diameter are subject to high contact stress and spline fretting.

Alignment between the mating spline's pitch diameters is another critical factor in determining the operating life of a splined drive connection. *Plug-in*, or *rigid* spline drive installations can impose severe radial loads on the shaft. The radial load is a function of the transmitted torque and shaft eccentricity.

System Design Parameters

Increased spline clearance will not totally alleviate this condition; BUT, increased spline clearance will prevent mechanical interference due to misalignment or radial eccentricity between the pitch diameters of the mating splines. Maximize spline life by adding an intermediate coupling between the bearing supported splined shafts.

Mounting Flange Loads

Estimating Overhung Load Moments

Adding auxiliary pumps and/or subjecting pumps to high shock loads may result in excessive loading of the mounting flange. Applications which experience extreme resonant vibrations or shock may require additional pump support. You can estimate the overhung load moment for multiple pump mounting using the formula below.

$M_S = G_S\,(W_1L_1 + W_2L_2 + ... + W_nL_n)$

$M_C = G_C\,(W_1L_1 + W_2L_2 + ... + W_nL_n)$

Where:

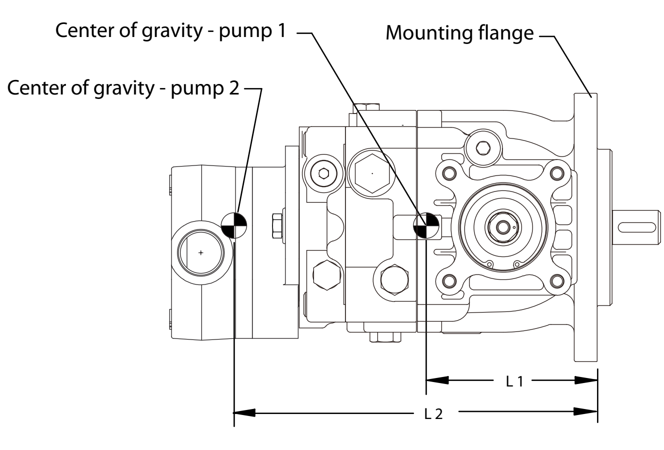
M_C	Rated load moment N•m [lbf•in]
M_S	Shock load moment N•m [lbf•in]
G_C	Rated (vibratory) acceleration (G's)* m/s^2 [ft/s^2]
G_S	Maximum (shock) acceleration (G's)* m/s^2 [ft/s^2]
W_n	Weight of nth pump
L_n	Distance from mounting flange to CG (center of gravity) of nth pump

(Refer to *Installation Drawings* on page 32 to locate CG of pump.)

** Carry out calculations by multiplying gravity (g = 9.81 m/s^2 [32 ft/s^2]) with a given factor. This factor depends on the application.*

Refer to the table below, for allowable overhung load moment values.

Shaft loading parameters



System Design Parameters

Mounting flange load

	Rated moment (M_R)		Shock load moment (M_S)	
	N•m	[lbf•in]	N•m	[lbf•in]
SAE B flange	461	[4080]	865	[7655]
SAE A flange	216	[1912]	404	[3576]

Only SAE B flange is available for the front pump of Tandem pump.

Typical G loads for various applications

Application	Rated (vibratory) acceleration (G_R)	Maximum (shock) acceleration (G_S)
Skid steer loader	4	10
Trencher (rubber tires)	3	8
Asphalt paver	2	6
Windrower	2	5
Aerial lift	1.5	4
Turf care vehicle	1.5	4
Vibratory roller	6	10

Understanding and minimizing system noise

Noise is transmitted in fluid power systems in two ways: as fluid borne noise, and structure borne noise.

Fluid-borne noise (pressure ripple or pulsation) is created as pumping elements discharge oil into the pump outlet. It is affected by the compressibility of the oil, and the pump's ability to transition pumping elements from high to low pressure. Pulsations travel through the hydraulic lines at the speed of sound until there is a change (such as an elbow) in the line. Amplitude varies with overall line length and position.

Structure borne noise is transmitted wherever the pump casing connects to the rest of the system. The way system components respond to excitation depends on their size, form, material, and mounting.

System lines and pump mounting can amplify pump noise.

Follow these suggestions to help minimize noise in your application:

- Use flexible hoses.
- Limit system line length.
- If possible, optimize system line position to minimize noise.
- If you must use steel plumbing, clamp the lines.
- If you add additional support, use rubber mounts.
- Test for resonance in the operating range; if possible avoid them.

System Design Parameters

Size Equations

The following equations are helpful when sizing hydraulic transmissions. Generally, the sizing process is initiated by an evaluation of the machine system to determine the required transmission speed and torque to perform the necessary work function. Refer to *Selection of Drive Line Components,* **BC157786484430**, for a more complete description of hydrostatic drive line sizing.

Based on SI units		**Based on US units**	
Output flow $Q = \frac{V_g \cdot n \cdot \eta_v}{1000}$	(l/min)	Output flow $Q = \frac{V_g \cdot n \cdot \eta_v}{231}$	(US gal/min)
Input torque $M = \frac{V_g \cdot \Delta p}{20 \cdot \pi \cdot \eta_m}$	(N•m)	Input torque $M = \frac{V_g \cdot \Delta p}{2 \cdot \pi \cdot \eta_m}$	(lbf•in)
Input power $P = \frac{M \cdot n \cdot \pi}{30\,000} = \frac{Q \cdot \Delta p}{600 \cdot \eta_t}$	(kW)	Input power $P = \frac{M \cdot n \cdot \pi}{198\,000} = \frac{Q \cdot \Delta p}{1714 \cdot \eta_t}$	(hp)

Variables:	*SI units [US units]*
Vg = Displacement per rev.	cm^3/rev [in^3/rev]
$\mathbf{p_O}$ = Outlet pressure	bar [psi]
$\mathbf{p_i}$ = Inlet pressure	bar [psi]
Δp = $p_{HD} - p_{ND}$ (system pressure)	bar [psi]
n = Speed	min^{-1} (rpm)
$\boldsymbol{\eta_v}$ = Volumetric efficiency	
$\boldsymbol{\eta_m}$ = Mechanical efficiency	
$\boldsymbol{\eta_t}$ = Overall efficiency ($\eta_v \cdot \eta_m$)	

Model Code

Model Code: A, B, R, C, E, G, M

A B R C E G M H K F J S L N P Y Z

DDC A N N A N N N

A - Base Frame Size

Code	Description
20	20 cc/rev
24	24 cc/rev

B - Production Version

Code	Description
A	Product Version "A"

R - Rotation (Viewed from input shaft)

Code	Description
R	Right hand, CW
L	Left hand, CCW

C - Valve Plate

Code	Description
RB	CW, High neutral seeking
LB	CCW, High neutral seeking

E - Control Arm Location and Configuration (Viewing from input shaft, system port up)

Code	Description
RSA	Right side, 17mm square, 100% displacement
LSA	Left side, 17mm square, 100% displacement

G - Neutral Assist Mechanism and Location

Code	Description
NN	None
AN	Detent

M - Bypass Valve (align with module J)

Code	Description
A	With bypass

Model Code

Model Code: H, K, F

H - Loop Flushing (align with module J)

Code	Description
N	None (with Charge/Implement Pump)
D	Defeated Loop Flushing (w/o Charge/Implement Pump)
2	With 2 lpm Flushing @ 7bar (w/o Charge/Implement Pump)
3	With 3.5 lpm Flushing @ 7bar (w/o Charge/Implement Pump)

K - Charge Pump Displacement (align with modules F and J)

Code	Description
N	None with Aux-Pad
3	3.1 cc/rev Charge Pump, Suction, w/o Aux-pad
5	4.8 cc/rev Charge Pump, Suction, w/o Aux-pad
B	7.5 cc/rev Charge Pump, Suction, w/o Aux-pad, CW
C	7.5 cc/rev Charge Pump, Suction, w/o Aux-pad, CCW
D	5.4 cc/rev Implement Pump, Remote, w/o Aux-pad, CW
E	5.4 cc/rev Implement Pump, Remote, w/o Aux-pad, CCW
F	7.5 cc/rev Implement Pump, Remote, w/o Aux-pad, CW
G	7.5 cc/rev Implement Pump, Remote, w/o Aux-pad, CCW

F - Pump Input Shaft (align with modules K and J)

<table>
<tr><th rowspan="2">Code</th><th colspan="2">Description</th></tr>
<tr><th>Input Shaft</th><th>Charge Pump, Aux-Pad</th></tr>
<tr><td>AA</td><td>0.875 inch dia, Straight Key, 33 mm</td><td rowspan="3">with 3.1/4.8 cc Charge Pump, w/o Aux Spline</td></tr>
<tr><td>AB</td><td>0.875 inch dia, Straight Key, 53 mm</td></tr>
<tr><td>AC</td><td>13 teeth, 16/32 pitch</td></tr>
<tr><td>BA</td><td>0.875 inch dia, Straight Key, 33 mm</td><td rowspan="3">w/o Charge Pump, w/ Aux Spline</td></tr>
<tr><td>BB</td><td>0.875 inch dia, Straight Key, 53 mm</td></tr>
<tr><td>BC</td><td>13 teeth, 16/32 pitch</td></tr>
<tr><td>DA</td><td>0.875 inch dia, Straight Key, 33 mm</td><td rowspan="3">with 7.5 cc/rev Charge Pump or Implement Pump w/o Aux Spline</td></tr>
<tr><td>DB</td><td>0.875 inch dia, Straight Key, 53 mm</td></tr>
<tr><td>DC</td><td>13 teeth, 16/32 pitch</td></tr>
</table>

Model Code

Model Code: J, S, L

J - Auxiliary Pad Configuration (align with modules M, H, K and F)

Code	Description	
	Aux-Pad	**Bypass/Loop Flush**
AAN9	SAE-A, 9T	Yes/Yes
AAN1	SAE-A, 11T	Yes/Yes
AAN3	SAE-A, 13T	Yes/Yes
ABN9	SAE-A, 9T	Yes/Defeated
ABN1	SAE-A, 11T	Yes/Defeated
ABN3	SAE-A, 13T	Yes/Defeated
ACA0	w/o Aux Pad, for 3.1/4.8 cc/rev Charge Pump	Yes/None
BCF0	w/o Aux Pad, for 7.5 cc/rev Charge Pump or Implement Pump	Yes/None

S - Input Flange

Code	Description
D	SAE B flange
H	SAE A flange

L - Charge Relief Valves & Setting

Code	Description
07	7 bar
11	11 bar
14	14 bar
18	18 bar
21	21 bar

Model Code

Model Code: N, P, Y, Z

N - System Pressure Protection (Port A) & P - System Pressure Protection (Port B)

Code	Description
00N	Poppet-type Check Valve
14N	High Pressure Relief Valve 140 bar
14A	High Pressure Relief Valve 140 bar w/ Orifice, (∅ 0.85)
17N	High Pressure Relief Valve 175 bar
17A	High Pressure Relief Valve 175 bar w/ Orifice, (∅ 0.85)
19N	High Pressure Relief Valve 190 bar
19A	High Pressure Relief Valve 190 bar w/ Orifice, (∅ 0.85)
21N	High Pressure Relief Valve 210 bar
21A	High Pressure Relief Valve 210 bar w/ Orifice, (∅ 0.85)
23N	High Pressure Relief Valve 230 bar
23A	High Pressure Relief Valve 230 bar w/ Orifice, (∅ 0.85)
25N	High Pressure Relief Valve 250 bar
25A	High Pressure Relief Valve 250 bar w/ Orifice, (∅ 0.85)
28N	High Pressure Relief Valve 280 bar
28A	High Pressure Relief Valve 280 bar w/ Orifice, (∅ 0.85)
30N	High Pressure Relief Valve 300 bar
30A	High Pressure Relief Valve 300 bar w/ Orifice, (∅ 0.85)

Y - Special Hardware

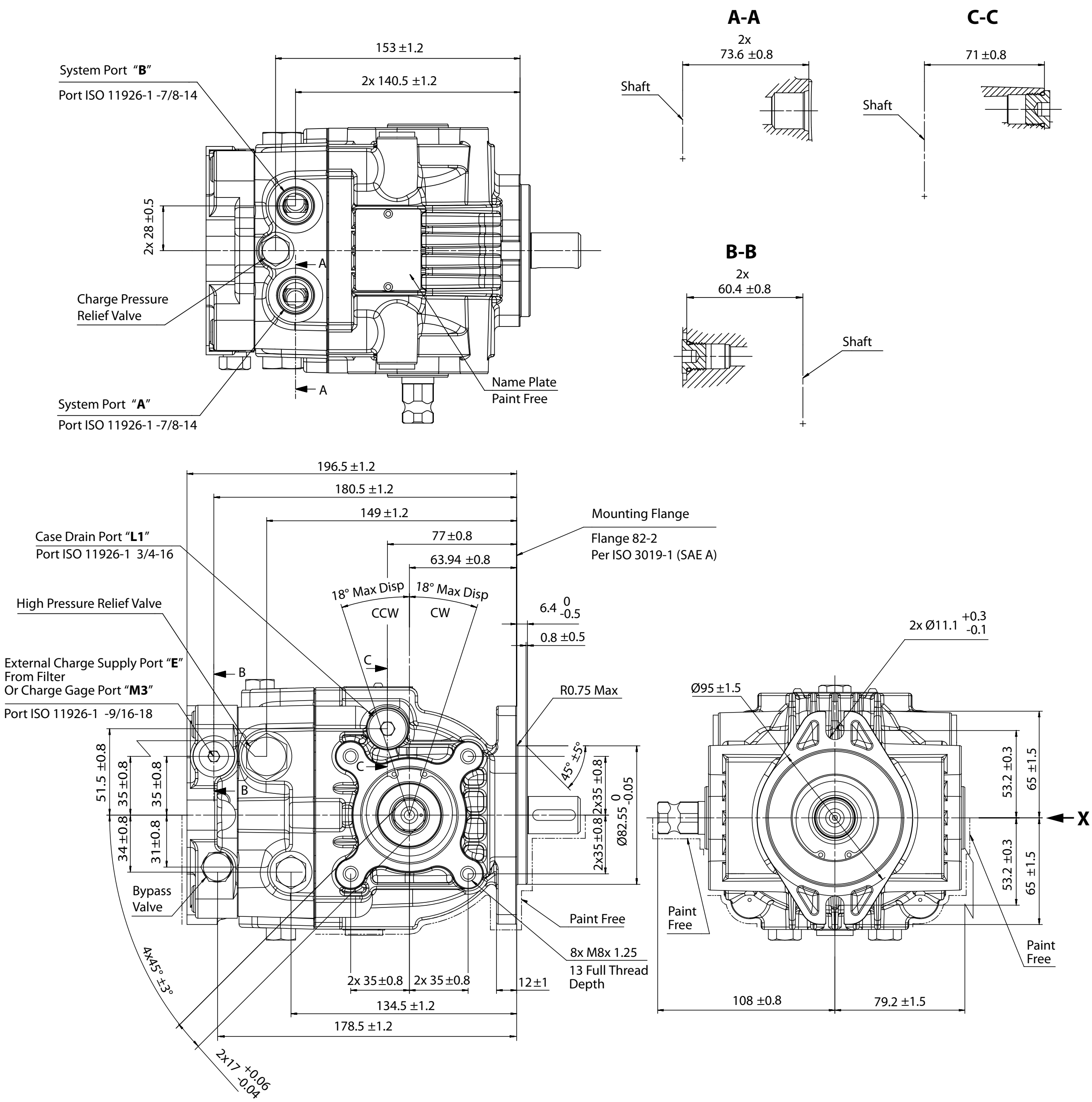
Code	Description
NNN	None

Z - Paint and Tag

Code	Description
NNN	Black Paint, Danfoss Logo

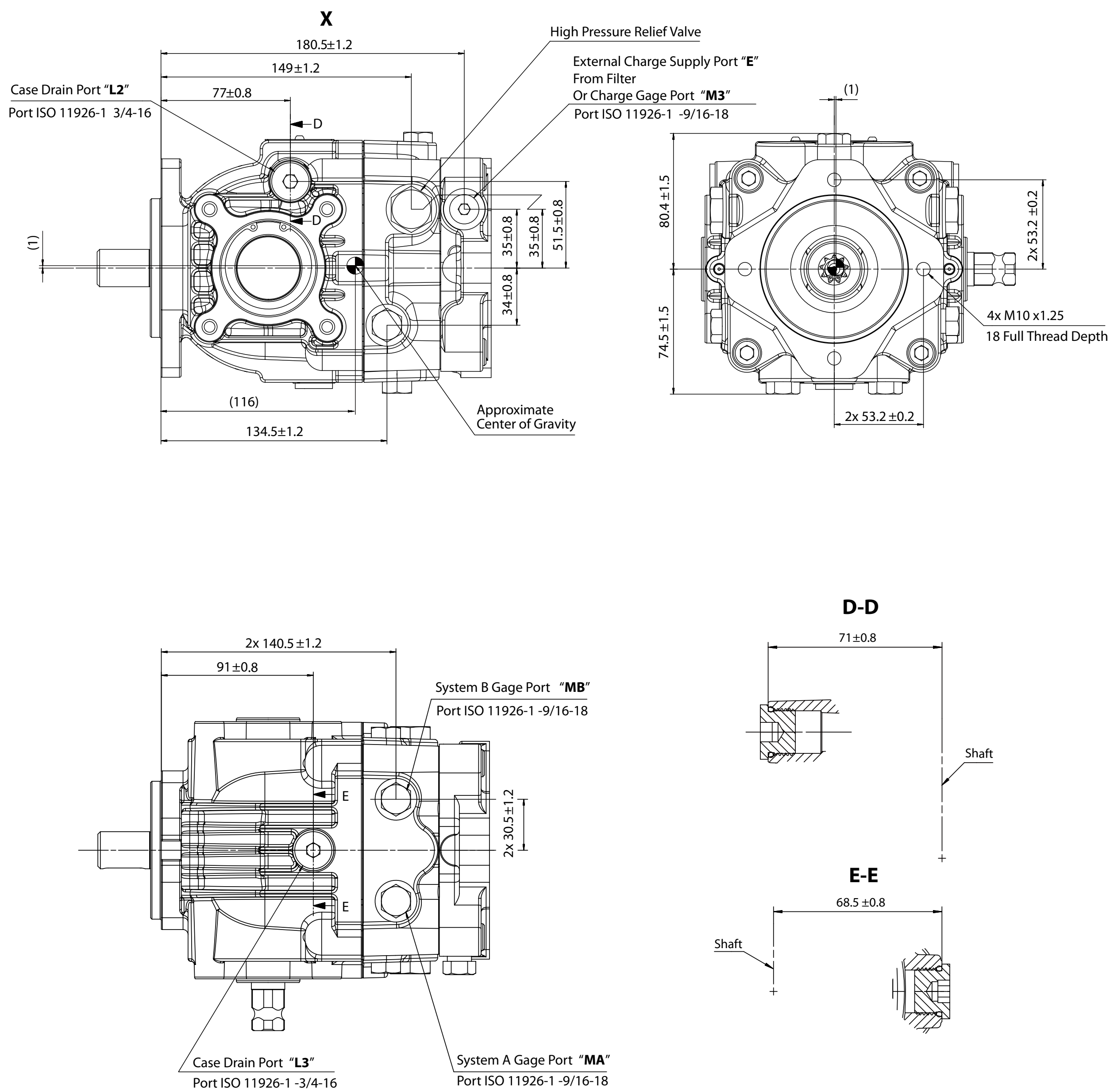
Installation Drawings

With Aux-Pad, No Charge Pump, Left Trunnion, SAE A Flange Configuration



Input shaft rotation	CW				CCW			
Trunnion rotation	Right		Left		Right		Left	
Trunnion rotation	CW	CCW	CW	CCW	CW	CCW	CW	CCW
Port A flow	Out	In	In	Out	In	Out	Out	In
Port B flow	In	Out	Out	In	Out	In	In	Out

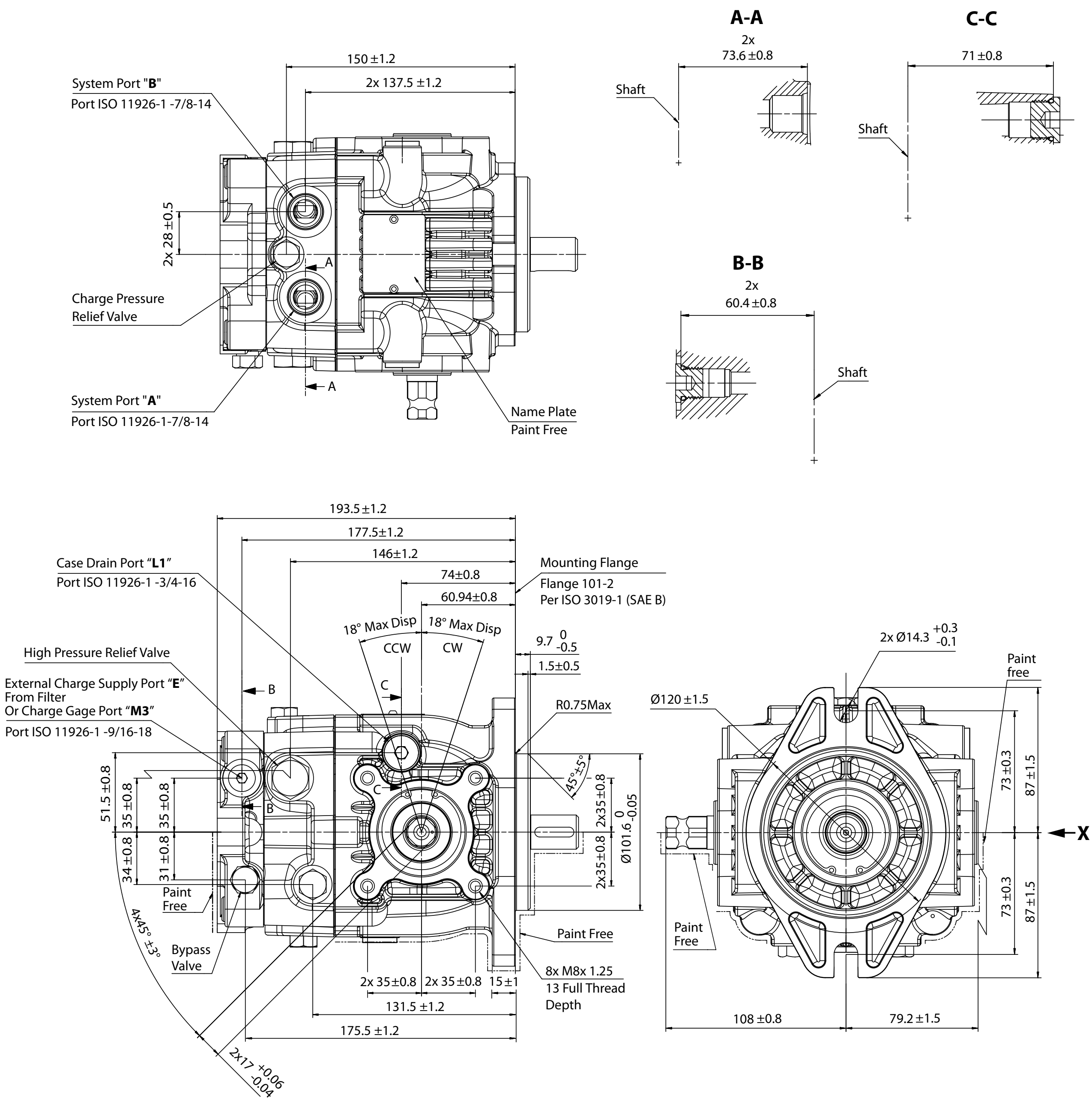
Installation Drawings



P400132

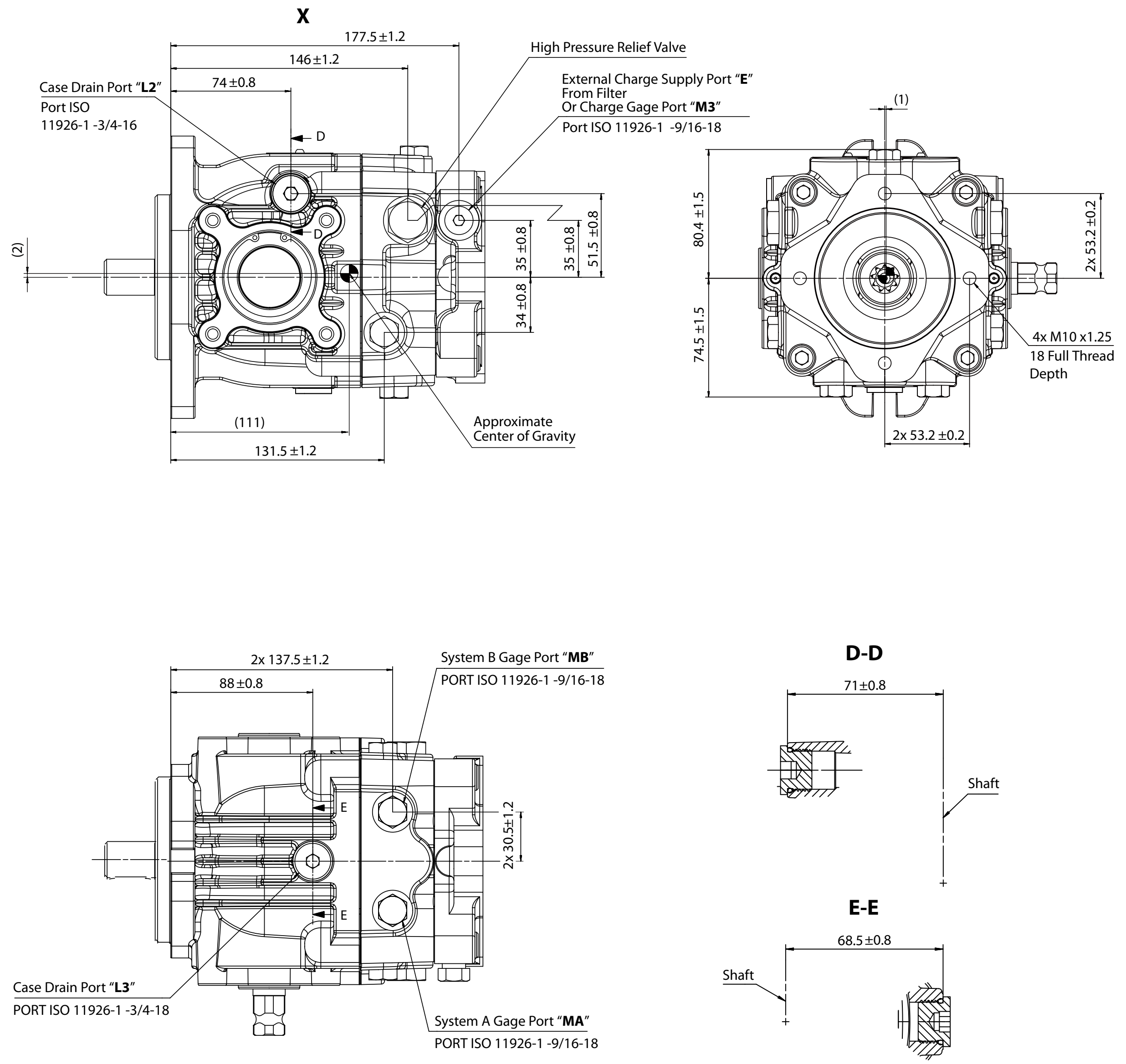
Installation Drawings

With Aux-Pad, No Charge Pump, Left Trunnion, SAE B Flange Configuration



P400036

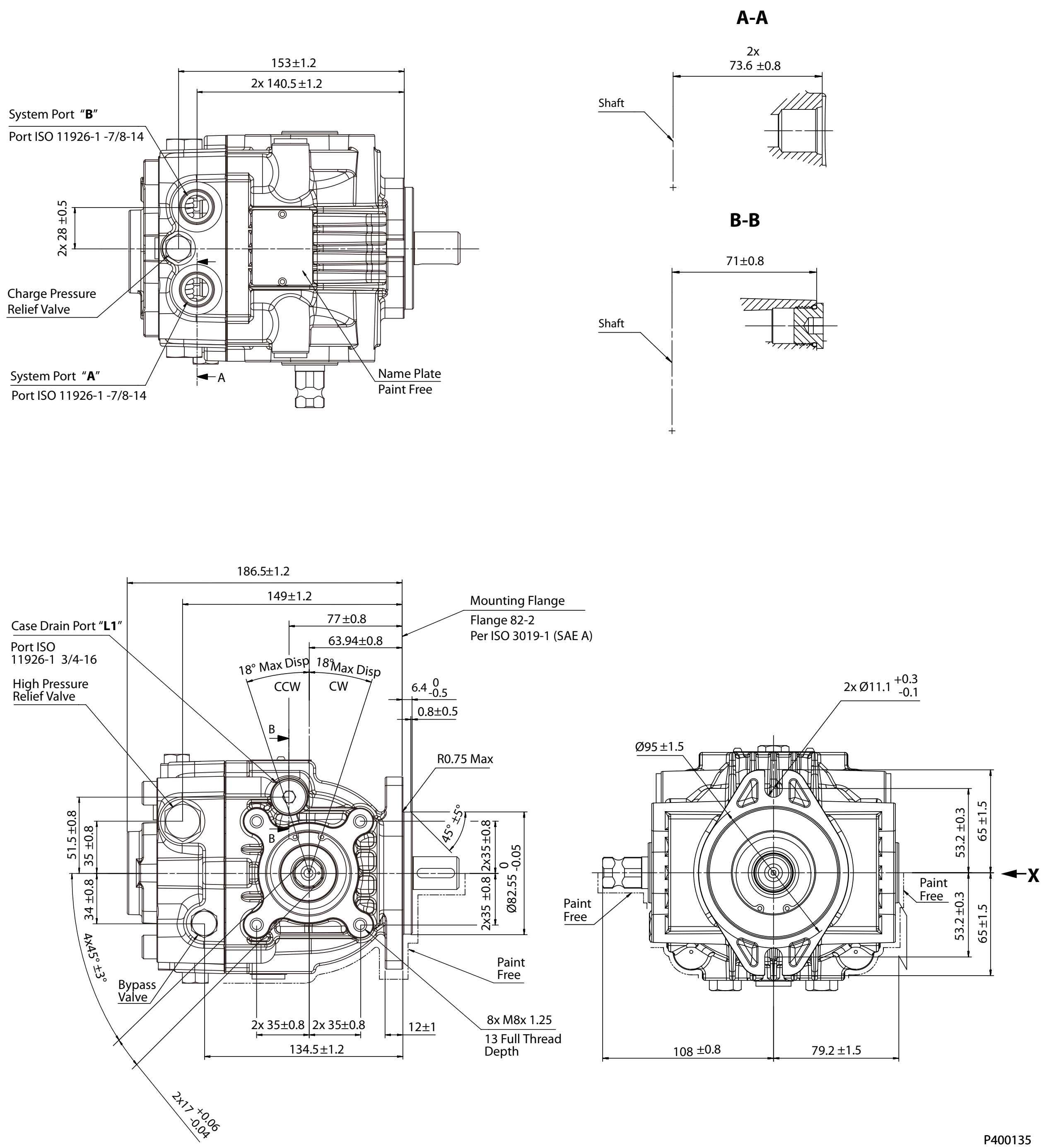
Installation Drawings



P400037

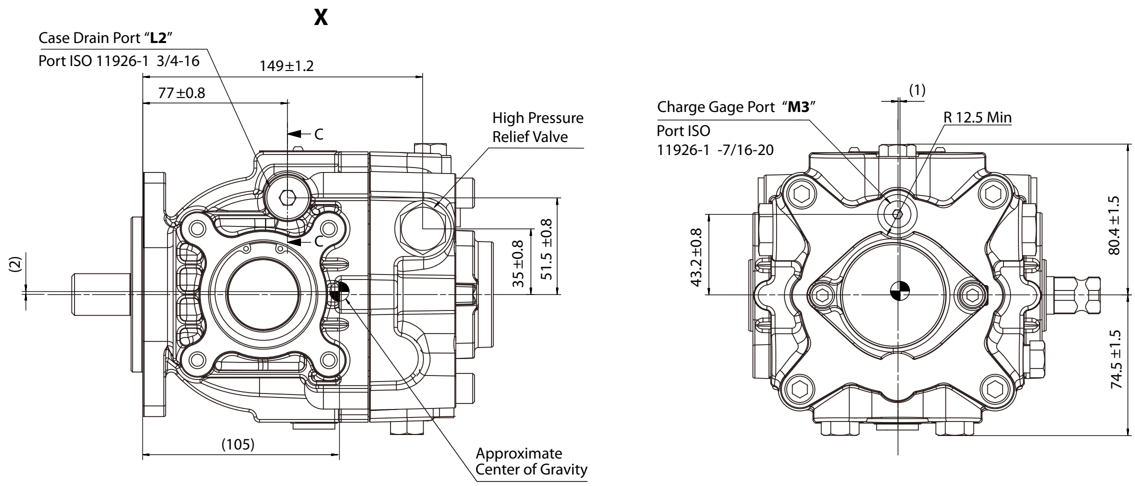
Installation Drawings

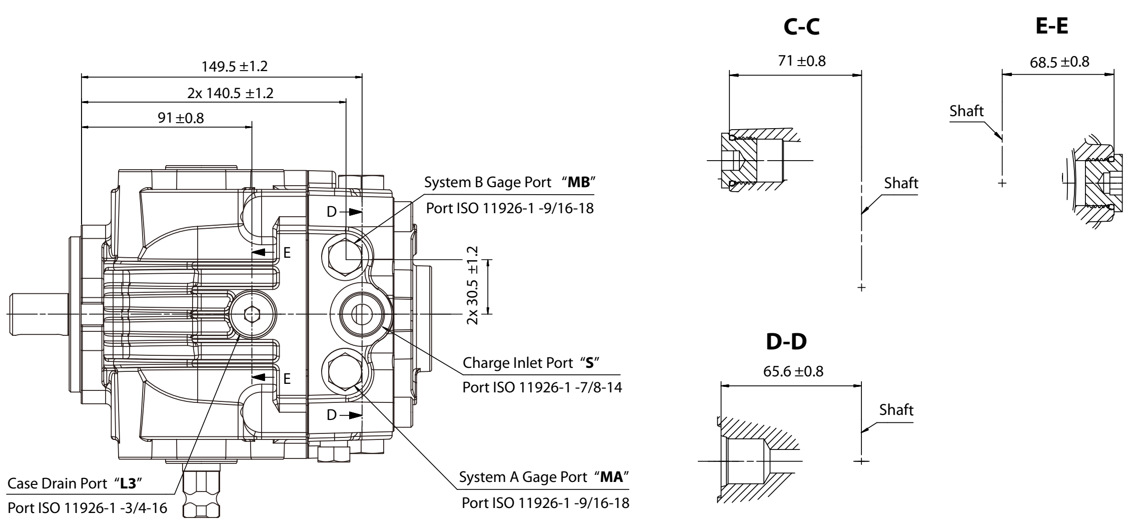
With Charge Pump, No Aux-Pad, Left Trunnion, SAE A Flange Configuration



P400135

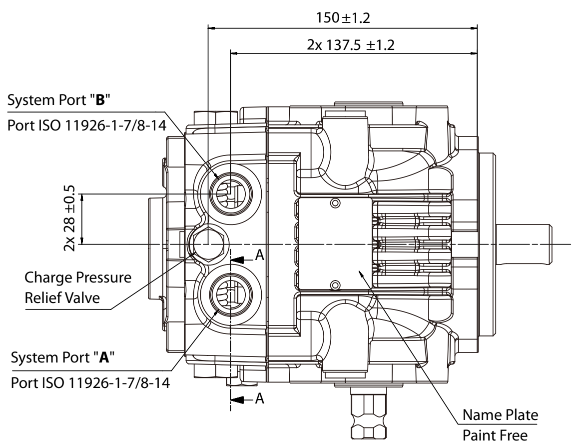
Installation Drawings

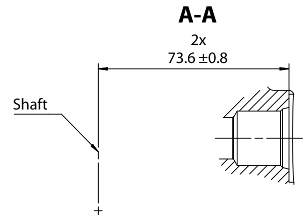


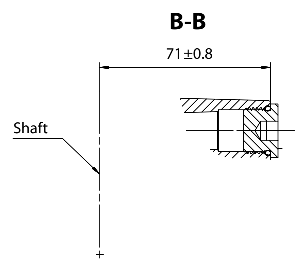


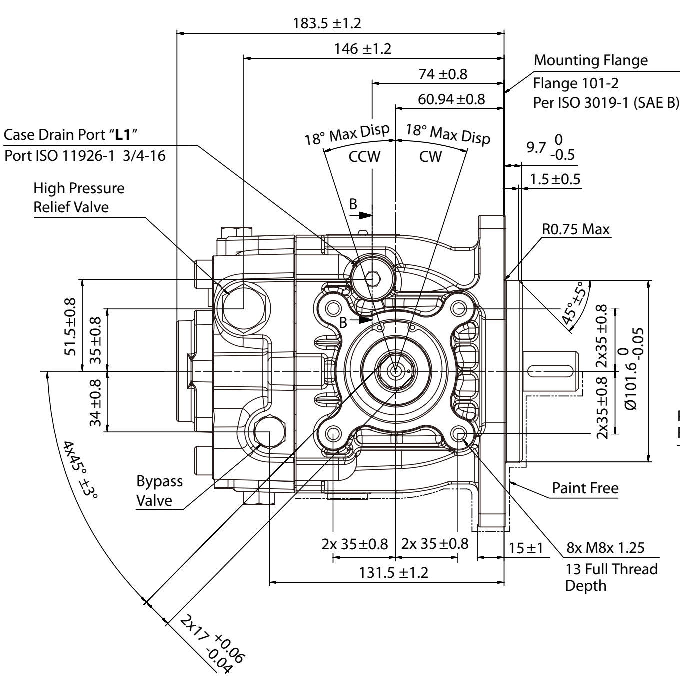
Installation Drawings

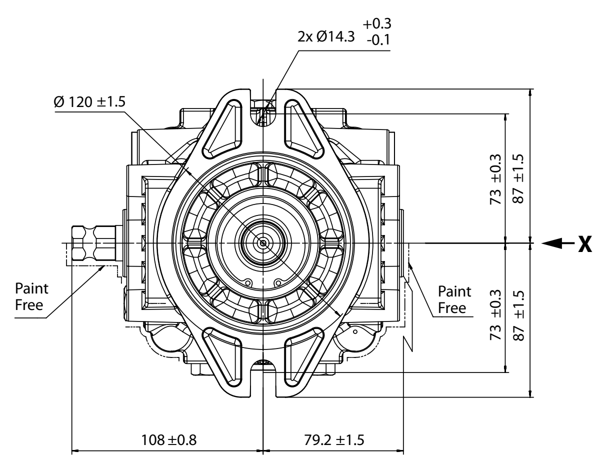
With Charge Pump, No Aux-Pad, Left Trunnion, SAE B Flange Configuration





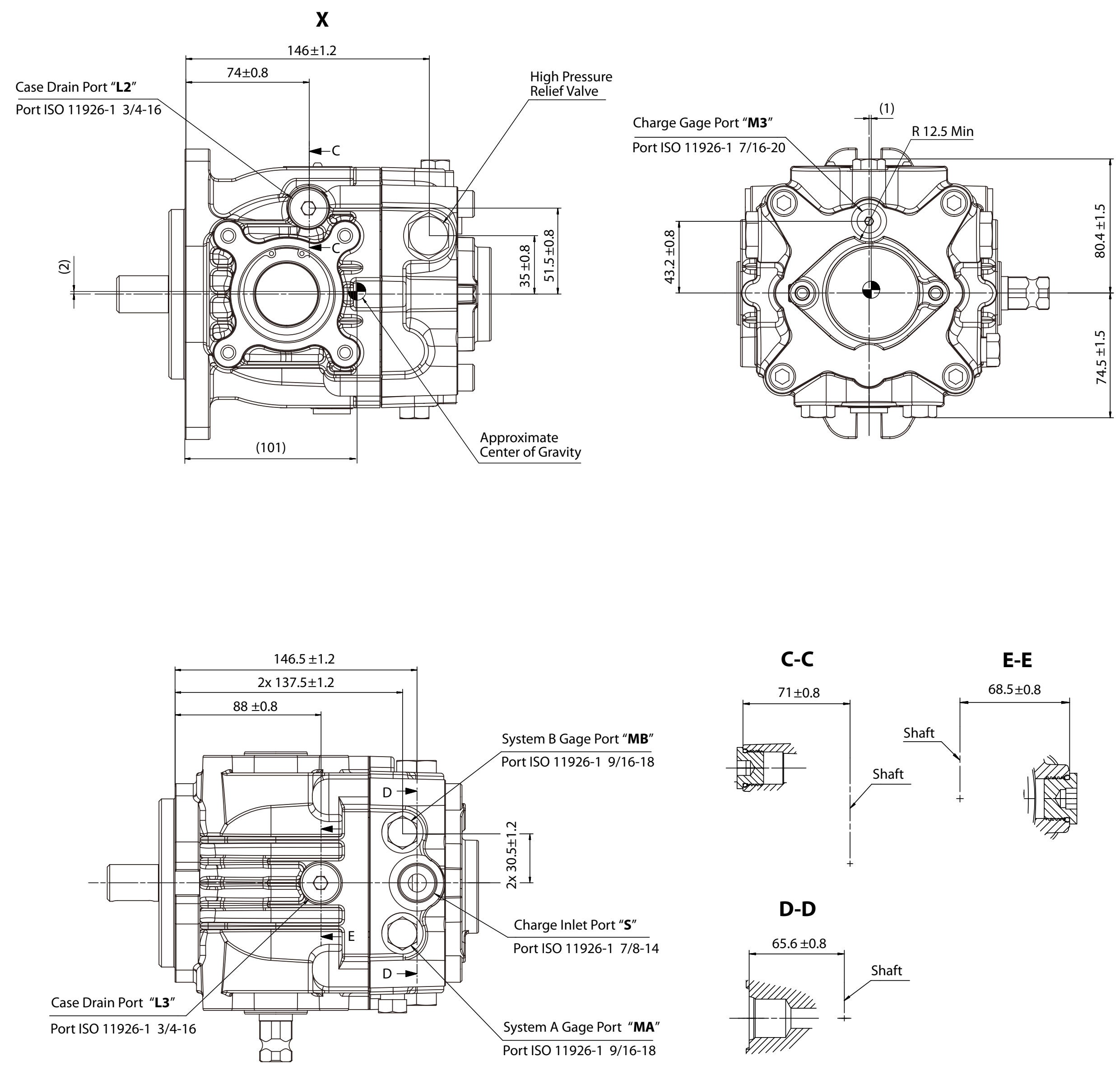






P400038

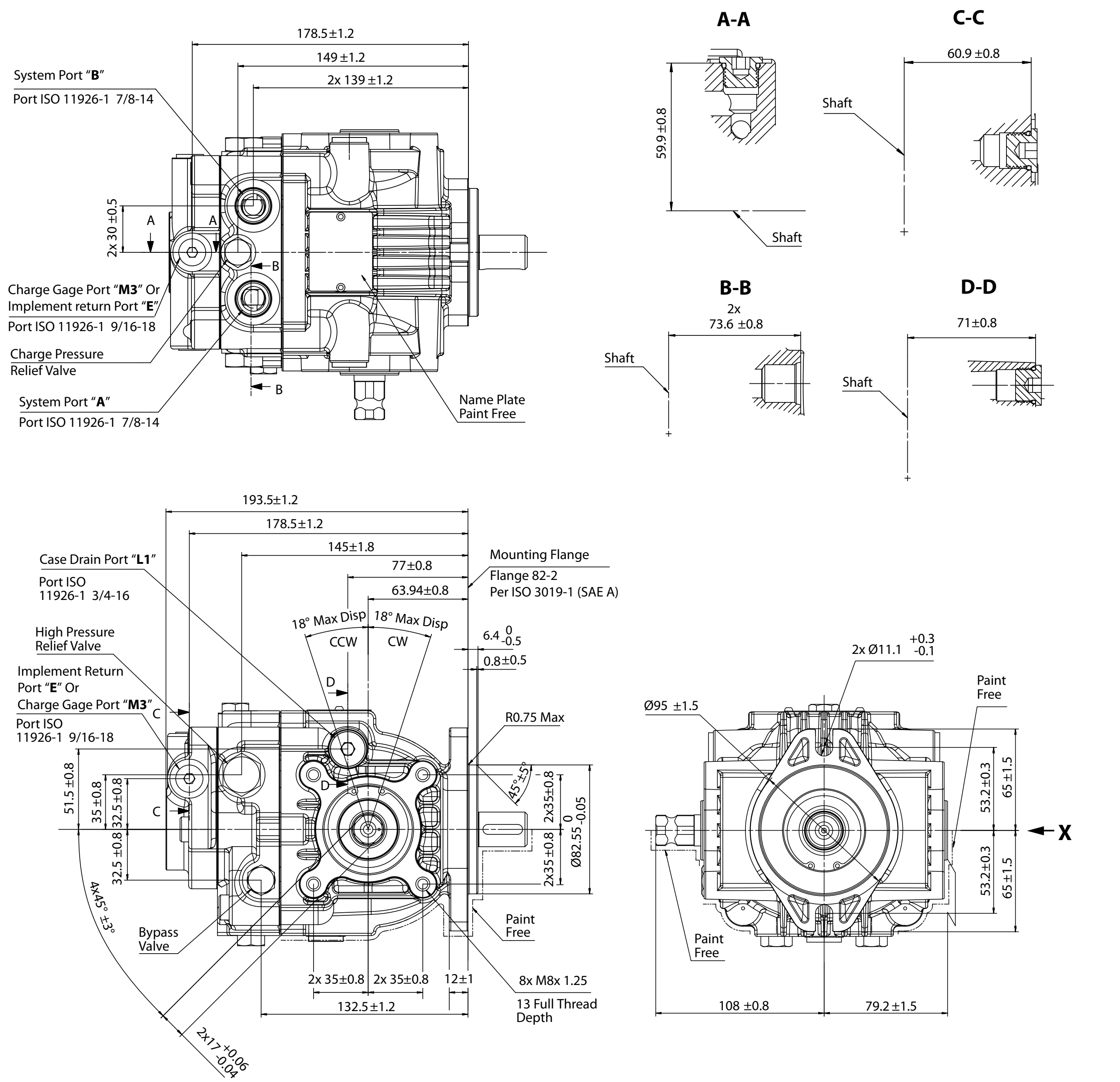
Installation Drawings



P400039

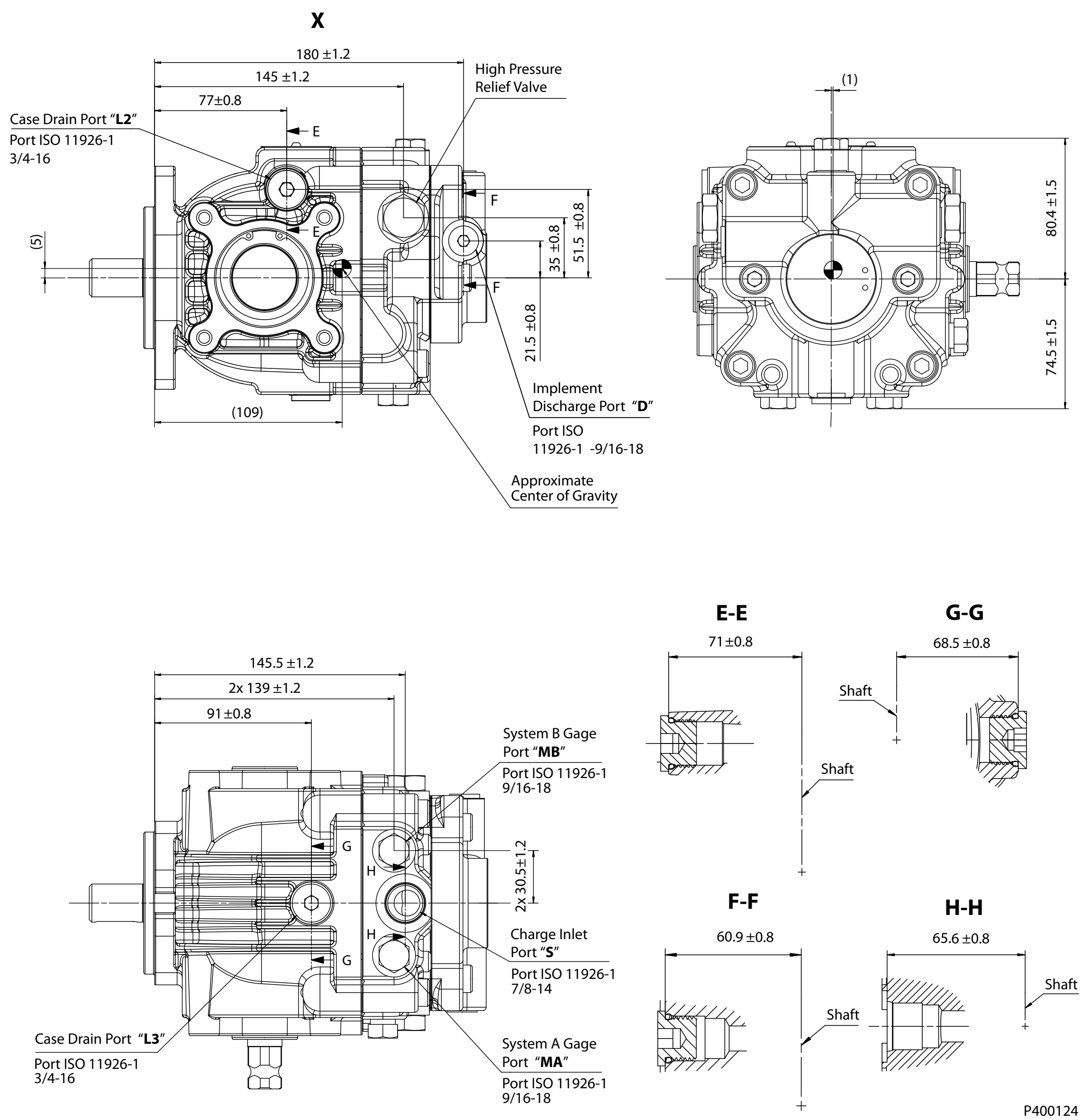
Installation Drawings

With Implement Pump, No Aux-Pad, Left Trunnion, SAE A Flange Configuration



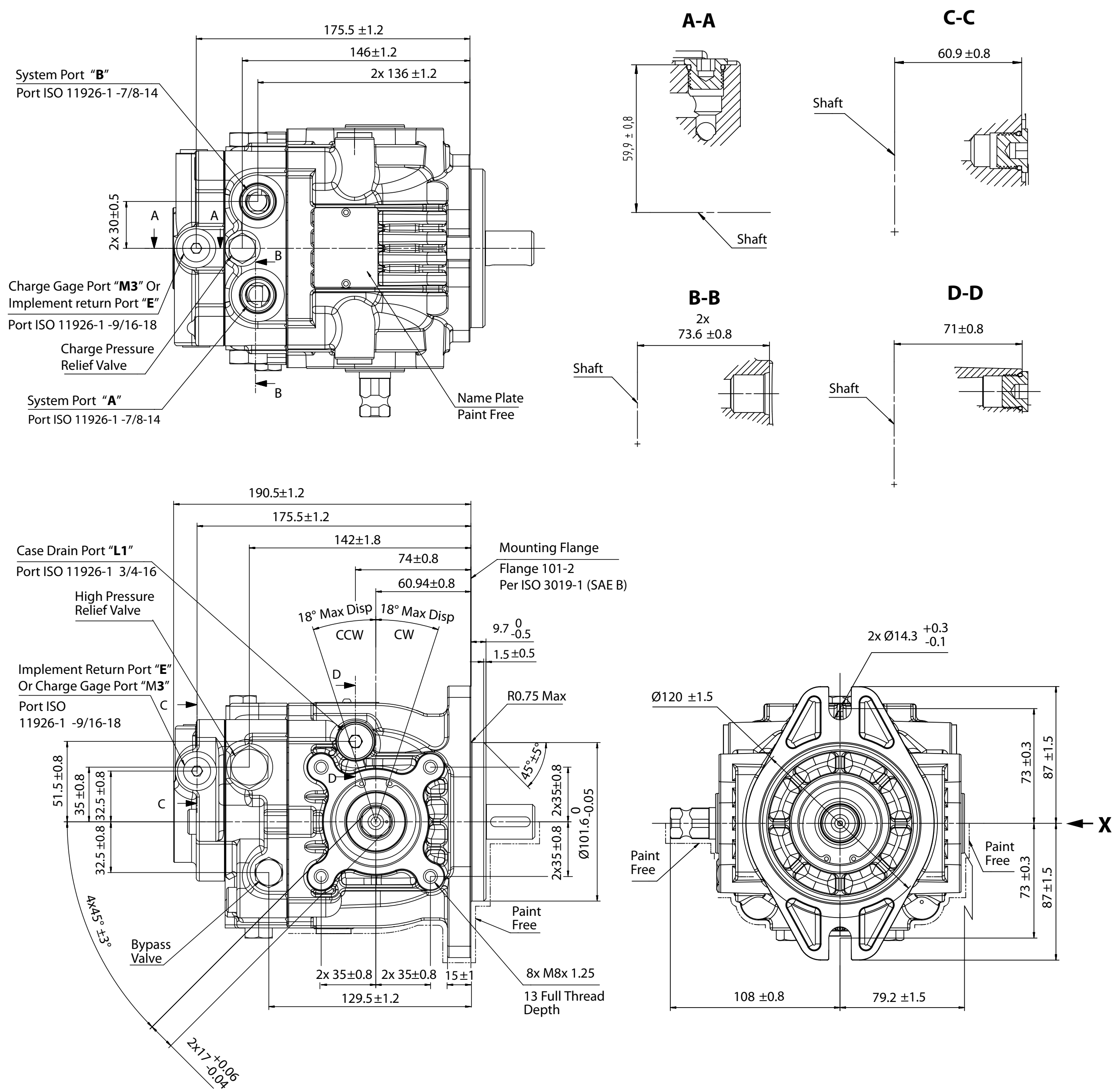
P400125

Installation Drawings



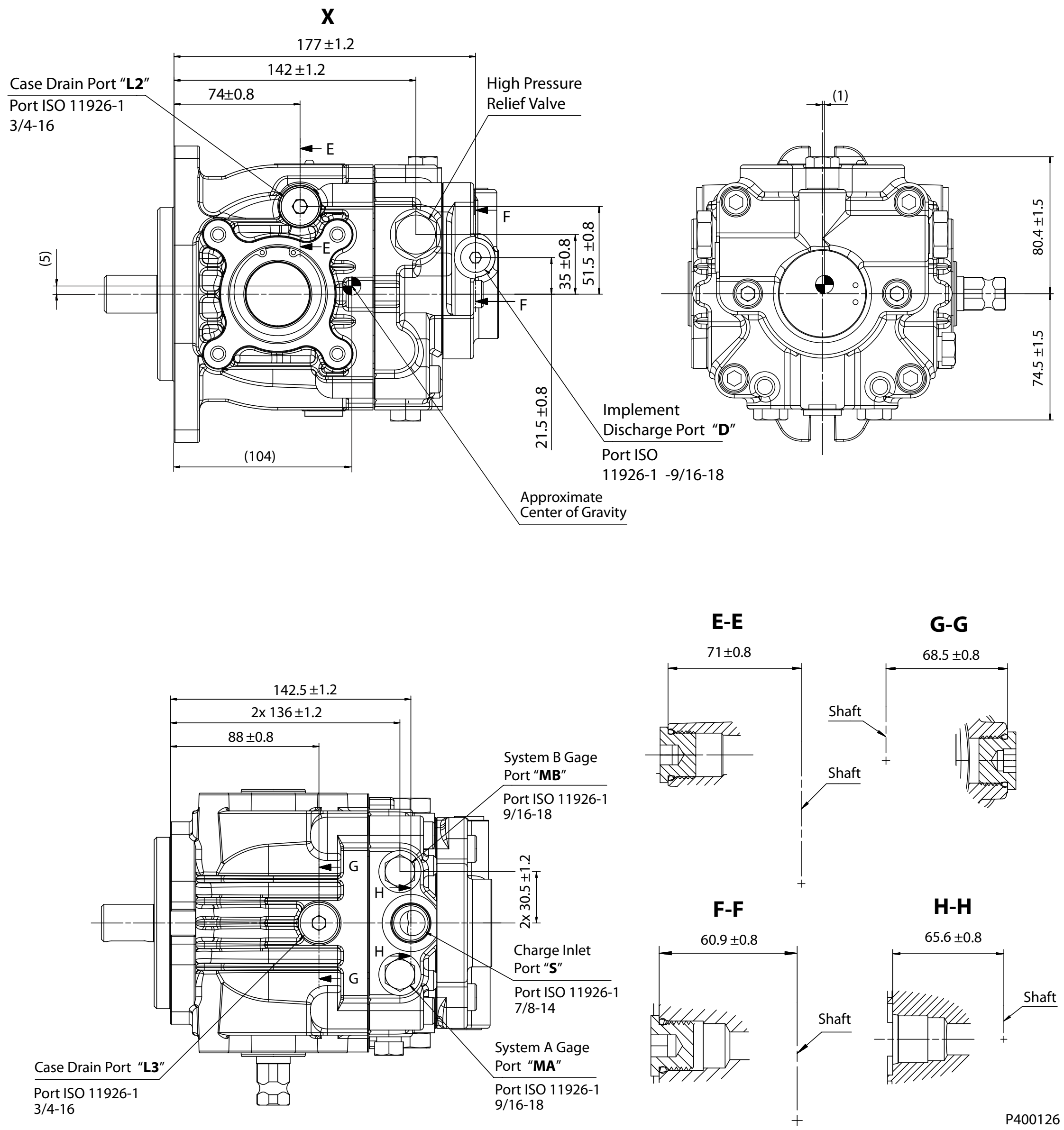
Installation Drawings

With Implement Pump, No Aux-Pad, Left Trunnion, SAE B Flange Configuration



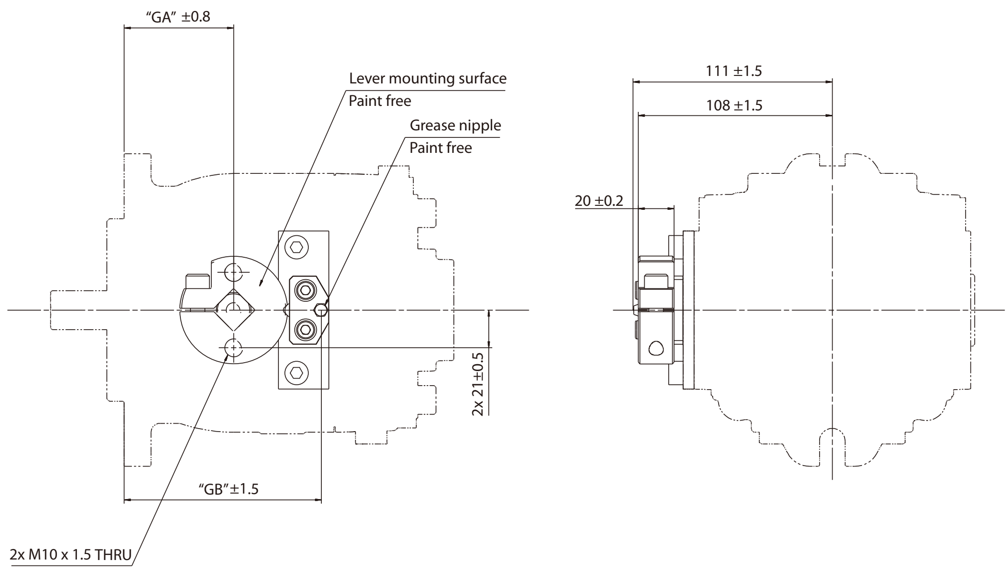
P400127

Installation Drawings



Installation Drawings

Option: Detent



P400749

Mounting flange	"GA" dimension	"GB" dimension
SAE A	63.94	112.44
SAE B	60.94	109.44

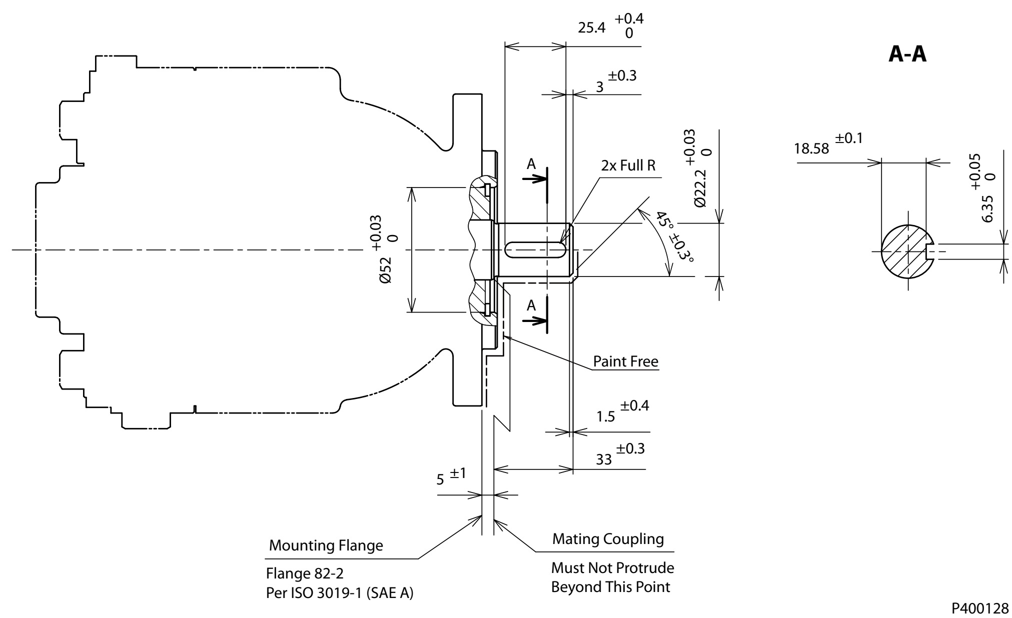
Installation Drawings

Input Shafts: AA, BA, DA

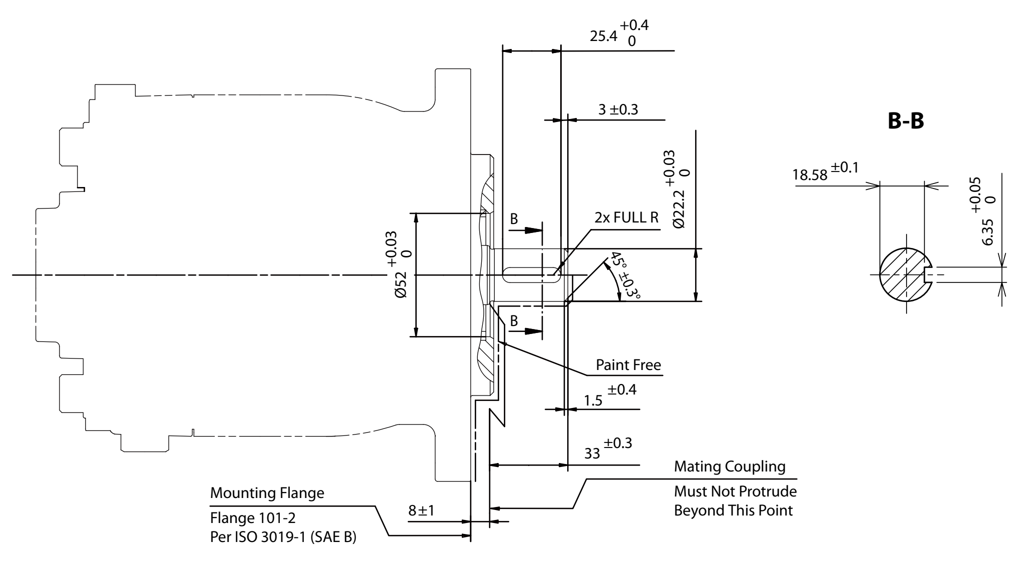
Shaft Availability and Torque Ratings

Option	Shaft Data	Torque Rating N•m [lbf•in]
		Maximum Torque
AA, BA, DA	Outer 0.875 inch dia, Straight key, 33mm	226 [2000]

SAE A



SAE B



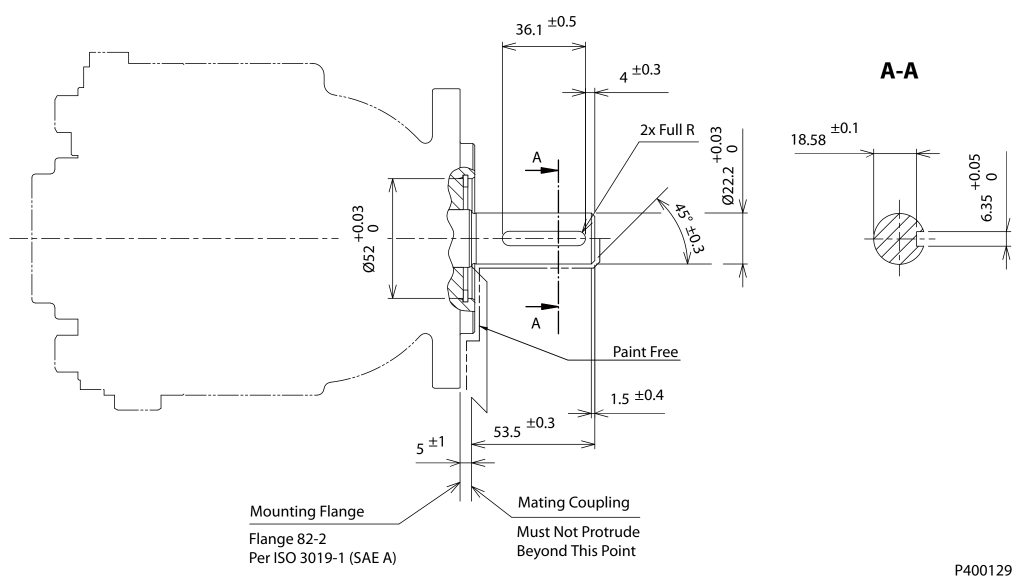
Installation Drawings

Input Shafts: AB, BB, DB

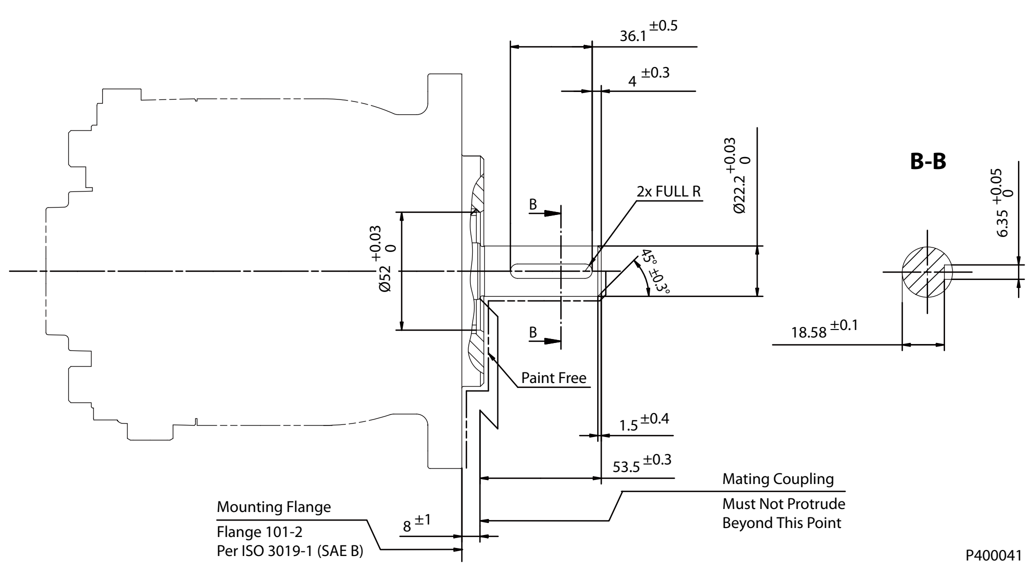
Shaft Availability and Torque Ratings

Option	Shaft Data	Torque Rating N•m [lbf•in]
		Maximum Torque
AB, BB, DB	Outer 0.875 inch dia, Straight key, 53mm	226 [2000]

SAE A



SAE B



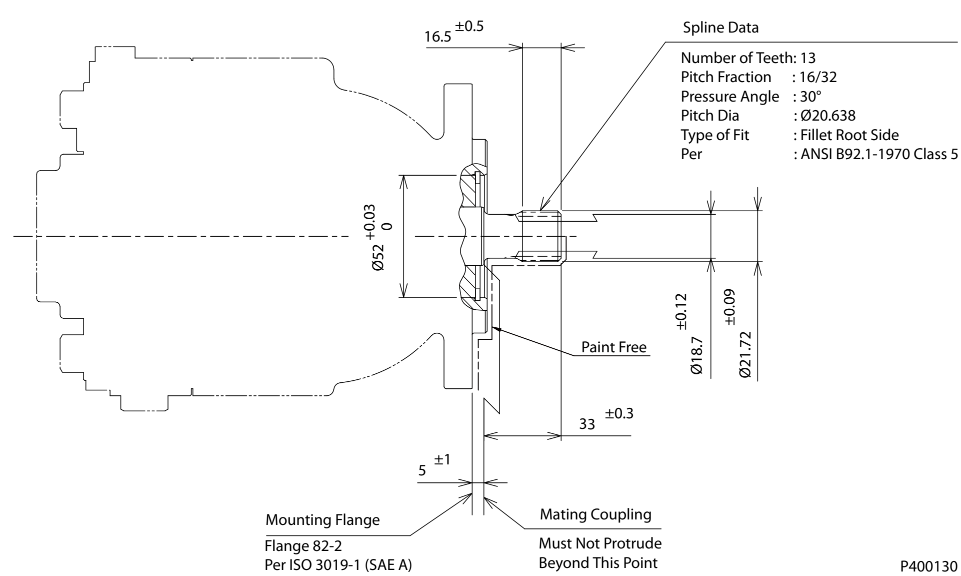
Installation Drawings

Input Shafts: AC, BC, DC

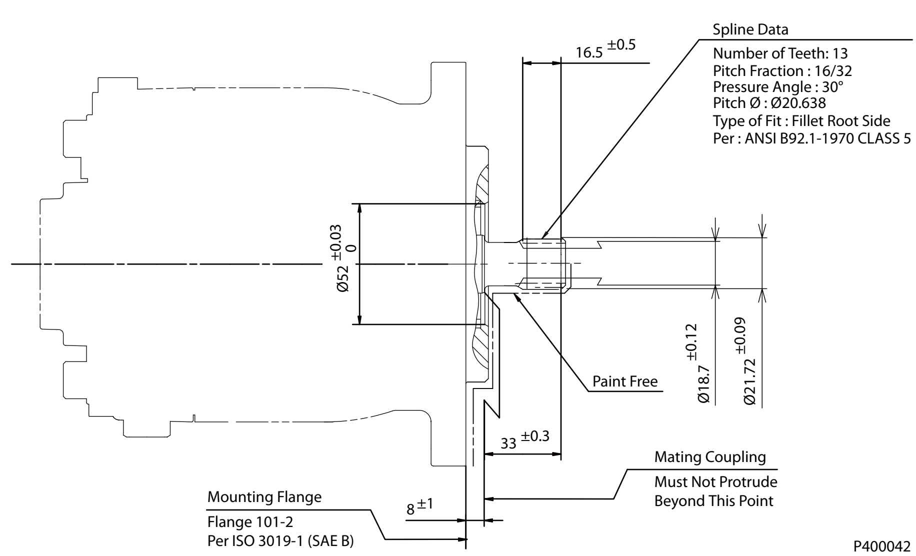
Shaft Availability and Torque Ratings

Option	Shaft Data	Torque Rating N•m [lbf•in]	
		Rated Torque	Maximum Torque
AC, BC, DC	13 teeth 16/32 pitch per ANSI B92.1-1970 CLASS5	180 [1593]	236 [2088]

SAE A



SAE B



Installation Drawings

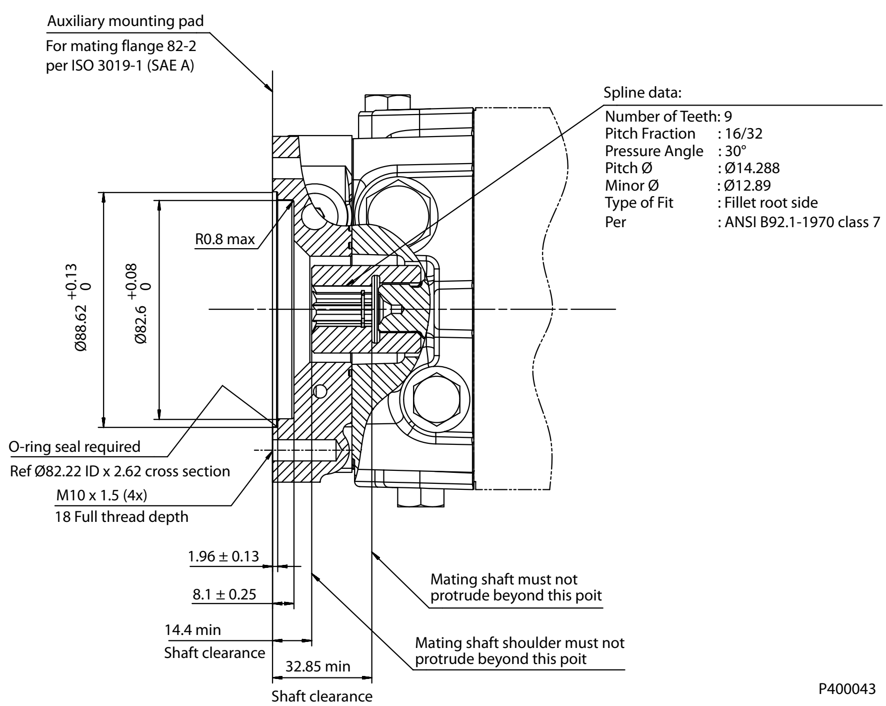
Auxiliary Mounting Pads

Shaft Availability and Torque Ratings

Pad Size	Flange	Spline	Minimum Spline Length mm [inch]	Maximum Torque N•m [lbf•in]
SAE A	ISO3019-1, flange82-2	9 teeth	13.5 [0.53]	162 [1434]
SAE A Special		11 teeth	13.5 [0.53]	194 [1717]
SAE A Special		13 teeth	13.5 [0.53]	207 [1823][1]

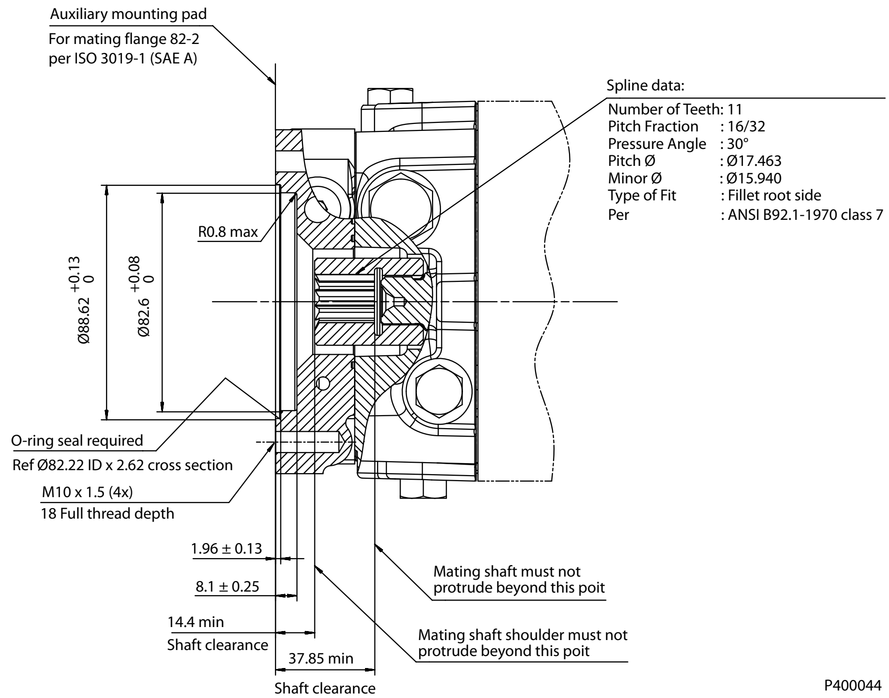
[1] Limited by 23T aux spline.

9 teeth (option)

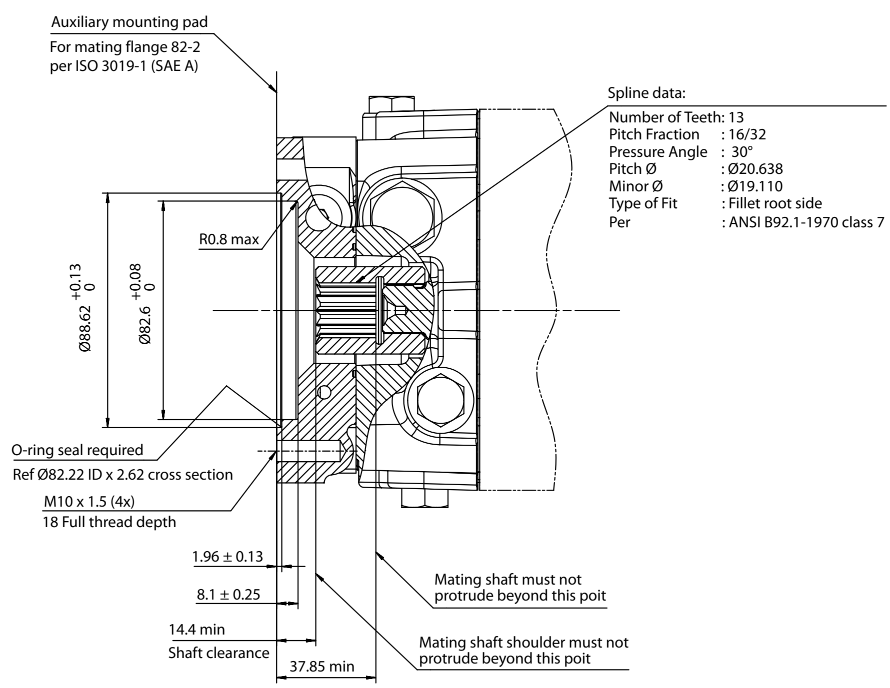


Installation Drawings

11 teeth (option)



13 teeth (option)



Reference Literature

Literature

Refer to the literature listed below for product information and specifications for DDC pumps and other Danfoss components.

DDC Pumps literature

- *DDC Axial Piston Pumps Service Manual* **AX152986482107**

Hydraulic Systems Guidelines

- *Hydraulic Fluids and Lubricants Technical Information* **BC152886484524**
- *Pressure and Speed Limits* **BC152886484313**
- *Design Guidelines for Hydraulic Fluid Cleanliness* **BC152886482150**
- *Experience with Biodegradable Hydraulic Fluids, Technical Information* **520L465**
- *Selection of Driveline Components* **BC157786484430**

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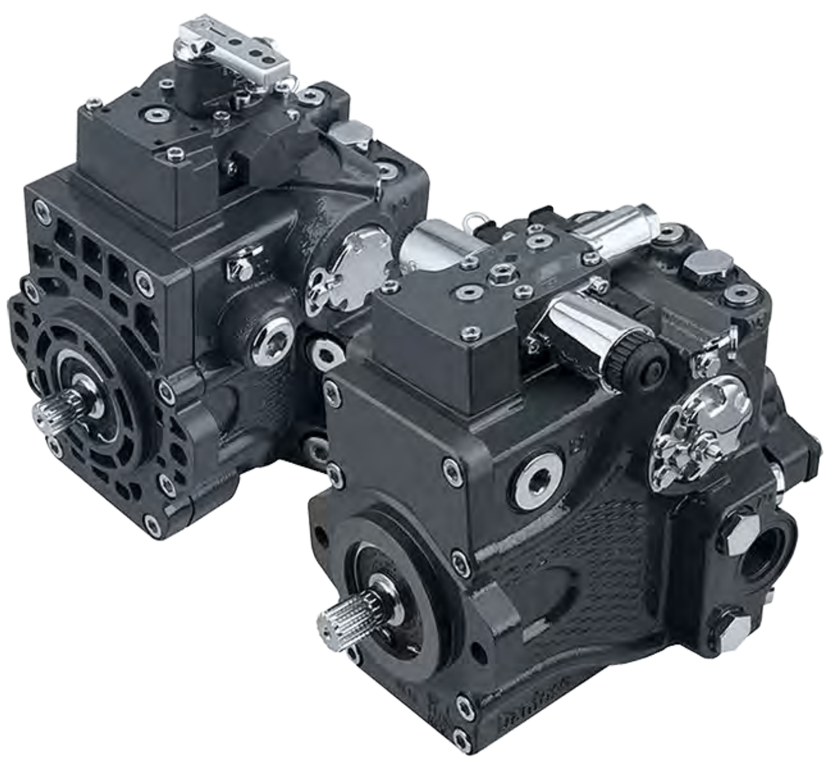
Technical Information

MP1 Axial Piston Pumps
Size 28/32, 38/45



Revision history

Table of revisions

Date	Changed	Rev
May 2022	Minor update onto 28/32 dimensions with speed sensor	0504
February 2022	Added option A3 endcap option to 38/45cc	0503
January 2022	Corrected the number of charge pressure in operating parameters	0502
December 2021	Added HDC control options	0501
April 2021	Corrected interface with ECU (EDC) graphic	0407
April 2020	Added model code option	0406
March 2020	Removed restricted model code options and changed document number from BC00000352	0405
January 2020	Added option A5 to system port type model code options	0303
November 2019	Fixed on P108935、P400313, P400325,	0302
October 2019	Updated with new control options	0301
March 2019	Updated with new control options	0201
May 2018	Add 14 tooth shaft, minor edits	0106
March 2018	Update MDC control illustrations	0105
January 2018	Add NFPE control	0104
October 2017	Minor edits	0103
April 2017	Minor edits	0102
August 2016	First Edition	0101

Contents

General description

Overview......6
Features......6
System diagram......7
Schematic......8

Technical specifications

Design specifications......9
Technical data......9
Operating parameters......10
Fluid specifications......10

Operation

High Pressure Relief Valve (HPRV) and charge checkHPRV and charge check......11
Bypass function......11
Charge Pressure Relief Valve (CPRV)CPRV function......12
Loop flushing valve......13
Electrical displacement control (EDC)......13
EDC principle......13
EDC operation......14
Control signal requirements, EDC MP1......14
EDC solenoid data......15
Control response......15
EDC response time......15
Manual override (MOR)......15
Hydraulic displacement control (HDC)......17
HDC principle......17
HDC operation......17
Hydraulic signal pressure range......18
Pump output flow direction vs. control pressure......18
Control response......18
Response time, HDC......19
Swashplate angle sensor for EDC controls......20
Swash plate angle sensor parameters (EDC)......20
Swash plate angle sensor connector......21
Interface with ECU (EDC)......21
Manual displacement control......21
MDC principle......21
MDC operation......23
MDC shaft rotation......23
Control response......24
MDC response time......24
Neutral start switch (NSS)......24
Case gauge port M14......25
Lever......25
Forward-neutral-reverse (FNR) electic control......26
FNR principle......26
Control response......28
Response time, FNR......28
Non feedback proportional electric control (NFPE)......28
Control signal requirements......29
Control response......30
Response time......31
Non-feedback, proportional hydraulic (NFPH) control......31
Control response......32
Response time......32
Automotive control (AC)......33
Control-cut-off valve (CCO valve)......35
CCO solenoid data......36
Brake gauge port with MDC......37

Contents

Displacement limiter....37
  Displacement change (approximate)....37
Speed sensor....38
  Temperature range....38
  Output pulses....38
  Mating connectors....38
  Speed sensor 4.5 – 8 V technical data....38
Temperature sensor data....39

Operating parameters

Input speed....40
System pressure....40
Charge pressure....41
Charge pump inlet pressure....41
Case pressure....41
Temperature....41
Viscosity....42

System design parameters

Filtration system....43
Filtration....43
  Suction filtration....43
  Charge pressure filtration....44
Independent braking system....45
Fluid selection....45
Reservoir....45
Case drain....45
Charge pump....45
  Charge pump sizing/selection....46
Charge pump output flow....47
Bearing life and external shaft loading....47
Hydraulic unit life....49
Mounting flange loads....49
Shaft torques....51
  Shaft selection....51
  Shaft torque and splines lubrication....51
  Shaft torque for tapered shafts....51
Shaft availability and torque ratings....52
Understanding and minimizing system noise....52
Sizing equations....54

Model code

Model code (A - B - C)....55
Model code (D)....56
Model code (F)....57
Model code (H - J - T)....58
Model code (K)....59
Model code (E - M - N - Z - L)....60
Model code (V - G - W)....61
Model code (X - Y)....63

Installation drawings

28/32 ports....64
38/45 ports....65
28/32 dimensions....66
28/32 dimensions with speed sensor....68
38/45 dimensions....69
38/45 dimensions with speed sensor....72
Input shafts: option G4, F6 (SAE B, 13 teeth)....73
Input shafts: option G1, F1 (SAE B, 14 teeth)....74
Input shafts: option G5, F5 (SAE B, 15 teeth)....75

Contents

Input shafts: option A7, A9 (SAE B, straight key shaft)....76
Input shafts: option G6, G7 (SAE B, 19 teeth)....77
Input shafts: option A6, A8 (SAE B, straight key shaft)....78
Input shafts: option F2, F3 (SAE B, taper key shaft) 79
Tapered shaft customer acknowledgement....79
Auxiliary mounting: option A16, B16, C16, D16, E16, F16 (SAE A, 9 teeth)....80
Auxiliary mounting: option A19, B19, C19, D19, E19, F19 (SAE A, 11 teeth)....81
Auxiliary mounting: option A22, B22, C22, D22, E22, F22 (SAE B, 13 teeth)....82
Auxiliary mounting: option A25, B25, C25, D25, E25, F25 (SAE B-B 15 teeth) 83

Controls

Electric displacement control (EDC)....84
Electric displacement control with CCO (EDC+CCO)....85
EDC with ASNSR....86
Hydraulic displacement control (HDC)....87
Manual displacement control (MDC)....88
MDC with NSS option M2....89
MDC with CCO options M3, M4....90
MDC with NSS and CCO options M5, M6....91
Forward-neutral-reverse (FNR)....92
Non-feedback proportional electric (NFPE)....93
Non-feedback proportional hydraulic (NFPH)....94
Automotive control (AC)....95
AC connectors dimensions....96

Filtration

Suction filtration: option S....97
Remote full flow charge pressure filtration: option R....98
External full flow charge pressure filtration: option E....99

General description

MP1 overview

The MP1 pump is a variable displacement axial piston pump intended for closed circuit medium power applications. The swashplate motion is controlled via compact hydraulic servo control system. A variety of controls are available. These include mechanic or electric actuated feedback controls, electric or hydraulic actuated non-feedback type controls, and a three-position electric control.. These controls feature low hysteresis and responsive performance.

MP1 features

Designed for quality and reliability

- Uniform design concept across frame sizes
- Single piece housing to minimize leaks
- Technologically advanced kit and servo system
- Predictable, low friction swashplate bearing for precise machine control

Machine integration benefits

- Industry leading pump length
- Clean side for easier machine integration
- Metric and Inch O-ring boss and Split flange (38/45 only) system port interfaces
- Standard connection interfaces

Greater total efficiency

- Increased pump efficiency
- Lower control pressure for less power consumption

Control options

- Electrical displacement control (EDC)
- Manual displacement control (MDC)
- Hydraulic displacement control (HDC)
- Automotive control (AC-1, AC-2)
- Forward-neutral-reverse (FNR)
- Non-feedback proportional electric (NFPE)
- Non-feedback proportional hydraulic (NFPH)
- Common control across entire family

Expanded functionality

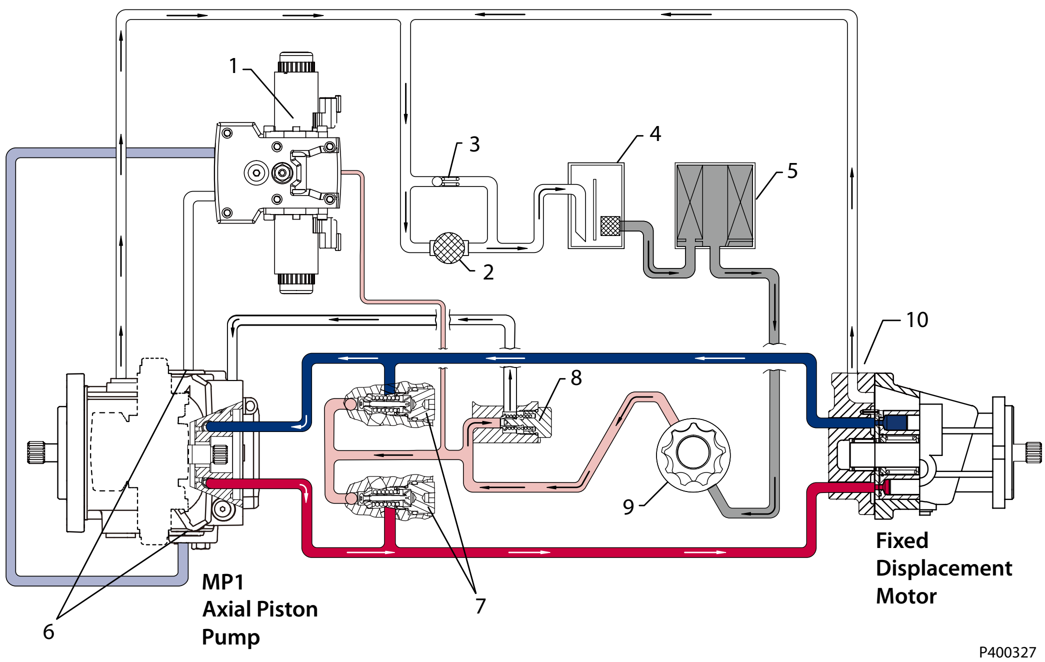
- PLUS+1® Compliant control and options
- Easy integration with Telematics
- Integrated Flushing valve available

Modularity

- Common control, charge pump and auxiliary pad options
- Easy and quick conversion to the right configuration

General description

MP1 system diagram



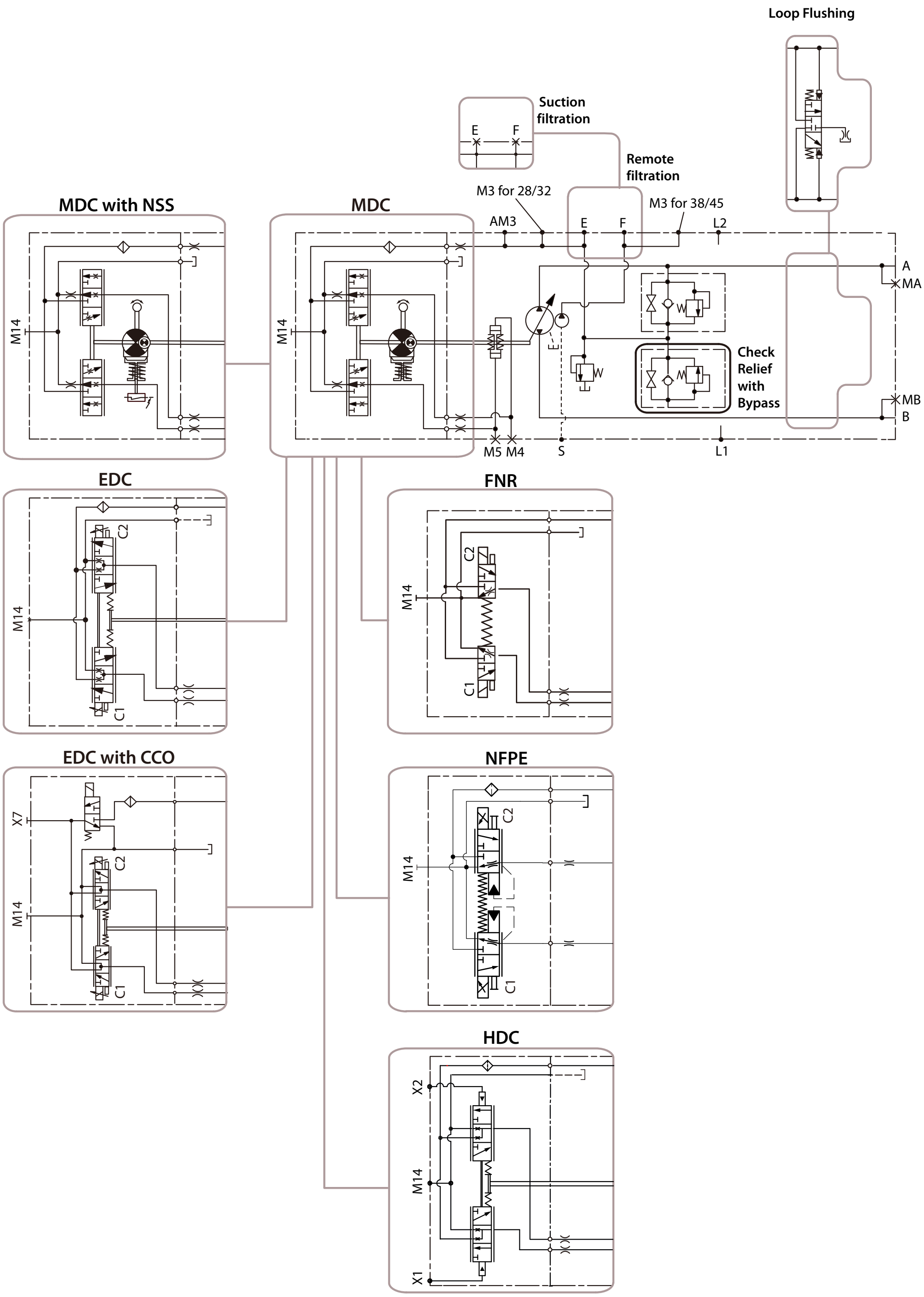
Servo Pressure	System High Pressure	System Low Pressure
Charge Pressure	Case Flow	Suction Flow
1. Control	2. Heat Exchanger	3. Heat Exchanger Bypass
4. Reservoir	5. Filter	6. Servo Piston
7. Check Valves with High Pressure Relief Valves	8. Charge Relief Valve	9. Charge Pump
10. Case Drain		

MP1 28/32

MP1 38/45

General description

MP1 schematic



Technical specifications

MP1 design specifications

Features	MP1
Design	Axial piston pump with variable displacement using compact servo piston control.
Direction of input rotation	Clockwise or counterclockwise
Recommended installation position	Pump installation position is discretionary, however the recommended control position is on the top or at the side with the top position preferred. If the pump is installed with the control at the bottom, flushing flow must be provided through port M14 located on the EDC, HDC, FNR, NFPE, NFPH, AC-1, AC-2 and MDC control. Vertical input shaft installation is acceptable. The housing must always be filled with hydraulic fluid. Recommended mounting for a multiple pump stack is to arrange the highest power flow towards the input source. Consult Danfoss for non-conformance to these guidelines.
Filtration configuration	Suction or charge pressure filtration

MP1 technical data

Feature	28	32	38	45
Displacement (cm^3/rev [in^3/rev])	28.0 [1.71]	31.8 [1.94]	38.0 [2.32]	45.1 [2.75]
Flow at rated (continuous) speed (l/min [US gal/min])	95.3 [25.2]	108.1 [28.5]	125.3 [33.1]	149.5 [39.5]
Torque at maximum displacement (N•m/bar [lbf•in/1000psi])	0.45 [272.0]	0.51 [308.9]	0.60 [369.1]	0.72 [438.1]
Mass moment of inertia of rotating components (kg•m^2 [slug•ft^2])	0.0020 [0.0015]		0.0030 [0.0022]	
Mass (kg [lb])	29.6 [65.3]		38 [83.8]	
Oil volume (liter [US gal])	1.5 [0.40]		2.0 [0.53]	
Mounting flange	ISO 3019-1 flange 101-2 (SAE B)			
Input shaft outer diameter, splines and tapered shafts	ISO 3019-1, outer Ø22mm - 4 (SAE B, 13 teeth) ISO 3019-1, outer Ø25mm - 4 (SAE B-B, 15 teeth)			
	ISO 3019-1, outer Ø22mm - 1 (Straight Key)		ISO 3019-1, outer Ø31mm - 4 (19 teeth) ISO 3019-1, outer Ø25mm - 4 (Straight Key) ISO 3019-1, outer Ø25mm -3 (Conical keyed, taper 1:8)	
Auxiliary mounting flange with metric fasteners, shaft outer diameter and splines	ISO 3019-1, flange 82-2, outer Ø16mm - 4 (SAE A, 9 teeth) ISO 3019-1, flange 82-2, outer Ø19mm - 4 (SAE A, 11 teeth) ISO 3019-1, flange 101-2, outer Ø22mm - 4 (SAE B, 13 teeth) ISO 3019-1, flange 101-2, outer Ø25mm - 4 (SAE B-B, 15 teeth)			
Main port configuration **A, B**	ISO 11926-1 - 1 1/16 - 12 (Inch O-ring boss)		ISO 11926-1 - 1 5/16 - 12 (Inch O-ring boss)	
	ISO 6149-1, M27x2 (Metric o-ring boss)		ISO 6162, Ø19mm, (Split flange boss, M10x1.5)	
			ISO 6149-1 - M33x2 (Metric O-ring boss)	
Case drain ports **L1, L2**	ISO 11926-1, 1 1/16 -12 (Inch O-ring boss) ISO 6149-1, M27x2 (Metric O-ring boss)			
Suction ports **S**	ISO 11926-1 - 1 1/16-12 (Inch O-ring boss) ISO 6149-1 - M27x2 (Metric O-ring boss)		ISO 11926-1 - 1 5/16-12 (Inch O-ring boss) ISO 6149-1 - M33x2 (Metric O-ring boss)	
Other ports	ISO 11926-1, (Inch O-ring boss) ISO 6149 -1, (Metric O-ring boss)			
Customer interface threads	Metric fasteners			

Technical specifications

MP1 operating parameters

Features		Units	28/32	38/45
Input speed	Minimum[1]	min^{-1} (rpm)	500	500
	Rated		3400	3300
	Maximum		4000	3900
System pressure	Maximum working pressure	bar [psi]	350 [5000]	350 [5000]
	Maximum pressure		380 [5429]	380 [5429]
	Minimum low loop (above case)		10 [143]	10 [143]
Charge pressure (minimum)		bar [psi]	16 [232]	16 [232]
Charge pump inlet pressure	Minimum (continuous)	bar (absolute) [in Hg vacuum]	0.8 [6]	0.8 [6]
	Minimum (cold start)		0.2 [24]	0.2 [24]
	Maximum		2.0	2.0
Case pressure	Rated	bar [psi]	3 [43]	3 [43]
	Maximum		5 [71]	5 [71]

[1] No load condition. Refer to System Design Parameters/Charge Pump for details.

MP1 fluid specifications

Features		Units	28/32/38/45
Viscosity	Intermittent[1]	mm^2/sec. [SUS]	5 [42]
	Minimum		7 [49]
	Recommended range		12 - 80 [66 - 370]
	Maximum (cold start)[2]		1600 [7500]
Temperature range[3]	Minimum (cold start)	°C [°F]	-40 [-40]
	Recommended range		60 - 85 [140 - 185]
	Maximum continuous		104 [220]
	Maximum intermittent		115 [240]
Filtration (recommended minimum)	Cleanliness per ISO 4406		22/18/13
	Efficiency (charge pressure filtration)	β-ratio	β15-20=75(β10≥10)
	Efficiency (suction filtration)		β35-45=75(β10≥2)
	Recommended inlet screen mesh size	µm	100 - 125

[1] Intermittent=Short term t <1 min per incident and not exceeding 2 % of duty cycle based load-life.

[2] Cold start = Short term t < 3 min, p < 50 bar [725 psi], n < 1000 min^{-1} (rpm)

[3] At the hottest point, normally case drain port.

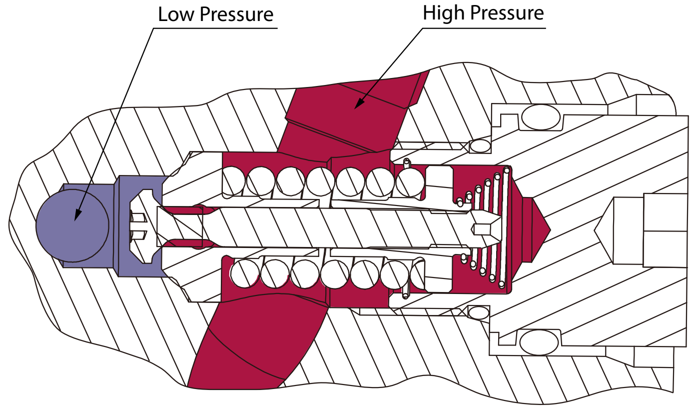
Operation

MP1 high pressure relief valve (HPRV) and charge check

All MP1 pumps are equipped with a combination high pressure relief and charge check valve. The high-pressure relief function is a dissipative (with heat generation) pressure control valve for the purpose of limiting excessive system pressures. The charge check function acts to replenish the low-pressure side of the working loop with charge oil. Each side of the transmission loop has a dedicated HPRV valve that is non-adjustable with a factory set pressure. When system pressure exceeds the factory setting of the valve, oil is passed from the high pressure system loop, into the charge gallery, and into the low pressure system loop via the charge check.

The pump order code allows for different pressure settings to be used at each system port. The system pressure order code for pumps with only HPRV is a reflection of the HPRV setting.

HPRV´s are factory set at a low flow condition. Any application or operating condition which leads to elevated HPRV flow will cause a pressure rise with flow above a valve setting. Consult factory for application review. Excessive operation of the HPRV will generate heat in the closed loop and may cause damage to the internal components of the pump.



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Bypass function

The bypass function allows a machine or load to be moved without rotating the pump shaft or prime mover. The single pump HPRV valve also provides a loop bypass function when each of the two HPRV hex plugs are mechanically backed out three full turns.

Engaging the bypass function mechanically connects both A & B sides of the working loop to the common charge gallery.

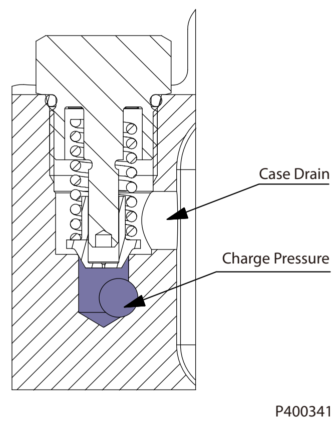
Possible damage to hydromotor(s).
Excessive speeds and extended load/vehicle movement must be avoided. The load or vehicle should be moved not more than 20% of maximum speed and for a duration not exceeding 3 minutes. When the bypass function is no longer needed, care should be taken to re-seat the HPRV hex plugs to the normal operating position.

Operation

MP1 charge pressure relief valve (CPRV) function

An internal charge pressure relief valve (CPRV) regulates charge pressure within the hydraulic circuit. The CPRV is a direct acting poppet valve that regulates charge pressure at a designated level above case pressure.

The charge pressure relief valve setting is specified within the model code of the pump. MP1 pumps with charge pump have the CPRV set at 1800 rpm while MP1 pumps without charge pump have the CPRV set with 18.9 l/min [5.0 US gal/min] of external supply flow. The charge pressure rise rate, with flow, is approximately 1 bar/10 liter [5.4 psi/US gal].



Operation

Loop flushing valve

MP1 pumps are available with an optional integral loop flushing. A loop flushing valve will remove heat and contaminants from the main loop at a rate faster than otherwise possible.

The MP1 loop flushing design is a simple spring centered shuttle spool with an orifice plug. The shuttle shifts at approximately . The flushing flow is a function of the low loop system pressure (charge) and the size of the plug.

When a MP1 pump is used with an external loop flushing shuttle valve, ensure that the charge setting of the pump matches the setting of the loop flushing shuttle valve. Contact your Danfoss representative for the availability of additional charge relief settings.

Electrical displacement control (EDC)

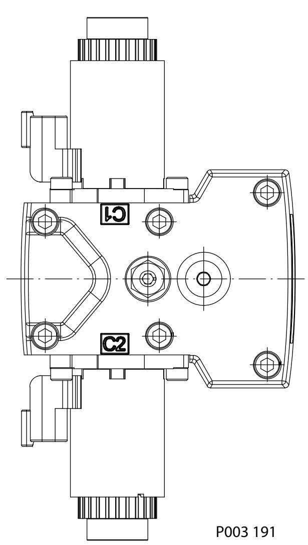
EDC principle

An EDC is a displacement (flow) control. Pump swashplate position is proportional to the input command and therefore vehicle or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

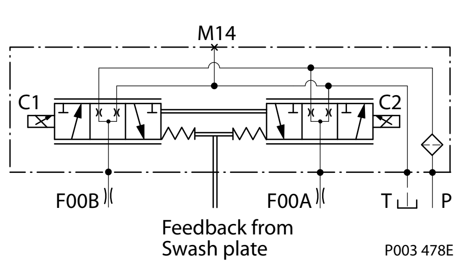
The Electrical Displacement Control (EDC) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction. Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

A 170 µm screen is located in the supply line immediately before the control porting spool.

EDC control



EDC schematic



Operation

EDC operation

EDC's are current driven controls requiring a Pulse Width Modulated (PWM) signal. Pulse width modulation allows more precise control of current to the solenoids. The PWM signal causes the solenoid pin to push against the porting spool, which pressurizes one end of the servo piston, while draining the other. Pressure differential across the servo piston moves the swashplate.

A swashplate feedback link, opposing control links, and a linear spring provide swashplate position force feedback to the solenoid. The control system reaches equilibrium when the position of the swashplate spring feedback force exactly balances the input command solenoid force from the operator. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

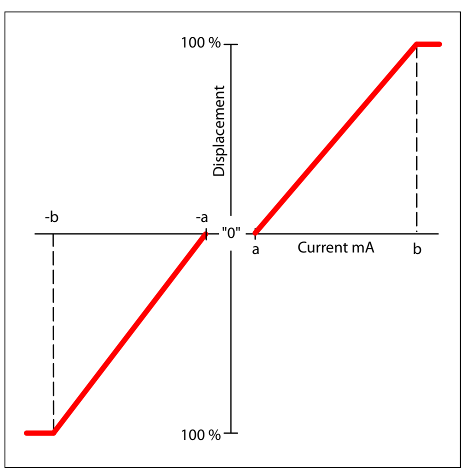
The EDC incorporates a positive neutral deadband as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold current is reached, the swashplate is positioned directly proportional to the control current. To minimize the effect of the control neutral deadband, we recommend the transmission controller or operator input device incorporate a jump up current to offset a portion of the neutral deadband.

The neutral position of the control spool does provide a positive preload pressure to each end of the servo piston assembly.

When the control input signal is either lost or removed, or if there is a loss of charge pressure, the spring-loaded servo piston will automatically return the pump to the neutral position.

Control signal requirements, EDC MP1

Pump displacement vs. control current



EDC control current

Voltage		12 V_{DC}	24 V_{DC}
Minimum current to stroke pump	**a***	640 mA	330 mA
	b	1640 mA	820 mA
Pin connections		any order	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Operation

EDC solenoid data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Pump output flow direction vs. control signal

Shaft rotation	CW		CCW	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	out	in	in	out
Port B	in	out	out	in
Servo port pressurized	M4	M5	M4	M5

* For coil location see Installation drawings.

Control response

MP1 controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

MP1 EDC response time

Stroking direction	0.8 mm [0.03 in] orifice		1.0 mm [0.04 in] orifice		1.3 mm [0.05 in] orifice		No orifice	
	28/32	**38/45**	**28/32**	**38/45**	**28/32**	**38/45**	**28/32**	**38/45**
Neutral to full flow	1.3 s	2.1 s	0.9 s	1.3 s	0.6 s	0.9 s	0.4 s	0.6 s
Full flow to neutral	1.0 s	1.5 s	0.7 s	0.9 s	0.4 s	0.6 s	0.2 s	0.3 s

Manual override (MOR)

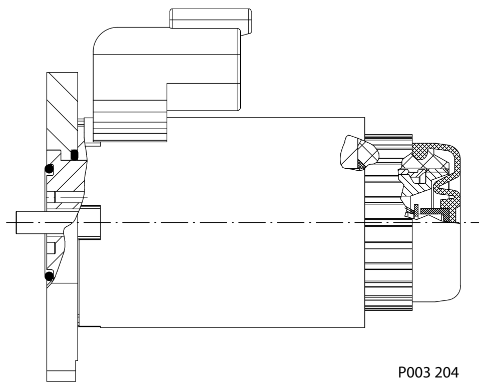
Initial actuation of the o-ring seal MOR plunger will require a force of 45 N. Additional actuations typically require less force to engage the MOR plunger. Proportional control of the pump via the MOR is not intended. The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke.

Operation

Unintended MOR operation can cause the pump to go into stroke.
The vehicle or device must always be in a safe condition (example: vehicle lifted off the ground) when using the MOR function. The MOR should be engaged anticipating a full stroke response from the pump.

Refer to control flow table for the relationship of solenoid to direction of flow.

MOR and schematic



Operation

Hydraulic displacement control (HDC)

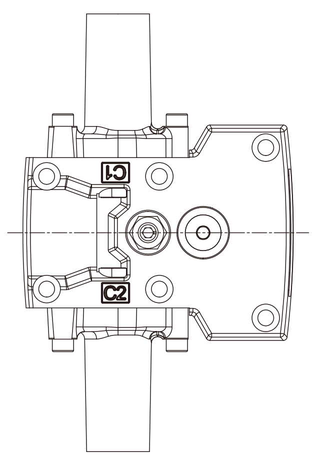
HDC principle

An HDC is a Hydraulic Displacement Control. Pump swashplate position is proportional to the input command and therefore vehicle speed or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The HDC control uses a hydraulic input signal to operate a porting spool, which ports hydraulic pressure to either side of a double acting servo piston. The hydraulic signal applies a force input to the spool which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction. Under some circumstances, such as contamination, the porting spool could stick and cause the pump to stay at some displacement.

A serviceable 175 µm screen is located in the supply line immediately before the control porting spool.

HDC control



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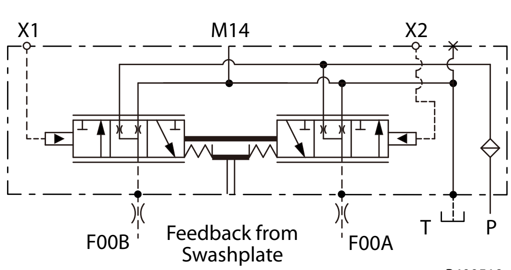
HDC schematic



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HDC operation

HDC's are hydraulically driven control which ports hydraulic pressure to either side of a porting spool, which pressurizes one end of the servo piston, while draining the other end to case. Pressure differential across the servo piston moves the swashplate.

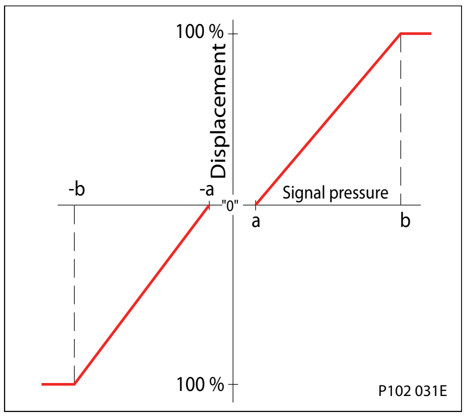
A swashplate feedback link, opposing control linkage, and a linear spring provide swashplate position force feedback to the hydraulic pressure. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

Operation

The HDC incorporates a positive neutral dead band as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold point is reached, the swashplate is positioned directly proportional to the control pressure.

When the control input is either lost or removed, or if there is a loss of charge pressure, the spring loaded servo piston will automatically return the pump to the neutral position.

Pump displacement vs signal pressure



Hydraulic signal pressure range

Option	Type	a*	b*	Max. pressure
T1	Standard	4.2 bar	16.2 bar	30 bar
T2	Option	3 bar	11.6 bar	30 bar

* Factory test current, for vehicle movement or application actuation expect a higher or lower value.

Pump output flow direction vs. control pressure

Shaft rotation HDC	Clockwise (CW) seen from shaft		Counter Clockwise (CCW) seen from shaft	
Port energized	X1	X2	X1	X2
Port A	Out (high)	In (low)	In (low)	Out (high)
Port B	In (low)	Out (high)	Out (high)	In (low)
Servo port high pressure	M4	M5	M4	M5

For appropriate performance of HDC characteristic, keep the drain pressure of pilot valve to be equal or slightly higher than pump case pressure.

Control response

MP1 controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Operation

Response time, HDC

Stroking direction	0.8 mm [0.03 in] orifice		1.0 mm [0.04 in] orifice		1.3 mm [0.05 in] orifice		No orifice	
	28/32	38/45	28/32	38/45	28/32	38/45	28/32	38/45
Neutral to full flow	1.3 s	2.1 s	0.9 s	1.3 s	0.6 s	0.9 s	0.3 s	0.6 s
Full flow to neutral	1.0 s	1.5 s	0.7 s	0.9 s	0.4 s	0.6 s	0.2 s	0.3 s

Operation

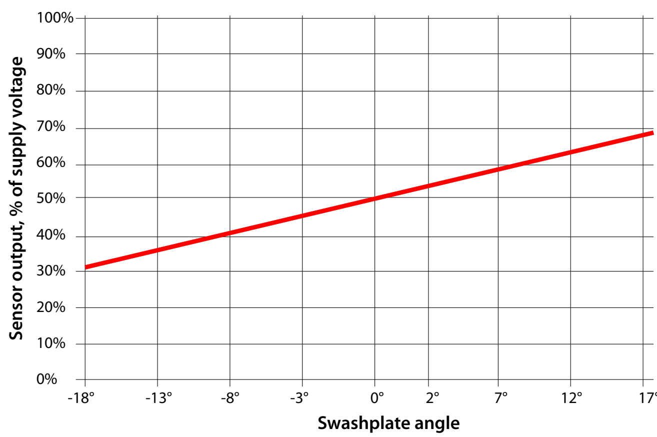
Swashplate angle sensor for EDC controls

The angle sensor detects the swash plate position with an accuracy dependent upon the calibration effort done for the application and direction of rotation from the neutral position. At minimum the sensor can be used for forward, neutral and reverse (FNR) detection.

The sensor works on the hall-effect technology. The implemented technology is based on a measurement of the magnetic field direction in parallel to the chip surface. This field direction is converted to a voltage signal at the output.

Enhanced calibration of the non-linear behavior leads to more exact calculation of the pump swashplate angle. The 4-pin DEUTSCH connector is part of the sensor housing. The swashplate angle sensor is available for all EDC controls for 12 V and 24 V.

Swashplate angle vs. output of supply voltage



Warning

Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

Contact your Danfoss representative in case the angle sensor will be used for safety functions.

Swash plate angle sensor parameters (EDC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.5 V_{DC}	5 V_{DC}	5.5 V_{DC}
Supply protection	–	–	18 V_{DC}
Pump neutral output (% of supply voltage)	–	50%	–
Working range (swash plate angle)	–18°	–	18°
Required supply current	–	–	30 mA
Output current signal	–	9 mA	11 mA
Working temperature	–40 °C	80 °C	115 °C

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector
EMC Immunity	ISO 11452-2	100 V/m

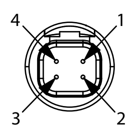
Operation

Calibration of the sensor output within the software is mandatory. Vehicle neutral thresholds in the software (±0.5°) are vehicle dependent and must consider different conditions, example: system temperature, system pressure and/or shaft speed.

For safety function: If the sensor fails (invalid signal <10% or >90% of supply voltage), it must be sure that the ECU will go into a diagnostic mode and shift into limited mode in order for the driver to take the full control or the mechanical breaks should be activated. Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

Swash plate angle sensor connector

Connector DEUTSCH, 4-pin



Pin assignment:

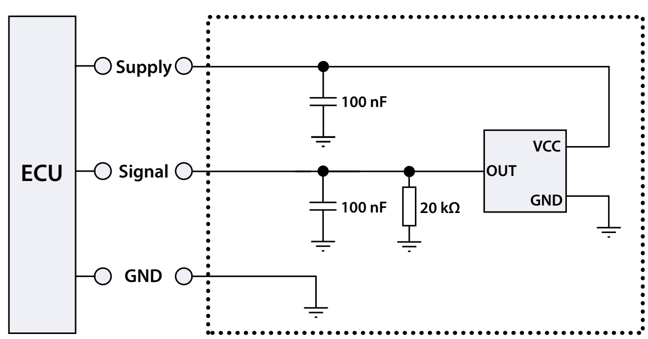
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connector order numbers

Description	Quantity	Order number
Mating connector DEUTSCH DTM06-4S-E004	1	**11105824**
Wedge lock WM-4S	1	not available
Socket contact 0462-201-2031	3	
Mating connector kit	1	**11212713**

Interface with ECU (EDC)

Interface with ECU diagram



Manual displacement control

MDC principle

An MDC is a Manual proportional Displacement Control (MDC). The MDC consists of a handle on top of a rotary input shaft. The shaft provides an eccentric connection to a feedback link. This link is connected on its one end with a porting spool. On its other end the link is connected the pumps swashplate.

This design provides a travel feedback without spring. When turning the shaft the spool moves thus providing hydraulic pressure to either side of a double acting servo piston of the pump.

Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement. Simultaneously the swashplate movement is fed back to the control spool providing proportionality between shaft rotation on the control and swashplate rotation.

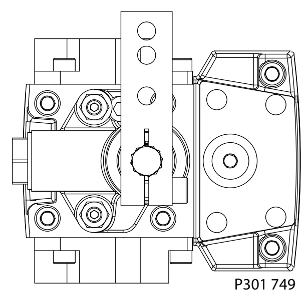
Operation

The MDC changes the pump displacement between no flow and full flow into opposite directions. Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

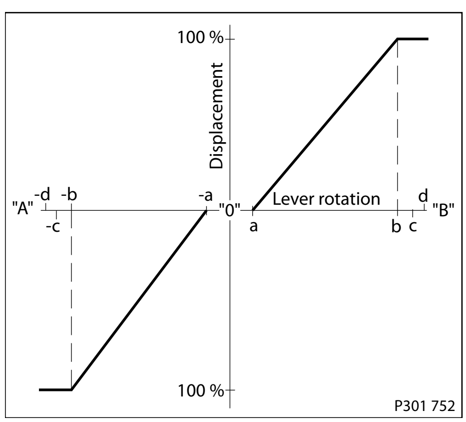
A 170 µm screen is located in the supply line immediately before the control porting spool.

The MDC is sealed by means of a static O-ring between the actuation system and the control block. Its shaft is sealed by means of a special O-ring which is applied for low friction. The special O-ring is protected from dust, water and aggressive liquids or gases by means of a special lip seal.

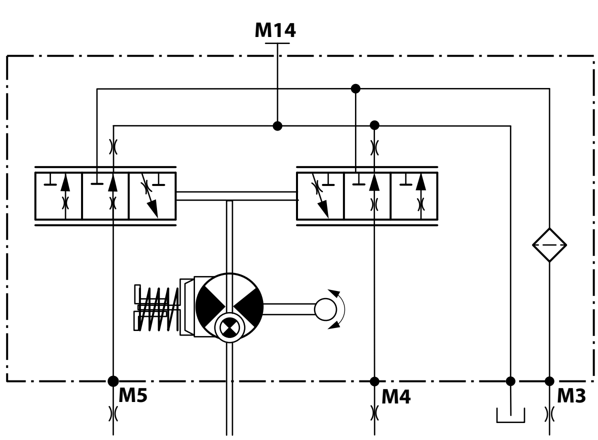
Manual Displacement Control



Pump displacement vs. control lever rotation



MDC schematic diagram



Where:

Deadband on **B** side – **a** = 3° ±1°

Maximum pump stroke – **b** = 30° +2/-1°

Operation

Required customer end stop – **c** = 36° ±3°

Internal end stop – **d** = 40°

MDC torque

Torque required to move handle to maximum displacement	1.4 N•m [12.39 lbf•in]
Torque required to hold handle at given displacement	0.6 N•m [5.31 lbf•in]
Maximum allowable input torque	20 N•m [177 lbf•in]

MDC operation

The MDC provides a mechanical dead-band required to overcome the tolerances in the mechanical actuation. The MDC contains an internal end stop to prevent turning the handle into any inappropriate position.

The MDC provides a permanent restoring moment appropriate for turning the MDC input shaft back to neutral position only. This is required to take the backlash out of the mechanical connections between the Bowden cable and the control.

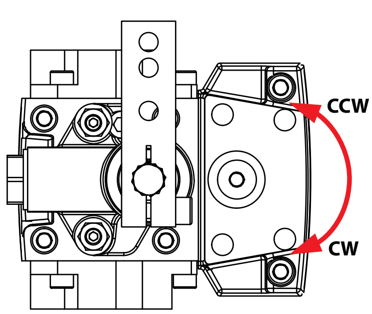
High case pressure may cause excessive wear and the NSS to indicate that the control is not in neutral position. In addition, if the case pressure exceeds 5 bar there is a risk of an insufficient restoring moment. The MDC is designed for a maximum case pressure of 5 bar and a rated case pressure of 3 bar.

- Customers must install some support to limit the setting range of their Bowden cable to avoid an overload of the MDC.
- Customers can apply their own handle design but they must care about a robust clamping connection between their handle and the control shaft and avoid overload of the shaft.
- Customers can connect two MDC's on a tandem unit in such a way that the actuation force will be transferred from the pilot control to the second control. The kinematic of the linkages must ensure that either control shaft is protected from torque overload.

Caution

Using the internal spring force on the input shaft is not an appropriate way to return the customer connection linkage to neutral, or to force a Bowden cable or a joystick back to neutral position. It is not applicable for any limitation of the Bowden cable stroke, except the applied torque to the shaft will never exceed 20 N•m.

MDC shaft rotation



Pump shaft rotation*	Clockwise (CW)		Counter-clockwise (CCW)	
MDC shaft rotation	**CW**	**CCW**	**CW**	**CCW**
Port A	in (low)	out (high)	out (high)	in (low)
Port B	out (high)	in (low)	in (low)	out (high)
Servo port high pressure	M5	M4	M5	M4

* As seen from shaft side.

Operation

Control response

MP1 controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

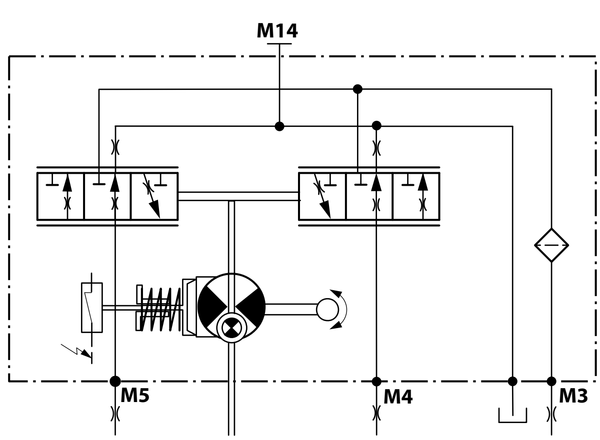
MP1 MDC response time

Code	Orifice description (mm)				Stroking direction (sec)			
	P	A	B	Tank (A +B)	Neutral to full flow		Full flow to neutral	
					28/32	38/45	28/32	38/45
C3	–	–	–	–	0.3	0.3	0.3	0.3
C6	–	–	–	1.0	0.5	1.0	0.5	0.7
C7	–	–	–	1.3	0.4	0.7	0.5	0.5
C8	0.8	–	–	0.6	1.5	2.6	1.4	1.9
C9	1.0	–	–	0.6	1.3	2.4	1.1	1.8
D1	1.0	–	–	0.8	0.9	1.6	0.8	1.1
D2	1.3	–	–	0.8	0.8	1.5	0.7	1.1
D3	1.3	–	–	1.0	0.6	1.1	0.6	0.8
D4	1.3	1.3	1.3	1.0	0.8	1.3	0.7	0.9
D5	0.6	0.8	0.8	0.6	3.2	4.0	2.0	2.9

Neutral start switch (NSS)

The Neutral Start Switch **(NSS)** contains an electrical switch that provides a signal of whether the control is in neutral. The signal in neutral is Normally Closed **(NC)**.

Neutral start switch schematic



Operation

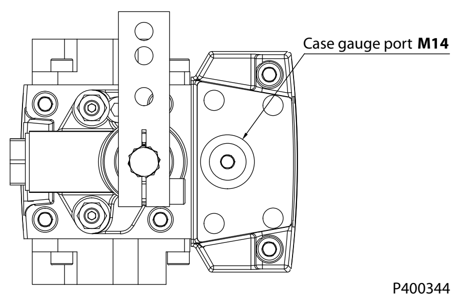
Neutral start switch data

Max. continuous current with switching	8.4 A
Max. continuous current without switching	20 A
Max. voltage	36 V_{DC}
Electrical protection class	IP67 / IP69K with mating connector

Case gauge port M14

The drain port should be used when the control is mounted on the unit's bottom side to flush residual contamination out of the control.

MDC w/h drain port shown



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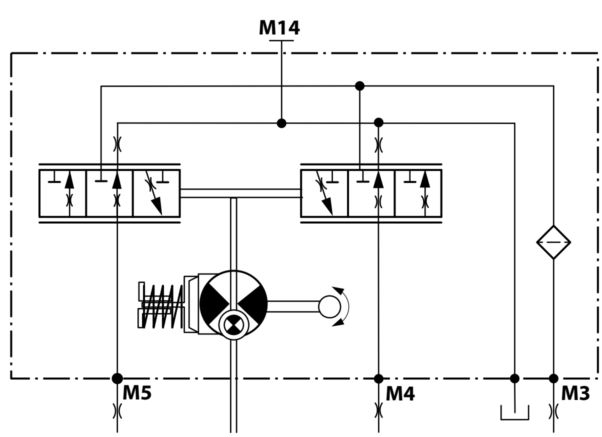
MDC schematic diagram



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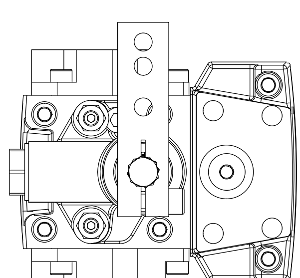
Lever

MDC controls are available with optional lever/handle. Align with Settings: Y module in the model code.

Standard orientation 90° from input shaft



P301 749

Operation

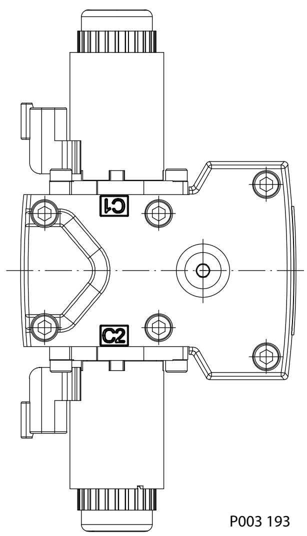
Forward-neutral-reverse (FNR) electic control

FNR principle

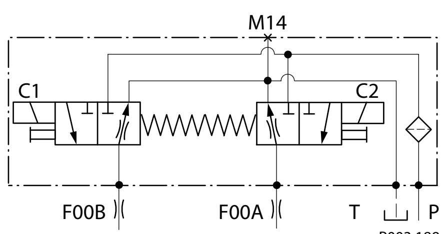
The 3-position **FNR** control uses an electric input signal to switch the pump to a full stroke position. Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

A 170 µm screen is located in the supply line immediately before the control porting spool.

Forward-Neutral-Reverse electric control (FNR)

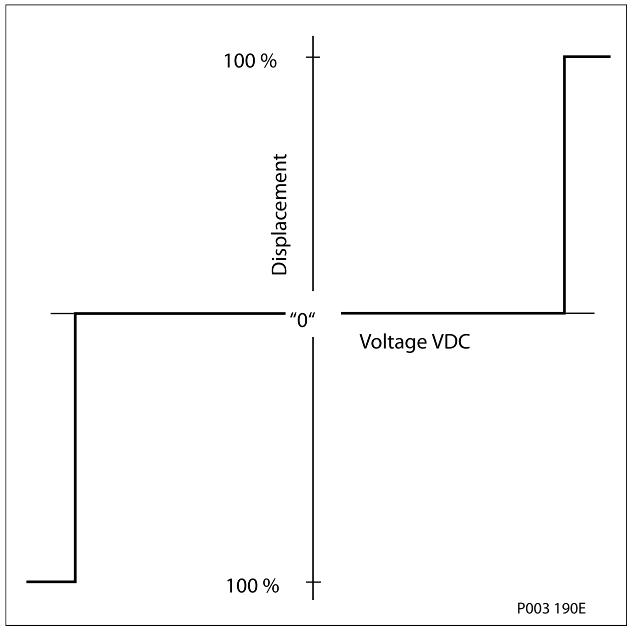


FNR hydraulic schematic



Operation

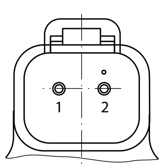
Pump displacement vs. electrical signal



Control current

Voltage	Min. current to stroke pump	Pin connections
12 V	750 mA	any order
24 V	380 mA	

DEUTSCH connector, 2-pin



Connector ordering data

Description	Quantity	Ordering data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16 and 18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Solenoid data

Voltage	12 V	24 V
Minimum supply voltage	9.5 V_{DC}	19 V_{DC}
Maximum supply voltage (continuous)	14.6 V_{DC}	29 V_{DC}
Maximum current	1050 mA	500 mA
Nominal coil resistance @ 20 °C [70 °F]	8.4 Ω	34.5 Ω
PWM Range	70-200 Hz	

Operation

Solenoid data (continued)

Voltage	12 V	24 V
PWM Frequency (preferred)*	100 Hz	
IP Rating (IEC 60 529) + DIN 40 050, part 9	IP 67 / IP 69K (part 9 with mating connector)	
Bi-directional diode cut off voltage	28 V_{DC}	53 V_{DC}

* PWM signal required for optimum control performance.

Pump output flow direction vs. control signal

Shaft rotation	CW		CCW	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see Installation Drawings.

Control response

MP1 controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response time, FNR

Stroking direction	0.8 mm [0.03 in] orifice		1.0 mm [0.04 in] orifice		1.3 mm [0.05 in] orifice		No orifice	
	28/32	**38/45**	**28/32**	**38/45**	**28/32**	**38/45**	**28/32**	**38/45**
Neutral to full flow	2.1 s	2.6 s	1.1 s	1.6 s	0.8 s	1.1 s	0.7 s	0.7 s
Full flow to neutral	1.1 s	1.8 s	0.9 s	1.0 s	0.6 s	0.7 s	0.3 s	0.3 s

Non feedback proportional electric control (NFPE)

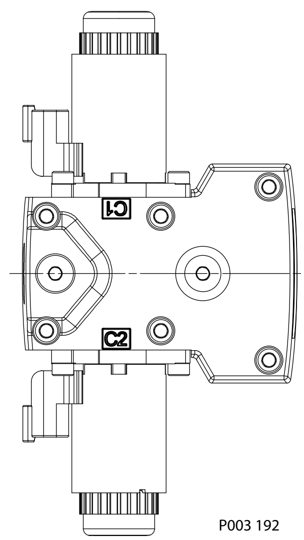
The Non Feedback Proportional Electric (**NFPE**) control is an electrical automotive control in which an electrical input signal activates one of two proportional solenoids that port charge pressure to either side of the pump servo cylinder. The NFPE control has no mechanical feedback mechanism.

A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

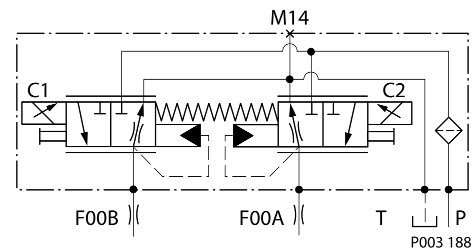
Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

Operation

NFPE control

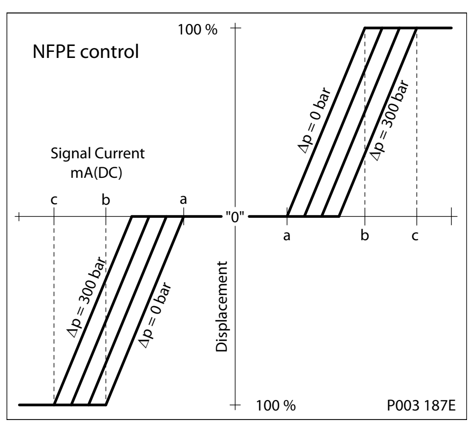


NFPE schematic



The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swashplate angle as system pressure increases. A typical response characteristic is shown in the accompanying graph. Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

NFPE pump displacement to input signal



Control signal requirements

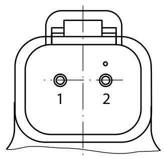
Control current

Voltage	a*	b	c	Pin connections
12 V	600 mA	1080 mA	1360 mA	any order
24 V	300 mA	540 mA	680 mA	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Operation

DEUTSCH connector, 2-pin



P003 480

Connector ordering data

Description	Quantity	Ordering data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16 and 18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Pump output flow direction vs. control signal

Shaft rotation	CW		CCW	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see Installation drawings.

Control response

MP1 controls are available with optional control passage orifices to assist in matching the rate of swashplate response to the application requirements (e.g. in the event of electrical failure). The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure. A swashplate response table is available for each frame indicating available swashplate response times. Testing should be conducted to verify the proper orifice selection for the desired response.

Typical response times at the following conditions:

Δp	250 bar [3626 psi]
Viscosity and temperature	30 mm^2/s [141 SUS] and 50°C [122 °F]
Charge pressure	24 bar [348 psi]
Speed	1800 min^{-1} (rpm)

Operation

Response time

Stroking direction	0.8 mm [0.03] orifice		1.0 mm [0.04] orifice		1.3 mm [0.05] orifice	
	28/32	38/45	28/45	38/45	28/45	38/45
Neutral to full flow	1.5 s	2.2 s	0.9 s	1.4 s	0.6 s	0.8 s
Full flow to neutral	0.9 s	1.1 s	0.6 s	0.7 s	0.4 s	0.5 s

Non-feedback, proportional hydraulic (NFPH) control

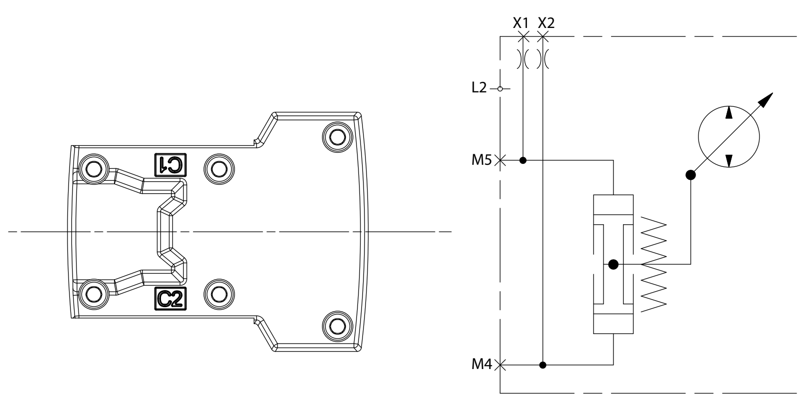
The non-feedback proportional hydraulic (NFPH) control is a hydraulic proportional control in which an input pressure signal directly controls the pump servo piston to achieve pump displacement.

MP1 pumps with NFPH control have a special servo cylinder capable of providing proportional control with a hydraulic input.

Swashplate position is proportional to the differential signal pressure at ports X1 and X2, but displacement is also dependent on pump speed and system pressure. This characteristic of non-feedback controls provides a natural power limiting function by reducing the pump swashplate angle as system pressure increases. The accompanying graph shows typical operating characteristics.

The system may require tuning through the pump orifice combinations, control pressure supply line sizing, actuation device output pressure and flow adjustments to achieve proper vehicle performance characteristics.

Non-feedback proportional hydraulic control schematic

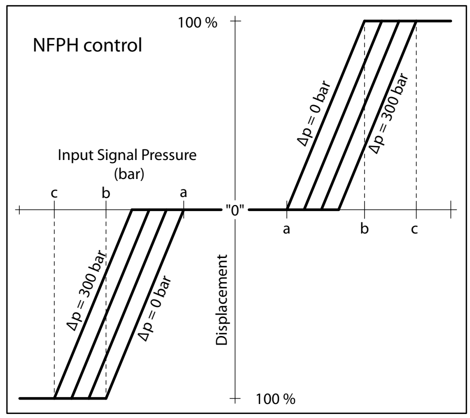


Pump flow direction with NFPH control

Input Shaft Rotation	CW		CCW	
Port A flow	Out	In	In	Out
Port B flow	In	Out	Out	In
High servo gauge port	M4	M5	M4	M5

Operation

NFPH pump displacement to Input signal



NFPH input signal pressure (bar)

Frame size	a	b	c
28/32	5.5	13.7	17
38/45	5	12.75	16

The values provided in the table above are approximations at 1800 RPM and system delta pressures as indicated in the graph provided. The values are dependent on input speed and delta pressure operating conditions.

Control response

MP1 controls are available with optional control passage orifices to assist in matching the rate of swashplate response to the application requirements (e.g. in the event of electrical failure). The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure. A swashplate response table is available for each frame indicating available swashplate response times. Testing should be conducted to verify the proper orifice selection for the desired response.

Typical response times at the following conditions:

Δp	250 bar [3626 psi]
Viscosity and temperature	30 mm^2/s [141 SUS] and 50°C [122 °F]
Charge pressure	24 bar [348 psi]
Speed	1800 min^{-1} (rpm)

Response time

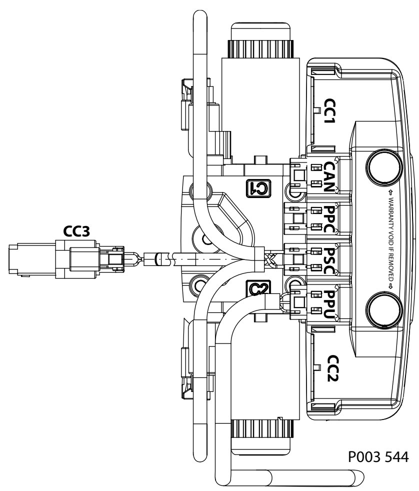
Stroking direction	0.8 mm [0.03] orifice		1.0 mm [0.04] orifice		1.3 mm [0.05] orifice	
	28/32	38/45	28/45	38/45	28/45	38/45
Neutral to full flow	1.5 s	2.2 s	0.9 s	1.4 s	0.6 s	0.8 s
Full flow to neutral	0.9 s	1.1 s	0.6 s	0.7 s	0.4 s	0.5 s

Operation

Automotive control (AC)

The Automotive control (AC) is an electric NFPE control with an integrated micro-controller, installed on the pump.

The integrated micro-controller enhanced control performance with a flexible, configurable control scheme for an entire single path propel transmission. It can be used in combination with fixed and variable displacement hydraulic motors. With the pre-installed application software and easily changeable control parameters, it is possible to tailor the vehicle's driving behavior to the individual requirements of the customer.



The H1 automotive control is divided into 2 systems:
- AC-1
- AC-2

AC-2 is an extension of AC-1 that features an integrated pump swash plate angle sensor and software enabled functions such as swash plate control.

Mode types

The application software provides 3 different hydrostatic propel methods, defined as mode types, which can be used individually.

Automotive Load dependent	Torque controlled driving behavior. Setpoint for the drive curve is the engine rpm.
Non-Automotive Load independent	Speed controlled driving mode. Setpoint for the drive curve is a joystick or drive pedal signal, independent of the engine rpm. The best performance will achieved with an AC-2 Swash Plate Sensor.
Creep-Automotive Load dependent	Torque controlled driving behavior (like Automotive). Setpoint for the drive curve is the engine rpm. The setpoint can be reduced by the creep potentiometer if a high engine rpm in combination with low vehicle speed is needed.

Basic functions

- Four selectable system modes, selectable via switch
- Individual settings for forward and reverse driving direction (4 x 2 curves)
- Independent pump and hydraulic motor profiling and ramping for each mode
- Electric drive pedal connection
- Electronic inching function without separate control valve

Operation

- Electric creep mode potentiometer
- Configurable System Mode and Direction change
- Load independent pump displacement control with integrated Swash Plate Angle Sensor (AC-2)
- Hydraulic motor displacement control including brake pressure defeat function

Performance functions

- ECO fuel saving mode with automatic reduction of the engine speed during transport (Cruise control)
- Vehicle constant speed drive control
- Vehicle speed limitation
- Dynamic brake light, automatic park brake, reverse buzzer and status LED outputs
- Vehicle speed controlled output function
- Temperature compensation for predictable performance
- Advanced CAN J1939 interface for the information exchange with the vehicle control system

Protection and safety functions

- Safety controlled vehicle start protection with engine speed check, battery check and FNR must be in neutral, etc.
- Operator presence detection
- Hydraulic system overheat and low-temperature protection
- Hydraulic motor over speed protection
- Park brake test mode for roller applications to fulfill SAE J1472/EN500-4
- SIL2 compliant

Engine control and protection

- CAN J1939 engine interface
- Engine speed control via drive pedal with safety controlled monitoring function
- Engine antistall protection
- Engine over speed protection during inching
- Engine speed dependent retarder control
- Engine cold start protection

Installation features

- Factory calibration for hysteresis compensation
- Starting current adjustment in the factory
- Pre-installed application software and parameter files

For more information, see *Integrated Automotive Control (AC) for MP1 and H1P Single Pumps 28-250 Technical Information*, BC152986482596.

Operation

Control-cut-off valve (CCO valve)

The pump offers an optional control cut off valve integrated into the control. This valve will block charge pressure to the control, allowing the servo springs to de-stroke the pump regardless of the pump´s primary control input. There is also a hydraulic logic port, X7, which can be used to control other machine functions, such as spring applied pressure release brakes. The pressure at X7 is controlled by the control cut off solenoid. The X7 port would remain plugged if not needed.

In the normal (de-energized) state of the solenoid charge flow is prevented from reaching the controls. At the same time the control passages and the X7 logic port are connected and drained to the pump case. The pump will remain in neutral, or return to neutral, independent of the control input signal. Return to neutral time will be dependent on oil viscosity, pump speed, swashplate angle, and system pressure.

When the solenoid is energized, charge flow and pressure is allowed to reach the pump control. The X7 logic port will also be connected to charge pressure and flow.

The solenoid control is intended to be independent of the primary pump control making the control cut off an override control feature. It is however recommended that the control logic of the CCO valve be maintained such that the primary pump control signal is also disabled whenever the CCO valve is de-energized. Other control logic conditions may also be considered.

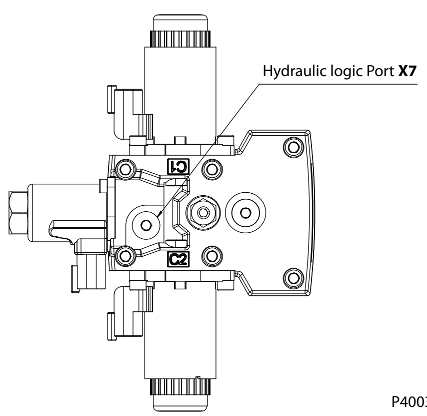
All EDC and MDC controls are available with a CCO valve.

The response time of the unit depends on the control type and the control orifices used.

The CCO-valve is available with 12 V or 24 V solenoid.

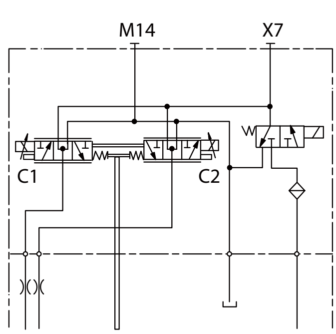
EDC with CCO

Control



P400346

Schematic



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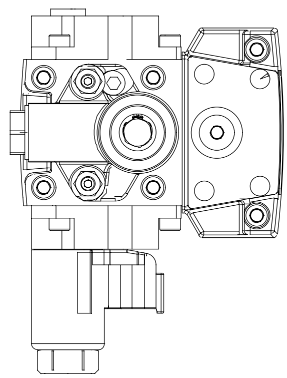
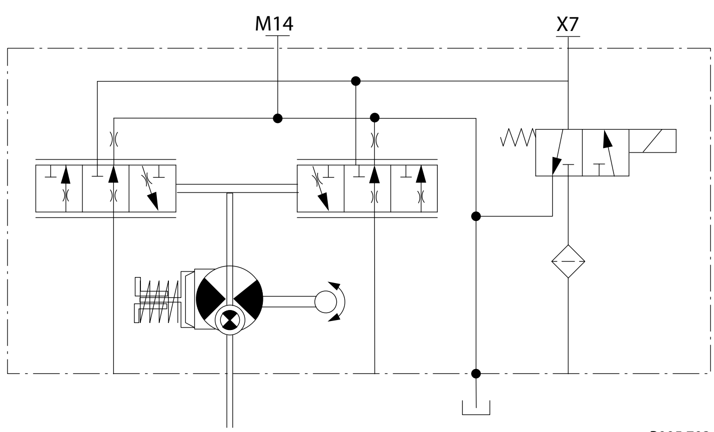
Operation

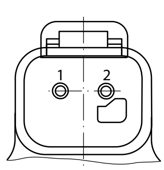
MDC with CCO

Control



Schematic





CCO solenoid data

Nominal supply voltage		12 V	24 V
Supply voltage	Maximum	14.6 V	29 V
	Minimum	9.5 V	19 V
Bi-directional diode cut off voltage		28 V	53 V
Nominal coil resistance at 20 °C		10.7 Ω	41.7 Ω
Supply current	Maximum	850 mA	430 mA
	Minimum	580 mA	300 mA
PWM frequency	Range	50 – 200 Hz	
	Preferred	100 Hz	
Electrical protection class		IP67 / IP69K with mating connector	

Operation

CCO solenoids are design for battery voltage application within the voltage range in the table above, in consideration of a wide range of environmental temperature common for known hydraulic applications. Closed loop PWM current supply can be also applied and is helpful in case that the voltage range is exceeded, or ambient temperature could rise in an unusual manner.

Brake gauge port with MDC

Caution

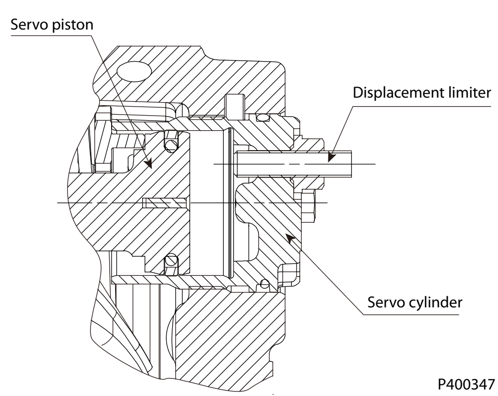
It is not recommended to use brake port for any external flow consumption to avoid malfunction of CCO function.

Displacement limiter

All pumps are designed with optional mechanical displacement (stroke) limiters factory set to max. displacement.

The maximum displacement of the pump can be set independently for forward and reverse using the two adjustment screws to mechanically limit the travel of the servo piston. Adjustment procedures are found in the Service Manual. Adjustments under operating conditions may cause leakage. The adjustment screw can be completely removed from the threaded bore if backed out to far.

Displacement limiter



Displacement change (approximate)

Parameter	28	32	38	45
1 Turn of displacement limiter screw	2.9 cm^3 [0.18 in^3]	3.3 cm^3 [0.20 in^3]	3.56 cm^3 [0.22 in^3]	4.22 cm^3 [0.26 in^3]
Internal wrench size	4 mm			
External wrench size	13 mm			
Torque for external hex seal lock nut	23 N•m [204 lbf•in]			

Operation

Speed sensor

The speed sensor is designed for rugged outdoor, mobile or heavy industrial speed sensing applications. The detection of the speed is contactless and does not need any calibration or adjustments.

For more information, see *Speed and Temperature Sensor, Technical Information*, **BC152886482203**.

Temperature range

Parameter	Minimum	Maximum
Operation temperature range	-40 °C	104 °C

115°C intermittent = short term; t < 1min per incident and not exceeding 2 % of duty cycle based load-life.

Output pulses

The expected number of output pulses per revolution is shown below.

The number of output (speed) pulses

MP1P size	28/32	38/45
Pulses (per rev)	9	11

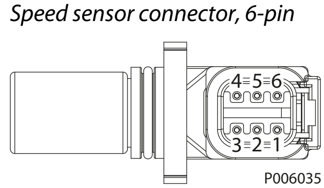
Mating connectors

There are available two types of mating connectors Assembly Bag DEUTSCH DTM06-6S, Black and Grey.

Ordering number	
11033865	11033863
Assembly Bag, DEUTSCH DTM06-6S-E004; black, (24-20 AWG) 0.21 -0.52 mm²	Assembly Bag, DEUTSCH DTM06-6S, gray, (24-20 AWG) 0.21 -0.52 mm²

Speed sensor 4.5 – 8 V technical data

Speed sensor connector, 6-pin



1. Speed signal 2
2. NC
3. Speed signal 1
4. Supply
5. Ground
6. Temperature

Technical data

Parameter	Min.	Nom.	Max.	Note
Supply voltage	4.5 V_{DC}	5 V_{DC}	8 V_{DC}	Regulated supply voltage. Reverse polarity protected.
Supply protection	–	–	30 V_{DC}	Shuts off above 9 V.
Max. required supply current	–	–	25 mA	At supply voltage
Max. output current	–	–	50 mA	
Operation mode	**NPN & PNP**			Push-Pull amplifier
Temperature signal	-40°C = 2.318V	–	100°C = 0.675V	
Output low	5 %	8.5 %	12 %	Ratiometric output voltage Low state > 0 V to provide wire fault detection

Operation

Technical data (continued)

Parameter	Min.	Nom.	Max.	Note
Output high	88 %	91.5 %	95 %	
Detectable frequency range	1 Hz	–	10 000 Hz	
Ordering number	**149055**			
Color of connector	Black			

Temperature sensor data

For calculation of the case fluid temperature and the output signal voltage, see the formulas below:

V_O – Measured output voltage (V)

$V_o = (-3.88 \cdot 10^{-6} \cdot T^2) + (-1.15 \cdot 10^{-2} \cdot T) + 1.8639$

T – Temperature (°C)

$$T = -1481.96 + \sqrt{2.1962 \cdot 10^{6} + \frac{(1.8639 - V_o)}{3.88 \cdot 10^{-6}}}$$

Output signal voltage vs. Temperature

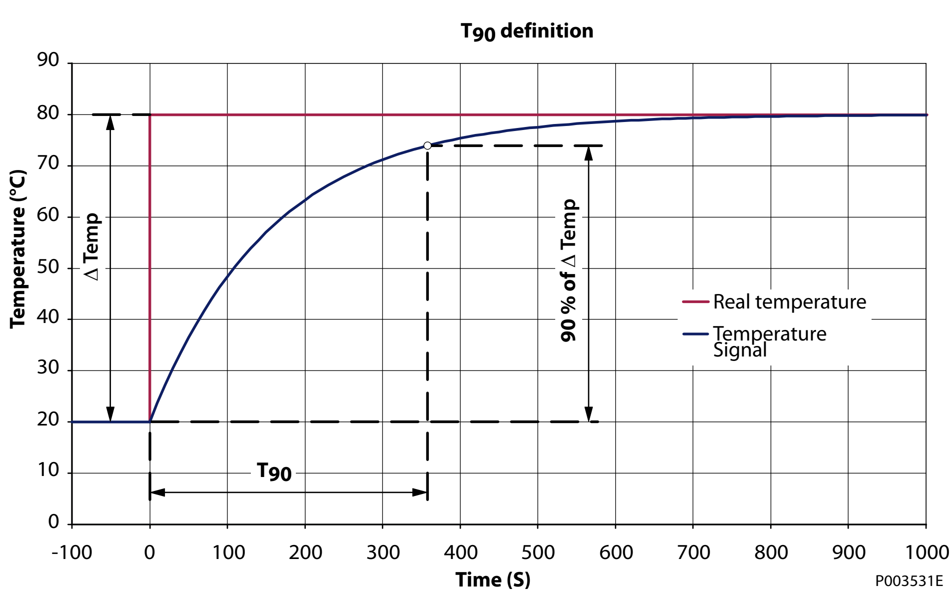
Temperature range							
-55 °C**	**-40 °C**	**-30 °C**	**0 °C**	**+30 °C***	**+80 °C**	**+100 °C**	**+130 °C****
2.485 V	2.318 V	2.205 V	1.864 V	1.515 V	0.919 V	0.675 V	0.303 V

* Accuracy: ±1. 5 to ± 4 °C

** Accuracy: ±2.5 to ± 5 °C

Response time in fluid

T_{90} definition



Response time in fluid (T_{90}) = 360 s

Operating parameters

Input speed

Minimum speed is the lowest input speed recommended during engine idle condition. Operating below minimum speed limits pump's ability to maintain adequate flow for lubrication and power transmission.

Rated speed is the highest input speed recommended at full power condition. Operating at or below this speed should yield satisfactory product life.

Maximum speed is the highest operating speed permitted. Exceeding maximum speed reduces product life and can cause loss of hydrostatic power and braking capacity. Never exceed the maximum speed limit under any operating conditions.

Operating conditions between Rated speed and Maximum speed should be restricted to less than full power and to limited periods of time. For most drive systems, maximum unit speed occurs during downhill braking or negative power conditions.

During hydraulic braking and downhill conditions, the prime mover must be capable of providing sufficient braking torque in order to avoid pump over speed. This is especially important to consider for turbocharged and Tier 4 engines.

Warning

Unintended vehicle or machine movement hazard.

Exceeding maximum speed may cause a loss of hydrostatic drive line power and braking capacity. You must provide a braking system, redundant to the hydrostatic transmission, sufficient to stop and hold the vehicle or machine in the event of hydrostatic drive power loss.

System pressure

System pressure is the differential pressure between system ports A and B. It is the dominant operating variable affecting hydraulic unit life. High system pressure, which results from high load, reduces expected life. Hydraulic unit life depends on the speed and normal operating, or weighted average, pressure that can only be determined from a duty cycle analysis.

Application pressure is the high pressure relief setting normally defined within the order code of the pump. This is the applied system pressure at which the driveline generates the maximum calculated pull or torque in the application.

Maximum working pressure is the highest recommended Application pressure. Maximum working pressure is not intended to be a continuous pressure. Propel systems with Application pressures at, or below, this pressure should yield satisfactory unit life given proper component sizing.

Maximum pressure is the highest allowable Application pressure under any circumstance. Application pressures above Maximum Working Pressure will only be considered with duty cycle analysis and factory approval. Pressure spikes are normal and must be considered when reviewing maximum working pressure.

All pressure limits are differential pressures referenced to low loop (charge) pressure. Subtract low loop pressure from gauge readings to compute the differential.

Minimum low loop pressure (above case pressure) is the lowest pressure allowed to maintain a safe working condition in the low side of the loop.

Operating parameters

Charge pressure

An internal charge relief valve regulates charge pressure. Charge pressure maintains a minimum pressure in the low side of the transmission loop.

The charge pressure setting listed in the order code is the set pressure of the charge relief valve with the pump in neutral, operating at 1800 min^{-1} [rpm], and with a fluid viscosity of 32 mm^2/s [150 SUS]. Pumps configured with no charge pump (external charge supply) are set with a charge flow of 18.9 l/min [5.0 US gal/min] and a fluid viscosity of 32 mm^2/s [150 SUS].

The charge pressure setting is referenced to case pressure.

Charge pump inlet pressure

At normal operating temperature charge inlet pressure must not fall below rated charge inlet pressure (vacuum).

Minimum charge inlet pressure is only allowed at cold start conditions. In some applications it is recommended to warm up the fluid (e.g. in the tank) before starting the engine and then run the engine at limited speed until the fluid warms up.

Maximum charge pump inlet pressure may be applied continuously.

Case pressure

Under normal operating conditions, the rated case pressure must not be exceeded. During cold start case pressure must be kept below **maximum intermittent case pressure**. Size drain plumbing accordingly.

Caution

Possible component damage or leakage

Operation with case pressure in excess of stated limits may damage seals, gaskets, and/or housings, causing external leakage. Performance may also be affected since charge and system pressure are additive to case pressure.

Temperature

The high temperature limits apply at the hottest point in the transmission, which is normally the motor case drain. The system should generally be run at or below the rated temperature.

The **maximum intermittent temperature** is based on material properties and should never be exceeded.

Cold oil will not affect the durability of the transmission components, but it may affect the ability of oil to flow and transmit power; therefore temperatures should remain 16 °C [30 °F] above the pour point of the hydraulic fluid.

The **minimum temperature** relates to the physical properties of component materials. Size heat exchangers to keep the fluid within these limits. Danfoss recommends testing to verify that these temperature limits are not exceeded.

Ensure fluid temperature and viscosity limits are concurrently satisfied.

Operating parameters

Viscosity

Viscosity For maximum efficiency and bearing life, ensure the fluid viscosity remains in the recommended range.

The **minimum viscosity** should be encountered only during brief occasions of maximum ambient temperature and severe duty cycle operation.

The **maximum viscosity** should be encountered only at cold start.

System design parameters

Filtration system

To prevent premature wear, ensure that only clean fluid enters the hydrostatic transmission circuit. A filter capable of controlling the fluid cleanliness to ISO 4406, class 22/18/13 (SAE J1165) or better, under normal operating conditions, is recommended.These cleanliness levels cannot be applied for hydraulic fluid residing in the component housing/case or any other cavity after transport.

Filtration strategies include suction or pressure filtration. The selection of a filter depends on a number of factors including the contaminant ingression rate, the generation of contaminants in the system, the required fluid cleanliness, and the desired maintenance interval. Filters are selected to meet the above requirements using rating parameters of efficiency and capacity.

Filter efficiency can be measured with a Beta ratio (β_X). For simple suction-filtered closed circuit transmissions and open circuit transmissions with return line filtration, a filter with a β-ratio within the range of $\beta_{35\text{-}45} = 75$ ($\beta_{10} \geq 2$) or better has been found to be satisfactory. For some open circuit systems, and closed circuits with cylinders being supplied from the same reservoir, a higher filter efficiency is recommended. This also applies to systems with gears or clutches using a common reservoir. For these systems, a charge pressure or return filtration system with a filter β-ratio in the range of $\beta_{15\text{-}20} = 75$ ($\beta_{10} \geq 10$) or better is typically required.

Because each system is unique, only a thorough testing and evaluation program can fully validate the filtration system. Please see *Design Guidelines for Hydraulic Fluid Cleanliness Technical Information,* **BC152886482150** for more information.

Cleanliness level and β_x-ratio[1]			
Filtration (recommended minimum)	Cleanliness per ISO 4406		22/18/13
	Efficiency (charge pressure filtration)	β-ratio	$\beta_{15\text{-}20} = 75$ ($\beta_{10} \geq 10$)
	Efficiency (suction and return line filtration)		$\beta_{35\text{-}45} = 75$ ($\beta_{10} \geq 2$)
	Recommended inlet screen mesh size	µm	100 – 125

[1] Filter β_x-ratio is a measure of filter efficiency defined by ISO 4572. It is defined as the ratio of the number of particles greater than a given diameter ("x" in microns) upstream of the filter to the number of these particles downstream of the filter.

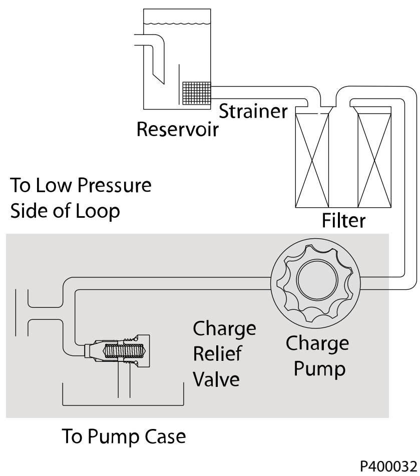
Filtration

Suction filtration

A suction circuit uses an internal charge pump. The filter is placed between the reservoir and the charge pump inlet. Do not exceed the inlet vacuum limits during cold start conditions.

System design parameters

Suction filtration

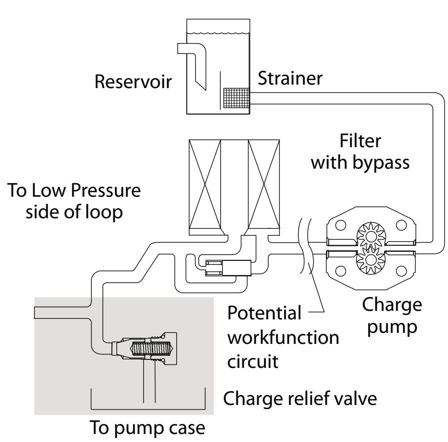


Charge pressure filtration

In a pressure filtration system the pressure filter is remotely mounted in the circuit, downstream of the charge supply. Pressure filtration is possible with, and without, an internal charge pump. Filters used in charge pressure filtration circuits should be rated to at least 35 bar [508 psi] pressure. Danfoss recommends locating a 100 – 125 micron screen in the reservoir or in the charge inlet when using charge pressure filtration.

A filter bypass valve is necessary to prevent damage to the hydrostatic system. In the event of high pressure drop associated with a blocked filter or cold start-up conditions, fluid may bypass the filter temporarily. Avoid working with an open bypass for an extended period. A visual or electrical bypass indicator is preferred. Proper filter maintenance is mandatory.

Charge pressure filtration



System design parameters

Independent braking system

Warning

Unintended vehicle or machine movement hazard.

The loss of hydrostatic drive line power, in any mode of operation (forward, neutral, or reverse) may cause the system to lose hydrostatic braking capacity. You must provide a braking system, redundant to the hydrostatic transmission, sufficient to stop and hold the vehicle or machine in the event of hydrostatic drive power loss.

Fluid selection

Ratings and performance data are based on operating with hydraulic fluids containing oxidation, rust and foam inhibitors. These fluids must possess good thermal and hydrolytic stability to prevent wear, erosion, and corrosion of pump components.

Caution

Never mix hydraulic fluids of different types.

Reservoir

The hydrostatic system reservoir should accommodate maximum volume changes during all system operating modes and promote de-aeration of the fluid as it passes through the tank.

A suggested minimum total reservoir volume is 5/8 of the maximum charge pump flow per minute with a minimum fluid volume equal to 1/2 of the maximum charge pump flow per minute. This allows 30 seconds fluid dwell for removing entrained air at the maximum return flow. This is usually adequate to allow for a closed reservoir (no breather) in most applications.

Locate the reservoir outlet (charge pump inlet) above the bottom of the reservoir to take advantage of gravity separation and prevent large foreign particles from entering the charge inlet line. A 100-125 µm screen over the outlet port is recommended.

Position the reservoir inlet (fluid return) to discharge below the normal fluid level, toward the interior of the tank. A baffle (or baffles) will further promote de-aeration and reduce surging of the fluid.

Case drain

The pump housing must remain full of oil at all times. The MP1 pump is equipped with two case drain ports to provide flexibility for hose routing and pump installation. Connect a line from one of the case drain ports to the reservoir. Case drain fluid is typically the hottest fluid in the system.

Charge pump

Charge flow is required on MP1 pumps. The charge pump provides flow to make up for system leakage, maintain a positive pressure in the main circuit, and provide flow for cooling and filtration.

Many factors influence the charge flow requirements and the resulting charge pump size selection. These factors include system pressure, pump speed, pump swashplate angle, type of fluid, temperature, size of heat exchanger, length and size of hydraulic lines, auxiliary flow requirements, hydrostatic motor type, etc. When initially sizing and selecting hydrostatic units for an application, it is frequently not possible to have all the information necessary to accurately evaluate all aspects of charge pump size selection.

Unusual application conditions may require a more detailed review of charge pump sizing. Charge pressure must be maintained at a specified level under all operating conditions to prevent damage to the transmission. Danfoss recommends testing under actual operating conditions to verify this.

System design parameters

Charge pump sizing/selection

In most applications a general guideline is that the charge pump displacement should be at least 10 % of the total displacement of all components in the system. Unusual application conditions may require a more detailed review of charge flow requirements. Please refer to *Selection of Drive line Components*, **BC157786484430** for a detailed procedure.

System features and conditions which may invalidate the 10 % guideline include (but are not limited to):

- Continuous operation at low input speeds {< 1500 min^{-1} (rpm)}
- High shock loading and/or long loop lines
- High input shaft speeds
- LSHT motors with large displacement and/or multiple LSHT motors
- High flushing flow requirements
- Automotive style operation where input speeds fluctuate or operate below 800 min-1 (rpm)

Contact your Danfoss representative for application assistance if your application includes any of these conditions.

System design parameters

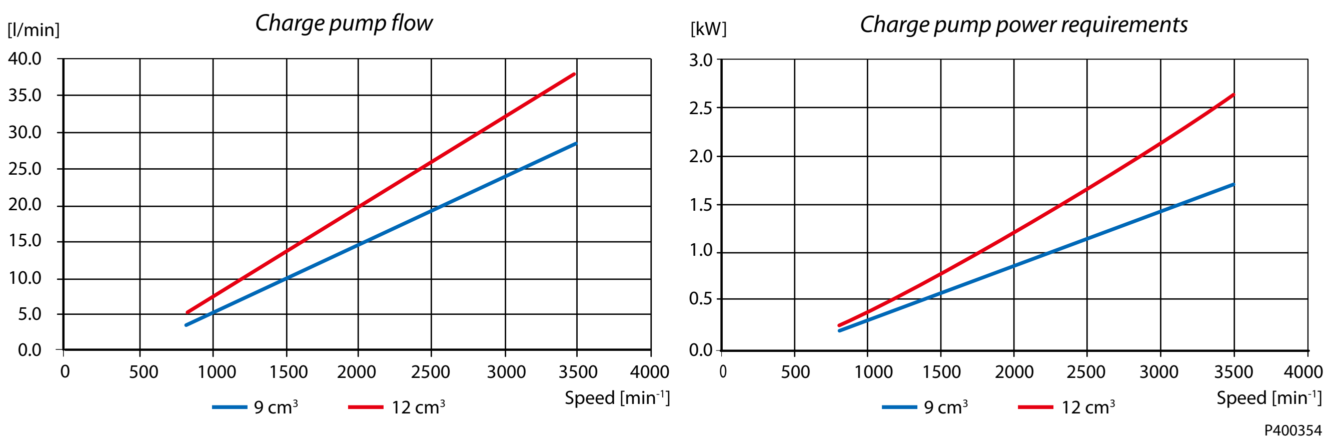
Charge pump output flow

Charge pump flow and power curves, 9/12 cm³

Charge pressure: 20 bar [290 psi]

Viscosity: 11 mm²/s [63 SUS]

Temperature: 80 °C [176 °F]



Bearing life and external shaft loading

Bearing life is a function of speed, system pressure, charge pressure, and swashplate angle, plus any external side or thrust loads. Other life factors include oil type and viscosity. The influence of swashplate angle includes displacement as well as direction. External loads are found in applications where the pump is driven with side/thrust load (belt or gear) as well as in installations with misalignment and improper concentricity between the pump and drive coupling. All external side loads will act to reduce the normal bearing life of a pump.

In vehicle propel drives with no external shaft loads and where the system pressure and swashplate angle are changing direction and magnitude regularly, the normal B10 bearing life (90% survival) will exceed the hydraulic load-life of the unit.

In non propel drives such as vibratory drives, conveyor drives, or fan drives, the operating speed and pressure are often nearly constant and the swashplate angle is predominantly at maximum. These drives have a distinctive duty cycle compared to a propulsion drive. In these types of applications a bearing life review is recommended.

MP1 pumps are designed with bearings that can accept some external radial. When external loads are present, the allowable radial shaft loads are a function of the load position relative to the mounting flange, the load orientation relative to the internal loads, and the operating pressures of the hydraulic unit. In applications where external shaft loads can not be avoided, the impact on bearing life can be minimized by proper orientation of the load. Optimum pump orientation is a consideration of the net loading on the shaft from the external load, the pump rotating group, and the charge pump load.

System design parameters

- In applications where the pump is operated such that nearly equal amounts of forward vs reverse swashplate operation is experienced; bearing life can be optimized by orientating the external side load to the 0 or 180 deg position (90 deg to rotating group load Fb). See drawing.
- In applications where the pump is operated such that the swashplate is predominantly (>75%) on one side of neutral (e.g. vibratory, conveyor, typical propel); bearing life can be optimized by orientating the external side load generally opposite of the internal rotating group load, Fb. The direction of the internal loading is a function of rotation and system port, which has flow out.
- Avoid axial thrust loads in either direction.

The **maximum allowable radial loads** (Re), based on the **maximum external moment** (Me) and the distance (L) from the mounting flange to the load, may be determined from the tables below and the cross section drawing.

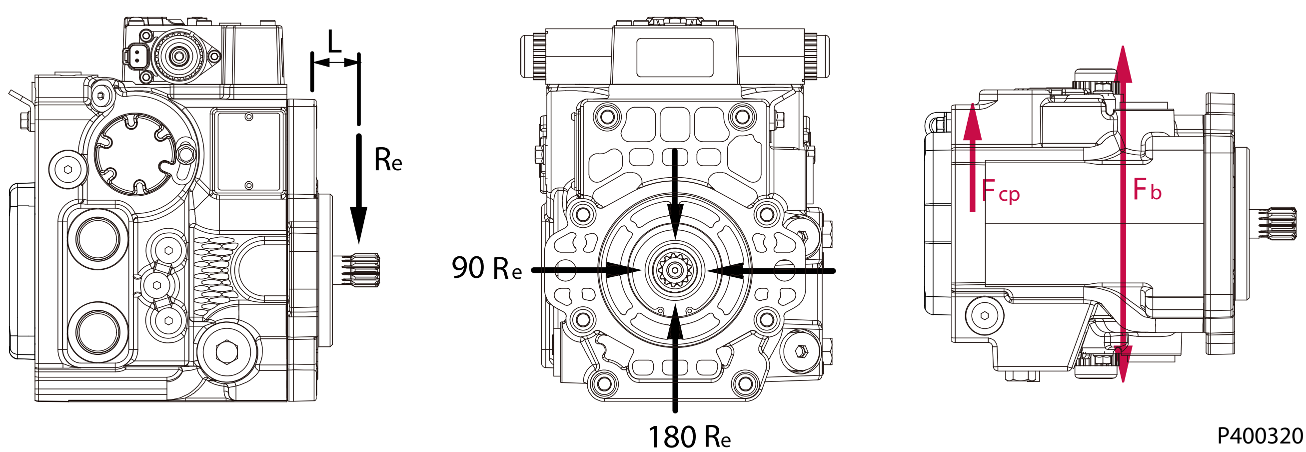
The maximum allowable radial load is calculated as: $\mathbf{R_e = M_e / L}$

Contact your Danfoss representative for an evaluation of unit bearing life if continuously applied external radial loads are 25% or more of the maximum allowable, or if thrust loads are known to exist. Use tapered output shafts or clamp-type couplings where radial shaft side loads are present.

Shaft loading parameters

Re	Maximum external radial load
Me	Maximum external moment
L	Distance from mounting flange to point of load
Fb	Internal rotating group load
Te	Thrust external load
Fcp	Force of charge pump

External radial shaft load



System design parameters

Hydraulic unit life

Hydraulic unit life is defined as the fatigue life expectancy of the hydraulic components. It is a function of speed and system pressure; however, system pressure is the dominant variable. High pressure, which results from high load, reduces expected hydraulic unit life.

System component selection is based on determination of the application maximum loads and speeds. Testing is recommended to secure duty cycle data in which to predict hydraulic unit life. Contact your Danfoss representative for assistance in unit life determination. If duty cycle data is not available, normal input power and maximum pump displacement can be used to determine an application pressure in which to predict life.

MP1 pumps will meet most application hydraulic unit life expectancies if applied within the parameters specified in this manual and chosen considering the guidelines within Danfoss publication *Selection of Driveline Components* **BC157786484430**. For more detailed information on hydraulic unit life, see Danfoss publication *Pressure and Speed Limits* **BC152886484313**.

Mounting flange loads

Shock load moment is the result of an instantaneous jolt to the system. **Continuous load moments** are generated by the typical vibratory movement of the application. Avoid excessive loading of the mounting flange such as adding tandem mounted auxiliary pumps and/or subjecting pumps to high shock loads. Design pump applications to stay within the allowable shock load moment and allowable continuous load moment.

Use the following formulas to estimate overhung load moment for multiple pump mountings:

$M_S = G_S\,(W_1L_1 + W_2L_2 + \dots + W_nL_n)$

$M_C = G_C\,(W_1L_1 + W_2L_2 + \dots + W_nL_n)$

Refer to the *Installation Drawings* section to find pump length (L). Refer to the table *Technical Specifications* in the *Specifications* section, to find pump weight (W). An exact measure of W will depend on the pump's features.

Overhung loading parameters

M_s	Shock load moment
M_c	Continuous load moment
G_s	Maximum shock acceleration (Gs)
G_c	Continuous (vibratory) acceleration (Gs)
W_n	Weight of nth pump
L_n	Distance from mounting flange to center of gravity of nth pump

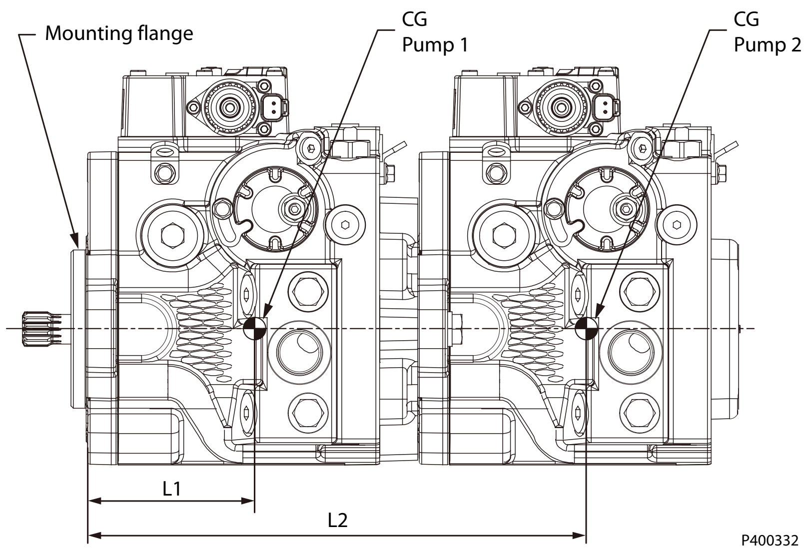
The tables below show allowable overhung load moment values. If system parameters exceed these values add additional pump support.

Allowable overhung parameters

Frame size	Continuous load moment (M_c) 10^7 cycles N•m [in·lbf]	Shock load moment (M_s) 10^3 cycles N•m [in·lbf]
28/32	1100 [9736]	2000 [17702]
38/45	1500 [13276]	2800 [24782]

System design parameters

Shaft loading parameters



This illustration shows two single pumps in tandem.

Estimated maximum and continuous acceleration factors for some typical applications are shown. Applications which experience extreme resonant vibrations may require additional pump support. Typical continuous (vibratory) values can vary significantly due to changes in engine and pump configuration and mounting methods.

G-factors for sample applications

Application	Continuous (vibratory) acceleration (G_c)	Maximum (shock) acceleration (G_s)
Trencher (rubber tires)	3	8
Asphalt paver	2	6
Windrower	2	5
Aerial lift	1.5	4
Turf care vehicle	1.5	4
Vibratory roller	6	10

* Applications which experience extreme resonant vibrations require addition pump support.

System design parameters

Shaft torques

Shaft selection

Base shaft selection on a review of the maximum torque required by the application and the maximum torque available from the prime mover. Application duty cycle and continuous torque rating of the prime mover are the main variable to consider when selecting a shaft.

Shaft torque and splines lubrication

The **rated torque** is a measure of tooth wear and is the torque level at which a normal spline life of 1 x 10^7 shaft revolutions can be expected. The rated torque presumes a regularly maintained minimum level of lubrication via a moly-disulfide grease in order to reduce the coefficient of friction and to restrict the presence of oxygen at the spline interface. It is also assumed that the mating spline has a minimum hardness of R_c 55 and full spline depth. The rated torque is proportional to the minimum active spline length.

However, a spline running in oil-flooded environment provides superior oxygen restriction in addition to contaminant flushing. The rated torque of a flooded spline can increase to that of the maximum published rating. A flooded spline would be indicative of a pump driven by a pump drive or plugged into an auxiliary pad of a pump.

Maximum torque ratings are based on torsional fatigue strength considering 1 x 10^5 full load reversing cycles.

Maintaining a spline engagement at least equal to the pitch diameter will also maximize spline life. Spline engagements of less than ¾ pitch diameter are subject to high contact stress and spline fretting.

Shaft torque for tapered shafts

The **rated torque** is based on the contact pressure between the shaft and hub surfaces with poor contact areas. With increased quality of the contact areas, the contact pressure between shaft and hub is increased, allowing higher torque to be transmitted.

A key is intended as an installation aid only. Any torque carried by the key as a result of poor contact area or mis-alignment will limit the torque carrying capability of the shaft significantly.

Maximum torque rating is based on an ideal contact area of 100% and the retaining nut properly torqued. This allows for the highest contact pressure between the shaft and the mating hub.

System design parameters

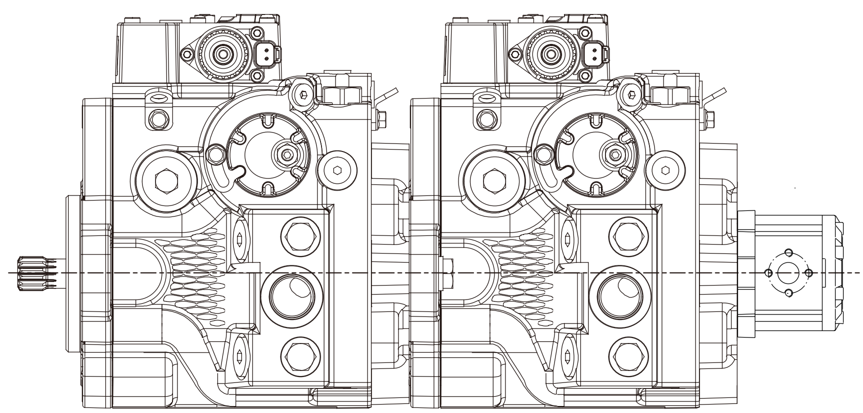
Shaft availability and torque ratings

Alignment between the mating spline's Pitch Diameters is another critical feature in determining the operating life of a splined drive connection. Plug-in, or rigid spline drive installations can impose severe radial loads on the shafts.

The radial load is a function of the transmitted torque and shaft eccentricity. Increased spline clearance will not totally alleviate this condition; BUT, increased spline clearance will prevent mechanical interference due to misalignment or radial eccentricity between the pitch diameters of the mating splines. Spline life can be maximized if an intermediate coupling is introduced between the bearing supported splined shafts.

Multiple pump installations must consider the loads from the entire pump stack and all torques are additive. Charge pumps loads must also be included.

Through torque diagram



Attention

Torque required by auxiliary pumps is additive. Ensure requirements do not exceed shaft torque ratings.

Understanding and minimizing system noise

Noise is transmitted in fluid power systems in two ways: as fluid borne noise, and structure borne noise.

Fluid-borne noise (pressure ripple or pulsation) is created as pumping elements discharge oil into the pump outlet. It is affected by the compressibility of the oil, and the pump's ability to transition pumping elements from high to low pressure. Pulsations travel through the hydraulic lines at the speed of sound until there is a change (such as an elbow) in the line. Amplitude varies with overall line length and position.

Structure borne noise is transmitted wherever the pump casing connects to the rest of the system. The way system components respond to excitation depends on their size, form, material, and mounting.

System lines and pump mounting can amplify pump noise.

Follow these suggestions to help minimize noise in your application:

- Use flexible hoses.
- Limit system line length.
- If possible, optimize system line position to minimize noise.

System design parameters

- If you must use steel plumbing, clamp the lines.
- If you add additional support, use rubber mounts.
- Test for resonance in the operating range; if possible avoid them.

System design parameters

Sizing equations

The following equations are helpful when sizing hydraulic pumps. Generally, the sizing process is initiated by an evaluation of the machine system to determine the required motor speed and torque to perform the necessary work function.

	Based on SI units		Based on US units	
Flow	Output flow $Q = \frac{V_g \cdot n \cdot \eta_v}{1000}$	(l/min)	Output flow $Q = \frac{V_g \cdot n \cdot \eta_v}{231}$	(US gal/min)
Torque	Input torque $M = \frac{V_g \cdot \Delta p}{20 \cdot \pi \cdot \eta_m}$	(N•m)	Input torque $M = \frac{V_g \cdot \Delta p}{2 \cdot \pi \cdot \eta_m}$	(lbf•in)
Power	Input power $P = \frac{M \cdot n \cdot \pi}{30\,000} = \frac{Q \cdot \Delta p}{600 \cdot \eta_t}$	(kW)	Input power $P = \frac{M \cdot n \cdot \pi}{198\,000} = \frac{Q \cdot \Delta p}{1714 \cdot \eta_t}$	(hp)

Variables

SI units [US units]

V_g = Displacement per revolution cm^3/rev [in^3/rev]

p_O = Outlet pressure bar [psi]

p_i = Inlet pressure bar [psi]

Δp = p_O - p_i (system pressure) bar [psi]

n = Speed min^{-1} (rpm)

η_v = Volumetric efficiency

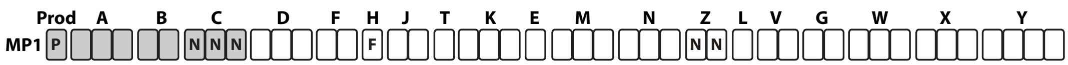
η_m = Mechanical efficiency

η_t = Overall efficiency ($\eta_v \cdot \eta_m$)

First, the motor is sized to transmit the maximum required torque. The pump is then selected as a flow source to achieve the maximum motor speed. Refer to *Selection of Drive Line Components*, **BC157786484430**, for a more complete description of hydrostatic drive line sizing.

Model code

Model code (A - B - C)



A - displacement and rotation

Code	Description
28R	28 cm^3, clockwise (right hand)
28L	28 cm^3, counterclockwise (left hand)
32R	32 cm^3, clockwise (right hand)
32L	32 cm^3, counterclockwise (left hand)
38R	38 cm^3, clockwise (right hand)
38L	38cm^3, counterclockwise (left hand)
45R	45 cm^3, clockwise (right hand)
45L	45 cm^3, counterclockwise (left hand)

B - product version and unit

Code	Description
AS	Product Version "A", Inch, Customer port sealing according to ISO 11926-1
AM	Product Version "A", Metric , Customer port sealing according to ISO 6149-1

C - automotive control and inching

Code	Description
NNN	None

Model code

Model code (D)

Prod A B C D F H J T K E M N Z L V G W X Y

MP1 P N N N F N N

D - controls

Code	Control type	Voltage	Options	Port	Connect or
SA2	**EDC** Electric displacement control	12V	—	Inch	DEUTSCH
SA3		24V	—	Inch	DEUTSCH
SA4		12V	Manual override	Inch	DEUTSCH
SA5		24V	Manual override	Inch	DEUTSCH
SE7		12V	Control cut-off	Inch	DEUTSCH
SE8		24V	Control cut-off	Inch	DEUTSCH
SG8		12V	Manual override, control cut-off	Inch	DEUTSCH
SH1		24V	Manual Override, Control Cut-Off	Inch	DEUTSCH
MA4		12V	Manual override	Metric	DEUTSCH
MA5		24V	Manual override	Metric	DEUTSCH
MG8		12V	Manual override, control Cut-Off	Metric	DEUTSCH
MH1		24V	Manual Override, Control Cut-Off	Metric	DEUTSCH
SH2		12V	Angle Sensor	Inch	DEUTSCH
SH7[1)]		24V	Angle Sensor, Manual Override	Inch	DEUTSCH
SM1	**MDC** Manual displacement control	-	Standard	Inch	-
SM2		-	Neutral Start Switch	Inch	DEUTSCH
MM1		-	Standard	Metric	-
MM2		-	Neutral Start Switch	Metric	DEUTSCH
SM3		12V	Control Cut-Off	Inch	DEUTSCH
SM4		24V	Control Cut-Off	Inch	DEUTSCH
SM5		12V	Control cut-off, neutral start switch	Inch	DEUTSCH
SM6		24V	Control cut-off, neutral start switch	Inch	DEUTSCH
MM3		12V	Control cut-off	Metric	DEUTSCH
MM4		24V	Control cut-off	Metric	DEUTSCH
MM5		12V	Control cut-off, neutral start switch	Metric	DEUTSCH
MM6		24V	Control cut-off, neutral start switch	Metric	DEUTSCH
SA9	**FNR** Forward-neutral-reverse	12V	Manual override	Inch	DEUTSCH
SB1		24V	Manual override	Inch	DEUTSCH
MA9		12V	Manual override	Metric	DEUTSCH
MB1		24V	Manual override	Metric	DEUTSCH
SN1	**NFPE** Non-feedback proportional electric	12V	Manual override	Inch	DEUTSCH
SN2		24V	Manual override	Inch	DEUTSCH
MN1		12V	Manual override	Metric	DEUTSCH
MN2		24V	Manual override	Metric	DEUTSCH
SNN	**NFPH** Non-feedback proportional hydraulic	-	-	Inch	-
MNN		-	-	Metric	-
AJ1	**AC-1** automotive control	12 V	Manual override	-	DEUTSCH

Model code

D - controls (continued)

Code	Control type	Voltage	Options	Port	Connect or
AJ3	**AC-2** automotive control	12 V	Angle sensor, manual override	-	DEUTSCH
AU1	**AC-1**	12 V	Manual override w/out PPU wiring	-	DEUTSCH
AU3	**AC-2**	12 V	Angle sensor, manual override, w/out PPU wiring	-	DEUTSCH

[1)] 28/32 only

Code	Control type	Control input pressure	Port
ST1	**HDC**Hydraulic displacement control	4.2 - 16.2 bar	Inch
MT1		4.2 - 16.2 bar	Metric
ST2		3.0 - 11.6 bar	Inch
MT2		3.0 - 11.6 bar	Metric

Align each with options **B**: Product Version, **E**: Displacement limitation, **F**: Orifices, and **W** : Special hardware features

Model code (F)

Prod A B C D F H J T K E M N Z L V G W X Y

MP1 P N N N F N N

F – orifices

Code	Orifice			Controls: (X marks compatible use)			
	Tank (A+B)	P	A / B	EDC, FNR	MDC	NFPE, AC	NFPH
C3	No orifice			X	X		
C1			0.8 mm	X	X	X	X
C2			1.3 mm	X	X	X	X
C4			1.0 mm	X	X	X	X
C6	1.0 mm				X		
C7	1.3 mm				X		
C8	0.6 mm	0.8 mm			X		
C9	0.6 mm	1.0 mm			X		
D1	0.8 mm	1.0 mm			X		
D2	0.8 mm	1.3 mm			X		
D3	1.0 mm	1.3 mm			X		
D4	1.0 mm	1.3 mm	1.3 mm		X		
D5	0.6 mm	0.6 mm	0.8 mm		X		
E2	0.8 mm	1.0 mm	0.8 mm		X		

Model code

Model code (H - J - T)

Prod A B C D F H J T K E M N Z L V G W X Y

MP1 P N N N F N N

H - mounting flange

Code	Description
F	ISO 3019-1, flange 101-2 (SAE B)

J - input shaft

Code	Description	28	32	38	45
G4	ISO 3019-1, outer dia. 22 mm (SAE B, 13 teeth splined shaft 16/32 pitch)	X	X	X	X
F6	ISO 3019-1, outer dia. 22 mm (SAE B, 13 teeth splined shaft 16/32 pitch -SPCL bearing (high capacity)	X	X	X	X
G5	ISO 3019-1, outer dia. 23 mm (SAE B 15 teeth splined shaft 16/32 pitch)	X	X	X	X
F5	ISO 3019-1, outer dia. 23 mm (SAE B 15 teeth splined shaft 16/32 pitch -SPCL bearing (high capacity)	X	X	X	X
F2	Conical keyed shaft similar to ISO 3019-1 code 25-3, taper*			X	X
A8	Round straight keyed Ø25.4 mm*			X	X
A7	Round straight keyed Ø22.23 mm*	X	X		
A9	Round straight keyed Ø22.23 mm in-SPCL Bearing (High Capacity)*	X	X		
G1	ISO 3019-1, outer dia. 31.58 mm (SAE B, 14 teeth splined shaft 12/24 pitch)			X	X
G6	ISO 3019-1, outer dia. 31.24 mm (SAE B 19 teeth splined shaft 16/32 pitch)			X	X
G7	ISO 3019-1, outer dia. 31.24 mm (SAE B 19 teeth splined shaft 16/32 pitch - SPCL bearing (high capacity)			X	X
F1	ISO 3019-1, outer dia. 31.58 mm (SAE B 14 teeth splined shaft 12/24 pitch -SPCL bearing (high capacity)			X	X
F3	Conical keyed shaft similar to ISO 3019-1 code 25-3, taper - SPCL bearing (high capacity)			X	X
A6	Round straight keyed Ø25.4mm - SPCL bearing (high capacity)			X	X

* (key not supplied with shaft)

T - filtration

Code	Description	Note
E	External charge flow filtration	Align with K: charge pump and auxiliary pad (no charge pump options)
R	Remote full charge flow filtration	Align with K: charge pump and auxiliary Pad (9 cc or 12 cc charge pump options)
S	Suction filtration	

Model code

Model code (K)

Prod A B C D F H J T K E M N Z L V G W X Y
MP1 P N N N F N N

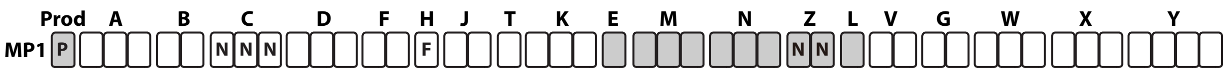
K - charge pump and auxiliary pad

Code	Description	28	32	38	45
A16	9 cm^3/rev charge pump, SAE A 9 tooth (w/shipping cover), inch	●	●	●	●
B16	9 cm^3/rev charge pump, SAE A 9 tooth (w/shipping cover), metric	●	●	●	●
A19	9 cm^3/rev charge pump, SAE A 11 tooth (w/shipping cover), inch	●	●	●	●
B19	9 cm^3/rev charge pump, SAE A 11 tooth (w/shipping cover), metric	●	●	●	●
A22	9 cm^3/rev charge pump, SAE B 13 tooth (w/shipping cover), inch	●	●	●	●
B22	9 cm^3/rev charge pump, SAE B 13 tooth (w/shipping cover), metric	●	●	●	●
A25	9 cm^3/rev charge pump, SAE B-B 15 tooth (w/shipping cover), inch			●	●
B25	9 cm^3/rev charge pump, SAE B-B 15 tooth (w/shipping cover), metric			●	●
ANN	9 cm^3/rev charge pump, none, SAE cover, inch	●	●	●	●
BNN	9 cm^3/rev charge pump, none, SAE cover, metric	●	●	●	●
C16	12 cm^3/rev charge pump, SAE A 9 tooth (w/shipping cover), inch	●	●	●	●
D16	12 cm^3/rev charge pump, SAE A 9 tooth (w/shipping cover), metric	●	●	●	●
C19	12 cm^3/rev charge pump, SAE A 11 tooth (w/shipping cover), inch	●	●	●	●
D19	12 cm^3/rev charge pump, SAE A 11 tooth (w/shipping cover), metric	●	●	●	●
C22	12 cm^3/rev charge pump, SAE B 13 tooth (w/shipping cover), inch	●	●	●	●
D22	12 cm^3/rev charge pump, SAE B 13 tooth (w/shipping cover), metric	●	●	●	●
C25	12 cm^3/rev charge pump, SAE B-B 15 tooth (w/shipping cover), inch			●	●
D25	12 cm^3/rev charge pump, SAE B-B 15 tooth (w/shipping cover), metric			●	●
CNN	12 cm^3/rev charge pump, none, SAE cover, inch	●	●	●	●
DNN	12 cm^3/rev charge pump, none, SAE cover, metric	●	●	●	●
E16	No charge pump, SAE A 9 tooth (w/shipping cover), inch	●	●	●	●
F16	No charge pump, SAE A 9 tooth (w/shipping cover), metric	●	●	●	●
E19	No charge pump, SAE A 11 tooth (w/shipping cover), inch	●	●	●	●
F19	No charge pump, SAE A 11 tooth (w/shipping cover), metric	●	●	●	●
E22	No charge pump, SAE B 13 tooth (w/shipping cover), inch	●	●	●	●
F22	No charge pump, SAE B 13 tooth (w/shipping cover), metric	●	●	●	●
E25	No charge pump, SAE B-B 15 tooth (w/shipping cover), inch			●	●
F25	No charge pump, SAE B-B 15 tooth (w/shipping cover), metric			●	●
ENN	No charge pump, none, SAE cover, inch	●	●	●	●
FNN	No charge pump, none, SAE cover, metric	●	●	●	●

Align with option **B** (product version and unit)
"Inch": option B="AS", inch O-ring boss port.
"Metric": option B="AM", metric O-ring boss port.

Model code

Model code (E - M - N - Z - L)



E - displacement limiter

Code	Description
N	No limiters
B	Adjustable externally
C	No limiters, required for FNR, NFPE, NFPH (align with option D: control)
D	Adjustable externally, required for FNR, NFPE, NFPH (align with option D: control)

Align with **Y**: settings if applicable

M - high pressure relief setting side "A" & N - high pressure relief setting side "B"

Code	Pressure setting
140	140 bar [2030 psi]
175	175 bar [2538 psi]
190	190 bar [2755 psi]
210	210 bar [3045 psi]
230	230 bar [3336 psi]
250	250 bar [3630 psi]
260	260 bar [3770 psi]
280	280 bar [4061 psi]
300	300 bar [4350 psi]
325	325 bar [4713 psi]
345	345 bar [5000 psi]

Please contact Danfoss Power Solutions for pressures not shown or for applied pressures above max. working pressure (see *MP1 operating parameters* on page 10).

Z - POR setting

Code	Description
NN	No pressure override

L - loop flushing

Code	Description	28	32	38	45
N	No loop flushing valve	X	X	X	X
B	Loop flushing; 1.6 mm orifice; 6 l/min	X	X	X	X

Align with **G**: system port type

Model code

Model code (V - G - W)

	Prod	A	B	C	D	F	H	J	T	K	E	M	N	Z	L	V	G	W	X	Y
MP1	P			N N N			F							N N						

V – charge pressure relief setting

Code	Description	
20	20 bar [290 psi]	Not to be used for NFPE or NFPH controls. NFPE is 24 bar or higher; NFPH is 26 bar or higher
22	22 bar [319 psi]	
24	24 bar [348 psi]	
26	26 bar [377 psi]	
28	28 bar [406 psi]	

G - system port type

Code	Description	28	32	38	45
A1	Inch O-ring boss per ISO 11926-1	X	X	X	X
A3	Inch O-ring boss per ISO 11926-1 with integral loop flush valve	X	X	X	X
A4	Inch O-ring boss per ISO 11926-1 with speed sensor	X	X	X	X
A5	Inch O-ring boss per ISO 11926-1 with integral loop flush and speed sensor	X	X	X	X
B1	Split flange per ISO 6162-2, (all other O-ring boss, inch per ISO 11926-1)			X	X
B3	Split flange per ISO 6162-2, (all other O-ring boss, inch per ISO 11926-1) with integral loop flush valve			X	X
B4	Split flange per ISO 6162-2, (all other O-ring boss, inch per ISO 11926-1) with speed sensor			X	X
B5	Split flange per ISO 6162-2, (all other O-ring boss, inch per ISO 11926-1) with speed sensor and loop flush			X	X
C1	Metric O-ring boss per ISO 6149-1	X	X	X	X
C3	Metric O-ring boss per ISO 6149-1 with integral loop flush valve	X	X	X	X
C4	Metric O-ring boss per ISO 6149-1 with speed sensor	X	X	X	X
C5	Metric O-ring boss per ISO 6149-1 with speed sensor and loop flush	X	X	X	X
D1	Split flange per ISO 6162-2, (all other O-ring boss, metric per ISO 6149-1)			X	X
D3	Split flange per ISO 6162-2, (all other O-ring boss, metric per ISO 6149-1) with integral loop flush valve			X	X
D4	Split flange per ISO 6162-2, (all other O-ring boss, metric per ISO 6149-1) with speed sensor			X	X
D5	Split flange per ISO 6162-2, (all other O-ring boss, metric per ISO 6149-1) with speed sensor and loop flush			X	X

Align with **B**: product version and unit, and **L**: loop flushing

W - special hardware features

Code	Description
RAC	Standard valve plate, CW, 28 cm^3
LAC	Standard valve plate, CCW, 28 cm^3
RAD	Standard valve plate, CW, 32 cm^3
LAD	Standard valve plate, CCW, 32 cm^3

Model code

W - special hardware features (continued)

Code	Description
RAE	Standard valve plate, CW, 38 cm^3
LAE	Standard valve plate, CCW, 38 cm^3
RAF	Standard valve plate, CW, 45 cm^3
LAF	Standard valve plate, CCW, 45 cm^3
RBC	NFPE/NFPH/AC valve plate, CW, 28cm^3
LBC	NFPE/NFPH/AC valve plate, CCW, 28cm^3
RBD	NFPE/NFPH/AC valve plate, CW, 32cm^3
LBD	NFPE/NFPH/AC valve plate, CCW, 32cm^3
RBE	NFPE/NFPH/AC valve plate, CW, 38cm^3
LBE	NFPE/NFPH/AC valve plate, CCW, 38cm^3
RBF	NFPE/NFPH/AC valve plate, CW, 45cm^3
LBF	NFPE/NFPH/AC valve plate, CCW, 45cm^3

Align with **A**: displacement and rotation : and **D**: controls

Model code

Model code (X - Y)

Prod A B C D F H J T K E M N Z L V G W X Y

MP1 P N N N F N N

X - paint and name tag

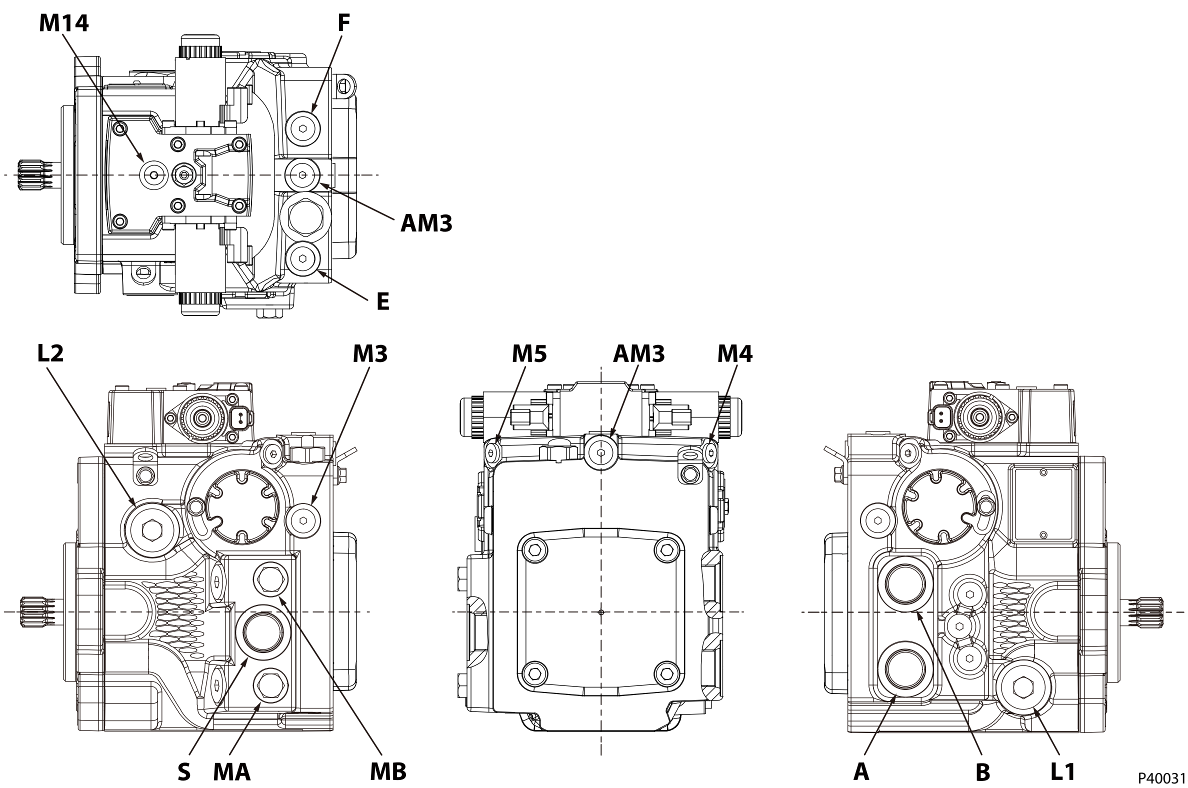
Code	Description
NNN	Black paint, standard name tag

Y - settings

Code	Description
NNNN	None
E095	Displacement limitation side A 95%, side B 95%
E090	Displacement limitation side A 90%, side B 90%
E085	Displacement limitation side A 85%, side B 85%
E080	Displacement limitation side A 80%, side B 80%
M00A	MDC control handle, standard orientation
M095	Displacement limitation side A 95%, side B 95%, MDC handle, standard orientation
M090	Displacement limitation side A 90%, side B 90%, MDC handle, standard orientation
M085	Displacement limitation side A 85%, side B 85%, MDC handle, standard orientation
M080	Displacement limitation side A 80%, side B 80%, MDC handle, standard orientation
AF1F	Standard propel functionality
AF2E	Standard propel functionality + ECO mode
AF1E	Standard propel functionality + ECO mode + Kubota engine protocol
AF2J	Standard propel functionality + ECO mode + cruise control + Kubota engine protocol
AF3J	Standard propel functionality + ECO mode + cruise control
AF4J	Standard propel functionality + ECO mode + cruise control

Installation drawings

28/32 ports

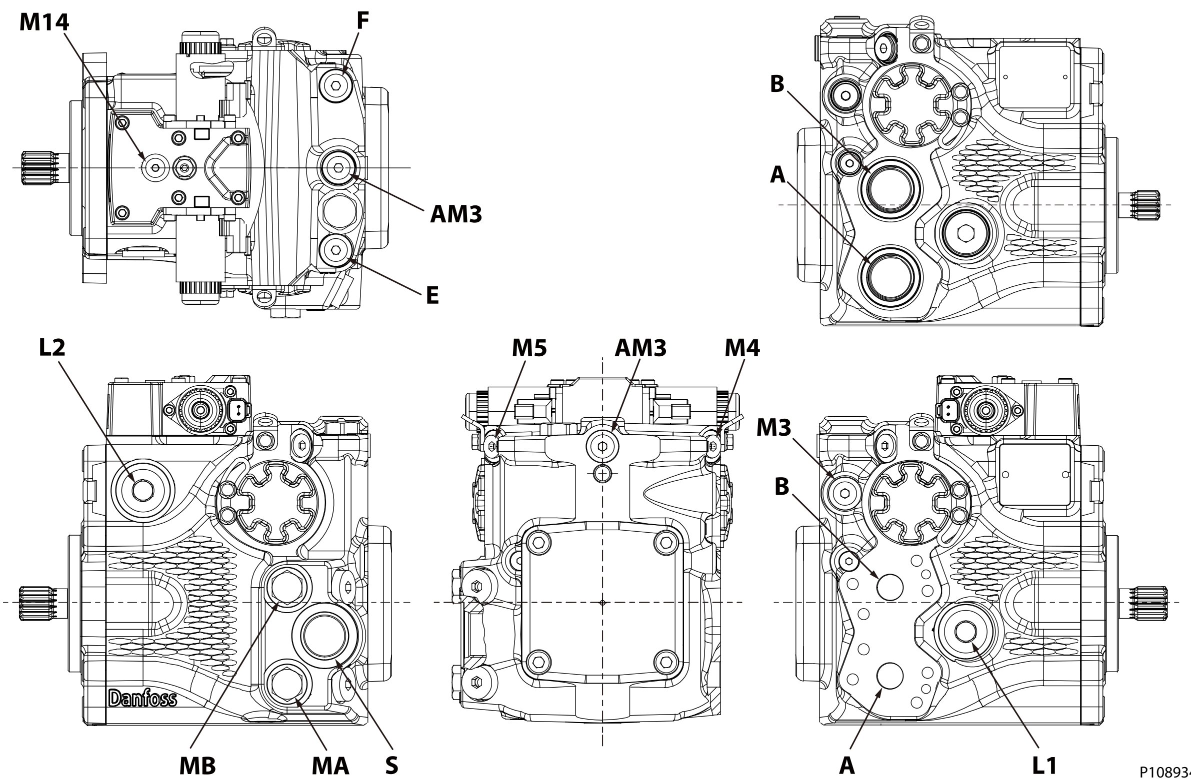


Port description

Port	Description	Code		Size
A/B	System	Inch	ISO 11926-1	1 1/16-12
		Metric	ISO 6149-1	M27x2
AM3	Alternative charge gauge	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
E/F	Filtration inlet/outlet	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
L1/L2	Case drain	Inch	ISO 11926-1	1 1/16-12
		Metric	ISO 6149-1	M27x2
MA/MB	System gauge	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
M3	Charge gauge	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
M4/M5	Servo gauge	Inch	ISO 11926-1	7/16-20
		Metric	ISO 6149-1	M12x1.5
M14	Case gauge port	Inch	ISO 11926-1	7/16-20
		Metric	ISO 6149-1	M12x1.5
S	Charge pump inlet	Inch	ISO 11926-1	1 1/16-12
		Metric	ISO 6149-1	M27x2

Installation drawings

38/45 ports

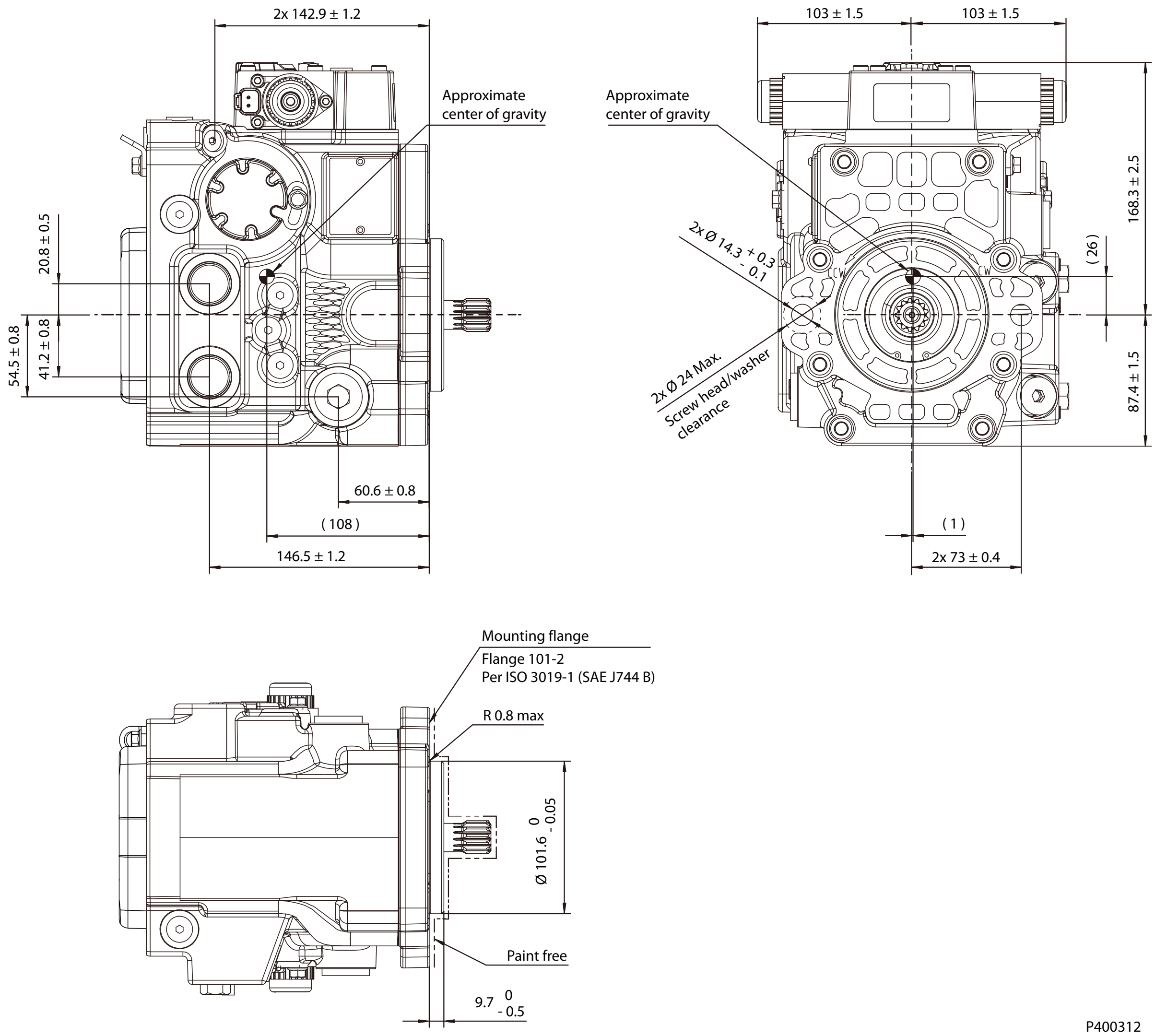


Port description

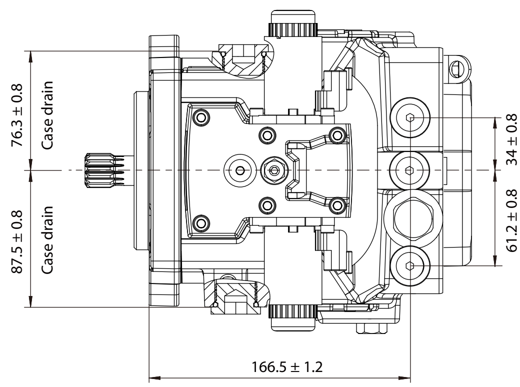
Port	Description	Code		Size
A/B	System	Inch	ISO 11926-1	1 5/16-12
		Metric	ISO 6149-1	M33x2
		Split flange port	ISO 6162-2	DN19 M10x1.5
AM3	Alternative charge gauge	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
E/F	Filtration inlet/outlet	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
L1/L2	Case drain	Inch	ISO 11926-1	1 1/16-12
		Metric	ISO 6149-1	M27x2
MA/MB	System gauge	Inch	ISO 11926-1	3/4-16
		Metric	ISO 6149-1	M18x1.5
M3	Charge gauge	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
M4/M5	Servo gauge	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
M14	Case gauge port	Inch	ISO 11926-1	7/16-20
		Metric	ISO 6149-1	M12x1.5
S	Charge Pump Inlet	Inch	ISO 11926-1	1 5/16-12
		Metric	ISO 6149-1	M33x2

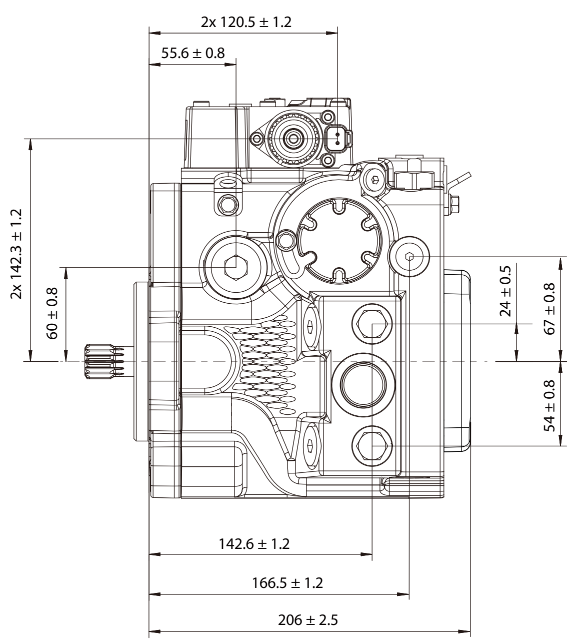
Installation drawings

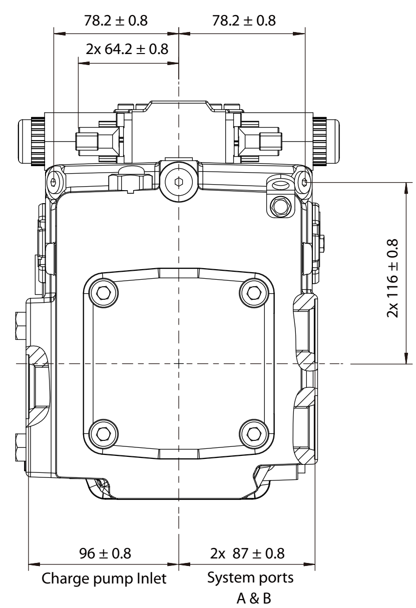
28/32 dimensions



Installation drawings



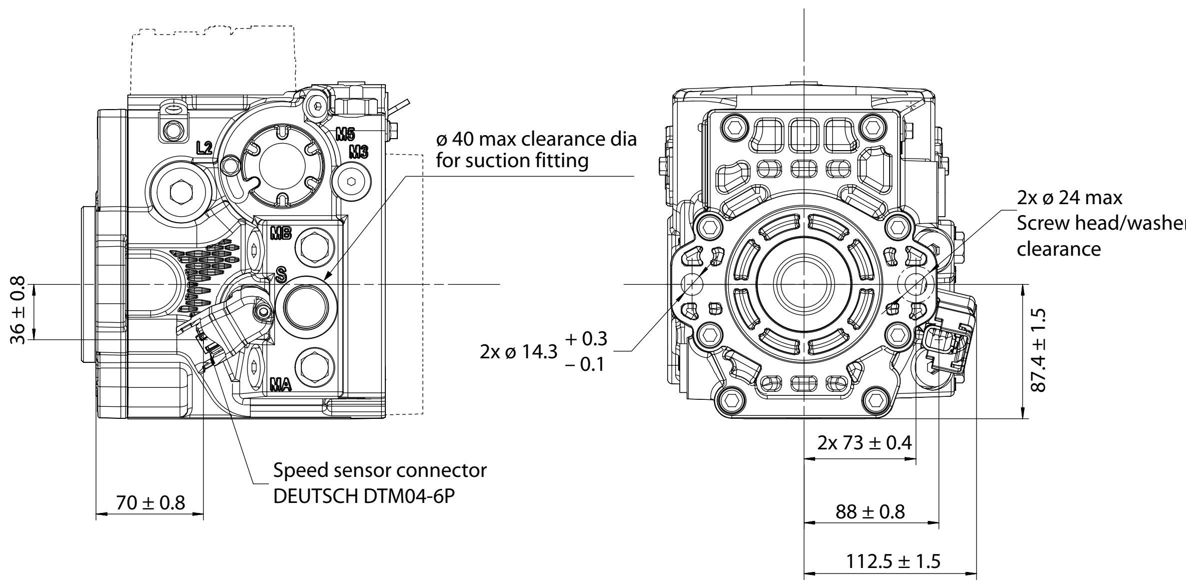




Please contact Danfoss representative for specific installation drawings.

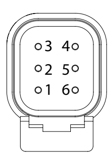
Installation drawings

28/32 dimensions with speed sensor



Please contact Danfoss representative for specific installation drawings.

Speed sensor connector

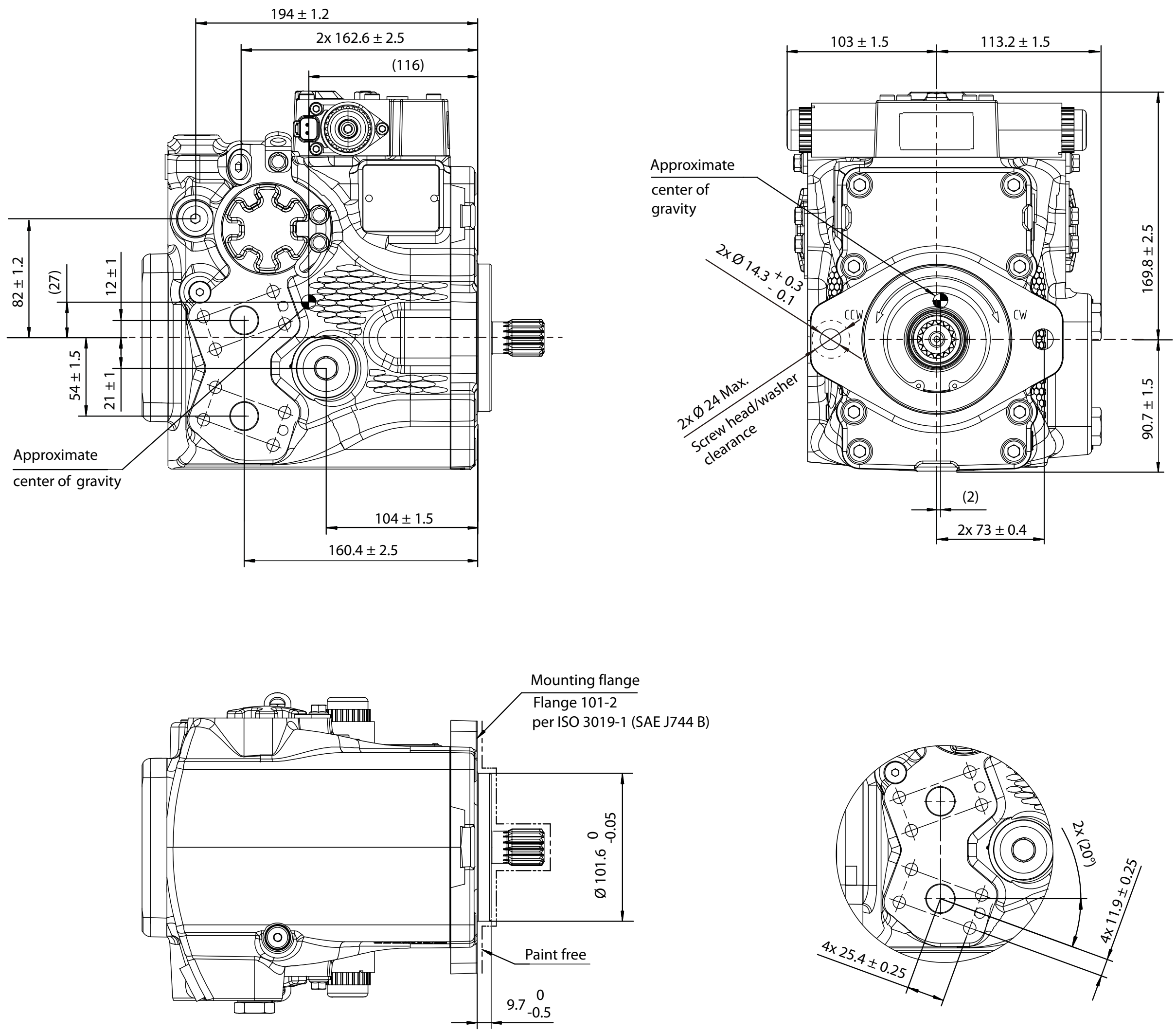


Pin	Assignment
1	Speed signal 1
2	NC
3	Speed signal 2
4	Supply
5	Ground
6	Temperature

Installation drawings

38/45 dimensions

Split flange type



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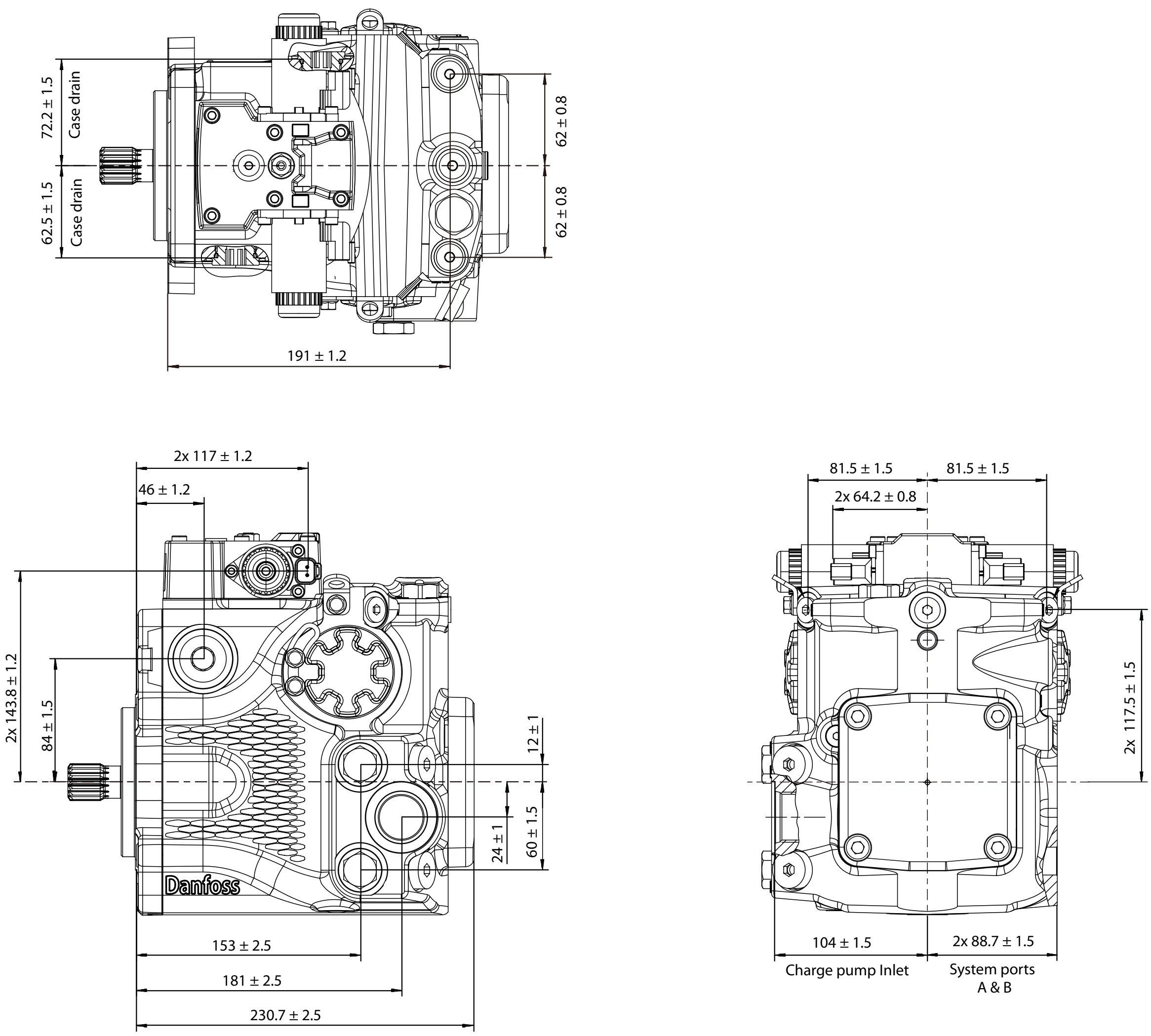
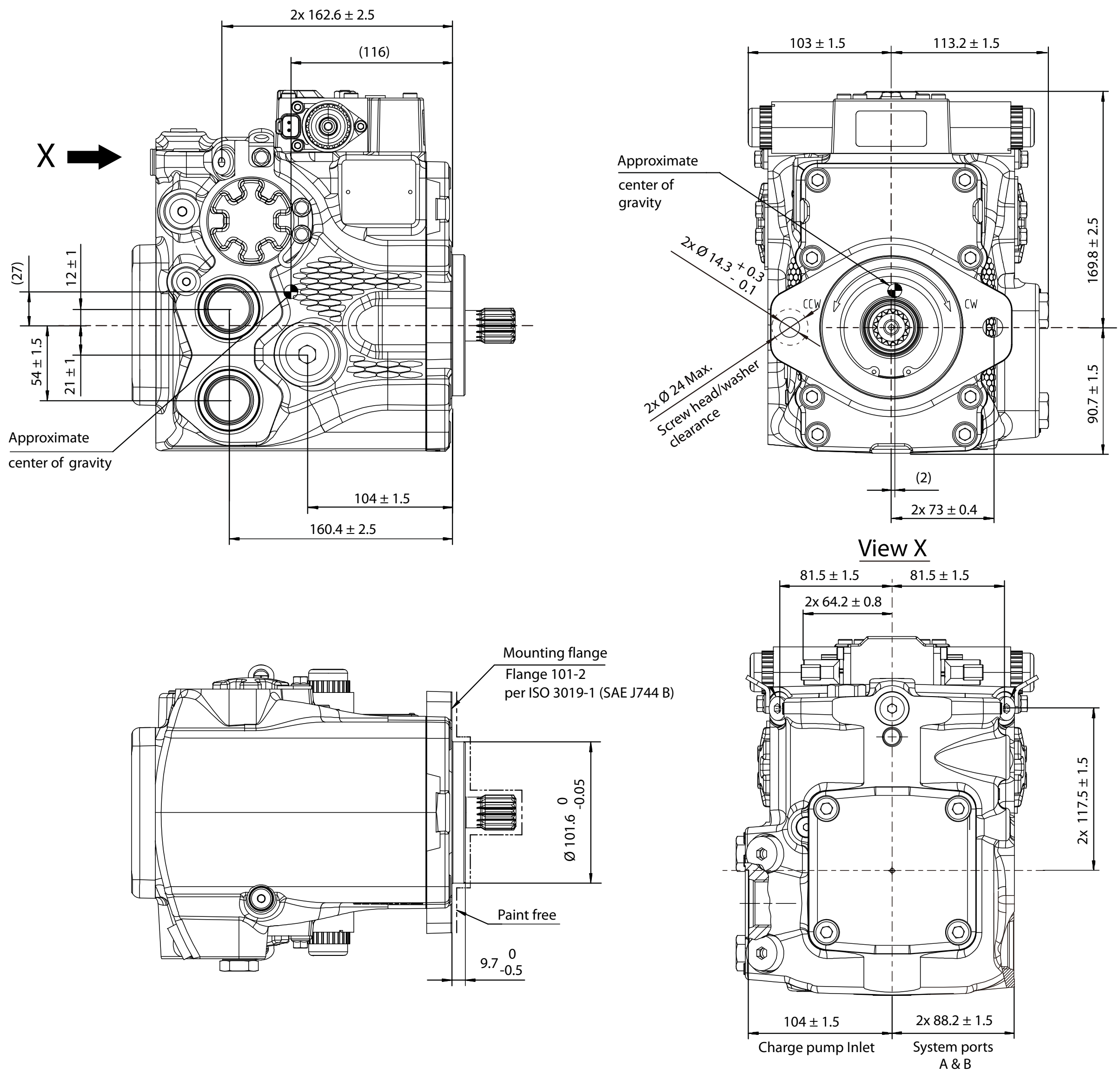
Installation drawings



P108957

Installation drawings

O-ring boss type



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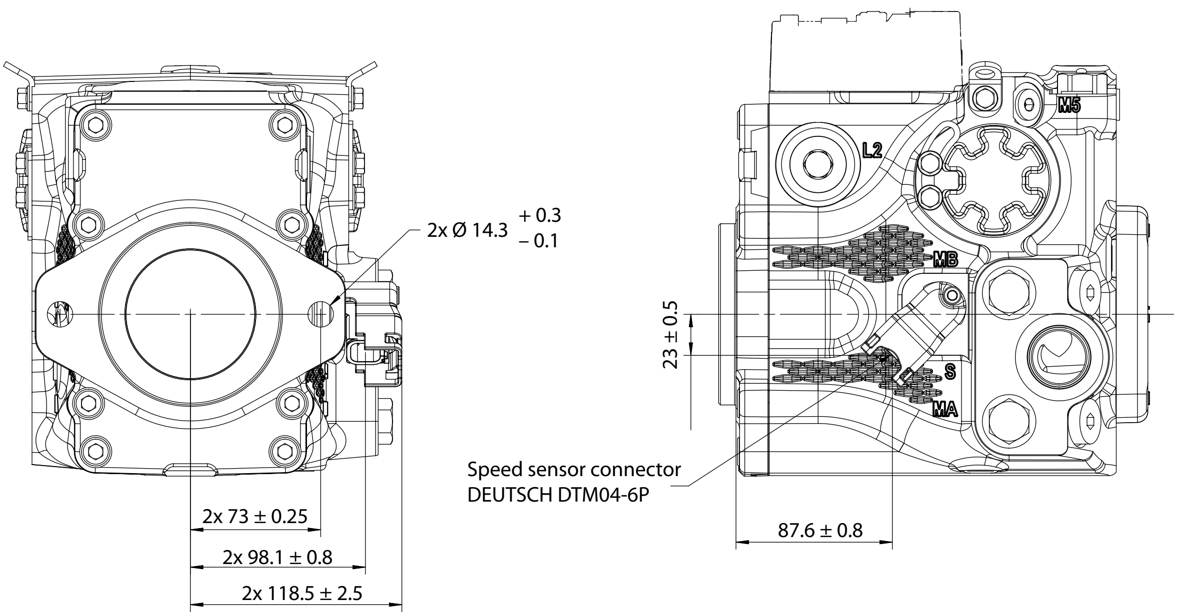
Please contact Danfoss representative for specific installation drawings.

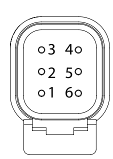
Installation drawings

38/45 dimensions with speed sensor



Please contact Danfoss representative for specific installation drawings.

Speed sensor connector

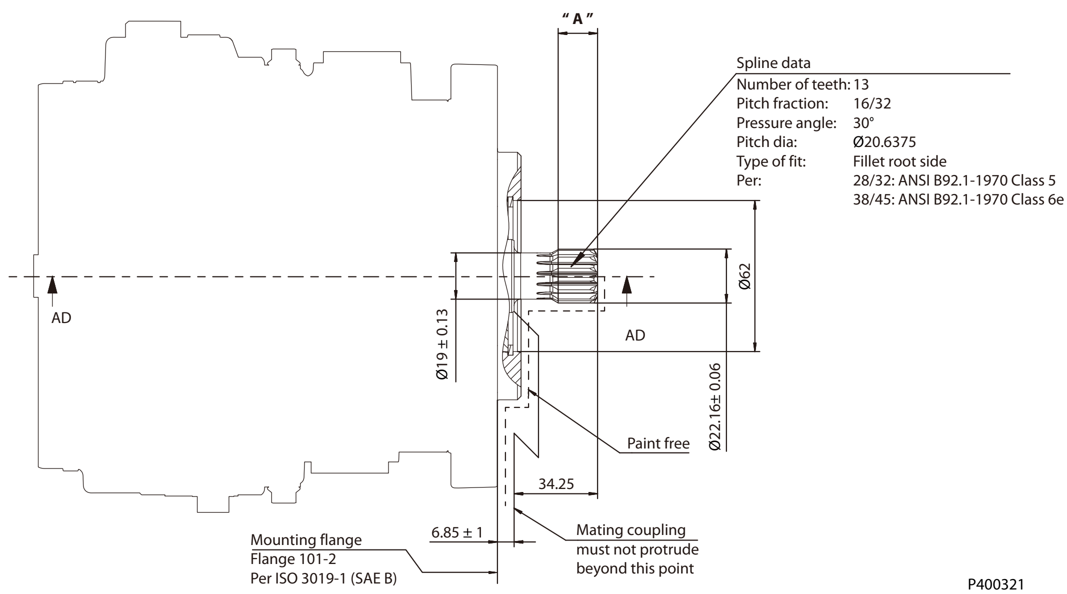


Pin	Assignment
1	Speed signal 1
2	NC
3	Speed signal 2
4	Supply
5	Ground
6	Temperature

Installation drawings

Input shafts: option G4, F6 (SAE B, 13 teeth)

Option G4, F6, ISO 3019-1, Outer dia 22 mm



Min. active spline length[1)]	28/32	38/45
A	16.17 ± 0.5	16.17 ± 0.15

[1)] Minimum active spline length for the specified torque ratings.

Specifications

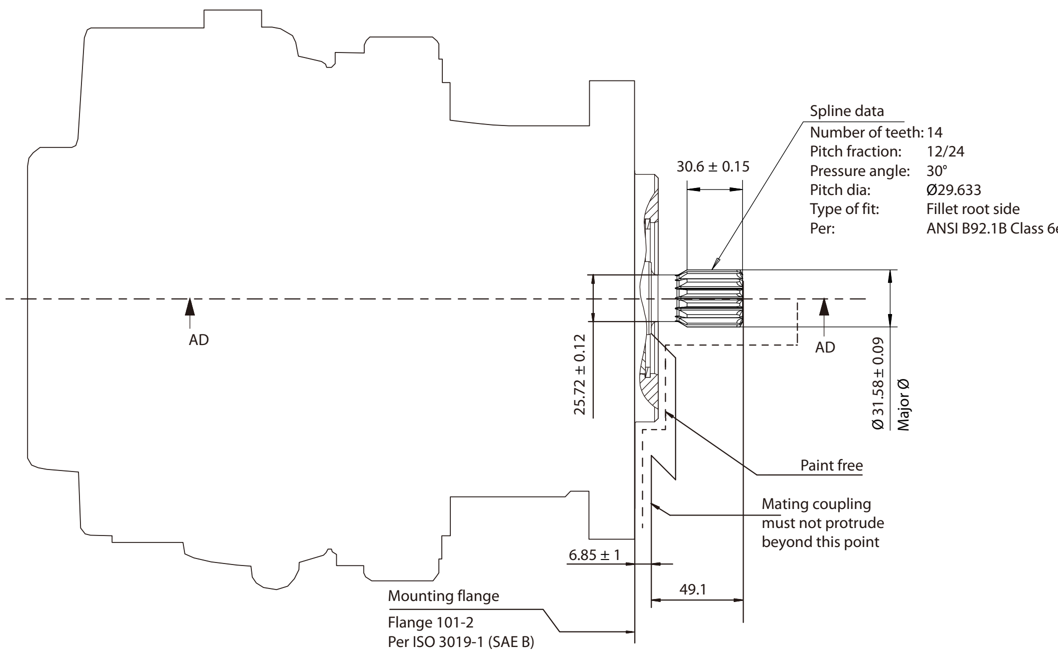
Option	G4, F6
Spline	13 teeth, 16/32 pitch
Maximum torque rating	226 N•m

Please contact Danfoss representative for specific installation drawings.

Installation drawings

Input shafts: option G1, F1 (SAE B, 14 teeth)

Option G1, F1, ISO 3019-1, Outer dia 31.58 mm (38/45 only)



Specifications

Option	G1, F1
Spline	14 teeth, 12/24 pitch
Min. active spline length[1)]	30.6 ± 0.15
Maximum torque rating	592 N•m [437 lbf•ft]

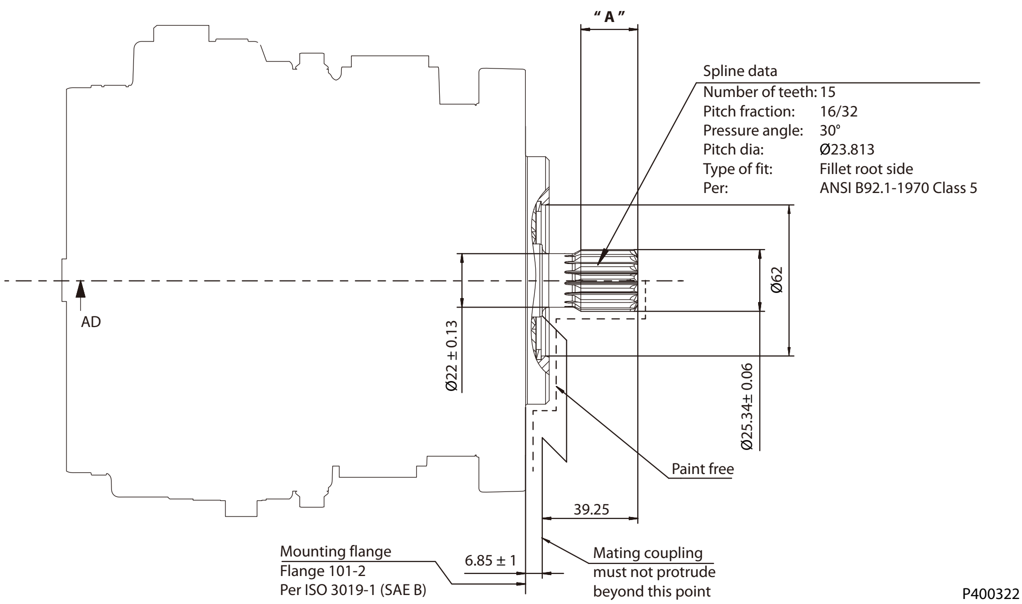
1) Minimum active spline length for the specified torque ratings.

Please contact Danfoss representative for specific installation drawings.

Installation drawings

Input shafts: option G5, F5 (SAE B, 15 teeth)

Option G5, F5, ISO 3019-1, outer dia 23 mm



Min. active spline length[1]	28/32	38/45
A	23.4 ± 0.5	22.0 ± 0.15

[1] Minimum active spline length for the specified torque ratings.

Specifications

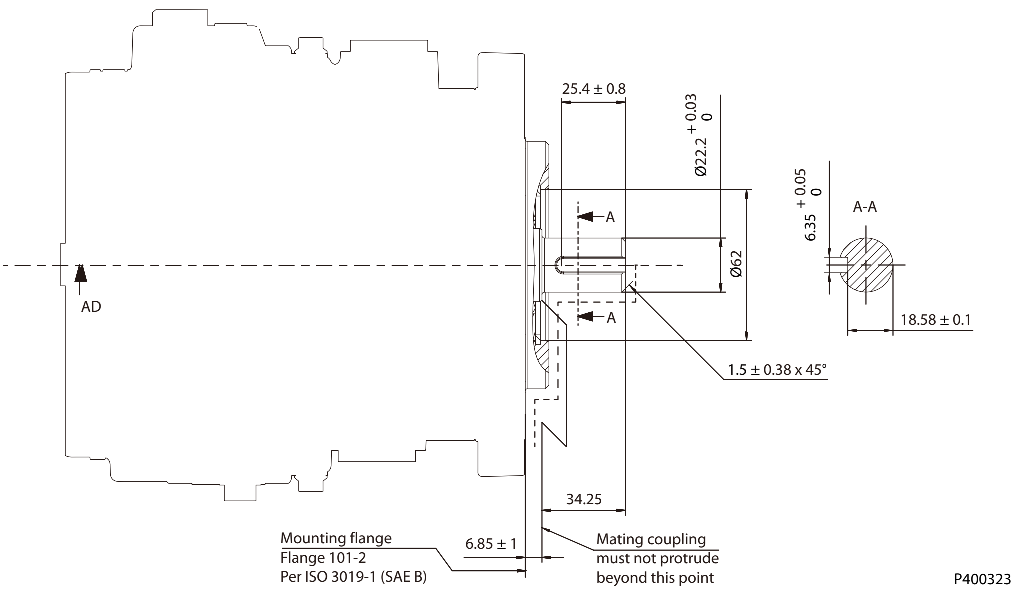
Option	G5, F5
Spline	15 teeth, 16/32 pitch
Maximum torque rating	362 N•m

Please contact Danfoss representative for specific installation drawings.

Installation drawings

Input shafts: option A7, A9 (SAE B, straight key shaft)

Option A7, A9, ISO 3019-1, outer dia 22 mm (28/32 only)



Specifications

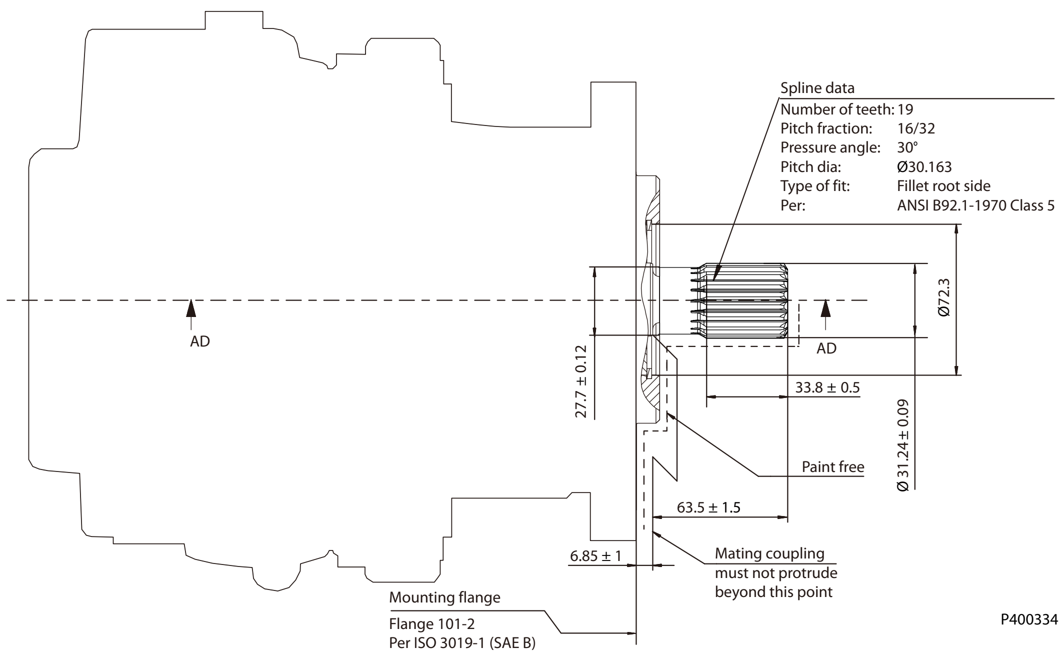
Option	A7, A9
Maximum torque rating	226 N•m

Please contact Danfoss representative for specific installation drawings.

Installation drawings

Input shafts: option G6, G7 (SAE B, 19 teeth)

Option G6, G7, ISO 3019-1, outer dia 31.24 mm (38/45 only)



Specifications

Option	G6, G7
Spline	19 teeth, 16/32 pitch
Min. active spline length[1)]	33.8 ± 0.5
Maximum torque rating	734 N•m

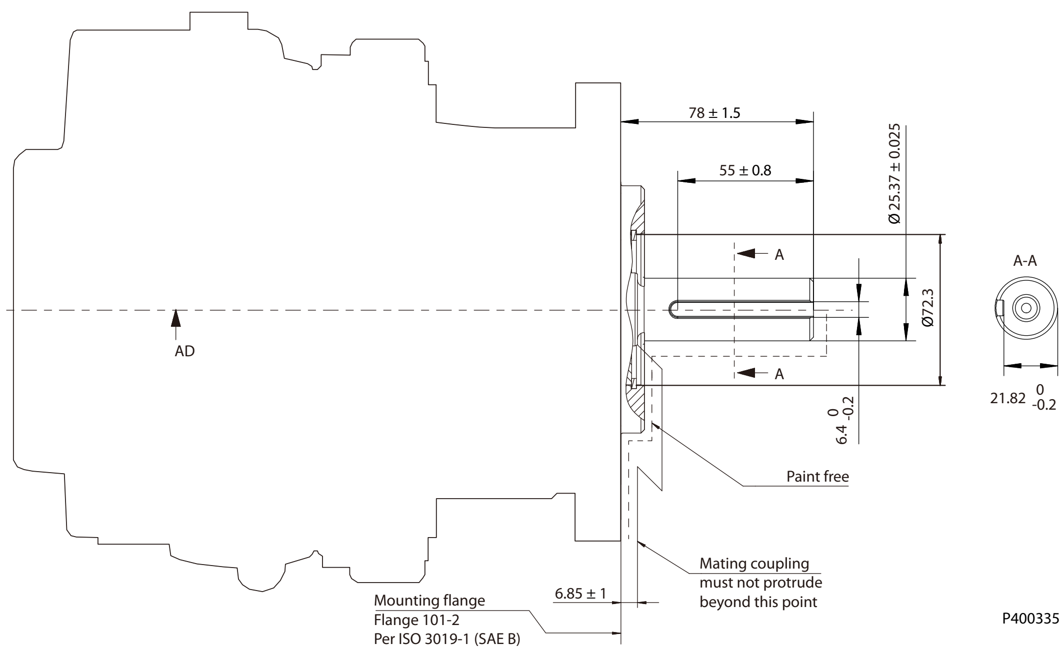
1) Minimum active spline length for the specified torque ratings.

Please contact Danfoss representative for specific installation drawings.

Installation drawings

Input shafts: option A6, A8 (SAE B, straight key shaft)

Option A8, A6, ISO 3019-1, outer dia 1 inch (38/45 only)



Specifications

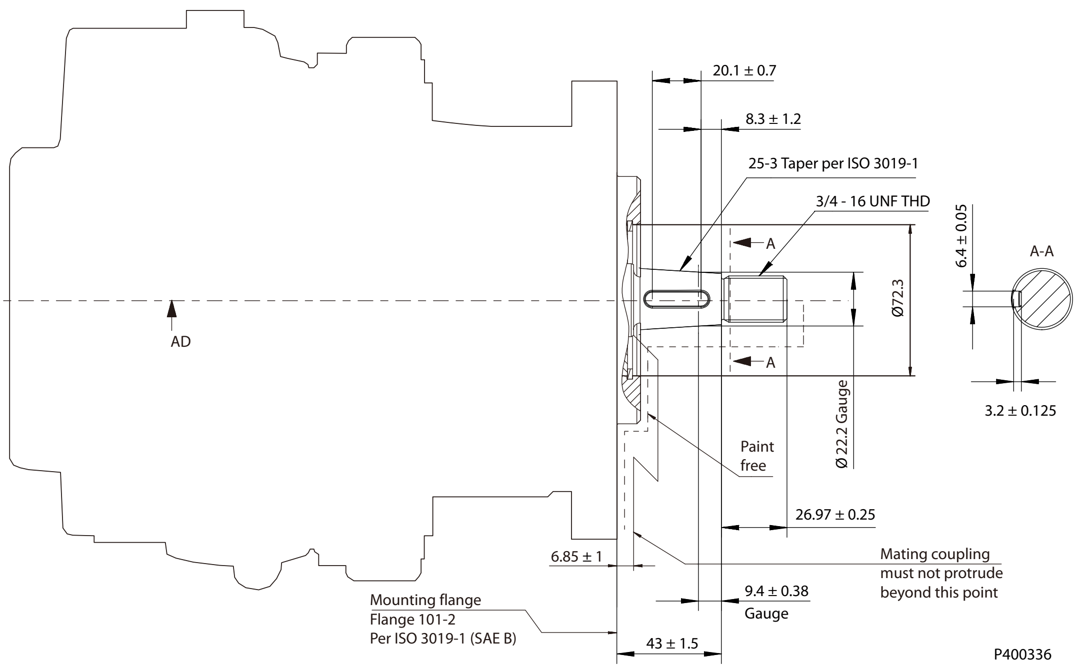
Option	A6, A8
Maximum torque rating	362 N•m

Please contact Danfoss representative for specific installation drawings.

Installation drawings

Input shafts: option F2, F3 (SAE B, taper key shaft)

Option F2, F3, ISO 3019-1, Code 25-3, Dia 22.2 Taper 1:8, without key, no through-hole in the end of the shaft (38/45 only)



Specifications

Option	F2, F3
Maximum torque rating	497 N•m

Please contact Danfoss representative for specific installation drawings.

Tapered shaft customer acknowledgement

The Danfoss MP1 tapered shaft has been designed using the industry standard ISO 3019-1, minus the through-hole in the end of the shaft. Danfoss recommends a self-locking nut instead of a castle nut and pin. The nut and mating square-cut key are customer supplied.

The specified torque rating of the tapered shaft documented above is based on the cross-sectional diameter of the shaft, through the keyway, and assumes the proper clamp and fit between shaft and coupling. Danfoss guarantees the design and manufactured quality of the tapered shaft. The customer is responsible for the design and manufactured quality of the mating female coupling and key and applied torque on the nut. Danfoss has made provisions for the key in accordance to the ISO specification with the understanding that the key is solely to assist in the installation of the mating coupling.

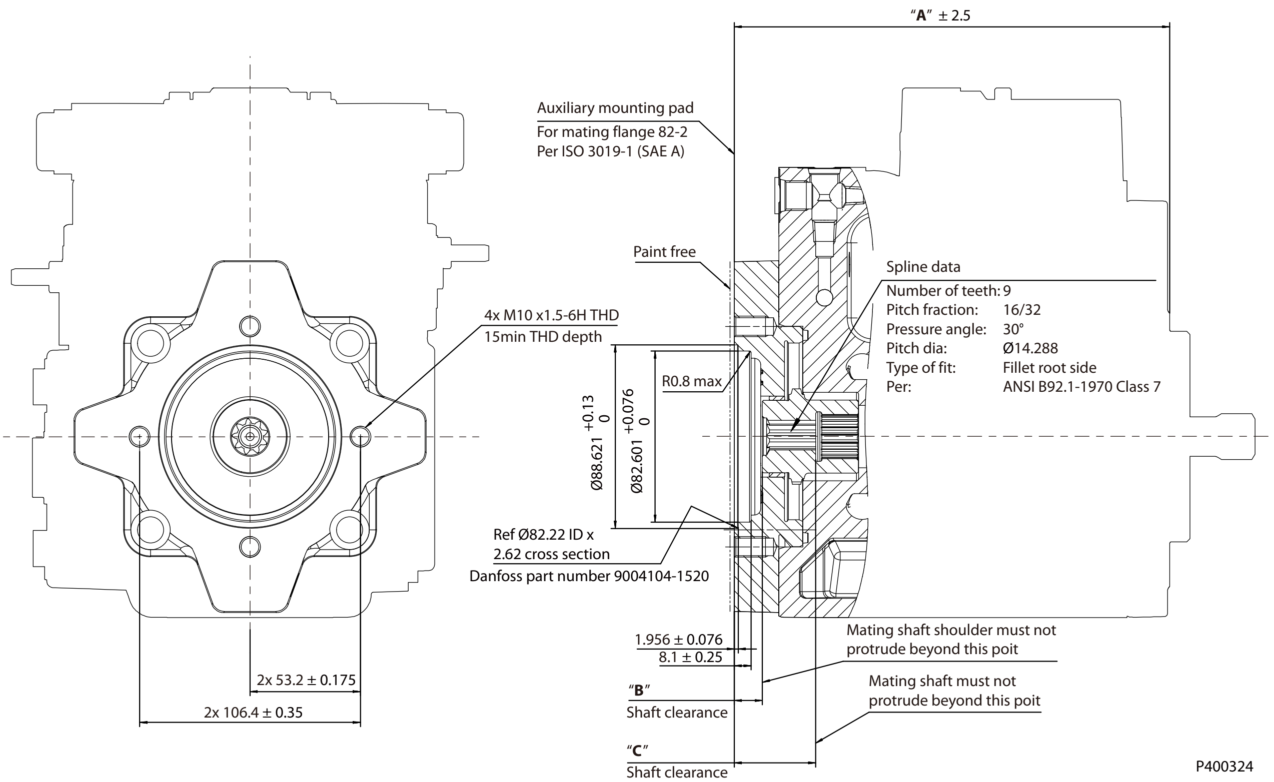
Caution

Torque must be transmitted by the taper fit between the shaft and it's mating coupling, not the key. Torque or loading inadvertently transmitted by the customer supplied key may lead to premature shaft failure.

Installation drawings

Auxiliary mounting: option A16, B16, C16, D16, E16, F16 (SAE A, 9 teeth)

Option A16, B16, C16, D16, E16, F16, ISO 3019-1, flange 82-2 (SAE A, 9 teeth)



Location	28/32	38/45
A	210	234.5
B	11.8 min shaft clearance	12.0 min shaft clearance
C	38.3 min shaft clearance	50.0 min shaft clearance

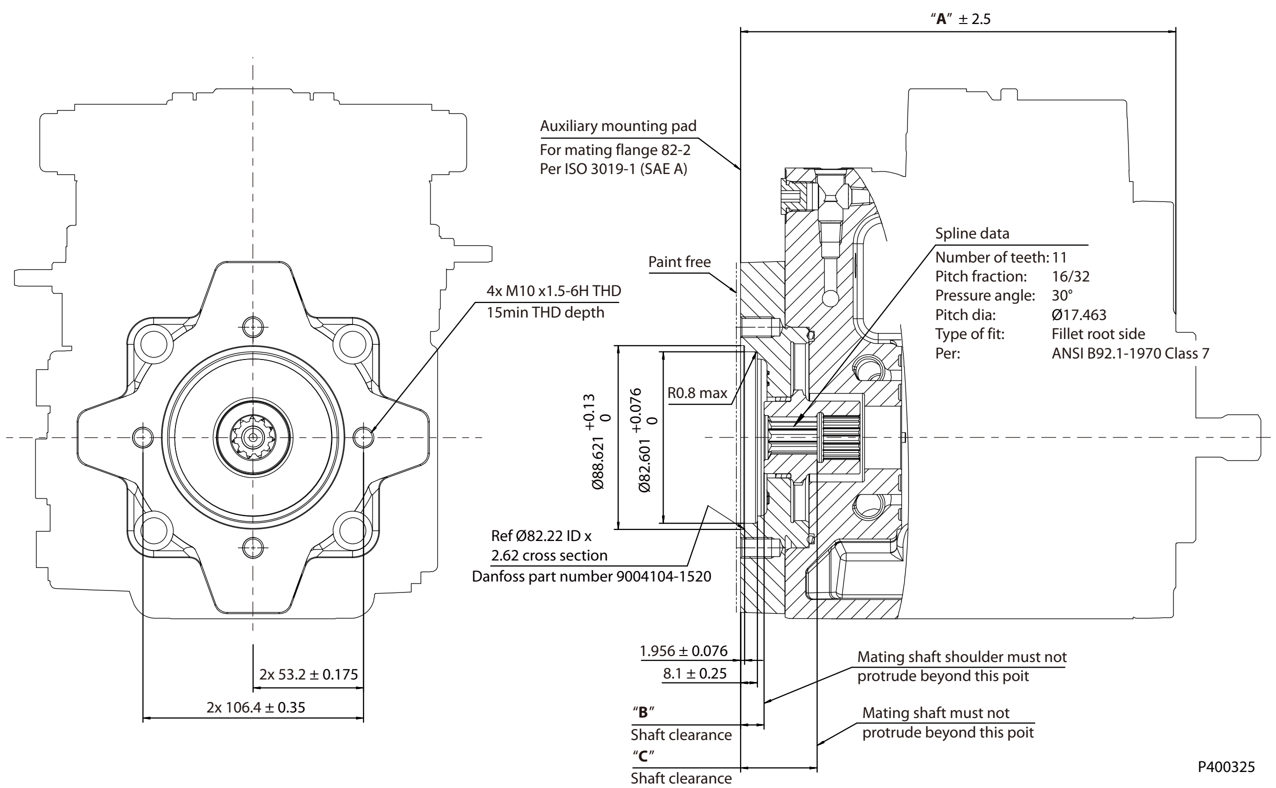
Specifications

Option	A16, B16, C16, D16, E16, F16
Spline	9 teeth, 16/32 pitch
Maximum torque	107 N•m

Installation drawings

Auxiliary mounting: option A19, B19, C19, D19, E19, F19 (SAE A, 11 teeth)

Option A19, B19, C19, D19, E19, F19, ISO 3019-1, flange 82-2 (SAE A, 11 teeth)



Location	28/32	38/45
A	210	234.5
B	11.8 min shaft clearance	12.0 min shaft clearance
C	38.3 min shaft clearance	50.0 min shaft clearance

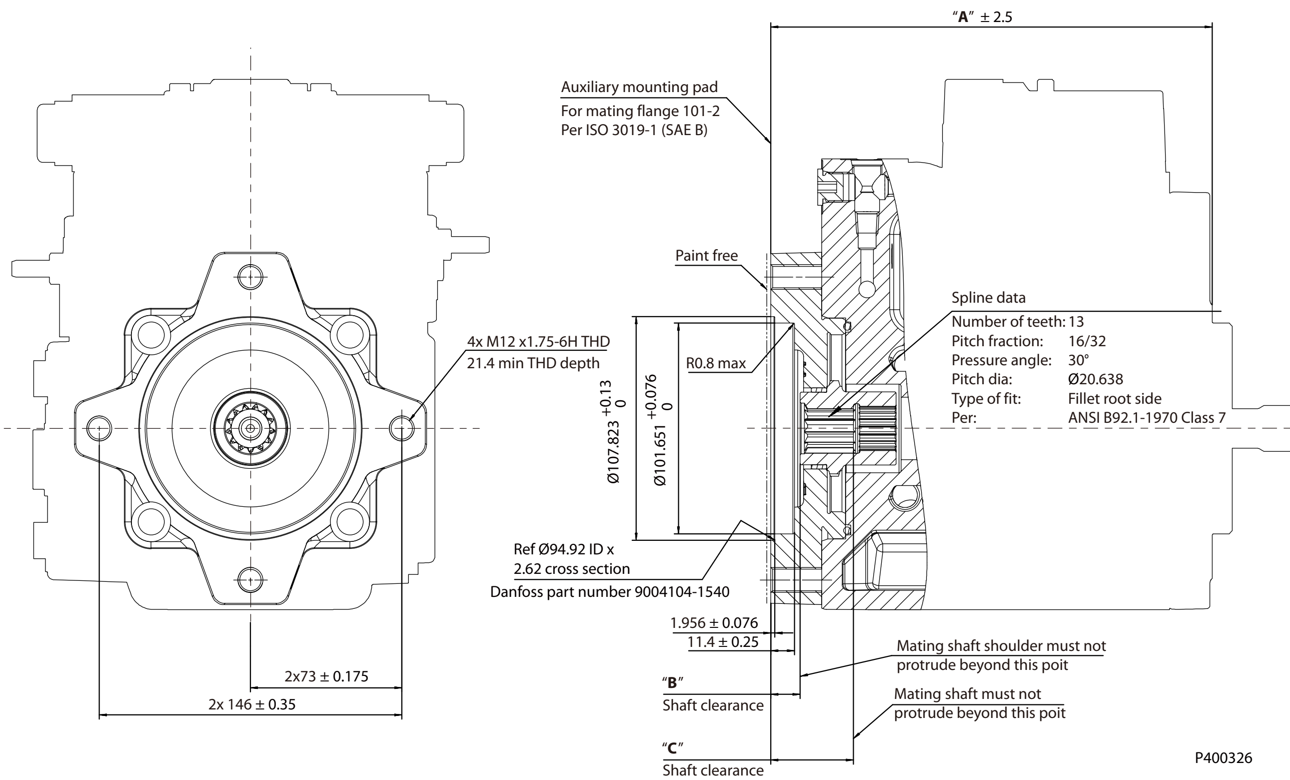
Specifications

Option	A19, B19, C19, D19, E19, F19
Spline	11 teeth, 16/32 pitch
Maximum torque	147 N•m

Installation drawings

Auxiliary mounting: option A22, B22, C22, D22, E22, F22 (SAE B, 13 teeth)

Option A22, B22, C22, D22, E22, F22, ISO 3019-1, flange 101-2 (SAE B, 13 teeth)



Location	28/32	38/45
A	213	234.5
B	14.8 min shaft clearance	12.0 min shaft clearance
C	41.3 min shaft clearance	50.0 min shaft clearance

Specifications

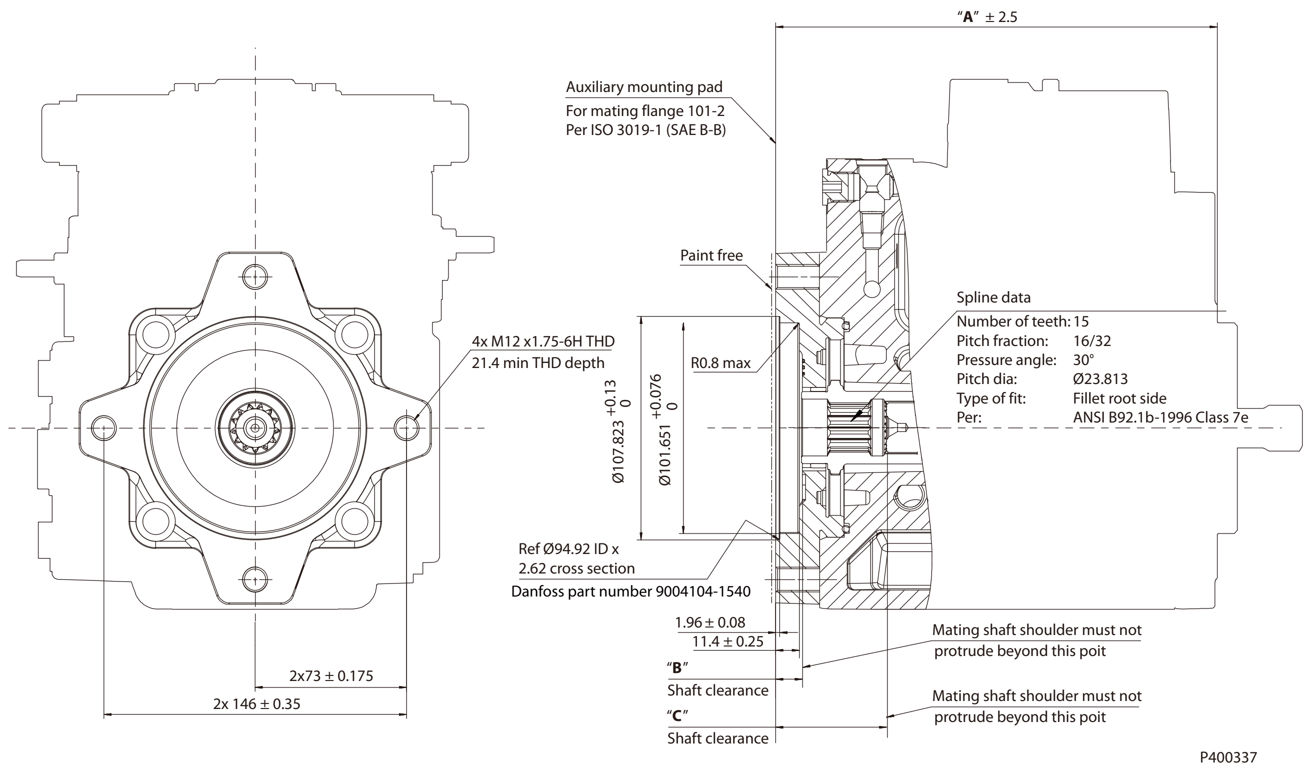
Option	A22, B22, C22, D22, E22, F22
Spline	13 teeth, 16/32 pitch
Maximum torque	248 N•m

Bolt length greater than 21.4 mm could result in a leak or damage the unit.

Installation drawings

Auxiliary mounting: option A25, B25, C25, D25, E25, F25 (SAE B-B 15 teeth)

Option A25, B25, C25, D25, E25, F25, ISO 3019-1, flange 101-2 (SAE B-B, 15 teeth) (38/45 only)



Location	38/45
A	234.5
B	12.0 min shaft clearance
C	50.0 min shaft clearance

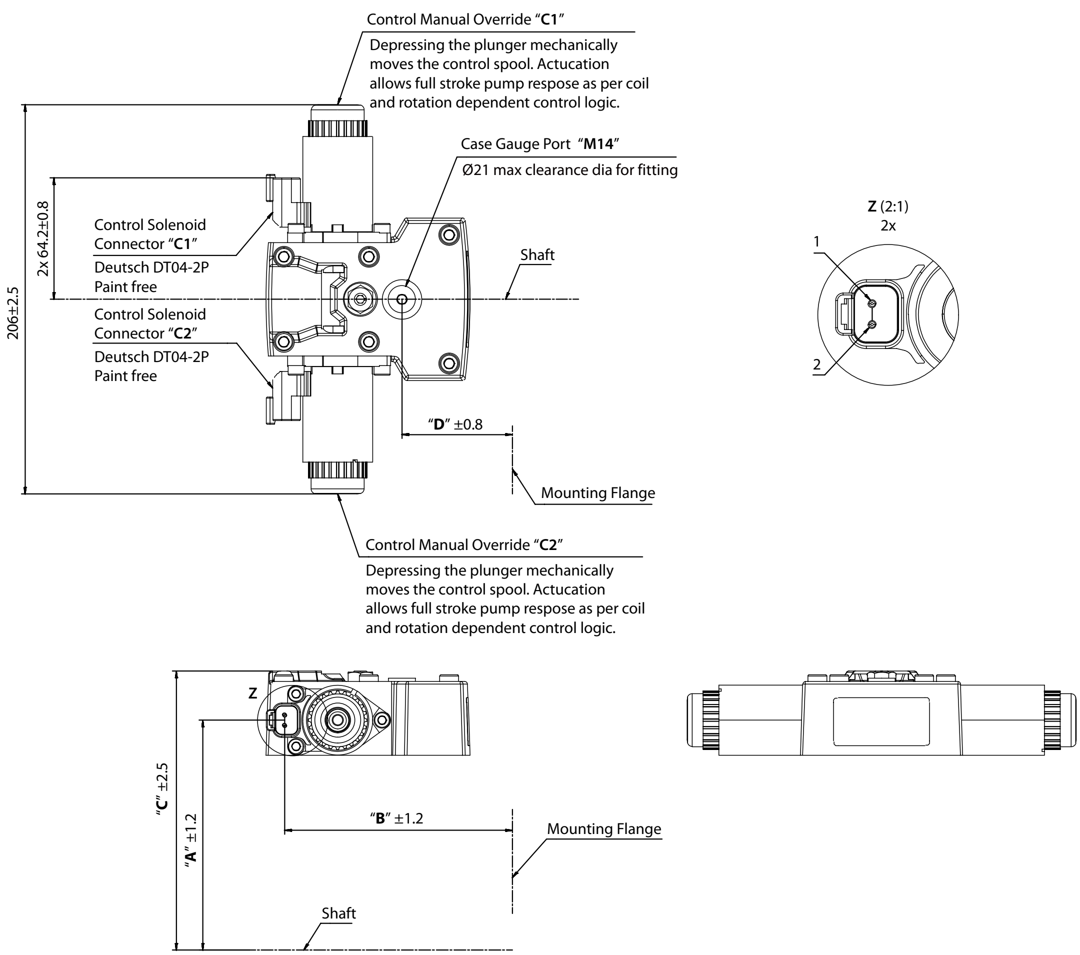
Specifications

Option	A25, B25, C25, D25, E25, F25
Spline	15 teeth, 16/32 pitch
Maximum torque	347 N•m

Bolt length greater than 21.4 mm could result in a leak or damage the unit.

Controls

Electric displacement control (EDC)



P400314

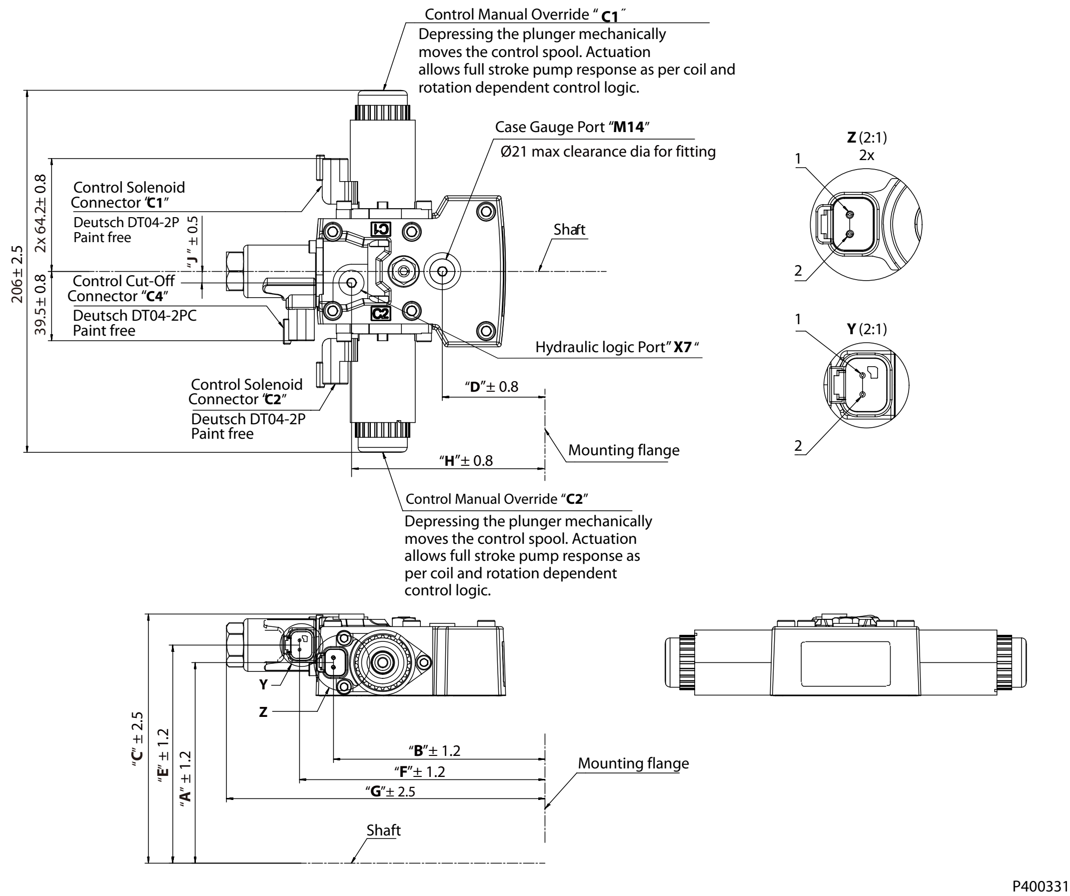
Control solenoid connector "C1" & "C2"				
Pin	Assignment	OR	Pin	Assignment
1	Supply		1	Ground
2	Ground		2	Supply

Location	28/32	38/45
A	142.3	143.8
B	120.5	117
C	168.3	169.8
D	58.4	54.9

Please contact Danfoss representative for specific installation drawings.

Controls

Electric displacement control with CCO (EDC+CCO)



P400331

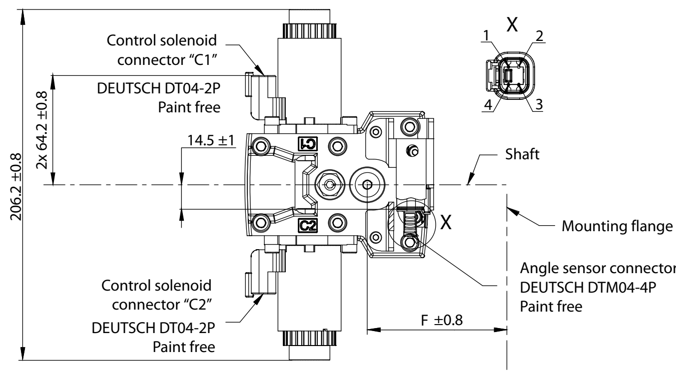
Control solenoid connector "C1" & "C2" & "C4"				
Pin	Assignment	OR	Pin	Assignment
1	Supply		1	Ground
2	Ground		2	Supply

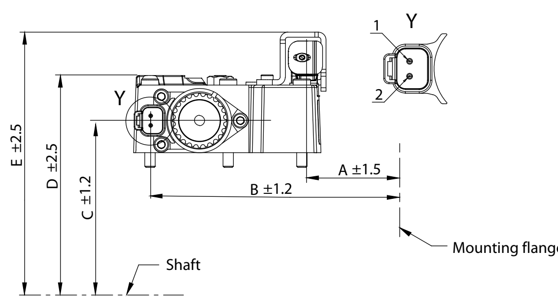
Location	28/32	38/45
A	142.3	143.8
B	120.5	117
C	169.6	171.4
D	58.4	54.9
E	152.3	153.8
F	139.8	136.3
G	181.4	178
H	110.2	106.7
J	6.5	

Please contact Danfoss representative for specific installation drawings.

Controls

EDC with ASNSR





Control solenoid connector "C1" & "C2"				
Pin	Assignment	OR	Pin	Assignment
1	Supply		1	Ground
2	Ground		2	Supply

Angle sensor connector pinout

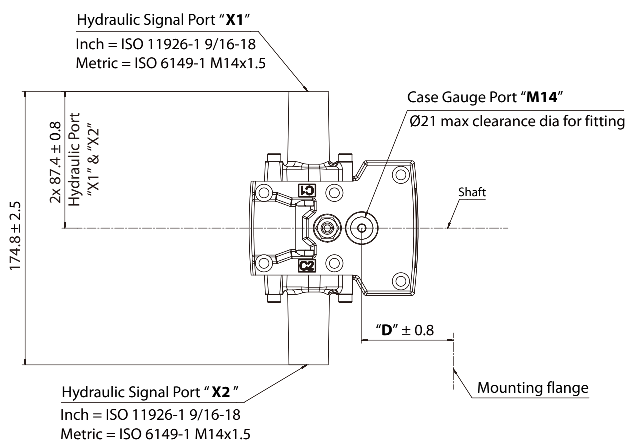
Pin	Assignment
1	Ground (GND)
2	Not connected
3	Output signal 1 (SIG 1)
4	Supply (V+)

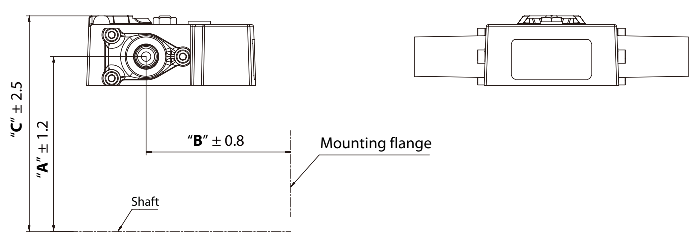
Dimensions

Reference	28/32	38/45
A	32.7	29.2
B	120.5	117
C	142.3	143.8
D	169.6	171.4
E	193.3	194.8
F	58.4	54.9

Controls

Hydraulic displacement control (HDC)





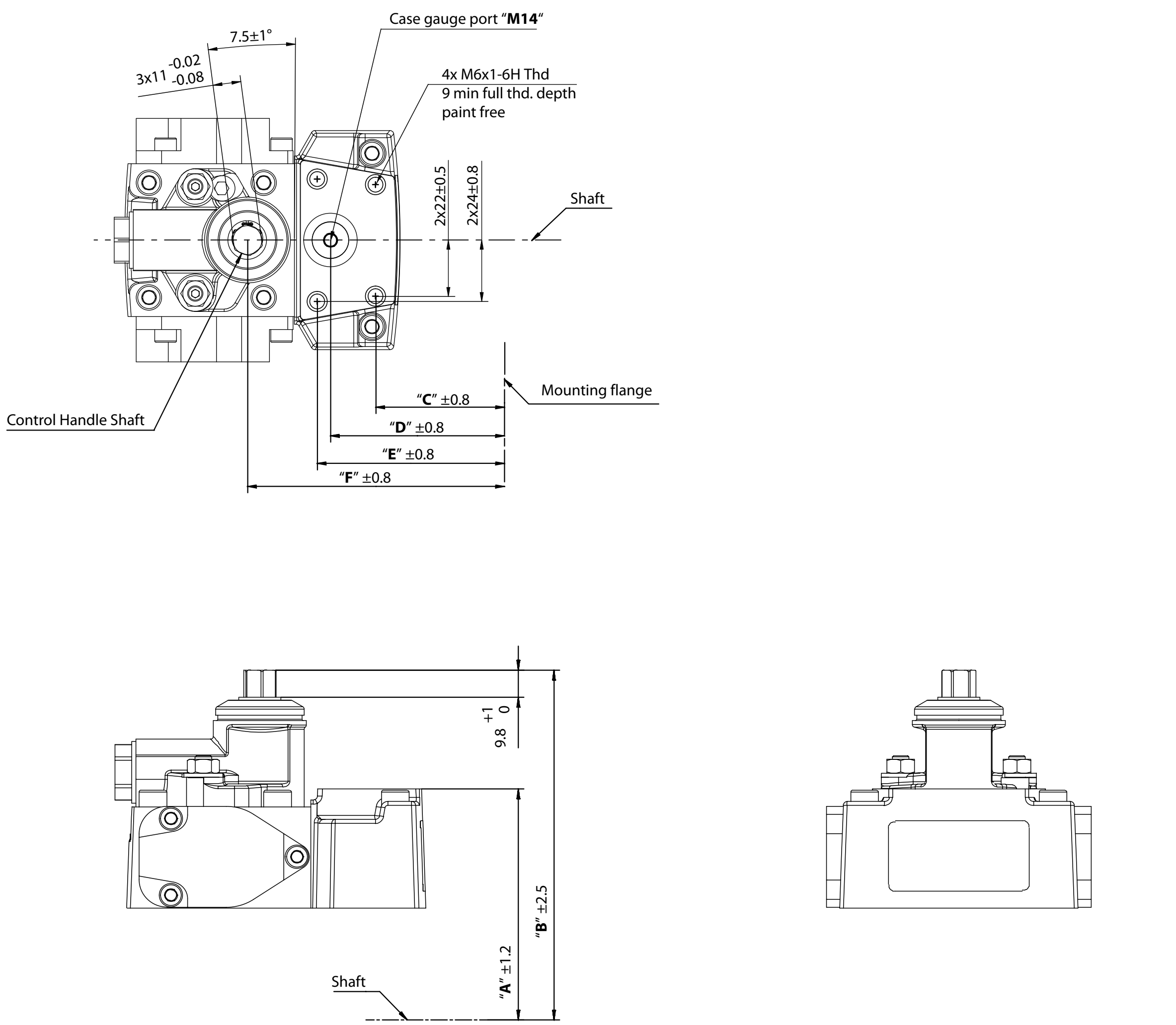
P400518

Legend

Dimension	28/32	38/45
A	142.3	143.8
B	92.4	88.9
C	168.3	169.8
D	58.4	54.9

Controls

Manual displacement control (MDC)



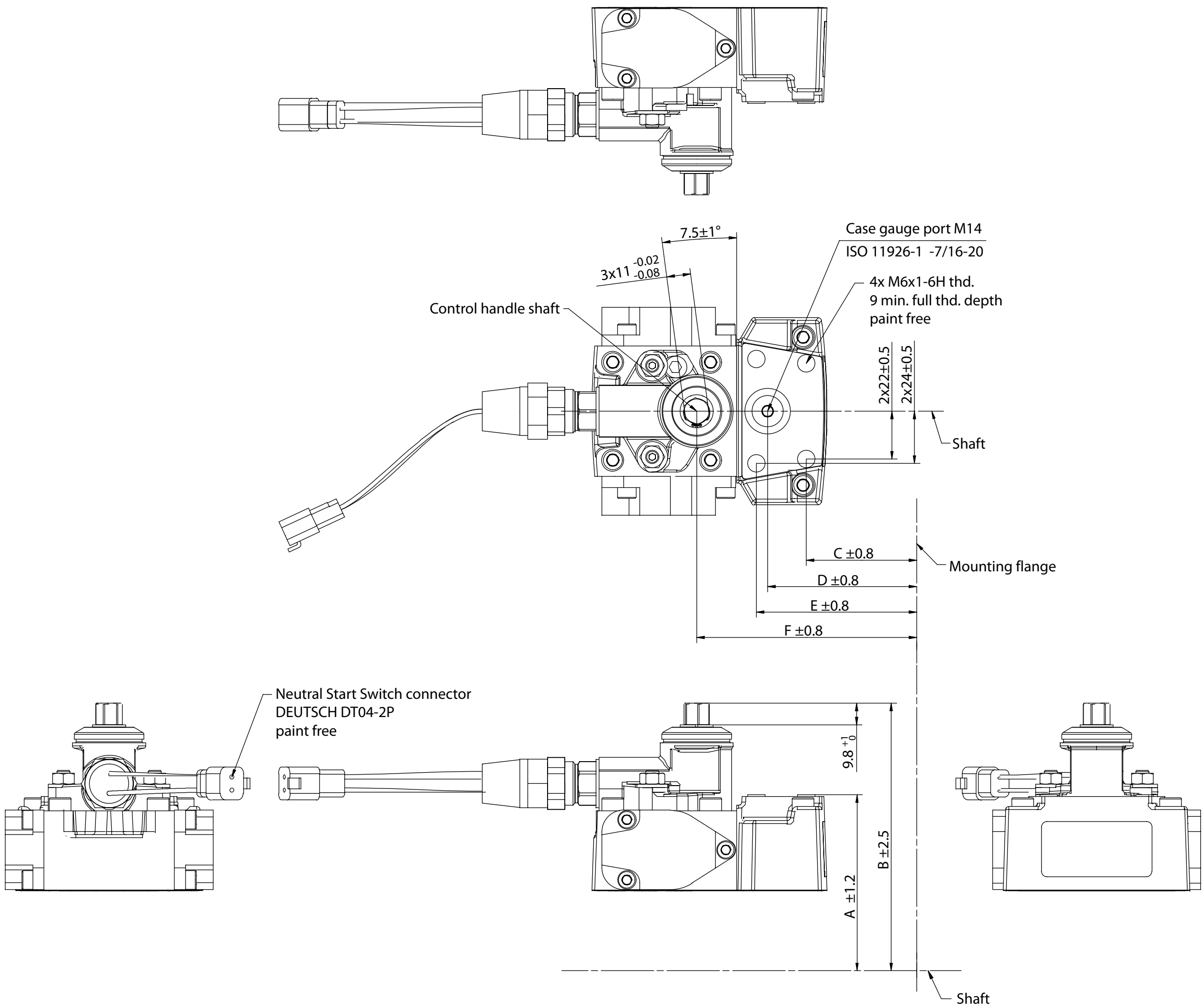
P400315

Location	28/32	38/45
A	166.8	168.3
B	209.7	211.2
C	31.9	28.4
D	49.7	46.2
E	54.9	51.4
F	82.3	78.8

Please contact Danfoss representative for specific installation drawings.

Controls

MP1 MDC with neutral start switch option: M2



Neutral start switch connector

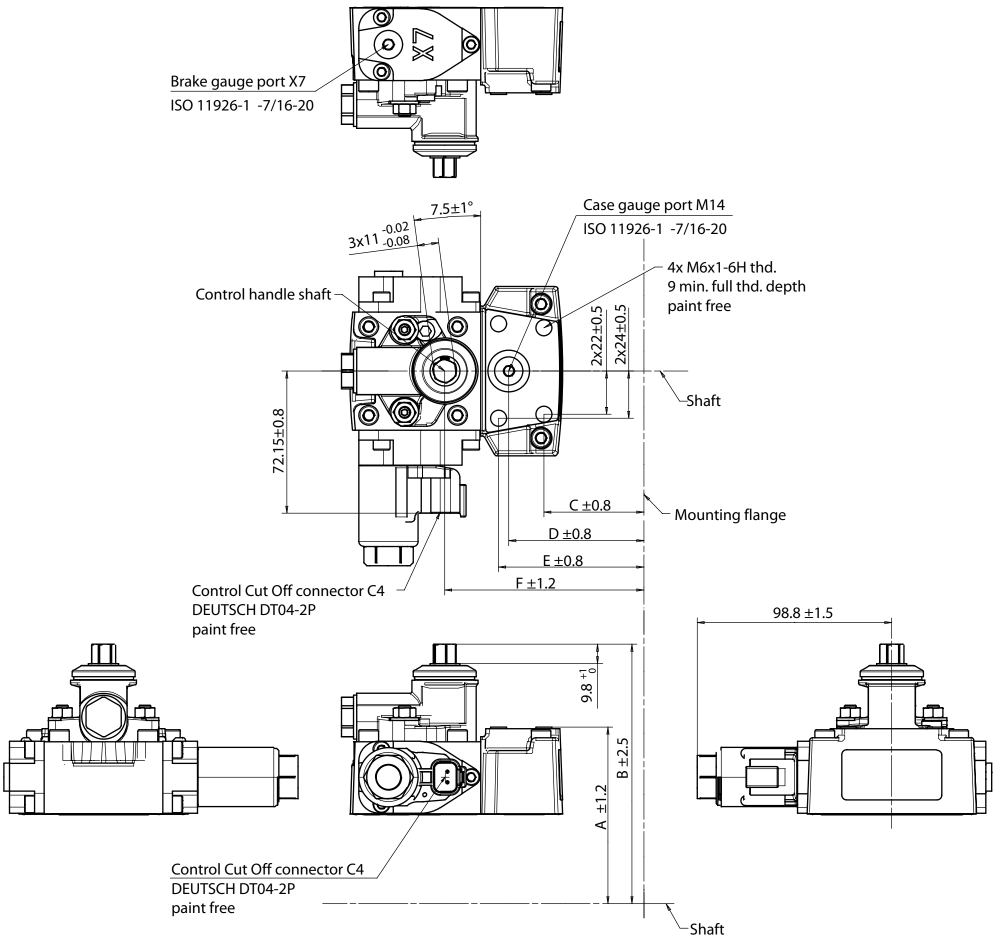
Pin	Assignment	Alternate	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Dimension	28/32	38/45
A	166.8	168.3
B	209.7	211.2
C	31.9	28.4
D	49.7	46.2
E	54.9	51.4
F	82.3	78.8

Please contact Danfoss representative for specific installation drawings.

Controls

MP1 MDC with CCO, options: M3, M4



Control cut off connector (C4)

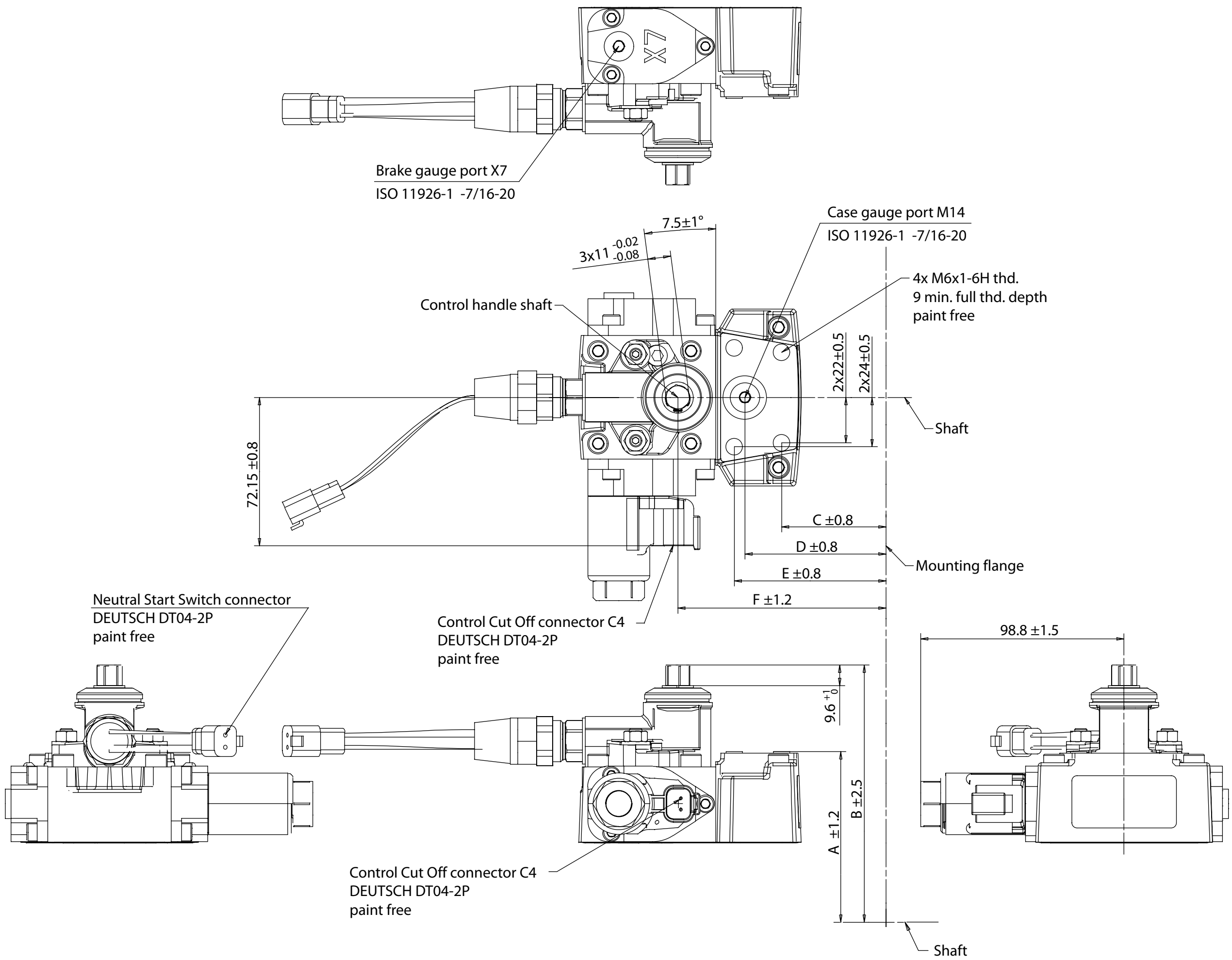
Pin	Assignment	Alternate	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Dimension	28/32	38/45
A	166.8	168.3
B	209.7	211.2
C	31.9	28.4
D	49.7	46.2
E	54.9	51.4
F	82.3	78.8

Please contact Danfoss representative for specific installation drawings.

Controls

MP1 MDC with NSS and CCO options: M5, M6



Neutral start switch, control cut off connectors

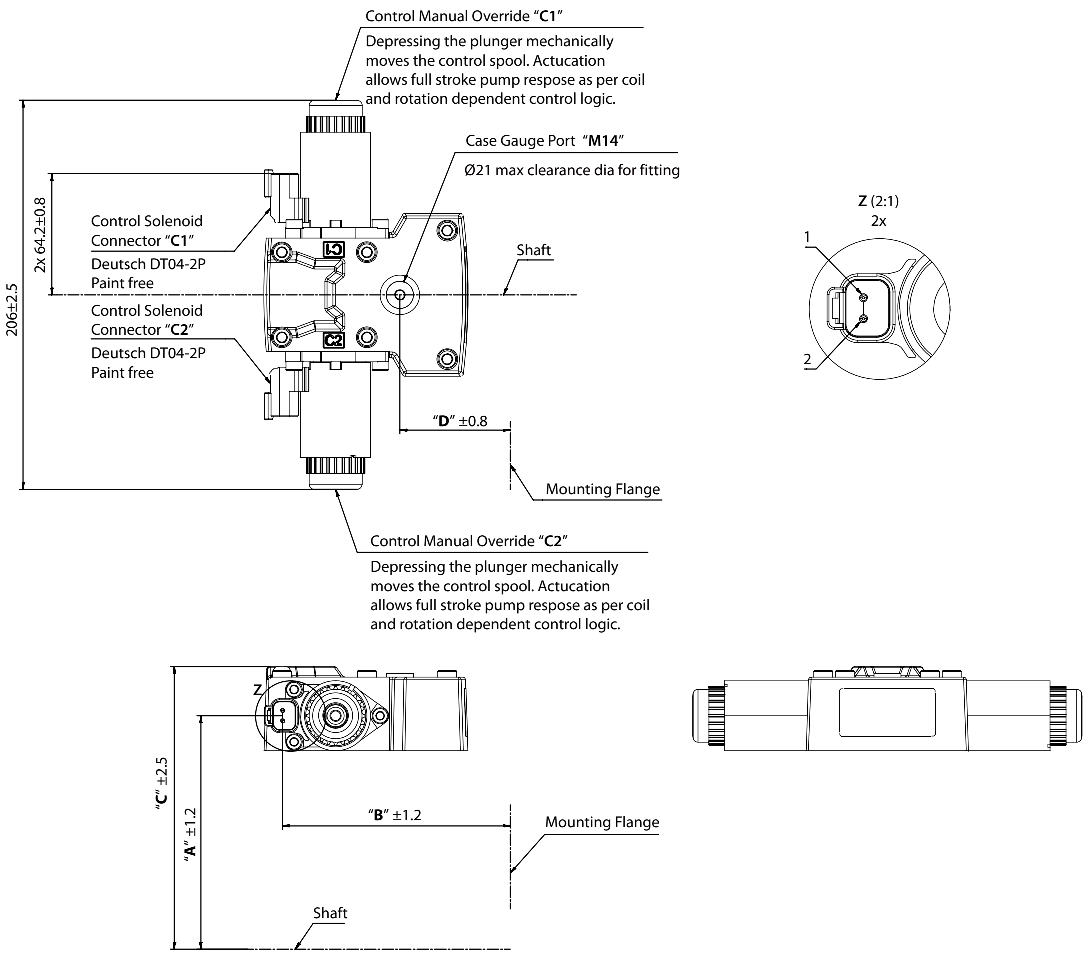
Pin	Assignment	Alternate	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Dimension	28/32	38/45
A	166.8	168.3
B	209.7	211.2
C	31.9	28.4
D	49.7	46.2
E	54.9	51.4
F	82.3	78.8

Please contact Danfoss representative for specific installation drawings.

Controls

Forward-neutral-reverse (FNR)



P400316

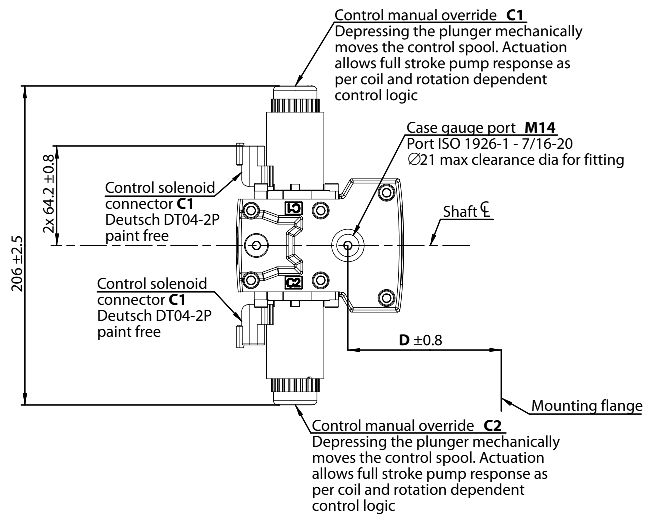
Control solenoid connector "C1" & "C2"				
Pin	Assignment	OR	Pin	Assignment
1	Supply		1	Ground
2	Ground		2	Supply

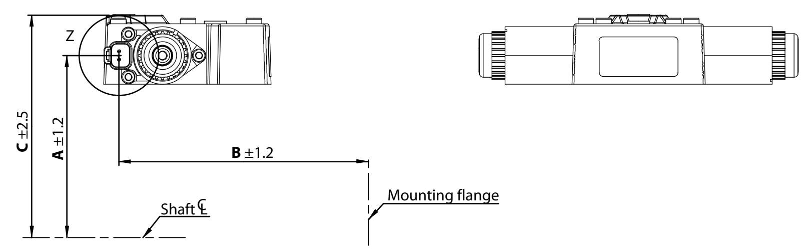
Dimension	28/32	38/45
A	142.3	143.8
B	120.5	117
C	168.3	169.8
D	58.4	54.9

Please contact Danfoss representative for specific installation drawings.

Controls

Non-feedback proportional electric (NFPE)





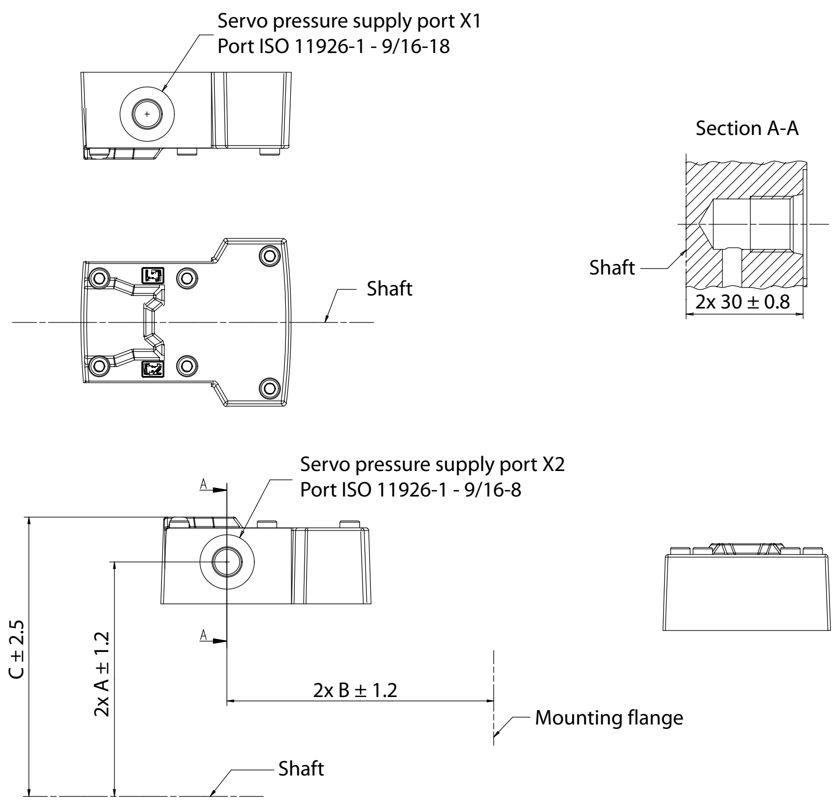
Control solenoid xonnector "C1" & "C2"				
Pin	Assignment	OR	Pin	Assignment
1	Supply		1	Ground
2	Ground		2	Supply

Dimension	28/32	38/45
A	142.3	143.8
B	120.5	117
C	168.3	169.8
D	58.4	54.9

Please contact Danfoss representative for specific installation drawings.

Controls

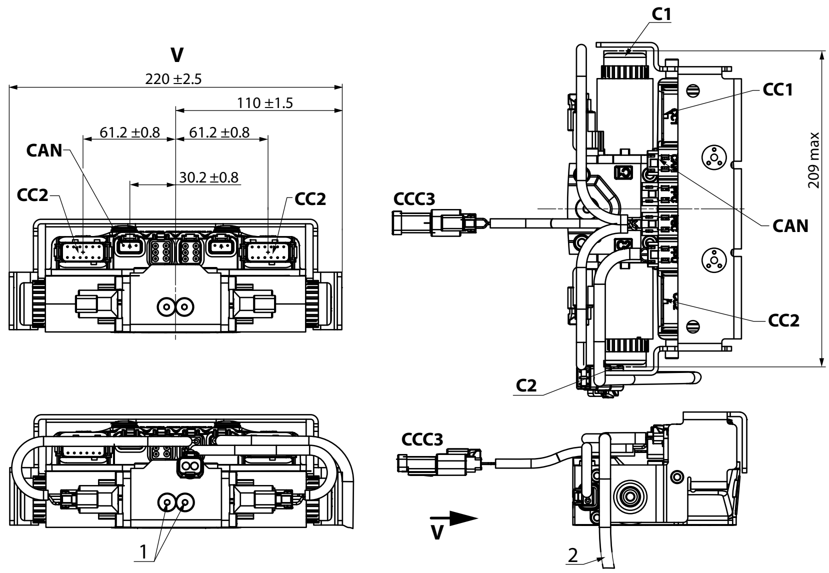
MP1 Non-feedback proportional hydraulic (NFPH)



Dimension	28/32	38/45
A	145.3	146.8
B	96.4	92.9
C	168.3	169.8

Controls

Automotive control (AC)



1 Plug removing can cause contamination issues

2 PPU wire harness is factory installed to speed sensor

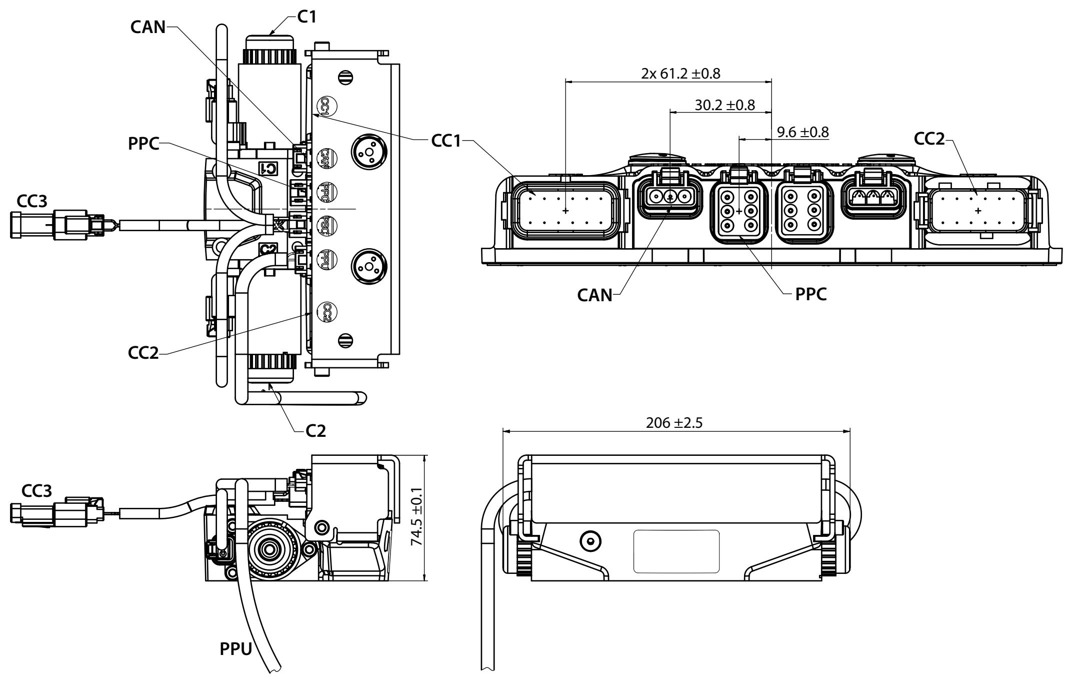
Connectors description

Port	Description
C1 and C2	**1.** Control manual override **C1** **2.** Control Manual Override **C2**
CC1	Port A control connector DEUTSCH DTM04-12P; paint free
CC2	Port B control connector DEUTSCH DTM04-12P; paint free
CC3	Control connector DEUTSCH DT06-2S; paint free; For using connector, the plug may be removed.
CAN	Control connector DEUTSCH DTM04-3P; paint free; For using connector, the plug may be removed.

Please contact Danfoss representative for specific installation drawings.

Controls

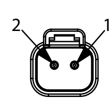
AC connectors dimensions



PPU wire harness is factory installed to speed sensor.

CC3

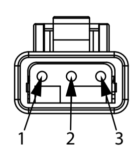
Connector DEUTSCH, 2-pin



1. Digital output A1 (+)
2. Digital output A2 (-)

CAN

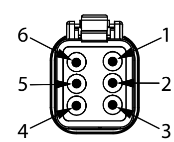
Connector DEUTSCH, 3-pin



1. CAN High
2. CAN Low
3. CAN Shield

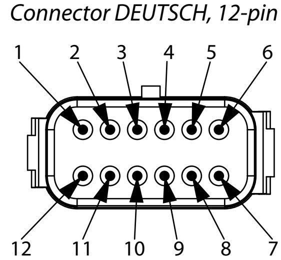
PPC

Connector DEUTSCH, 6-pin



1. Sensor A (+)
2. Analog input A
3. Sensor A (-)
4. Sensor B (-)
5. Analog input B
6. Sensor B (+)

Connector DEUTSCH, 12-pin



CC1

1. Battery (-)
2. Battery (+)
3. Sensor (+)
4. Sensor (-)
5. Motor rpm input (frequency)
6. Forward input (digital)
7. Reverse input (digital)
8. Sensor (+)
9. Sensor (-)
10. Drive pedal input (analog – nominal)
11. Drive pedal input (analog – red)
12. Neural input (digital)

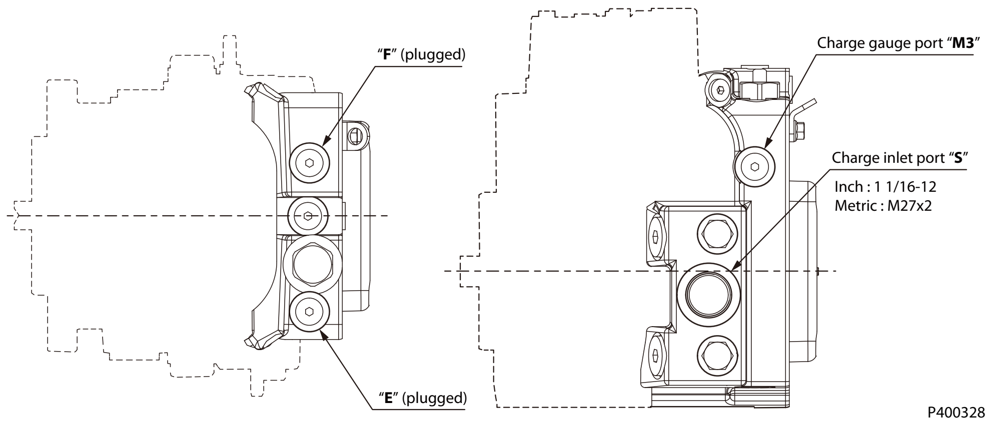
CC2

1. Inch input (analog – red)
2. Mode switch B input (digital – nominal)
3. Motor prop/PCOR driver
4. Motor direction input (analog)
5. Sensor (+)
6. Sensor (-)
7. Inch input (analog – nominal)
8. Motor BPD driver
9. Digital output B2 (-)
10. Digital output B1 (+)
11. Mode switch A input (digital)
12. Mode switch B input (digital – red)

Filtration

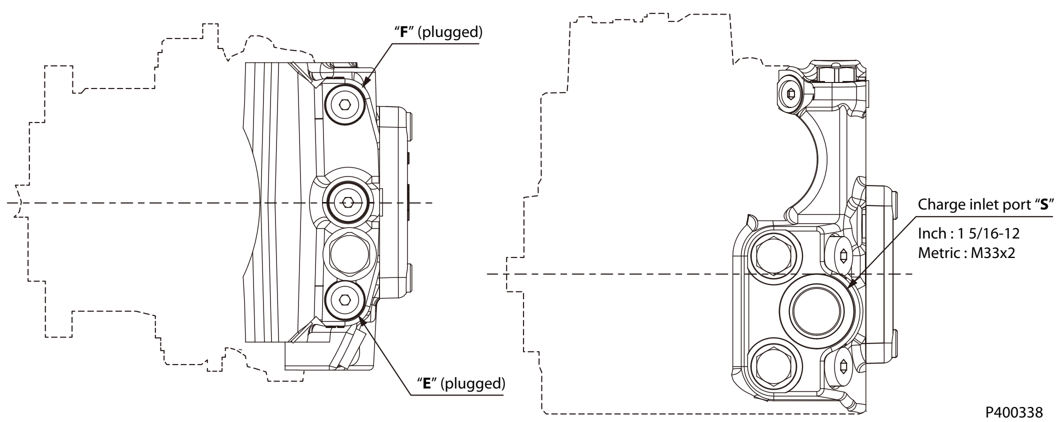
Suction filtration: option S

28/32



Please contact Danfoss representative for specific installation drawings.

38/45

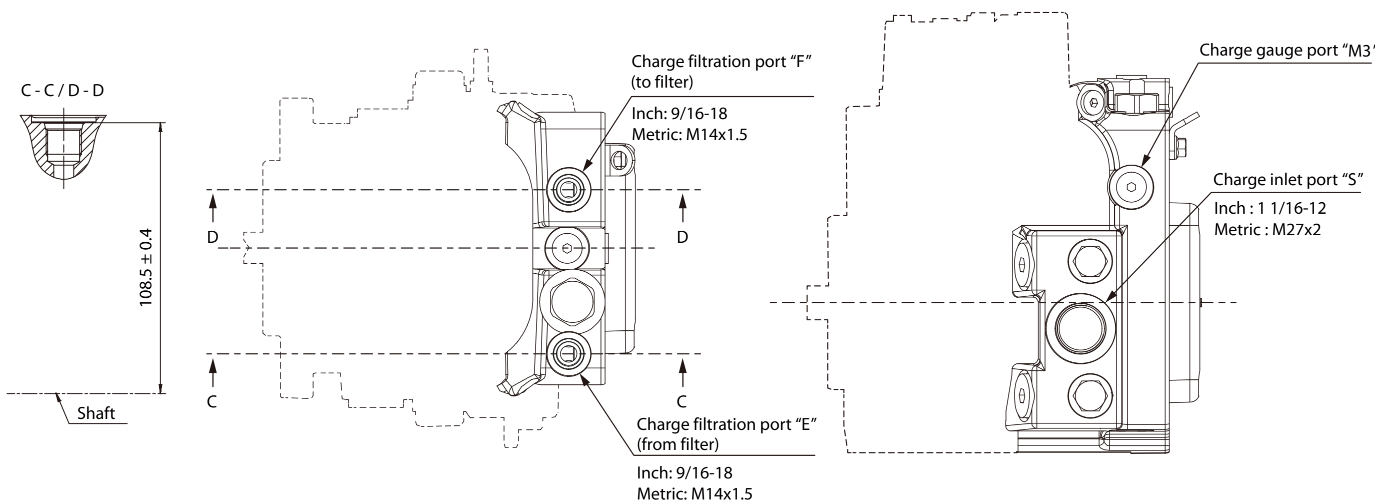


Please contact Danfoss representative for specific installation drawings.

Filtration

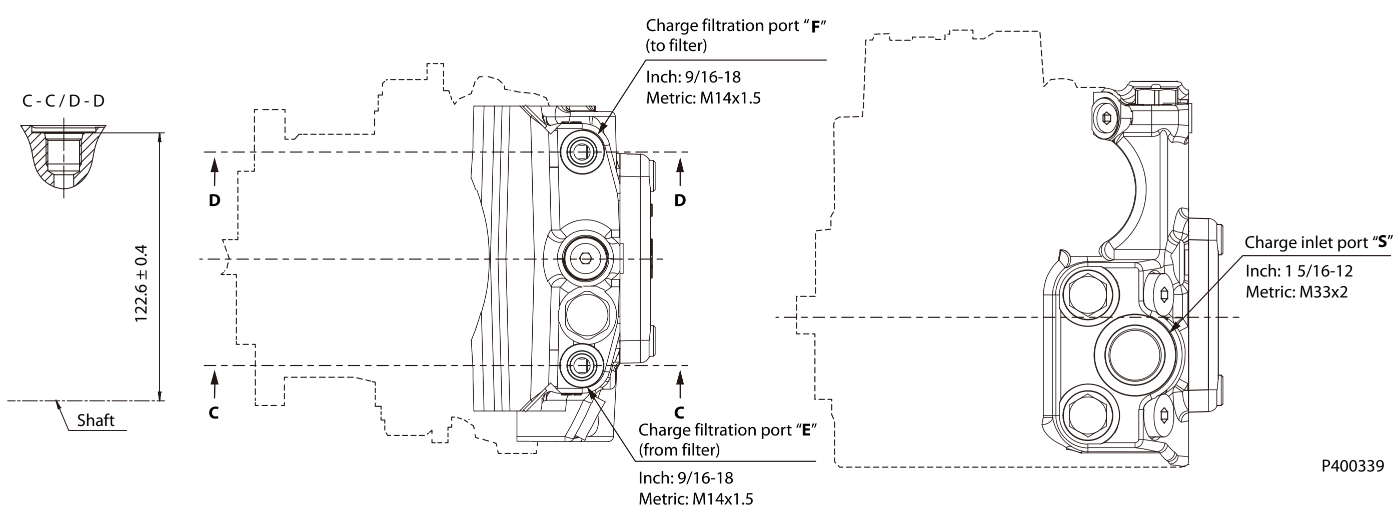
Remote full flow charge pressure filtration: option R

28/32



Please contact Danfoss representative for specific installation drawings.

38/45

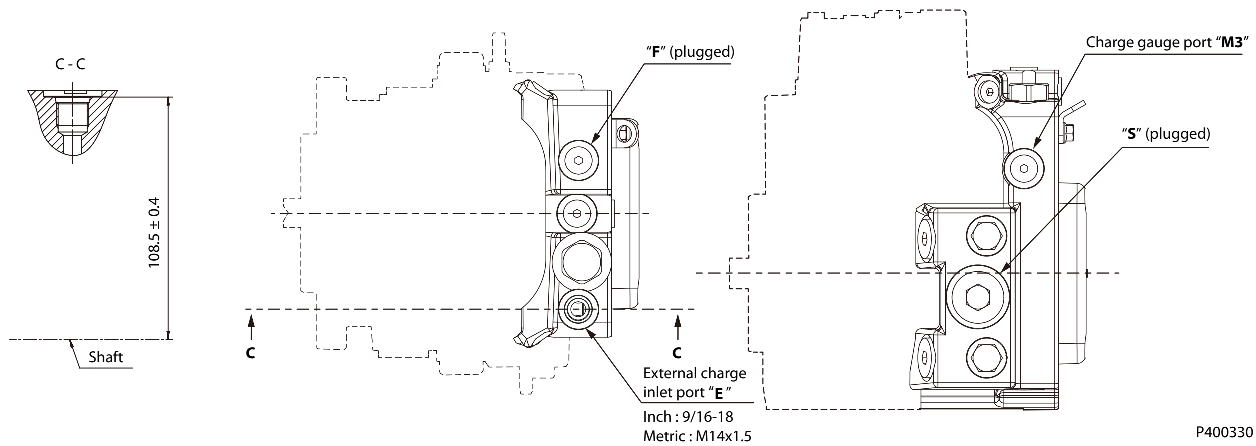


Please contact Danfoss representative for specific installation drawings.

Filtration

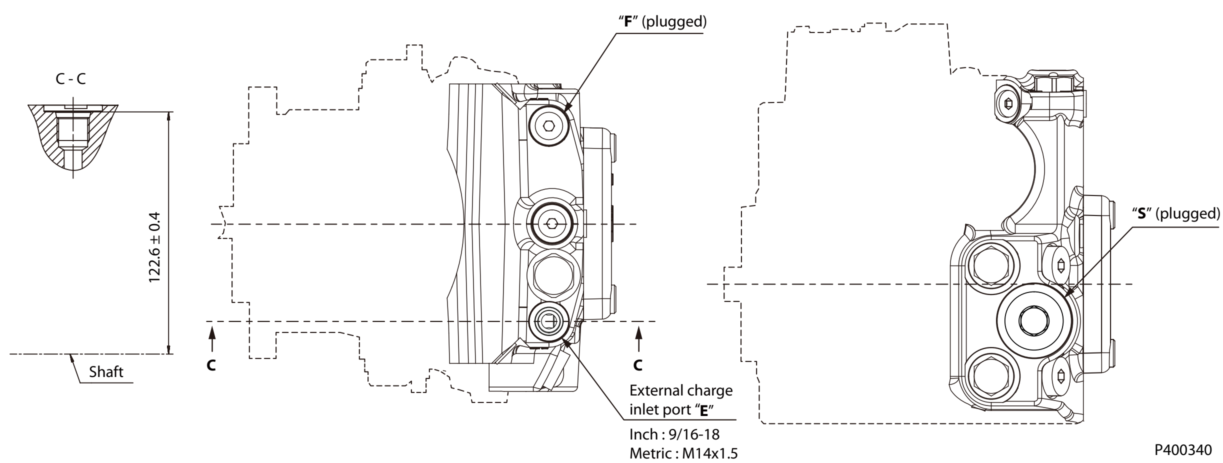
External full flow charge pressure filtration: option E

28/32



Please contact Danfoss representative for specific installation drawings.

38/45



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ENGINEERING
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ENGINEERING TOMORROW

Technical Information

H1P 045/053
Axial Piston Single Pumps

www.danfoss.com

Revision history

Table of revisions

Date	Changed	Rev
May 2022	Corrected HDC control information	1601
December 2021	Added HDC control	1501
April 2021	Added missing Jxx pressure protection settings to model code	1401
September 2020	corrected dimensions and mounting screws information	1306
June 2020	Added caution note to mounting dimensions	1305
April 2020	Corrected swash plate angle sensor connector and CCO connector descriptions	1304
February 2020	Added NFPE control options and changed document number from BC00000059	1303
June 2019	Major revision.	1201
May 2018	Major revision.	1101
May 2017	NFPE gen. 3 changes.	1001
November 2015	Master Model Code changes.	0900
2010-2014	Various changes.	BA-IA
Jul 2009	First edition	AA

Contents

Technical Specifications

H1 Pumps General Specification....6
H1P 045/053 Technical Data....6
H1P 045/053 Operating Parameters....7
Fluid Specification....8
H1P 045/053 Mounting Flange Loads....9
Bearing Life and External Radial Shaft Loads....10
Charge pump....11
  Charge Pump Selection....11
  12 cm^3 Charge Pump – Flow and Power Curves....11

Master Model Code

Displacement, A—Rotation, B—Product Version, Z—Port Configuration....12
D—Controls....13
  Electronic Displacement Controls....13
  Fan Drive Controls....13
  Forward-Neutral-Reverse (FNR) Controls....13
  Non-Feedback Proportional Electric (NFPE) Controls....13
  Automotive Controls....14
  Manual Displacement Control....14
  Hydraulic Displacement Control....14
F—Orifices, E—Displacement Limiters....15
G—Endcap....16
H—Mounting Flange, J—Input Shaft, K—Aux Pad....17
M, N—Overpressure Protection Settings....18
S—Charge Pump, T—Filtration, V—Charge Pressure Relief....20
W—Special Hardware, X—Paint, Y—Special Features....21

Control Options

Electrical Displacement Control (EDC)....22
  Control signal requirements, EDC 045/053....22
  Control Solenoid Data....23
  Single Pump Output Flow Direction....23
  Connector....23
  Control response....24
  Response Time, EDC 045/053....24
Manual Displacement Control (MDC)....25
  MDC operation....25
  MDC shaft rotation....26
  MDC Torque....26
  Control response....27
  Response time, MDC 045/053....27
  Connector....27
  Neutral start switch (NSS)....28
  Case Gauge Port M14....28
  Lever....28
Hydraulic Displacement Control (HDC)....29
  HDC principle....29
  HDC operation....29
  Hydraulic signal pressure range....30
  Pump output flow direction vs. control pressure....30
  Control response....30
  Response Time, HDC 045/053....31
Forward-Neutral-Reverse Control (FNR)....32
  Single Pump Output Flow Direction....32
  FNR Solenoid Data....33
  Control response....33
  Connector....33
  Response Time, FNR 045/053....33
Non feedback proportional electric control (NFPE)....34

Contents

Control Signal Requirements, NFPE 045/053 ... 34
Control Solenoid Data ... 35
Single Pump Output Flow Direction ... 35
Connector ... 35
Control response ... 36
Response Time, NFPE 045/053 ... 36
Automotive Control (AC) ... 37
Mode types ... 37
Basic functions ... 37
Performance functions ... 38
Protection and safety functions ... 38
Engine control and protection ... 38
Installation features ... 38
Fan Drive Control (FDC) ... 39
Control Signal Requirements, FDC 045/053 ... 40
Control Solenoid Data ... 40
Single Pump Output Flow Direction ... 41
Connector ... 41
Control response ... 41
Response Time, FDC 045/053 ... 41
Manual Override (MOR) ... 42
Swashplate angle sensor for EDC controls ... 43
Swash plate angle sensor parameters (EDC) ... 43
Swashplate Angle Sensor Connector ... 44
Interface with ECU (EDC) ... 44
Swash Plate Angle Sensor for NFPE and AC2 Controls ... 45
Swash Plate Angle Characteristic ... 45
Swash Plate Angle Sensor Parameters (NFPE/AC) ... 46
Swash Plate Angle Sensor Connector (NFPE) ... 46
Interface with ECU (NFPE) ... 46
Control Cut Off Valve (CCO) ... 47
Brake gauge port with MDC ... 47
CCO Connector (MDC) ... 48
H1P CCO Connector (EDC, NFPE) ... 48
CCO solenoid data ... 48
Displacement Limiter ... 49
H1P 045/053 Displacement Change (approximately) ... 49

Dimensions and Data

H1P 045/053 Input Shaft Option G1 (SAE C, 14 teeth) ... 50
H1P 045/053 Input Shaft Option G4 (SAE B, 13 teeth) ... 51
H1P 045/053 Input Shaft Option G5 (SAE B-B, 15 teeth) ... 52
H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth) ... 53
H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth) ... 54
H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth) ... 55
H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth) ... 56
H1P Displacement Limiter, Option B and D ... 57
H1P 045/053 End Cap, Options D6, D8, F2, F3 ... 57
Speed and temperature sensor, option H (for mounting flange option K) ... 58
Single Pump Ports ... 59
H1P Dimensions ... 60
Controls ... 63
EDC Options A2 and A3 (12/24 V) ... 63
EDC with MOR, Options A4 and A5 (12/24 V) ... 64
EDC with CCO (key C), Options E7 and E8 (12/24 V) ... 65
EDC with ASNSR, Options: H2 and H3 (12/24 V) ... 66
EDC with MOR and ASNSR, Options H6 and H7 (12/24 V) ... 67
EDC with CCO and ASNSR, Options H8 and H9 (12/24 V) ... 68
MDC Option: M1 ... 69
MDC with Neutral Start Switch Option: M2 ... 70

Contents

MDC with CCO, Options: M3, M4 ... 71
MDC with NSS and CCO Options: M5, M6 ... 72
HDC, Options: T1, T2 ... 73
NFPE with MOR, Options: N1, N2 (12/24 V) ... 74
NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V) ... 75
NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V) ... 76
NFPE with MOR and CCO, Options: N7, N8 (12/24 V) ... 77
Automotive control (AC) ... 78
AC connectors dimensions ... 79
Filtration ... 80
Suction Filtration Option L ... 80
Full Flow Charge Pressure Filtration Option P ... 81
External Full Flow Charge Pressure Filtration, Option E ... 82

Technical Specifications

H1 Pumps General Specification

Axial piston closed circuit variable displacement pumps of cradle swash-plate design with clockwise or counterclockwise direction of rotation.

Pipe connections

- Main pressure ports: ISO split flange boss
- Remaining ports: SAE straight thread O-ring boss

Recommended installation position

Pump installation position is discretionary, however the recommended control position is on the top or at the side with the top position preferred. If the pump is installed with the control at the bottom, flushing flow must be provided through port M14 located on the EDC, FNR and NFPE control.

Vertical input shaft installation is acceptable. If input shaft is at the top, 1 bar case pressure must be maintained during operation. The housing must always be filled with hydraulic fluid. Recommended mounting for a multiple pump stack is to arrange the highest power flow towards the input source. Consult Danfoss for nonconformance to these guidelines.

Auxiliary cavity pressure

Auxiliary cavity pressure will be inlet pressure with internal charge pump or case pressure with external charge supply. For reference see Operating Parameters. Please verify mating pump shaft seal capability.

H1P 045/053 Technical Data

Feature	Size 045	Size 053
Displacement	45.0 cm^3 [2.75 in^3]	53.8 cm^3 [3.28 in^3]
Flow at rated speed (continuous)	153 l/min [40 US gal/min]	183 l/min [48 US gal/min]
Torque at maximum displacement (theoretical)	0.72 N•m/bar [437.7 lbf•in/1000 psi]	0.86 N•m/bar [522.0 lbf•in/1000 psi]
Mass moment of inertia of rotating components	0.00465 kg•m^2 [0.00343 slug•ft^2]	0.00458 kg•m^2 [0.00338 slug•ft^2]
Mass (dry–no charge pump)	41 kg [90 lb]	41 kg [90 lb]
Oil volume	1.3 l [0.34 US gal]	1.3 l [0.34 US gal]

Shaft, flange and ports description

Input shaft per ISO 3019-1 (outer diameter)	• Outer Ø22 mm – 4 (SAE B, 13 teeth) • Outer Ø25 mm – 4 (SAE B-B, 15 teeth) • Outer Ø32 mm – 4 (SAE B, 14 teeth)
Mounting flange per ISO 3019-1	Flange 101–2 (SAE B)
Auxiliary mounting flange with metric fasteners, with shaft outer diameter	• Flange 82-2 (SAE A, 9 teeth and 11 teeth) • Flange 101-2 (SAE B, 13 teeth and SAE B-B, 15 teeth)
Suction port per ISO 3019-1	$1\frac{5}{16}$–12 (SAE O-ring boss)
Main configuration port	Ø19 mm, 450 bar Split flange boss per ISO 6162, M10x1.5
Case drain ports L2, L4 per ISO 3019-1	$1\frac{1}{16}$–12 (SAE O-ring boss)
Other ports	SAE O-ring boss
Customer interface threads	Metric fasteners

Technical Specifications

H1P 045/053 Operating Parameters

Parameter		Unit	Size 045	Size 053
Input speed	Min. for internal[1] and external[2] charge supply	min^{-1} (rpm)	500	500
	Min. for full performance, internal charge supply		1175	1250
	Rated		3400	3400
	Maximum		3500	3500
System pressure	Maximum working	bar [psi]	420 [6092]	380 [5511]
	Maximum		450 [6527]	400 [5802]
	Max./Min. low loop		45/10 [653/145]	
Charge pressure	Minimum	bar [psi]	16 [232]	
	Maximum		35 [508]	
Control pressure	Minimum (at corner power for EDC, MDC, FNR)		21.5 [312]	
	Minimum (at corner power for NFPE, FDC, AC)		25 [363]	
	Maximum		40 [580]	
Charge pump inlet pressure	Rated	bar (absolute) [in Hg vacuum]	0.7 [9.0]	
	Minimum (cold start)		0.2 [24.0]	
	Maximum	bar [psi]	4.0 [58.0]	
Case pressure	Rated		3.0 [44.0]	
	Maximum		5.0 [73.0]	
Lip seal maximum pressure (external)			0.4 [5.8]	

[1] Performance (displacement and pressure) may be limited due to limited control pressure.

[2] Full performance (displacement and pressure) possible at minimum charge and control pressure supply.

Filtration, cleanliness level and β_x-ratio (recommended minimum)

Cleanliness per ISO 4406	22/18/13
Efficiency β_x (charge pressure filtration)	$\beta_{15\text{-}20} = 75$ ($\beta_{10} \geq 10$)
Efficiency β_x (suction and return line filtration)	$\beta_{35\text{-}45} = 75$ ($\beta_{10} \geq 2$)
Recommended inlet screen mesh size	100 – 125 µm

Technical Specifications

Fluid Specification

Viscosity

Intermittent[1)]	5 mm^2/s [42 SUS]
Minimum	7 mm^2/s [49 SUS]
Recommended range	12 – 80 mm^2/s [66 – 370 SUS]
Maximum	1600 mm^2/s [7500 SUS]

1) Intermittent = Short term t < 1 min per incident and not exceeding 2 % of duty cycle based load-life.

Temperature

Minimum [1)]	-40°C [-40°F]
Rated	104°C [220°F]
Recommended range[2)]	60 – 85°C [140 – 185°F]
Maximum Intermittent	115°C [240°F]

1) Cold start = Short term t > 3 min, p ≤ 50 bar [725 psi], n ≤ 1000 min-1 (rpm).

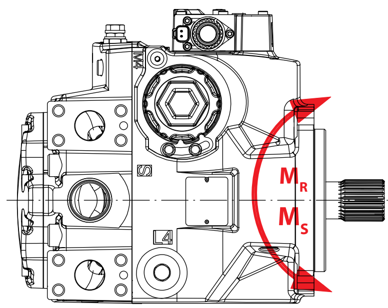
2) At the hottest point, normally case drain port.

Technical Specifications

H1P 045/053 Mounting Flange Loads

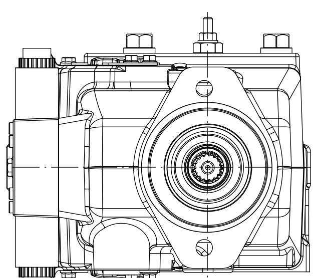
The Rated and Shock load moments apply for top or side orientation of control.

Mounting flange load with control on top



Rated moment	$\mathbf{M_R}$ = 2020 N•m [17 880 lbf•in]
Shock load moment	$\mathbf{M_S}$ = 4110 N•m [36 380 lbf•in]

Mounting flange load with control on side



P301 214b

Rated moment	$\mathbf{M_R}$ = 1300 N•m [11 510 lbf•in]
Shock load moment	$\mathbf{M_S}$ = 2930 N•m [25 935 lbf•in]

For more information, see *H1 Axial Piston Pumps, Basic Information,* **BC152886483968**, the section "Mounting flange loads".

Technical Specifications

Bearing Life and External Radial Shaft Loads

All external shaft loads affect bearing life. The pumps are designed with bearings that can accept some external radial loads. The external radial shaft load limits are a function of the load position and orientation, and the operating conditions of the unit.

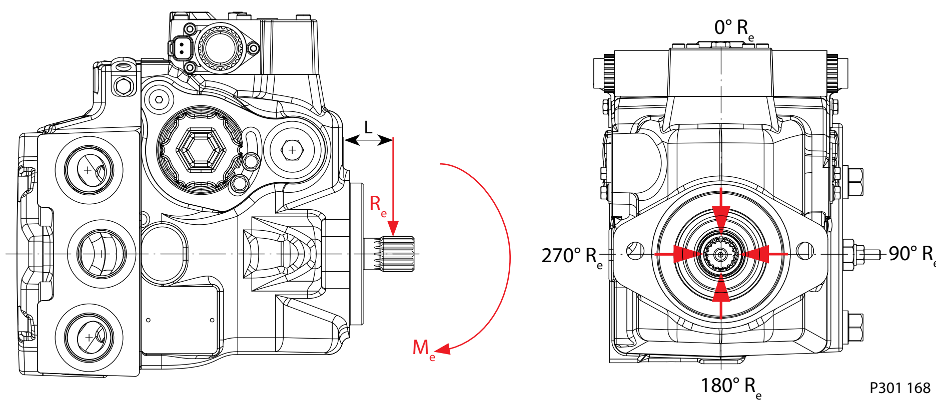
Danfoss recommends clamp-type couplings for applications with radial shaft loads. Contact your Danfoss representative for an evaluation of unit bearing life if you have continuously applied external loads exceeding 25 % of the maximum allowable radial load (R_e) or the pump swash-plate is positioned on one side of center all or most of the time.

Maximum external shaft load based on shaft deflection

External radial moment	Unit	Size 045/053
M_e	N•m [lbf•in]	TBD

External radial shaft loads impact lifetime. For lifetime calculations please contact your Danfoss representative. In applications with external shaft loads, minimize the impact by positioning the load at 0° or 180° as shown below.

Radial load position



The maximum allowable radial shaft load (R_e) is based on the maximum external moment (M_e) and the distance (L) from the mounting flange to the load. It may be determined using the following formula:

$$\mathbf{R_e} = \frac{\mathbf{M_e}}{\mathbf{L}}$$

Thrust loads should be avoided. Contact your Danfoss representative in the event thrust loads are anticipated.

Technical Specifications

Charge pump

Charge Pump Selection

In most applications a general guideline is that the charge pump displacement should be at least 10% of the total displacement of all components in the system. Unusual application conditions may require a more detailed review of charge flow requirements. System features and conditions which may invalidate the 10% guideline include (but are not limited to):

- Continuous operation at low input speeds < 1500 min^{-1} (rpm)
- High shock loading and/or long loop lines
- High flushing flow requirements
- Multiple low speed high torque motors
- High input shaft speeds

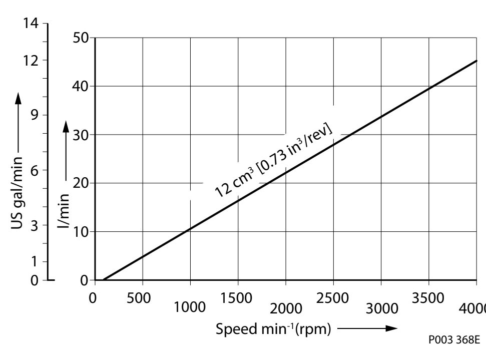
Contact your Danfoss representative for application assistance if your application includes any of these conditions.

12 cm^3 Charge Pump – Flow and Power Curves

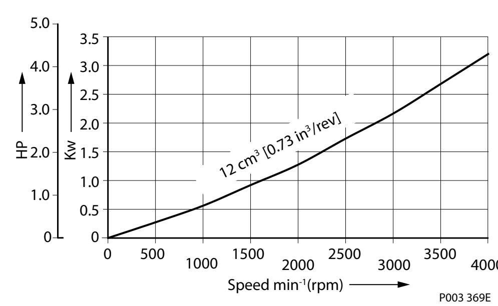
Charge pump flow and power requirements curves shown below at the following conditions:

Charge pressure = 20 bar [290 psi]
Viscosity = 11 mm^2/s [63 SUS]
Temperature = 80°C [176°F]

Charge pump flow

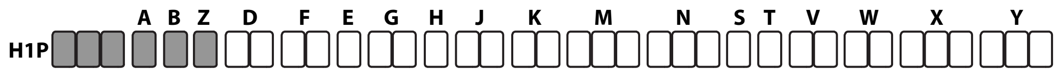


Charge pump power requirements



Master Model Code

Displacement, A—Rotation, B—Product Version, Z—Port Configuration



Displacement

045	45.0 cm^3 [2.75 in^3]
053	53.8 cm^3 [3.28 in^3]

A – Direction of Rotation

L	Left hand (counter clockwise)
R	Right hand (clockwise)

B – Product version

A	Revision code

Z – Port configuration

A	Inch, Customer O-ring port sealing according to ISO 11926-1

Master Model Code

D—Controls

H1P A B Z D F E G H J K M N S T V W X Y

Electronic Displacement Controls

Code	Control type	Voltage	MOR	CCO with key C	Angle sensor	Connector
A2	EDC	12 V	—	—	—	DEUTSCH
A3	EDC	24 V	—	—	—	DEUTSCH
A4	EDC	12 V	●	—	—	DEUTSCH
A5	EDC	24 V	●	—	—	DEUTSCH
E7	EDC	12 V	—	●	—	DEUTSCH
E8	EDC	24 V	—	●	—	DEUTSCH
H2	EDC	12 V	—	—	●	DEUTSCH
H3	EDC	24 V	—	—	●	DEUTSCH
H6	EDC	12 V	●	—	●	DEUTSCH
H7	EDC	24 V	●	—	●	DEUTSCH
H8	EDC	12 V	—	●	●	DEUTSCH
H9	EDC	24 V	—	●	●	DEUTSCH

● – To be used for the control; — Not to be used for the control

Fan Drive Controls

F1	FDC	12 V	DEUTSCH Connector
F2	FDC	24 V	DEUTSCH Connector

Align with options: **F:** Orifices, **E:** Displacement limiters, **M, N:** Overpressure protection, and **W:** Special hardware.

Forward-Neutral-Reverse (FNR) Controls

A9	FNR	12 V	with MOR	DEUTSCH Connector
B1	FNR	24 V	with MOR	DEUTSCH Connector

Non-Feedback Proportional Electric (NFPE) Controls

Code	Control type	Voltage	MOR	CCO with key C	Angle sensor	Connector
N1	NFPE	12 V	●	—	—	DEUTSCH
N2	NFPE	24 V	●	—	—	DEUTSCH
N3	NFPE	12 V	●	●	●	DEUTSCH
N4	NFPE	24 V	●	●	●	DEUTSCH
N5	NFPE	12 V	●	—	●	DEUTSCH
N6	NFPE	24 V	●	—	●	DEUTSCH
N7	NFPE	12 V	●	●	—	DEUTSCH
N8	NFPE	24 V	●	●	—	DEUTSCH

Align with options: **E:** Displacement limiters and **W:** Special hardware.

Master Model Code

Automotive Controls

Automotive Control (AC)

Code	AC type	Voltage	MOR	Speed sensor	Wire harness	Angle sensor	Connector
P6	AC–1	12 V	●	●	●	—	DEUTSCH
P7	AC–1	24 V	●	●	●	—	DEUTSCH
P8	AC–2	12 V	●	●	●	●	DEUTSCH
P9	AC–2	24 V	●	●	●	●	DEUTSCH
P5	AC–1	12 V	●	—	—	—	DEUTSCH
R3	AC–1	24 V	●	—	—	—	DEUTSCH
R4	AC–2	12 V	●	—	—	●	DEUTSCH
R5	AC–2	24 V	●	—	—	●	DEUTSCH

● – To be used for the control; — Not to be used for the control

Manual Displacement Control

Manual Displacement Control (MDC)

Code	Control type	CCO Voltage	CCO	Neutral Start Switch	Connector
M1	MDC	—	—	—	—
M2	MDC	—	—	●	DEUTSCH
M3	MDC	12 V	●	—	DEUTSCH
M4	MDC	24 V	●	—	DEUTSCH
M5	MDC	12 V	●	●	DEUTSCH
M6	MDC	24 V	●	●	DEUTSCH

Align with options **F:** Orifices and **Y:** Settings for adjustment (if applicable).

Hydraulic Displacement Control

Hydraulic Displacement Control (HDC)

Code	Pressure range	Ports
T1	4.2 - 16.2 bar	Inch ports 9/16-18
T2	3.0 - 11.6 bar	Inch ports 9/16-18

Master Model Code

F—Orifices, E—Displacement Limiters

A B Z D F E G H J K M N S T V W X Y

H1P

F – Orifices Options

Orifices options related to control type

Code	Tank (A+B)	P orifice	A/B orifices	EDC, FNR	MDC	NFPE, AC	FDC
C3	No orifice			●	●	–	–
C1	–	–	0.8 mm	●	●	●	–
C2	–	–	1.3 mm	●	●	●	●
C4	–	–	1.8 mm	●	●	●	–
C6	1.0 mm	–	–	–	●	–	
C7	1.3 mm	–	–	–	●	–	–
D1	0.8 mm	1.0 mm	–	–	●	–	–
D2	0.8 mm	1.3 mm	–	–	●	–	–
D3	1.0 mm	1.3 mm	–	–	●	–	–
D4	1.0 mm	1.3 mm	1.3 mm	–	●	–	–
D5	0.6 mm	0.6 mm	0.8 mm	–	●	–	–
D6	1.3 mm	1.3 mm	–	–	●	–	–
D8	–	–	2.3 mm	–	–	●	–

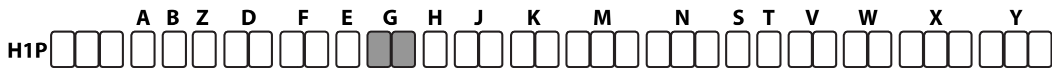
E – Displacement Limiter Options

N	None
B	Adjustable externally
C	No limiters, with nested springs, required for NFPE, AC, FDC*
D	Adjustable externally with nested springs, required for NFPE, AC, FDC*

* Align with option **Y:** Settings for adjustment (if applicable).

Master Model Code

G—Endcap



G – End-cap Options

Twin port, ISO 6162 split flange ports; Align with T: Filtration

D6	Suction filtration, Code 62
E6	Suction filtration, ORB
F1	Suction filtration, ORB, HPRV only
F3	Suction filtration, Code 62, HPRV only
D8	Remote filtration, Code 62
E5	Remote filtration, ORB
E9	Remote filtration, ORB, HPRV only
F2	Remote filtration, Code 62, HPRV only

Master Model Code

H—Mounting Flange, J—Input Shaft, K—Aux Pad

H1P	A	B	Z	D	F	E	G	H	J	K	M	N	S	T	V	W	X	Y

H – Mounting options

Mounting to be aligned with option W: Special hardware

F	ISO 3019-1 flange 101–2 (SAE B)
J	ISO 3019-1 flange 101–2 (SAE B), 2-bolt, with speed sensor

J – Input Shaft options

G1	ISO 3019-1, outer Ø32 mm - 4 (14 teeth splined shaft 12/24 pitch)
G4	ISO 3019-1, outer Ø22 mm - 4 (13 teeth splined shaft 16/32 pitch)
G5	ISO 3019-1, outer Ø25 mm - 4 (15 teeth splined shaft 16/32 pitch)

K – Auxiliary Mounting Pad options (ISO 3019-1)

NN	None
H1	Flange 82–2 (SAE A, 11 teeth, 16/32 coupling); shipping cover
H2	Flange 82–2 (SAE A, 9 teeth, 16/32 coupling); shipping cover
H3	Flange 101–2 (SAE B, 13 teeth, 16/32 coupling); shipping cover
H5	Flange 101–2 (SAE B-B, 15 teeth, 16/32 coupling); shipping cover

Master Model Code

M, N—Overpressure Protection Settings

A B Z D F E G H J K M N S T V W X Y

H1P

M and N – Overpressure protection options

J	**Pressure limiter setting**
J18	180 bar [2610 psi]
J20	200 bar [2900 psi]
J23	230 bar [3336 psi]
J25	250 bar [3630 psi]
J28	280 bar [4061 psi]
J30	300 bar [4350 psi]
J33	330 bar [4786 psi]
J35	350 bar [5076 psi]
J38	380 bar [5511 psi]
J40	400 bar [5800 psi] (H1P 045 only)
J42	420 bar [6090 psi] (H1P 045 only)

L	**Pressure limiter setting**	**HPRV with bypass setting**[1)]
L15	150 bar [2900 psi]	230 bar [3336 psi]
L18	180 bar [2610 psi]	230 bar [3336 psi]
L20	200 bar [2900 psi]	250 bar [3630 psi]
L23	230 bar [3336 psi]	280 bar [4061 psi]
L25	250 bar [3630 psi]	300 bar [4350 psi]
L28	280 bar [4061 psi]	330 bar [4786 psi]
L30	300 bar [4350 psi]	350 bar [5076 psi]
L33	330 bar [4786 psi]	380 bar [5510 psi]
L35	350 bar [5080 psi]	400 bar [5800 psi]
L38	380 bar [5510 psi]	420 bar [6090 psi]
L40	400 bar [5800 psi]	450 bar [6526 psi] (H1P 045 only)
L41	410 bar [5946 psi]	450 bar [6526 psi] (H1P 045 only)
L42	420 bar [6090 psi]	450 bar [6526 psi] (H1P 045 only)
Overpressure protection type and setting for FDC		
F01	150 bar [2175 psi]	250 bar [3630 psi]
F02	150 bar [2175 psi]	300 bar [4350 psi] (H1P 045 only)

[1)] Pressure limiter and HPRV with bypass, over-pressure protection type must be the same for both sides “A” and “B”.

K	**Pressure setting** [1)]
K18	180 bar [2610 psi]
K20	200 bar [2900 psi]
K23	230 bar [3336 psi]
K25	250 bar [3630 psi]

Master Model Code

K	Pressure setting [1]
K28	280 bar [4061 psi]
K30	300 bar [4350 psi]
K33	330 bar [4786 psi]
K35	350 bar [5076 psi]
K38	380 bar [5510 psi]
K40	400 bar [5800 psi] (available for H1P 045 only)
K41	410 bar [5946 psi] (available for H1P 045 only)
K42	420 bar [6090 psi] (available for H1P 045 only)

[1] Pressure limiter and HPRV with bypass, over-pressure protection type must be the same for both sides "A" and "B".

Please contact Danfoss Power Solutions for pressures not shown or for applied pressure above max. working pressure.

Master Model Code

S—Charge Pump, T—Filtration, V—Charge Pressure Relief

A B Z D F E G H J K M N S T V W X Y

H1P

S – Charge pump options

B	12 cm^3/rev [0.73 in^3/rev]

T – Filtration options

Filtration to be aligned with G: End cap selection

L	Suction filtration
P	Remote full charge flow filtration
E	External full charge flow filtration (Align with options **N, S**)

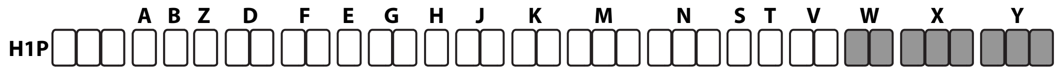
V – Charge pressure relief valve (CPRV) setting

18*	18 bar [261 psi]
20*	20 bar [290 psi]
22*	22 bar [319 psi]
24*	24 bar [348 psi]
26	26 bar [377 psi]
28	28 bar [406 psi]
30	30 bar [435 psi]
32	32 bar [464 psi]

* Not to be used for **NFPE, AC** and **FDC** controls.

Master Model Code

W—Special Hardware, X—Paint, Y—Special Features



W – Special Hardware features

Hardware features to be aligned with options D, E

P1	NFPE/FDC valve plate
P2	NFPE/FDC/AC valve plate and speed ring on the cylinder block
P4	EDC/FNR/MDC valve plate and speed ring on the cylinder block
PN	EDC/FNR/MDC valve plate
H1	MDC/EDC/FNR valve plate with MDC handle

X – Paint and Name-tag

NNN	Black paint and Danfoss name-tag
C08	Paint none and Danfoss name-tag

Y – Special settings (SIL-2 non-certifiable, without customer files)

Code	CAN J1939	ECO fuel saving mode	Functional option	Cruise control	Control	AC type
D3E	in/out	●	E	–	N1 (12 V_{DC})	AC–1
D3F	in/out	–	F	–		
D4E	in/out	●	E	–	N2 (24 V_{DC})	
D4F	in/out	–	F	–		
D5F	in/out	–	F	–	P8 (12 V_{DC})	AC–2 (with swash plate angle sensor)
D5J	in/out	●	J	●		
D6F	in/out	–	F	–	P9 (24 V_{DC})	
D6J	in/out	●	J	●		
M00	MDC handle standard position					
NNN	None					

● – To be used for the control; — Not to be used for the control

Control Options

Electrical Displacement Control (EDC)

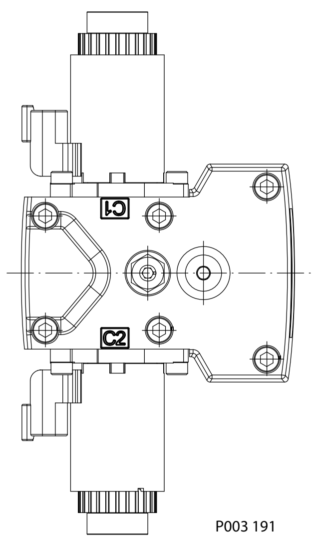
An EDC is a displacement (flow) control. Pump swash plate position is proportional to the input command and therefore vehicle or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The Electrical Displacement Control (**EDC**) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

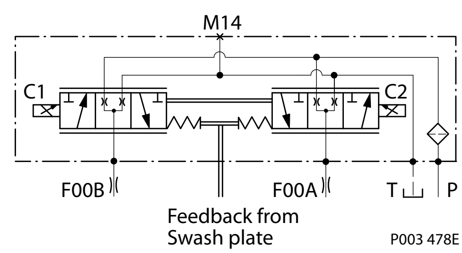
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

Electrical Displacement Control

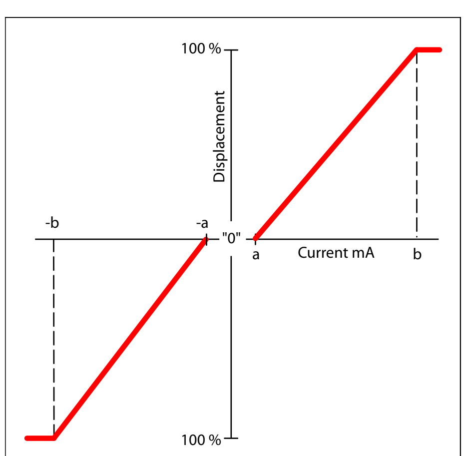


EDC schematic, feedback from swash plate



Control signal requirements, EDC 045/053

Pump displacement vs. control current



Control Options

EDC control current

Voltage		12 V_{DC}	24 V_{DC}
Minimum current to stroke pump	**a***	640 mA	330 mA
	b	1640 mA	820 mA
Pin connections		any order	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

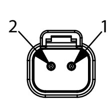
Single Pump Output Flow Direction

Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	out	in	in	out
Port B	in	out	out	in
Servo port pressurized	M4	M5	M4	M5

* For coil location see installation drawings.

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control Options

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, EDC 045/053

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	1.7 s	0.9 s	0.5 s
Full flow to neutral	1.1 s	0.6 s	0.3 s

Control Options

Manual Displacement Control (MDC)

A Manual proportional Displacement Control (**MDC**) consists of a handle on top of a rotary input shaft. The shaft provides an eccentric connection to a feedback link. This link is connected on its one end with a porting spool. On its other end the link is connected the pumps swashplate.

This design provides a travel feedback without spring. When turning the shaft the spool moves thus providing hydraulic pressure to either side of a double acting servo piston of the pump.

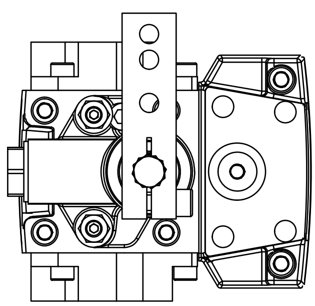
Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement. Simultaneously the swashplate movement is fed back to the control spool providing proportionality between shaft rotation on the control and swash-plate rotation. The MDC changes the pump displacement between no flow and full flow into opposite directions.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

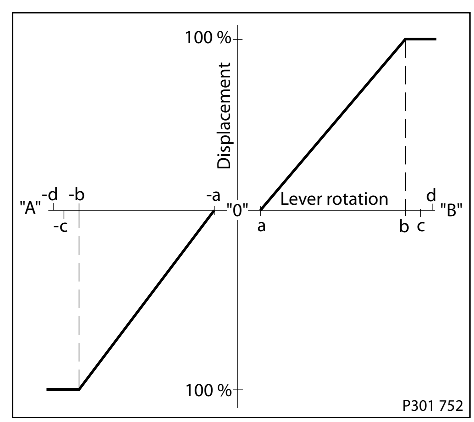
For the MDC with CCO option the brake port (X7) provides charge pressure when the coil is energized to activate static function such as a brake release. The X7 port must not be used for any continuous oil consumption.

The MDC is sealed by means of a static O-ring between the actuation system and the control block. Its shaft is sealed by means of a special O-ring which is applied for low friction. The special O-ring is protected from dust, water and aggressive liquids or gases by means of a special lip seal.

Manual Displacement Control



Pump displacement vs. control lever rotation



Deadband on **B** side: **a = 3° ±1°**
Maximum pump stroke: **b = 30° +2/-1°**
Required customer end stop: **c = 36° ±3°**
Internal end stop: **d = 40°**

MDC operation

The MDC provides a mechanical dead-band required to overcome the tolerances in the mechanical actuation. The MDC contains an internal end stop to prevent turning the handle into any inappropriate position.

The MDC provides a permanent restoring moment appropriate for turning the MDC input shaft back to neutral position only. This is required to take the backlash out of the mechanical connections between the Bowden cable and the control.

High case pressure may cause excessive wear and the NSS to indicate that the control is not in neutral position. In addition, if the case pressure exceeds 5 bar there is a risk of an insufficient restoring moment. The MDC is designed for a maximum case pressure of 5 bar and a rated case pressure of 3 bar.

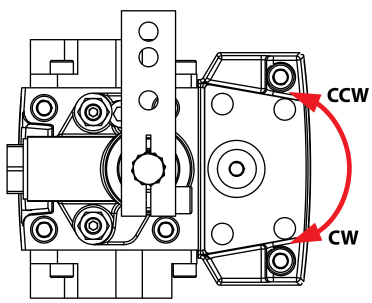
Control Options

- Customers must install some support to limit the setting range of their Bowden cable to avoid an overload of the MDC.
- Customers can apply their own handle design but they must care about a robust clamping connection between their handle and the control shaft and avoid overload of the shaft.
- Customers can connect two MDC's on a tandem unit in such a way that the actuation force will be transferred from the pilot control to the second control. The kinematic of the linkages must ensure that either control shaft is protected from torque overload.

Caution

Using the internal spring force on the input shaft is not an appropriate way to return the customer connection linkage to neutral, or to force a Bowden cable or a joystick back to neutral position. It is not applicable for any limitation of the Bowden cable stroke, except the applied torque to the shaft will never exceed 20 N•m.

MDC shaft rotation



Pump shaft rotation*	Clockwise (CW)		Counter-clockwise (CCW)	
MDC shaft rotation	**CW**	**CCW**	**CW**	**CCW**
Port A	in (low)	out (high)	out (high)	in (low)
Port B	out (high)	in (low)	in (low)	out (high)
Servo port high pressure	M5	M4	M5	M4

* As seen from shaft side.

MDC Torque

Description	Value
Torque required to move handle to maximum displacement	1.4 N•m [12.39 lbf•in]
Torque required to hold handle at given displacement	0.6 N•m [5.31 lbf•in]
Maximum allowable input torque	20 N•m [177 lbf•in]

Caution

Volumetric efficiencies of the system will have impacts on the start and end input commands.

Control Options

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

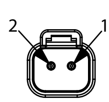
Response time, MDC 045/053

Code	Orifice description (mm)			Stroking direction	
	Tank (A+B)	P	A/B	Neutral to full flow	Full flow to neutral
C3	No orifice			0.3 s	0.4 s
C6	1	–	–	0.9 s	0.8 s
C7	1.3	–	–	0.6 s	0.6 s
D1	0.8	1	–	1.7 s	1.2 s
D2	0.8	1.3	–	1.5 s	1.1 s
D3	1	1.3	–	1.1 s	0.8 s
D4	1	1.3	1.3	1.3 s	1.0 s

For further data please contact your Danfoss representative.

Connector

Connector DEUTSCH, 2-pin



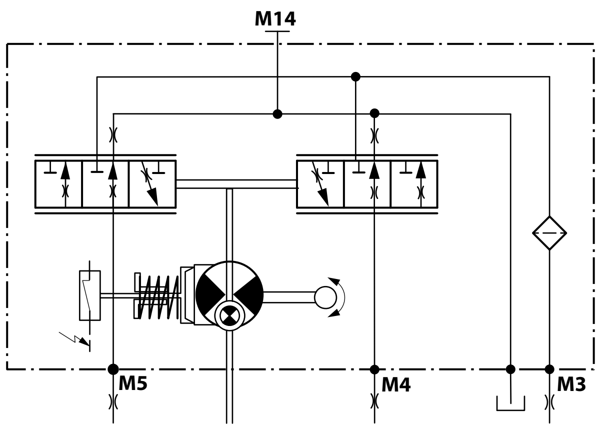
Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control Options

Neutral start switch (NSS)

The Neutral Start Switch **(NSS)** contains an electrical switch that provides a signal of whether the control is in neutral. The signal in neutral is Normally Closed **(NC)**.

Neutral start switch schematic



Neutral start switch data

Max. continuous current with switching	8.4 A
Max. continuous current without switching	20 A
Max. voltage	36 V_{DC}
Electrical protection class	IP67 / IP69K with mating connector

Case Gauge Port M14

The drain port should be used when the control is mounted on the unit's bottom side to flush residual contamination out of the control.

Lever

MDC-controls are available with an integrated lever.

Control Options

Hydraulic Displacement Control (HDC)

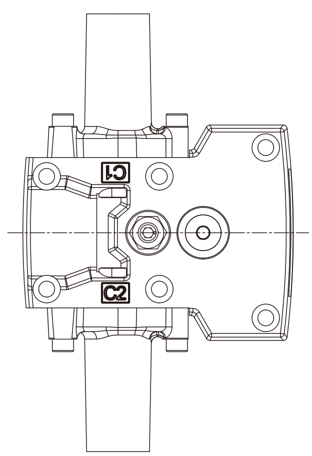
HDC principle

An HDC is a Hydraulic Displacement Control. Pump swashplate position is proportional to the input command and therefore vehicle speed or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The HDC control uses a hydraulic input signal to operate a porting spool, which ports hydraulic pressure to either side of a double acting servo piston. The hydraulic signal applies a force input to the spool which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction. Under some circumstances, such as contamination, the porting spool could stick and cause the pump to stay at some displacement.

A serviceable 175 µm screen is located in the supply line immediately before the control porting spool.

HDC control



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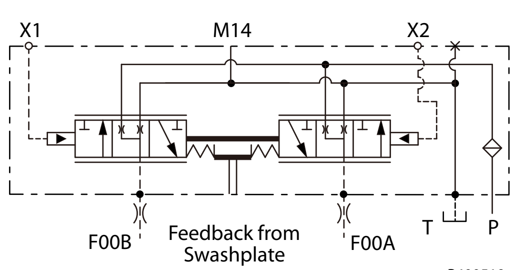
HDC schematic



P400519

HDC operation

HDC's are hydraulically driven control which ports hydraulic pressure to either side of a porting spool, which pressurizes one end of the servo piston, while draining the other end to case. Pressure differential across the servo piston moves the swashplate.

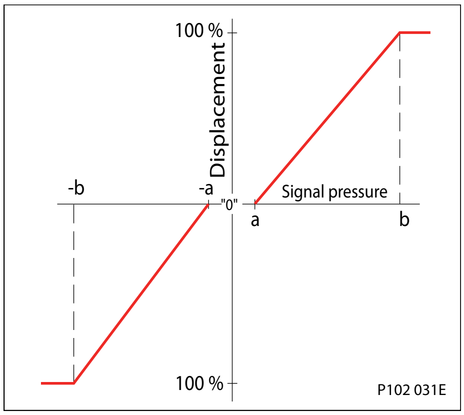
A swashplate feedback link, opposing control linkage, and a linear spring provide swashplate position force feedback to the hydraulic pressure. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

Control Options

The HDC incorporates a positive neutral dead band as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold point is reached, the swashplate is positioned directly proportional to the control pressure.

When the control input is either lost or removed, or if there is a loss of charge pressure, the spring loaded servo piston will automatically return the pump to the neutral position.

Pump displacement vs signal pressure



Hydraulic signal pressure range

Option	Type	a*	b*	Max. pressure
T1	Standard	4.2 bar	16.2 bar	30 bar
T2	Option	3 bar	11.6 bar	30 bar

* Factory test current, for vehicle movement or application actuation expect a higher or lower value.

Pump output flow direction vs. control pressure

Shaft rotation HDC	Clockwise (CW) seen from shaft		Counter Clockwise (CCW) seen from shaft	
Port energized	X1	X2	X1	X2
Port A	Out (high)	In (low)	In (low)	Out (high)
Port B	In (low)	Out (high)	Out (high)	In (low)
Servo port high pressure	M4	M5	M4	M5

For appropriate performance of HDC characteristic, keep the drain pressure of pilot valve to be equal or slightly higher than pump case pressure.

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Control Options

Response Time, HDC 045/053

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	1.6s	0.7s	0.4s
Full flow to neutral	0.9s	0.4s	0.2s

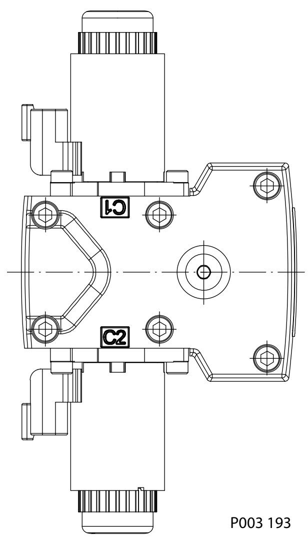
Control Options

Forward-Neutral-Reverse Control (FNR)

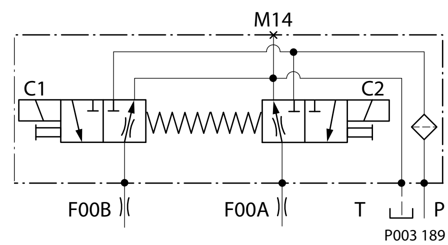
The 3-position FNR control options **A9** (12 V) and **B1** (24 V) uses an electric input signal to switch the pump to a full stroke position. A serviceable 125 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool can stick and cause the pump to stay at some displacement.

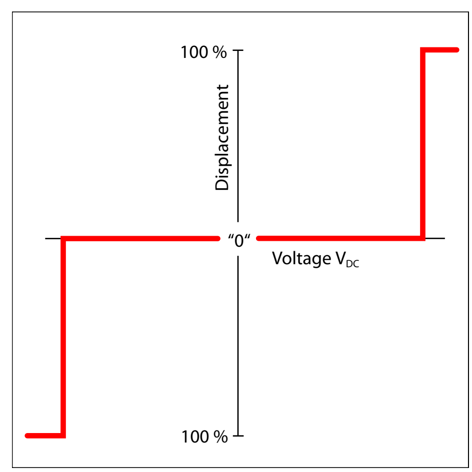
Forward-Neutral-Reverse electric control (FNR)



FNR hydraulic schematic



Pump displacement vs. electrical signal



FNR control current

Voltage	12 V_{DC}	24 V_{DC}
Minimum current to stroke pump	750 mA	380 mA
Pin connections	any order	

Single Pump Output Flow Direction

Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	C1	C2	C1	C2
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see installation drawings.

Control Options

FNR Solenoid Data

Solenoid data

Voltage	12 V_{DC}	24 V_{DC}
Minimum supply voltage	9.5 V_{DC}	19 V_{DC}
Maximum supply voltage (continuous)	14.6 V_{DC}	29 V_{DC}
Bi-directional diode cut off voltage	28 V_{DC}	53 V_{DC}
Maximum current	1050 mA	500 mA
Nominal coil resistance @ 20°C	8.4 Ω	34.5 Ω
PWM Range	70 – 200 Hz	
PWM Frequency (preferred)*	100 Hz	

* PWM signal required for optimum control performance.

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

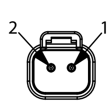
The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Response Time, FNR 045/053

Stroking direction	0.8 [0.03] orifice	1.3 [0.05] orifice	No orifice
Neutral to full flow	1.8 s	0.9 s	0.5 s
Full flow to neutral	1.6 s	0.8 s	0.4 s

Control Options

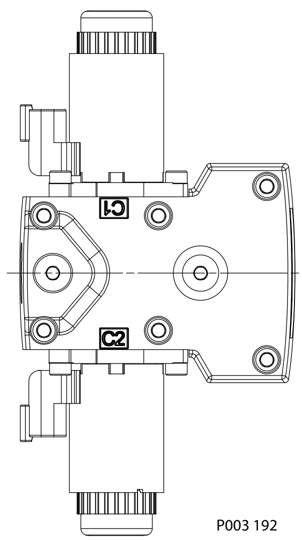
Non feedback proportional electric control (NFPE)

The Non Feedback Proportional Electric (**NFPE**) control is an electrical automotive control in which an electrical input signal activates one of two proportional solenoids that port charge pressure to either side of the pump servo cylinder. The NFPE control has no mechanical feedback mechanism.

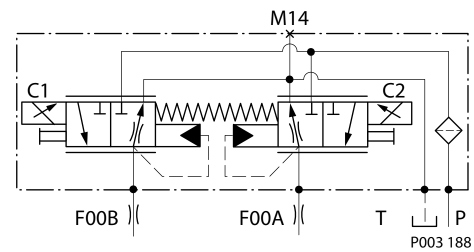
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

NFPE control



NFPE schematic

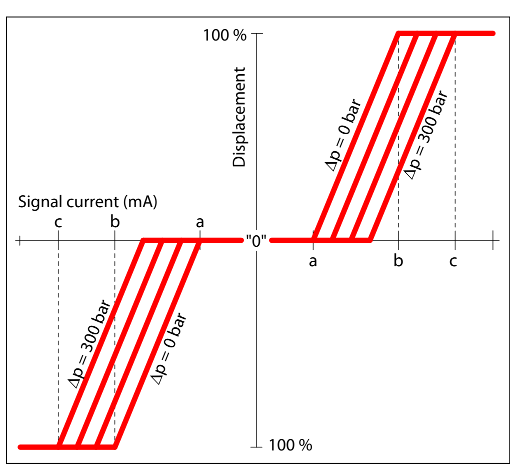


Control Signal Requirements, NFPE 045/053

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash-plate angle as system pressure increases.

A typical response characteristic is shown in the accompanying graph below:

Pump displacement vs. input signal



Control Options

Control current requirements

Voltage*	a	b	c	Pin config.
12 V_{DC}	310 mA	1050 mA	1540 mA	any order
24 V_{DC}	309 mA	551 mA	770 mA	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

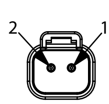
Single Pump Output Flow Direction

Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	C1	C2	C1	C2
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see installation drawings.

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control Options

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

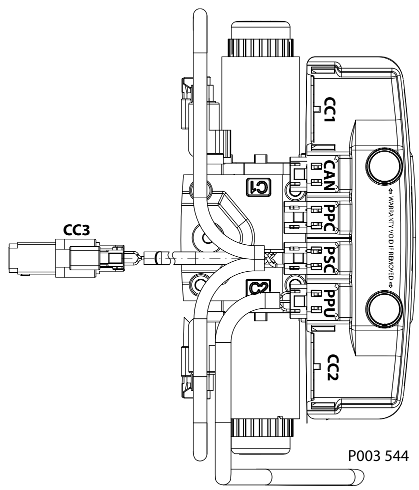
Response Time, NFPE 045/053

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	2.3 mm [0.09 in] orifice
Neutral to full flow	1.8 s	0.8 s	0.3 s
Full flow to neutral	1.2 s	0.5 s	0.2 s

Control Options

Automotive Control (AC)

The H1 **A**automotive **C**ontrol (AC) is an electric NFPE Control with an integrated micro-controller, installed on the pump. The integrated micro-controller enhanced control performance with a flexible, configurable control scheme for an entire single path propel transmission. It can be used in combination with fixed and variable displacement hydraulic-motors. With the pre-installed application software and easily changeable control parameters, it is possible to tailor the vehicle's driving behavior to the individual requirements of the customer.



The H1 Automotive Control is divided into 2 systems:
- AC-1
- AC-2

AC-2 is an extension of AC-1 that features an integrated pump swash plate angle sensor and software enabled functions such as Swash Plate Control.

Mode types

The application software provides 3 different hydrostatic propel methods, defined as mode types, which can be used individually.
- **Automotive Load dependent** (torque controlled) driving behavior. Setpoint for the drive curve is the engine rpm.
- **Non-Automotive Load independent** (speed controlled) driving mode. Setpoint for the drive curve is a Joystick or drive pedal signal, independent of the engine rpm. The best performance will achieved with an AC-2 Swash Plate Angle Sensor.
- **Creep-Automotive Load dependent** (torque controlled) driving behavior (like Automotive). Setpoint for the drive curve is the engine rpm. The setpoint can be reduced by the creep potentiometer if a high engine rpm in combination with low vehicle speed is needed.

Basic functions

- Four selectable system modes, selectable via switch.
- Individual settings for forward and reverse driving direction (4 x 2 curves).
- Independent pump and hydraulic-motor profiling and ramping for each mode.
- Electric drive pedal connection
- Electronic inching function without separate control valve
- Electric creep mode potentiometer

Control Options

- Configurable System Mode & Direction change
- Load independent pump displacement control with integrated Swash Plate Angle Sensor (AC-2)
- Hydraulic-motor displacement control including brake pressure defeat function

Performance functions

- ECO fuel saving mode with automatic reduction of the engine speed during transport (Cruise control)
- Vehicle constant speed drive control
- Vehicle speed limitation
- Dynamic brake light, automatic park brake, reverse buzzer and status LED outputs
- Vehicle speed controlled output function.
- Temperature compensation for predictable performance
- Advanced CAN J1939 interface for the information exchange with the vehicle control system

Protection and safety functions

- Safety controlled vehicle start protection with engine speed check, battery check and FNR must be in neutral, etc..
- Operator presence detection
- Hydraulic system overheat and low-temperature protection
- Hydraulic motor over speed protection
- Park brake test mode for roller applications to fulfill SAE J1472 / EN500-4.
- SIL2 compliant

Engine control and protection

- CAN J1939 engine interface
- Engine speed control via drive pedal with safety controlled monitoring function
- Engine antistall protection
- Engine over speed protection during inching
- Engine speed dependent Retarder control
- Engine cold start protection

Installation features

- Factory calibration for hysteresis compensation.
- Starting current adjustment in the factory
- Pre-installed application software and parameter files

For more information, see *Automotive Control for H1 Single Pumps Technical Information*, **BC152986482596**.

Control Options

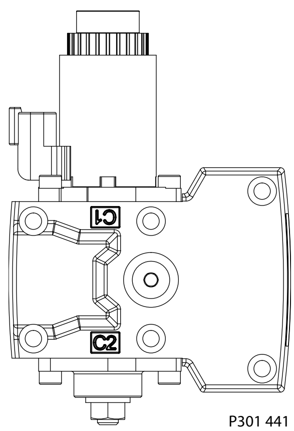
Fan Drive Control (FDC)

The Fan Drive Control (**FDC**) is a non-feedback control in which an electrical input signal activates the proportional solenoid that ports charge pressure to either side of the pump servo cylinder. The single proportional solenoid is used to control pump displacement in the forward or reverse direction.

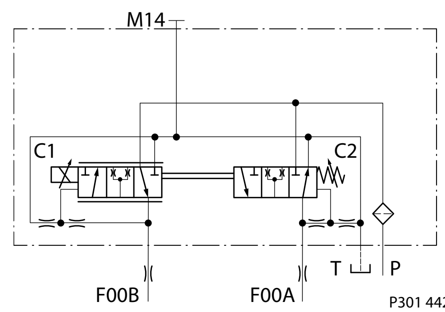
The control spool is spring biased to produce maximum forward pump displacement in the absence of an electrical input signal. Based on the spring bias spool default forward flow for a CW rotation pump is out of port B while default forward flow for a CCW rotation pump is out of port A.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

FDC control



FDC schematic



The pump should be configured with 0.8 mm control orifices to provide slowest response and maximize system stability. Additionally, pressure limiter (PL) valves are used to limit maximum fan trim speed in both (forward and reverse) directions.

H1 pumps with FDC will be delivered from factory with nominal pressure limiter setting of 150 bar [2175 psi]. The PL must be re-adjusted to ensure that the fan reaches the desired fan speed to satisfy the cooling needs of the system. HPRV setting must be always at least 30 bar [435 psi] higher than PL setting.

For more information necessary to properly size and configure a hydraulic fan drive system, see *Hydraulic Fan Drive Design Guidelines* **AB152886482265**.

Warning

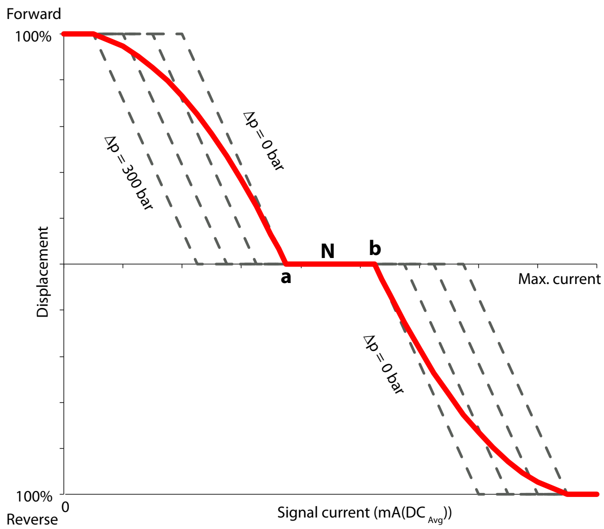
Use in other systems could result in unintended movement of the machine or it's elements. Loss of the input signal to this control will cause the pump to produce maximum flow.
The FDC is for Fan Drive systems only!

Due to the fail-safe functionality of the FDC control the pump will stroke to max. displacement in case the input signal to the pump control and the Diesel engine will be switched off at the same time. In this situation a low loop event can occur which may damage the pump. Therefore, it's strictly recommended to keep the input signal to the pump control alive while switching off the engine.
For further information please contact your Danfoss representative.

Control Options

Control Signal Requirements, FDC 045/053

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash plate angle as system pressure increases. A typical response characteristic is shown in the accompanying graph below:



a – Forward threshold

b – Reverse threshold

N – Neutral override current

Control current requirements

Voltage*	a	N	b	Pin config.
12 V_{DC}	780 mA	1100 mA	1300 mA	any order
24 V_{DC}	400 mA	550 mA	680 mA	

* Factory test current, for fan movement expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Control Options

Single Pump Output Flow Direction

Pump output flow direction vs. control signal

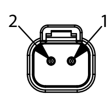
Shaft rotation		**ClockWise**			**CounterClockWise**		
Control Logic	**12 V**	**0-780 mA**	**1100 mA**	**1300-1800 mA**	**0-780 mA**	**1100 mA**	**1300-1800 mA**
	24 V	**0-400 mA**	**550 mA**	**680-920 mA**	**0-400 mA**	**550 mA**	**680-920 mA**
Port A		in	no flow	out	out	no flow	in
Port B		out	no flow	in	in	no flow	out
Servo port pressurized		M5	n/a	M4	M5	n/a	M4

Warning

Loss of input signal to the control will cause the pump to produce maximum flow.

Connector

Connector DEUTSCH, 2-pin



Description	**Quantity**	**Order data**
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, FDC 045/053

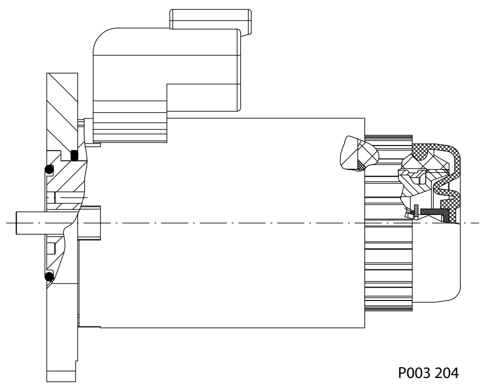
Stroking direction	**0.8 mm [0.03 in] orifice**
Full flow to neutral	1.9 s
Full forward flow to full reverse flow	2.8 s

Control Options

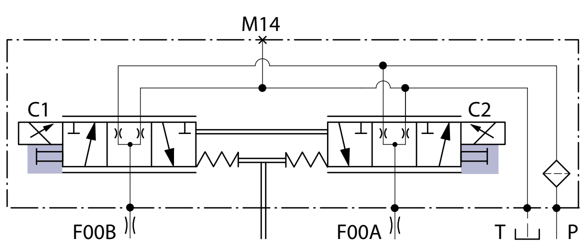
Manual Override (MOR)

All controls are available with a manual override functionality, either as a standard or as an option for temporary actuation of the control to aid in diagnostics.

Control with manual override



MOR schematic (EDC control shown)



Feedback from swash plate.

The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke. The MOR should be engaged anticipating a full stroke response from the pump.

An o-ring seal is used to seal the MOR plunger where initial actuation of the function will require a force of 45 N to engage the plunger. Additional actuation typically require less force to engage the MOR plunger.

Proportional control of the pump using the MOR should not be expected.

Warning

Unintended MOR operation will cause the pump to go into stroke; *example:* vehicle lifted off the ground. The vehicle or device must always be in a safe condition when using the MOR function.

Refer to control flow table for the relationship of solenoid to direction of flow.

Control Options

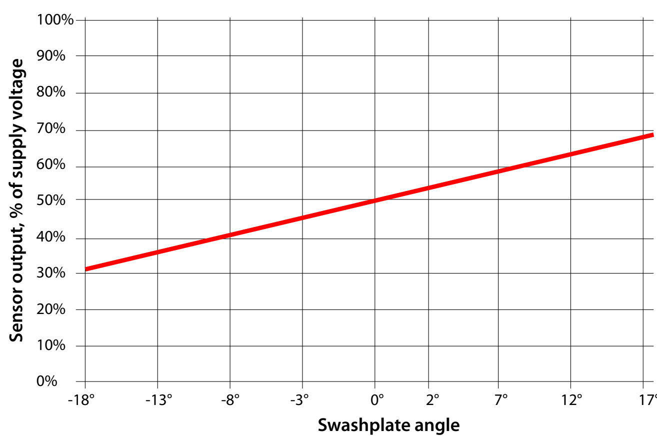
Swashplate angle sensor for EDC controls

The angle sensor detects the swash plate position with an accuracy dependent upon the calibration effort done for the application and direction of rotation from the neutral position. At minimum the sensor can be used for forward, neutral and reverse (FNR) detection.

The sensor works on the hall-effect technology. The implemented technology is based on a measurement of the magnetic field direction in parallel to the chip surface. This field direction is converted to a voltage signal at the output.

Enhanced calibration of the non-linear behavior leads to more exact calculation of the pump swashplate angle. The 4-pin DEUTSCH connector is part of the sensor housing. The swashplate angle sensor is available for all EDC controls for 12 V and 24 V.

Swashplate angle vs. output of supply voltage



Warning

Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

Contact your Danfoss representative in case the angle sensor will be used for safety functions.

Swash plate angle sensor parameters (EDC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.5 V_{DC}	5 V_{DC}	5.5 V_{DC}
Supply protection	–	–	18 V_{DC}
Pump neutral output (% of supply voltage)	–	50%	–
Working range (swash plate angle)	–18°	–	18°
Required supply current	–	–	30 mA
Output current signal	–	9 mA	11 mA
Working temperature	–40 °C	80 °C	115 °C

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector
EMC Immunity	ISO 11452-2	100 V/m

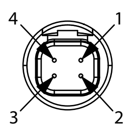
Control Options

Calibration of the sensor output within the software is mandatory. Vehicle neutral thresholds in the software (±0.5°) are vehicle dependent and must consider different conditions, example: system temperature, system pressure and/or shaft speed.

For safety function: If the sensor fails (invalid signal <10% or >90% of supply voltage), it must be sure that the ECU will go into a diagnostic mode and shift into limited mode in order for the driver to take the full control or the mechanical breaks should be activated. Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

H1P Swash Plate Angle Sensor Connector

Connector DEUTSCH, 4-pin



1 Ground (GND)

2 Not connected

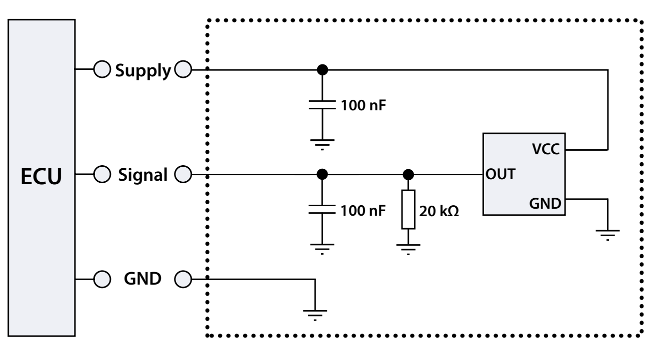
3 Output signal 1 (SIG 1)

4 Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Interface with ECU (EDC)

Interface with ECU diagram

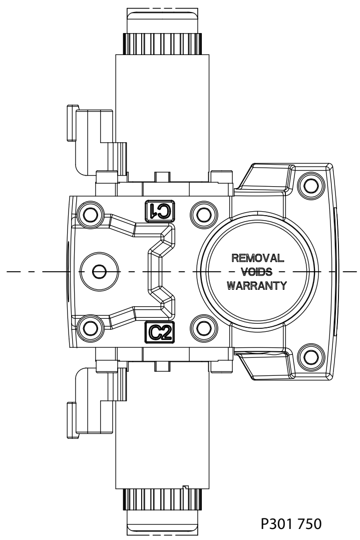


Control Options

Swash Plate Angle Sensor for NFPE and AC2 Controls

The angle sensor detects the swash plate angle position and direction of rotation from the zero position. The swash angle sensor works on the AMR sensing technology. Under the saturated magnetic field, the resistance of the element varies with the magnetic field direction.

The output signal give a linear output voltage for the various magnet positions in the sensing range.

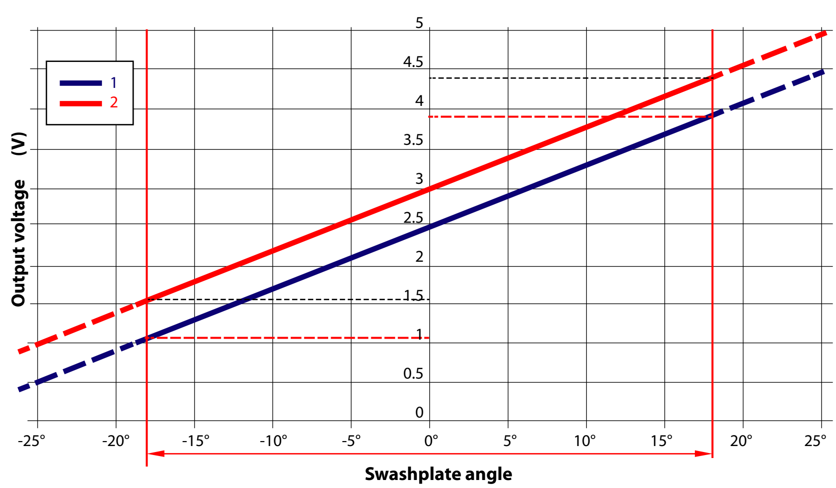


P301 750

Swash Plate Angle Characteristic

The volumetric losses depend on pump max. displacement, actual displacement, speed, delta pressure, viscosity and temperature.

Swashplate angle vs. output voltage (calibrated at 50 °C)



1. Signal 1 (nominal)
2. Signal 2 (redundant)

The displacement can be calculated by:

$$V = \frac{\tan\alpha \cdot V}{\tan 18°} \ (\text{cm}^3)$$

The corresponding flow is:

$$Q = \frac{V \cdot n \cdot \eta_{vol}}{1000} \ (\text{l/min})$$

Control Options

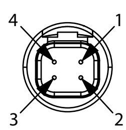
Swash Plate Angle Sensor Parameters (NFPE/AC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.75 V	5 V	5.25 V
Supply protection	–	–	28 V
Supply current	–	22 mA	25 mA
Output current (Signal 1, 2)	–	0.1 mA	–
Short circuit output current to supply or GND[1)]	–	–	7.5 mA
Sensitivity	70.0 mV/deg	78.0 mV/deg	85.8 mV/deg
Working range (swash plate angle)	−18°	0°	18°
Correlation between signals 1 and 2[2)]	475 mV	500 mV	525 mV

[1)] Up to duration of 2.5 seconds at 25°C

[2)] Signal 1 (nominal) is lower than signal 2 (redundant)

H1P Swash Plate Angle Sensor Connector (NFPE)



1 Ground (GND)

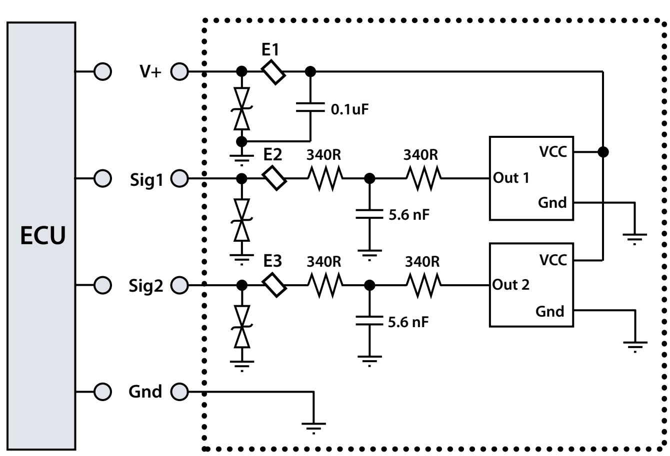
2 Output Signal 2 (SIG 2) – Secondary (redundant)

3 Output signal 1 (SIG 1)

4 Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Interface with ECU (NFPE)



Minimum recommended load resistance is 100 kΩ.

Control Options

Control Cut Off Valve (CCO)

The H1 pump offers an optional control cut off valve integrated into the control. All EDC, NFPE and MDC controls are available with a CCO valve. This valve will block charge pressure to the control, allowing the servo springs to de-stroke both pumps regardless of the pump´s primary control input.

There is also a hydraulic logic port, X7, which can be used to control other machine functions, such as spring applied pressure release brakes. The pressure at X7 is controlled by the control cut off solenoid. The X7 port would remain plugged if not needed.

In the normal (de-energized) state of the solenoid charge flow is prevented from reaching the controls. At the same time the control passages and the X7 logic port are connected and drained to the pump case. The pump will remain in neutral, or return to neutral, independent of the control input signal. Return to neutral time will be dependent on oil viscosity, pump speed, swashplate angle, and system pressure.

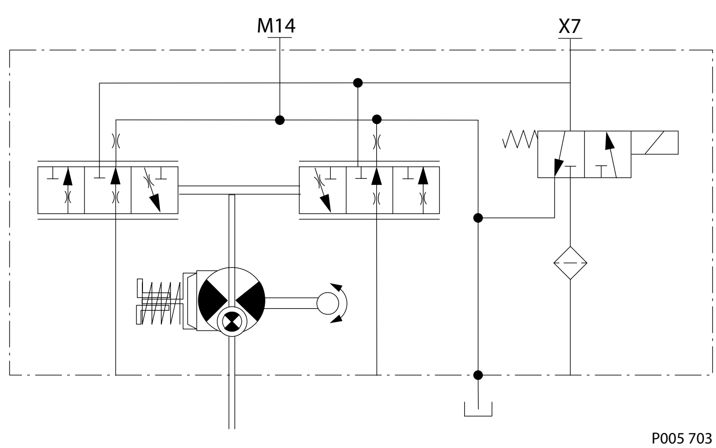
When the solenoid is energized, charge flow and pressure is allowed to reach the pump control. The X7 logic port will also be connected to charge pressure and flow.

The solenoid control is intended to be independent of the primary pump control making the control cut off an override control feature. It is however recommended that the control logic of the CCO valve be maintained such that the primary pump control signal is also disabled whenever the CCO valve is de-energized. Other control logic conditions may also be considered.

The CCO valve is available with 12 V or 24 V solenoid.

The response time of the unit depends on the control type and the used control orifices.

CCO schematic (MDC shown)



Brake gauge port with MDC

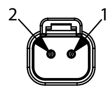
Caution

It is not recommended to use brake port for any external flow consumption to avoid malfunction of CCO function.

Control Options

CCO Connector (MDC)

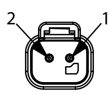
Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

H1P CCO Connector (EDC, NFPE)

Connector CCO DEUTSCH, 2-pin with key C



Description	Quantity	Order number
Mating connector	1	DEUTSCH DT06-2S-C015
Wedge lock	1	DEUTSCH W2SC-P012
Socket contact	4	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	11212714

CCO solenoid data

Nominal supply voltage		12 V	24 V
Supply voltage	Maximum	14.6 V	29 V
	Minimum	9.5 V	19 V
Bi-directional diode cut off voltage		28 V	53 V
Nominal coil resistance at 20 °C		10.7 Ω	41.7 Ω
Supply current	Maximum	850 mA	430 mA
	Minimum	580 mA	300 mA
PWM frequency	Range	50 – 200 Hz	
	Preferred	100 Hz	
Electrical protection class		IP67 / IP69K with mating connector	

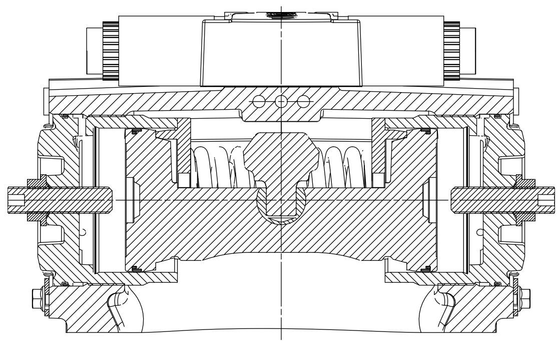
CCO solenoids are design for battery voltage application within the voltage range in the table above, in consideration of a wide range of environmental temperature common for known hydraulic applications. Closed loop PWM current supply can be also applied and is helpful in case that the voltage range is exceeded, or ambient temperature could rise in an unusual manner.

Control Options

Displacement Limiter

H1 pumps are designed with optional mechanical displacement (stroke) limiters factory set to max. displacement. The maximum displacement of the pump can be set independently for forward and reverse using the two adjustment screws to mechanically limit the travel of the servo piston down to 50% displacement.

Adjustments under operating conditions may cause leakage. The adjustment screw can be completely removed from the threaded bore if backed out to far.



P003 266

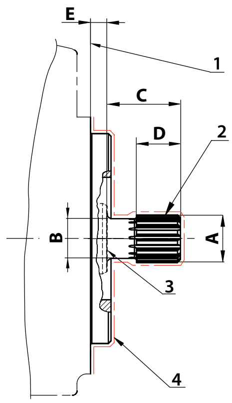
H1P 045/053 Displacement Change (approximately)

Parameter	Size 045	Size 053
1 turn of displacement limiter screw	5.1 cm^3 [0.31 in^3]	6.0 cm^3 [0.37 in^3]
Internal wrench size	4 mm	
External wrench size	13 mm	
Torque for external hex seal lock nut	23 N•m [204 lbf•in]	

For more information, see *H1 Axial Piston Pumps, Service Manual,* **AX152886482551**, the section “Displacement Limiter Adjustment”.

Dimensions and Data

H1P 045/053 Input Shaft Option G1 (SAE C, 14 teeth)



1. Surface of mounting flange 101 – 2 per ISO 3019-1 (SAE B); to be paint free
2. **Spline Data:** 14 teeth, Pressure angle: 30°, Pitch: 12/24, Ø29.633 [1.167]; Fillet root side fit per ANSI B92.1b, Class 6e
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø31.58 ±0.09 [1.243 ±0.004]	Ø25.72 ±0.12 [1.024 ±0.005]	48.0 ±0.68 [1.89 ±0.003]	30.6 ±0.15 [1.205 ±0.006]	8.0 ±0.8 [0.315 ±0.03]

1) Minimum active spline length for the specified torque ratings.

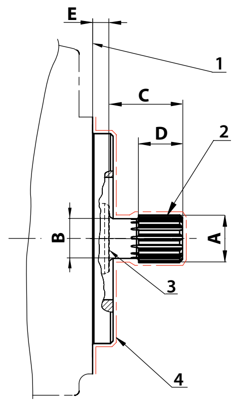
Torque rating

Rated torque	Maximum torque
534 N•m [4720 lb•in]	592 N•m [5240 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P 045/053 Input Shaft Option G4 (SAE B, 13 teeth)



1. Surface of mounting flange 101 – 2 per ISO 3019-1 (SAE B); to be paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 16/32, Ø20.6375 [0.813]; Fillet root side fit per ANSI B92.1b, Class 6e
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø22.085 ±0.09 [0.869 ±0.004]	Ø18.5 ±0.12 [0.728 ±0.005]	33.0 ±0.68 [1.3 ±0.003]	16.5 ±0.15 [0.65 ±0.006]	8.0 ±0.8 [0.315 ±0.03]

[1)] Minimum active spline length for the specified torque ratings.

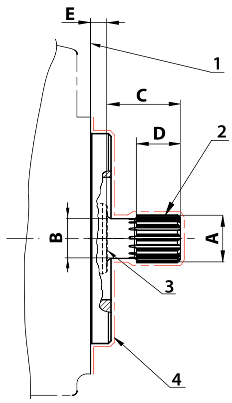
Torque rating

Rated torque	Maximum torque
180 N•m [1600 lbf•in]	222 N•m [1970 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P 045/053 Input Shaft Option G5 (SAE B-B, 15 teeth)



1. Surface of mounting flange 101 – 2 per ISO 3019-1 (SAE B); to be paint free
2. **Spline Data:** 15 teeth, Pressure angle: 30°, Pitch: 16/32, Ø23.813 [0.938]; Fillet root side fit per ANSI B92.1b, Class 6e
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1]	E
Ø25.23 ±0.09 [0.993 ±0.004]	Ø21.98 ±0.12 [0.865 ±0.005]	38.0 ±0.68 [1.496 ±0.003]	22.0 ±0.15 [0.866 ±0.006]	8.0 ±0.8 [0.315 ±0.03]

[1] Minimum active spline length for the specified torque ratings.

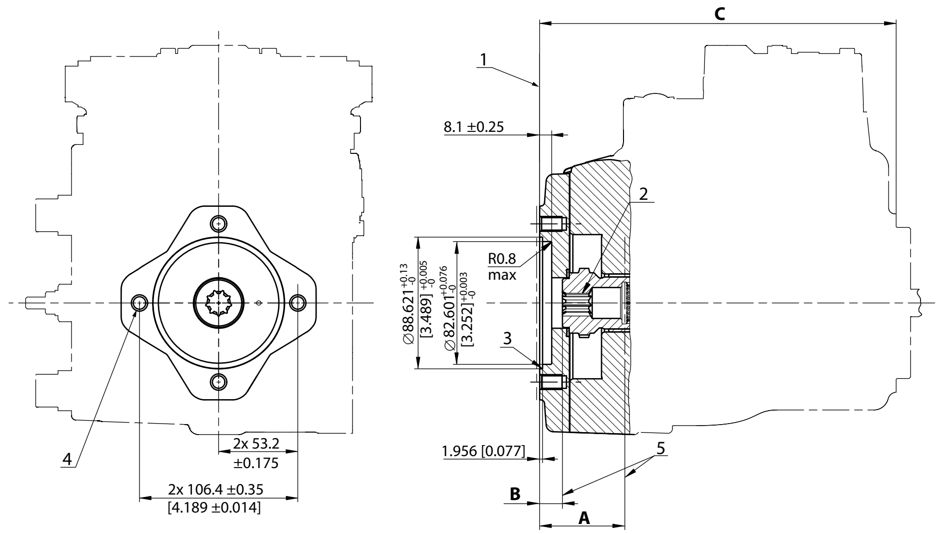
Torque rating

Rated torque	Maximum torque
277 N•m [2450 lbf•in]	370 N•m [3270 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth)



1. Auxiliary mounting pad for mating flange 82-2 per ISO 3019-1 (SAE A); Paint free
2. **Spline Data:** 11 teeth, Pressure angle: 30°, Pitch: 16/32, Ø17.463 [0.688]; Fillet root side fit per ANSI B92.1b, Class 7e
3. O-ring seal required; Ref. Ø82.22 ID x 2.62, cross section
4. Thread: M10x1.5-6H; 15 [0.59] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Dimensions and torque

A	B	C	Max. Torque
57.2 min.; Shaft clearance	14.5 min.; Shaft clearance	239.6 ±2.5 [9.43 ±0.003]	296 N•m [2620 lbf•in]

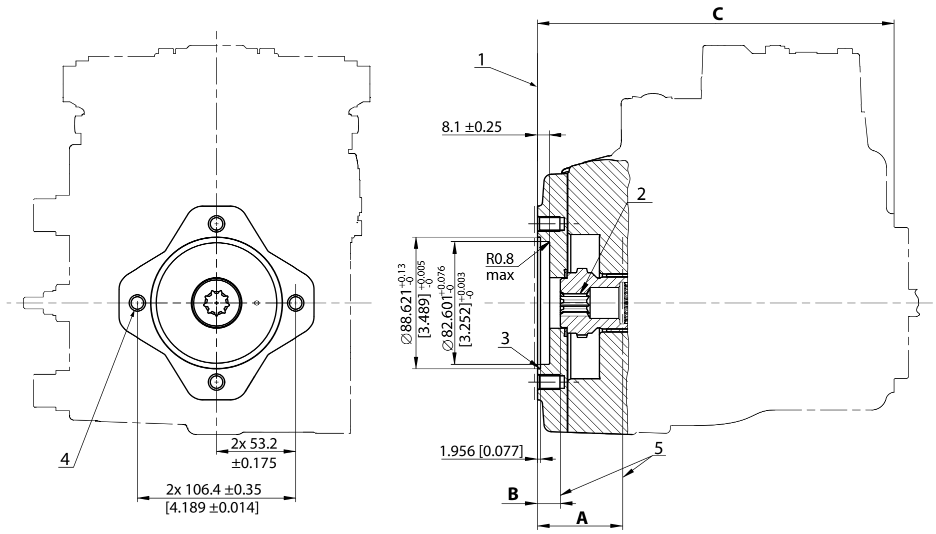
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth)



1. Auxiliary mounting pad for mating flange 82-2 per ISO 3019-1 (SAE A); Paint free
2. **Spline Data:** 9 teeth, Pressure angle: 30°, Pitch: 16/32, Ø14.288 [0.563]; Fillet root side fit per ANSI B92.1b, Class 7e
3. O-ring seal required; Ref. Ø82.22 ID x 2.62, cross section
4. Thread: M10x1.5-6H; 15 [0.59] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Dimensions and torque

A	B	C	Max. Torque
57.2 min.; Shaft clearance	14.5 min.; Shaft clearance	239.6 ±2.5 [9.43 ±0.003]	162 N•m [1430 lbf•in]

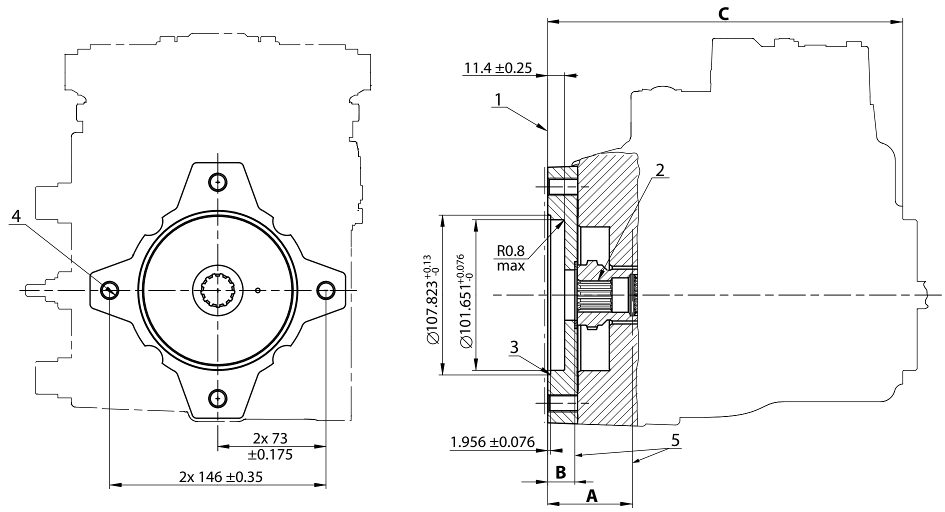
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 16/32, Ø20.638 [0.813]; Fillet root side fit per ANSI B92.1-1996, Class 6
3. O-ring seal required; Ref. Ø94.92 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 19.75 [0.778] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Bolt length > 19.75 mm could result in a leak or damage to the unit.

Dimensions and torque

A	B	C	Max. Torque
57.2 min.; Shaft clearance	14.5 min.; Shaft clearance	239.6 ±2.5 [9.43 ±0.003]	395 N•m [3500 lbf•in]

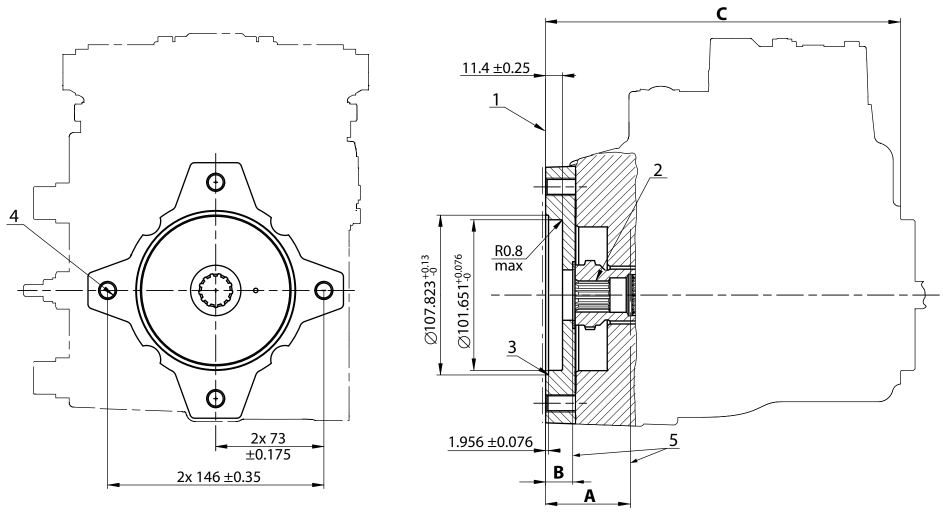
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 15 teeth, Pressure angle: 30°, Pitch: 16/32, Ø23.813 [0.938]; Fillet root side fit per ANSI B92.1b, Class 7e
3. O-ring seal required; Ref. Ø94.92 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 19.75 [0.778] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Bolt length > 19.75 mm could result in a leak or damage to the unit.

Dimensions and torque

A	B	C	Max. Torque
57.2 min.; Shaft clearance	14.5 min.; Shaft clearance	239.6 ±2.5 [9.43 ±0.003]	405 N•m [3580 lbf•in]

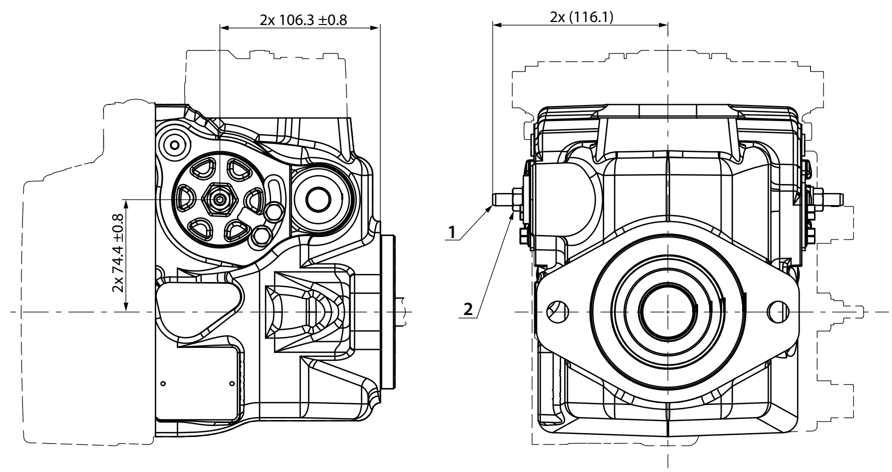
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Displacement Limiter, Option B and D



1. Displacement limiter screw (2x)
2. Displacement limiter seal nut (2x)

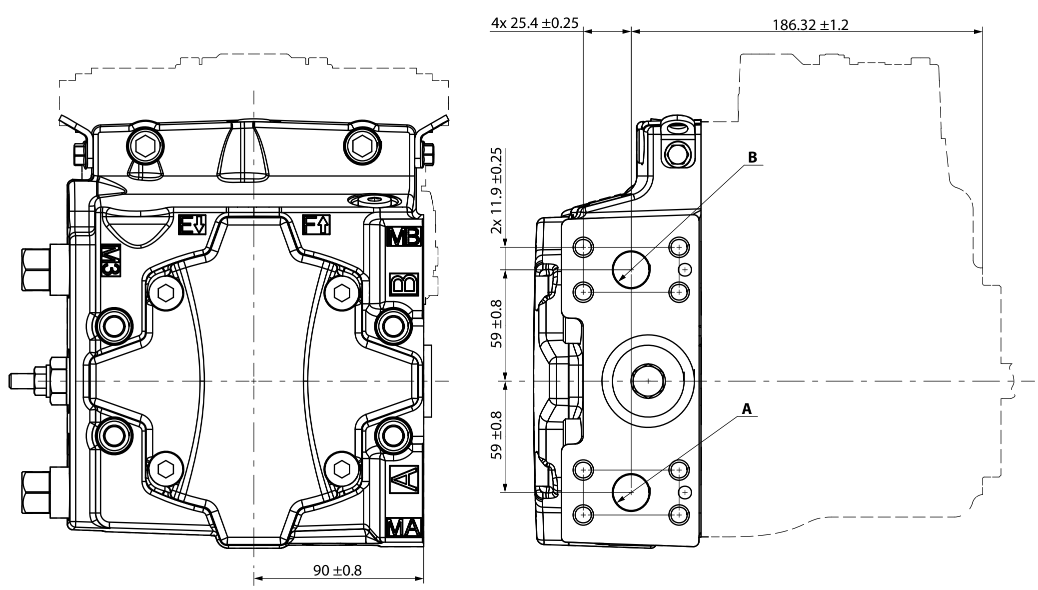
Wrench size, torque

Wrench size for DL screw	Wrench size for DL seal nut	Torque
4 internal hex	13 external hex	24 N•m [18 lb•ft]

Please contact Danfoss representative for specific installation drawings.

H1P 045/053 End Cap, Options D6, D8, F2, F3

End cap, twin port Code 62, metric 4-bold flange

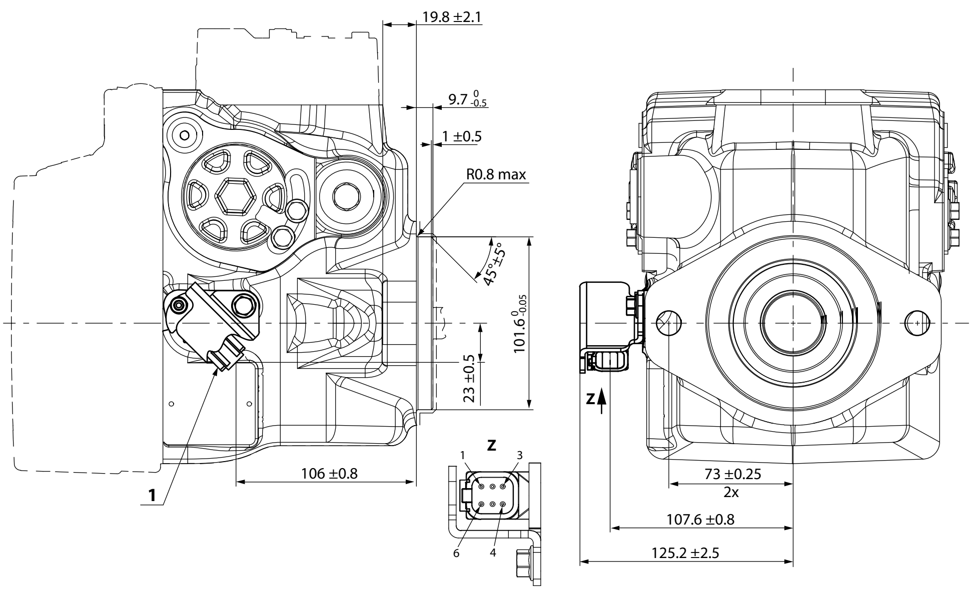


A/B System port Ø19 – 450 bar; Split flange boss per ISO 6162
M10x1.5; 18 full thread depth

Please contact Danfoss representative for specific installation drawings.

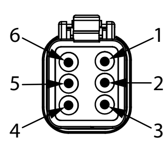
Dimensions and Data

Speed and temperature sensor, option H (for mounting flange option K)



1. Speed sensor connector DEUTSCH DTM04-6P, paint free

Connector DEUTSCH, 6-pin



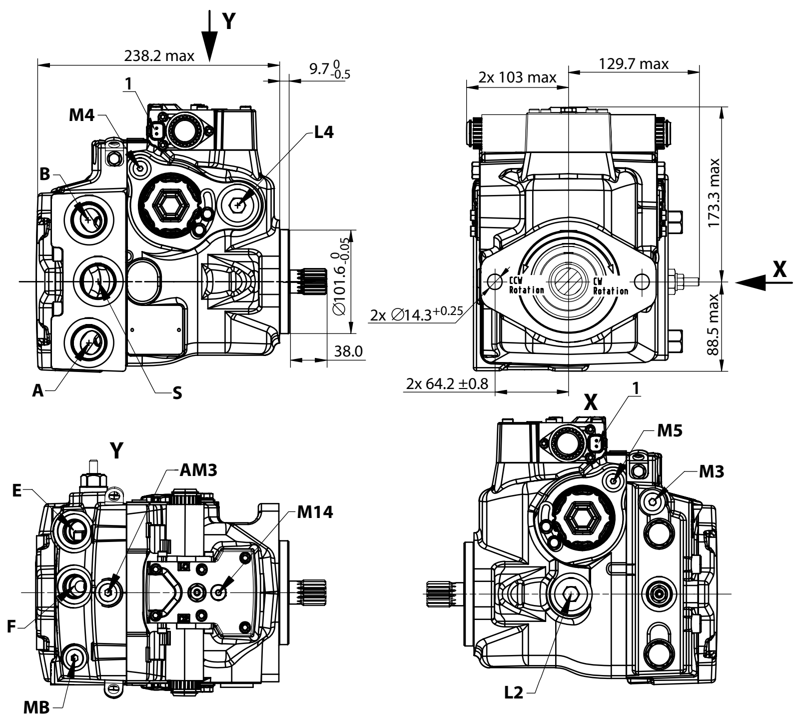
Pinout:

1. Speed signal 1
2. Direction signal
3. Speed signal 2
4. Ground (GND)
5. Supply
6. Temperature

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Single Pump Ports



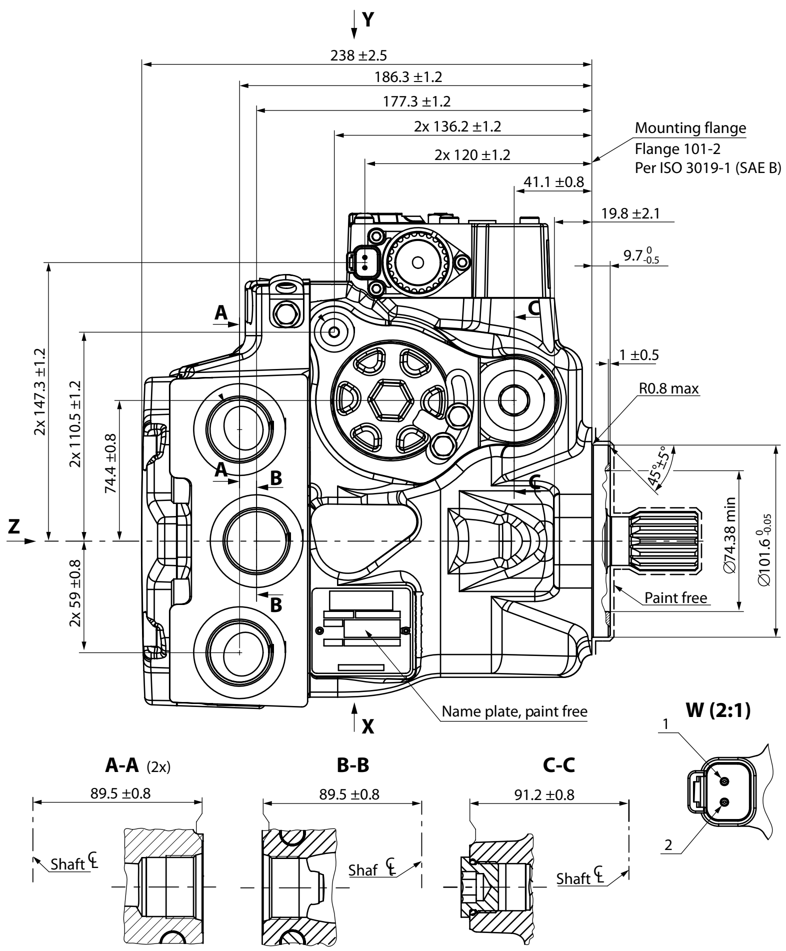
Ports per ISO 11 926-1

Port	Description	Size
A, B	System ports	$1\frac{5}{16}$–12
L2, L4	Case drain ports	$1\frac{1}{16}$–12
MA, MB	System **A/B** gauge ports	$\frac{9}{16}$–18
E/F	Charge filtration ports	$\frac{7}{8}$–14
M3, AM3	Charge pressure port (AM3-Alternate)	$\frac{9}{16}$–18
M4, M5	Servo gauge port	$\frac{7}{16}$–20
M14	Case gauge port (EDC, FNR, NFPE)	$\frac{7}{16}$–20
S	Charge inlet port	$1\frac{5}{16}$–12
1	Connector DEUTSCH DT04-2P, to be paint free	

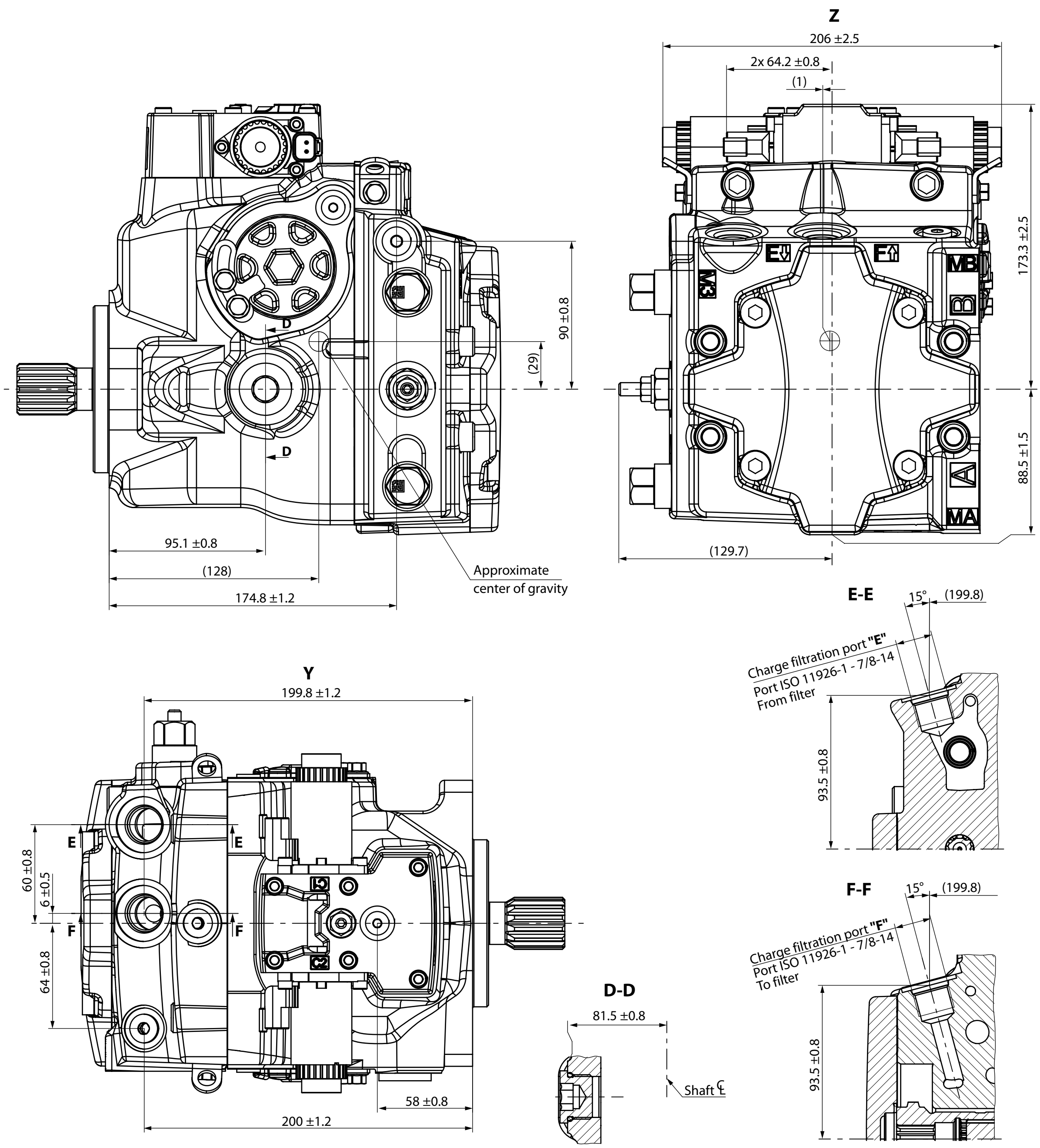
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

H1P Dimensions

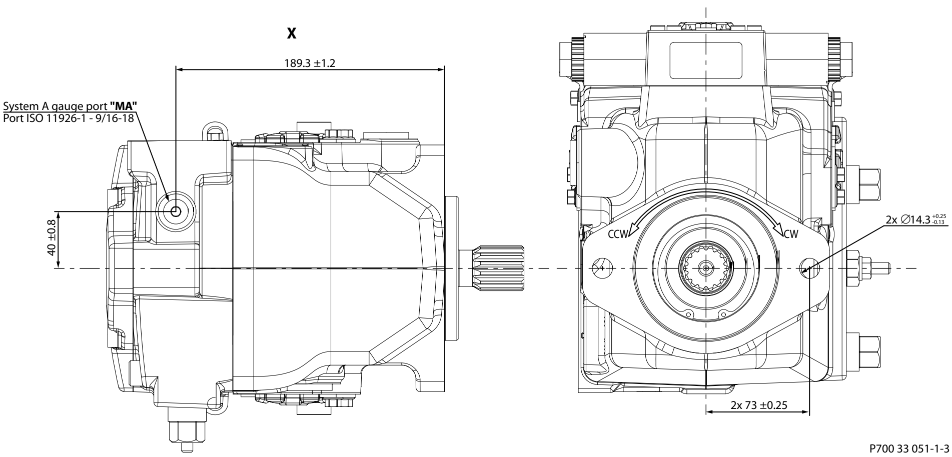


Dimensions and Data



1 — Approximate center of gravity

Dimensions and Data



1 — Other side screw head space

Caution

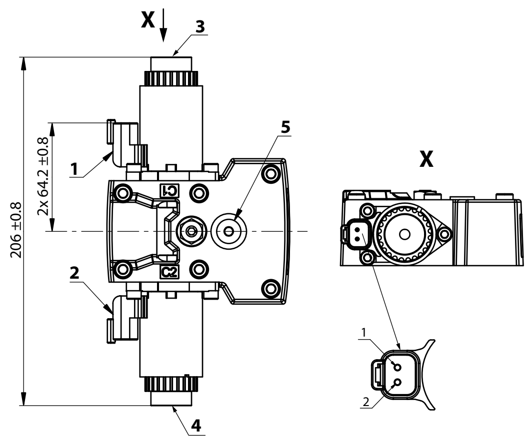
M12X1.75 or ½" screws with hardened washer (ASTM F436M or ISO 7089 300HV) must be used to mount the pump. Using M14 screws may cause issues when mounting.

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Controls

EDC Options A2 and A3 (12/24 V)



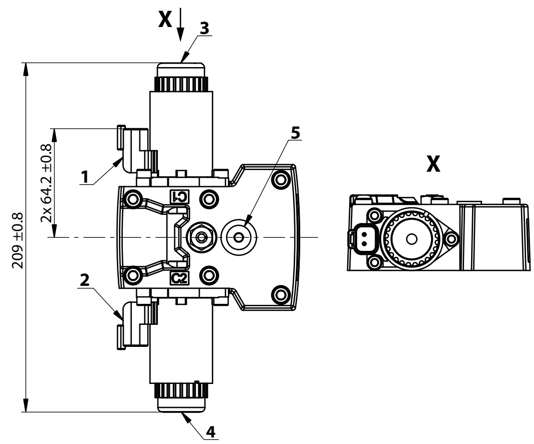
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

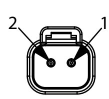
EDC with MOR, Options A4 and A5 (12/24 V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}\!/_{16}$–20

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

*Connector **C1/C2**: DEUTSCH DTM04-2P*

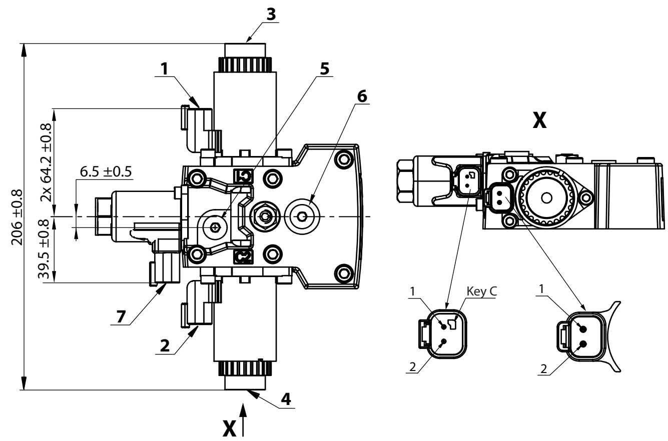


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

EDC with CCO (key C), Options E7 and E8 (12/24 V)



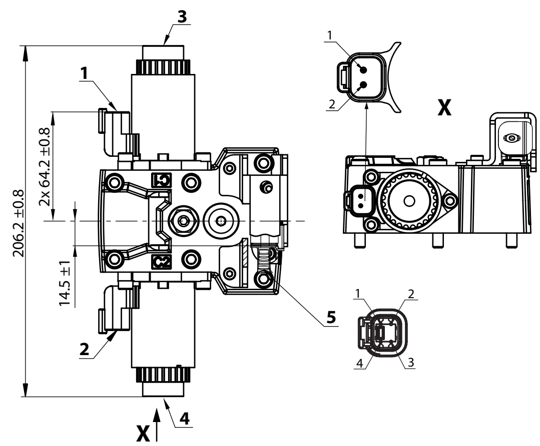
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Brake gauge port **X7** per ISO 1926-1: $^7/_{16}$–20
6. Case gauge port **M14** per ISO 1926-1: $^7/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

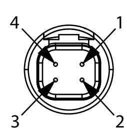
Dimensions and Data

EDC with ASNSR, Options: H2 and H3 (12/24 V)



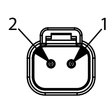
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Angle sensor connector **S2** DEUTSCH DT04-4P, paint free

Connector DEUTSCH, 4-pin



4-pin assignment:
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connector C1/C2: DEUTSCH DTM04-2P

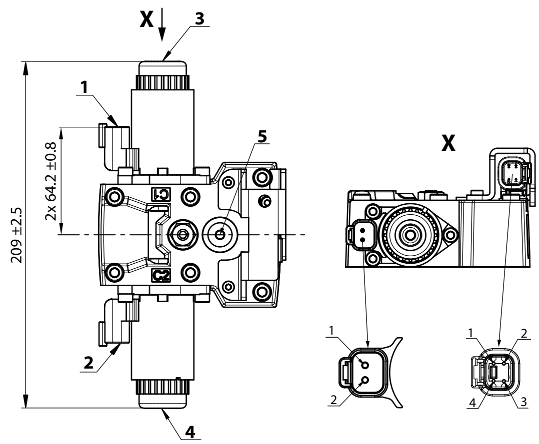


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

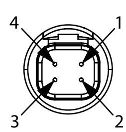
Dimensions and Data

EDC with MOR and ASNSR, Options H6 and H7 (12/24 V)



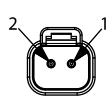
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Connector DEUTSCH, 4-pin



4-pin assignment:
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connector C1/C2: DEUTSCH DTM04-2P

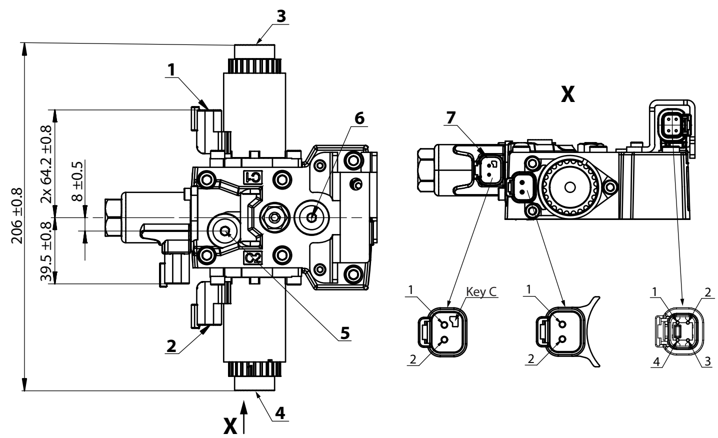


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

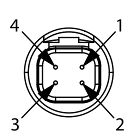
EDC with CCO and ASNSR, Options H8 and H9 (12/24 V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
6. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

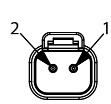
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector DEUTSCH, 4-pin



Angle sensor connector S2: DEUTSCH DTM04-4P
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connectors C1/C2/C4: DEUTSCH DTM04-2P

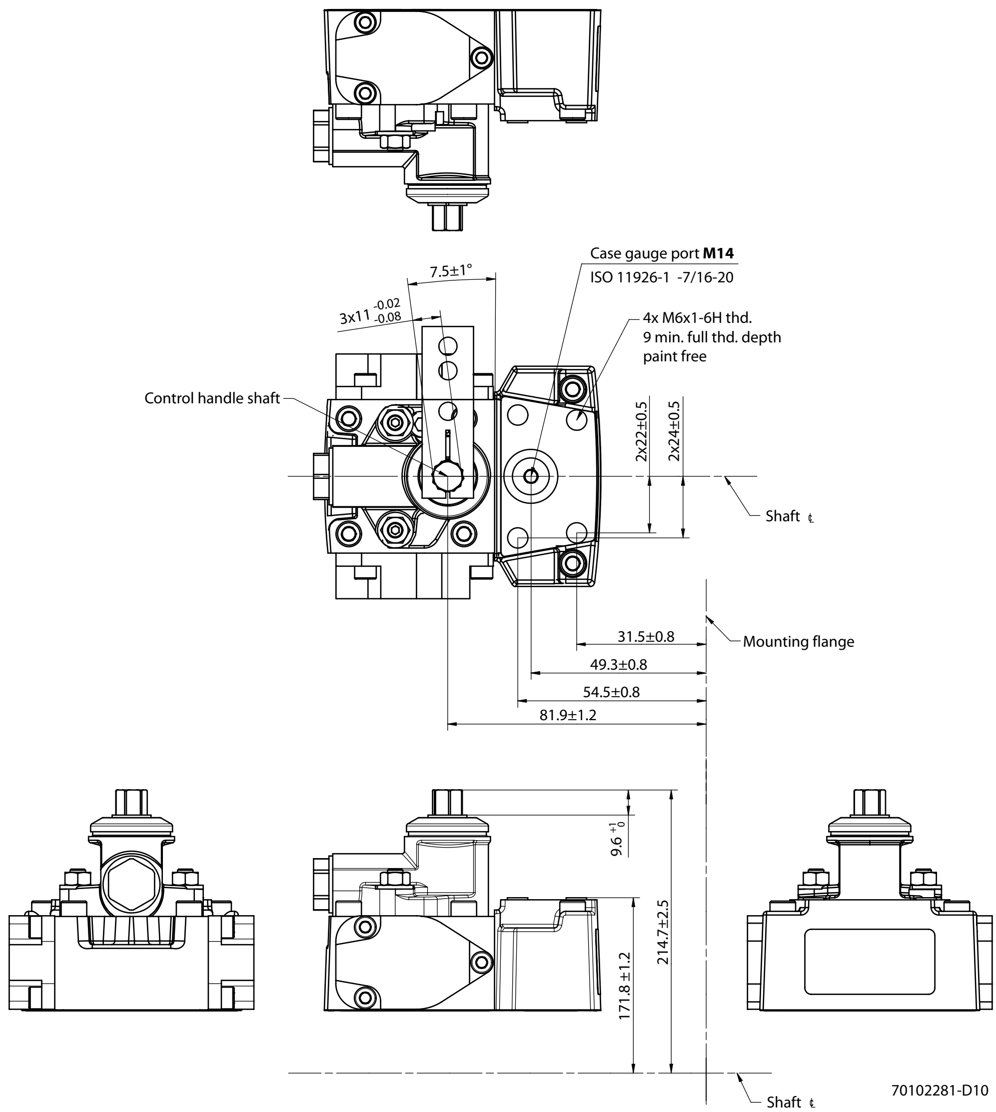


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

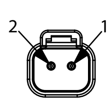
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC Option: M1



Connector DEUTSCH, 2-pin

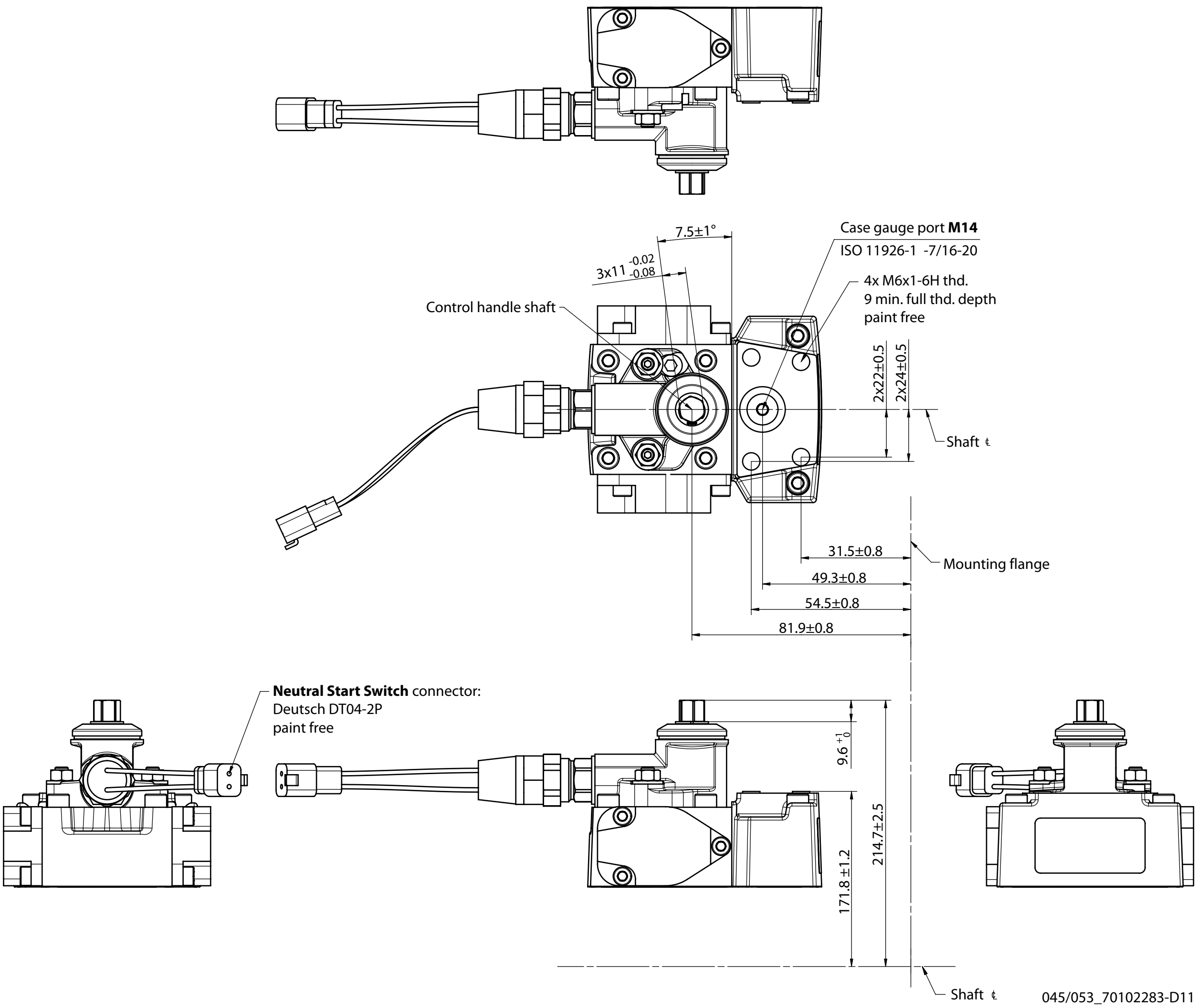


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

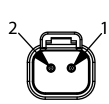
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with Neutral Start Switch Option: M2



Connector DEUTSCH, 2-pin

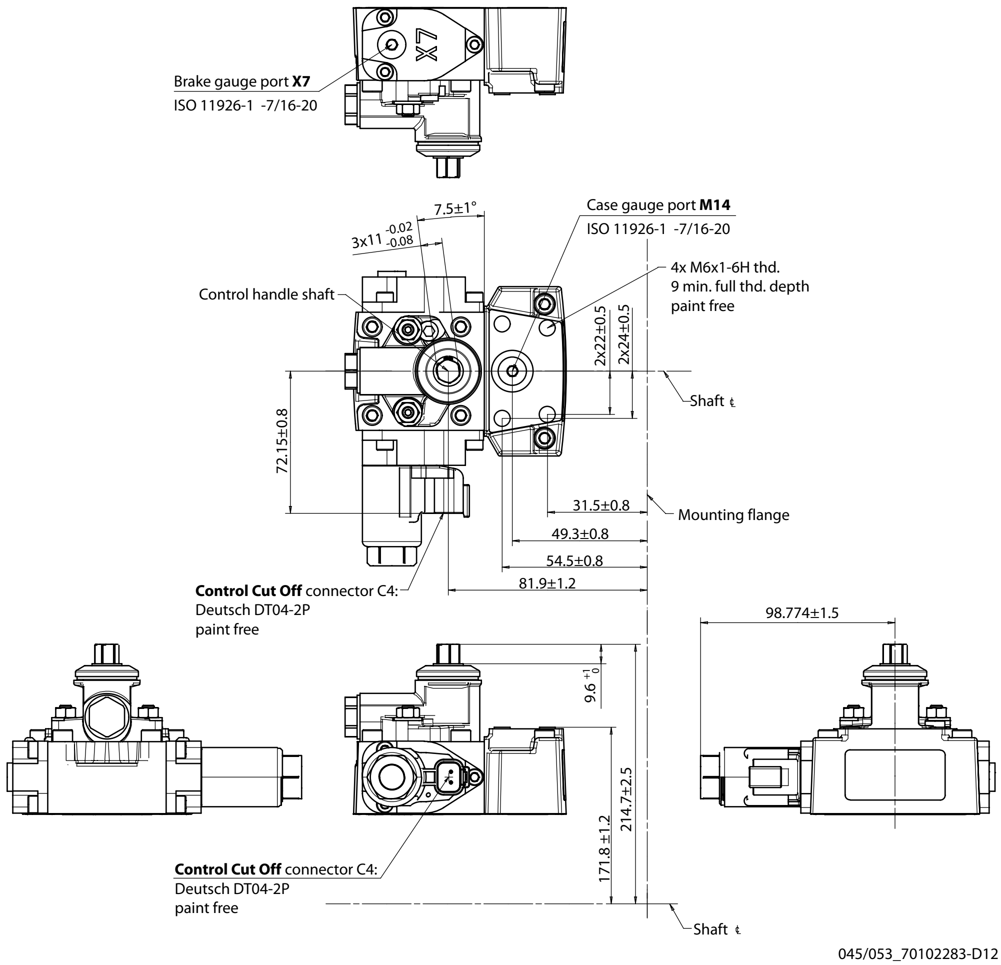


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

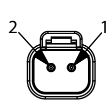
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with CCO, Options: M3, M4



Connector DEUTSCH, 2-pin

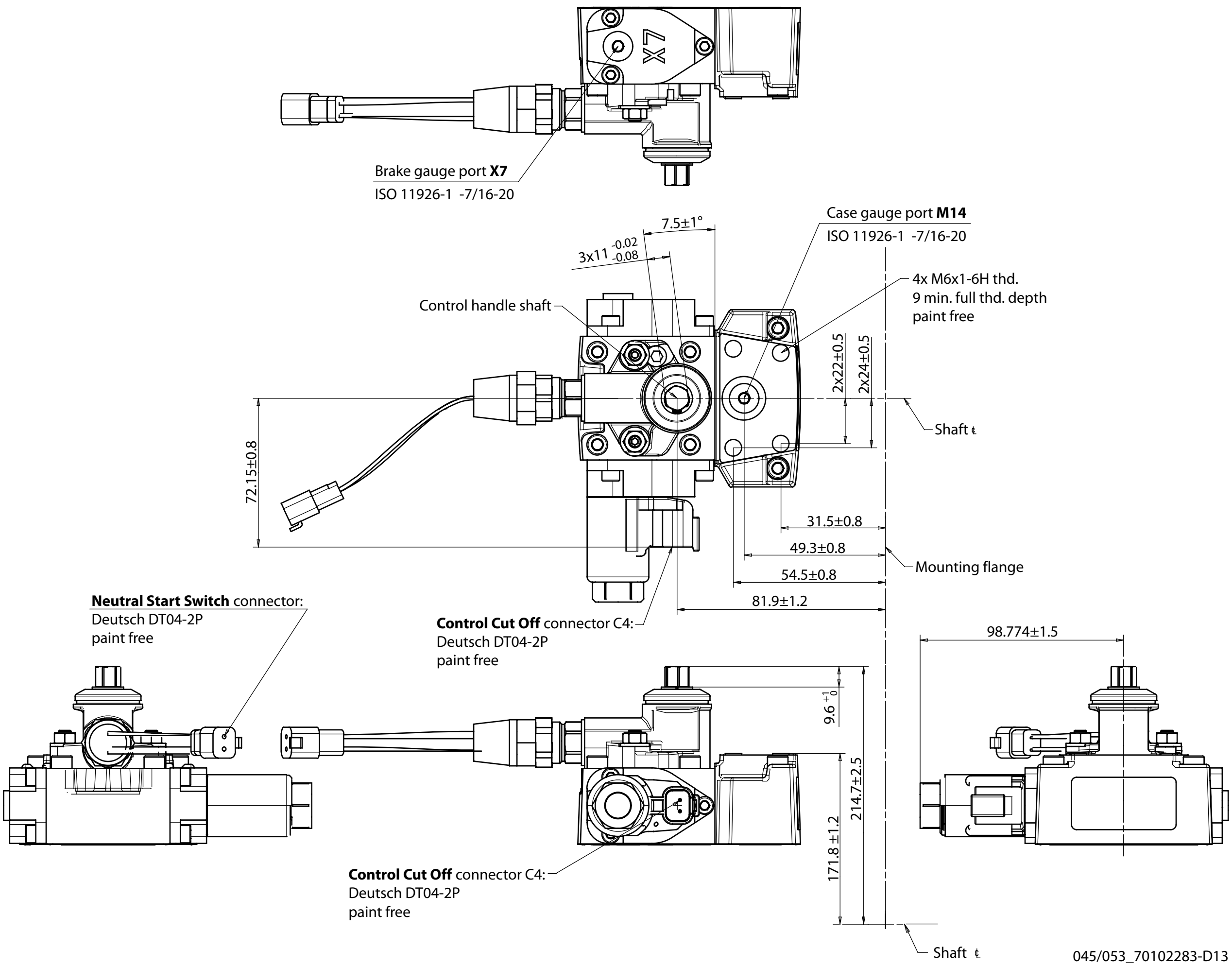


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

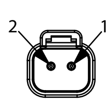
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with NSS and CCO Options: M5, M6



Connector DEUTSCH, 2-pin



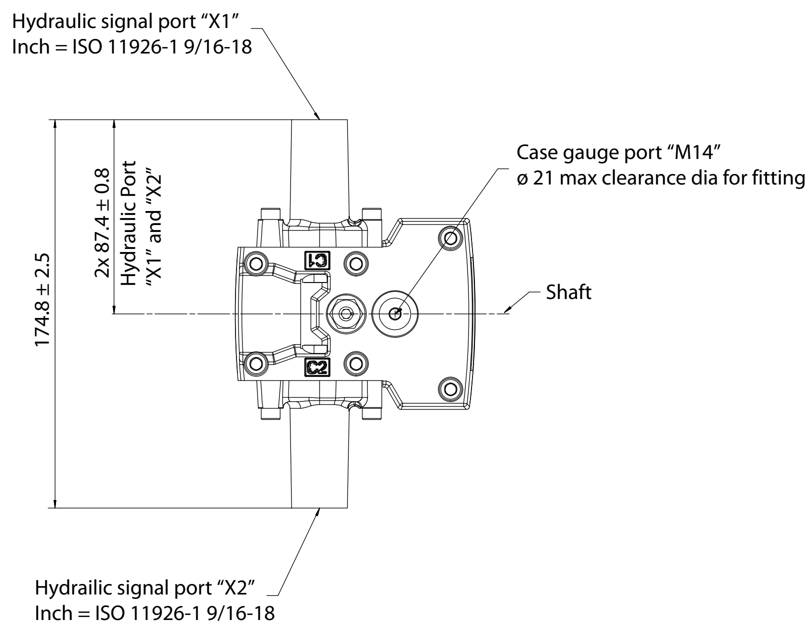
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

H1P HDC, Options: T1, T2

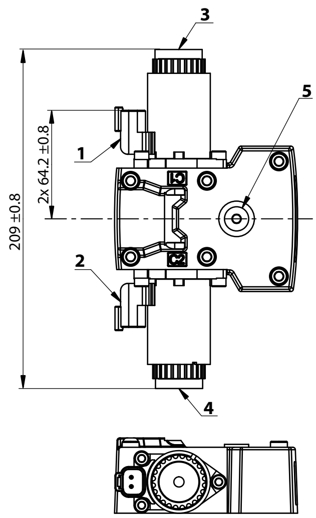
Dimensions in mm



Dimensions and Data

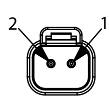
NFPE with MOR, Options: N1, N2 (12/24 V)

Non-Feedback Proportional Electric control with Manual Over Ride options N1 (12 V) and N2 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

*Control solenoid connectors **C1/C2** DEUTSCH DTM04-2P pin/assignment*



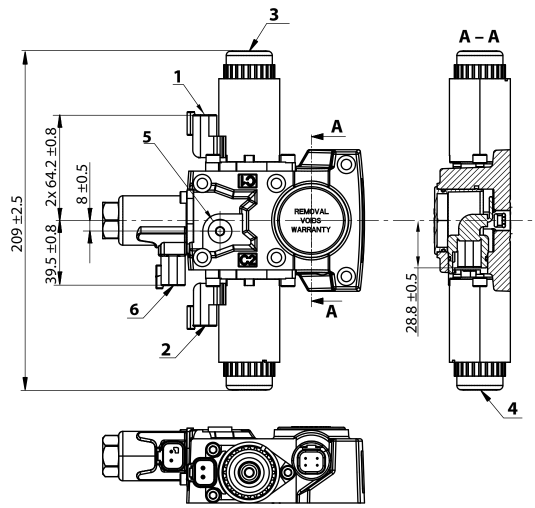
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V)

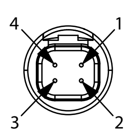
Non-Feedback Proportional Electric control with Control-Cut-Off valve with key C, Manual Over Ride and Angle Sensor, options N3 (12 V) and N4 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
6. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

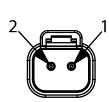
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Control solenoid connectors **C1/C2/C4** DEUTSCH DTM04-2P pin/assignment*



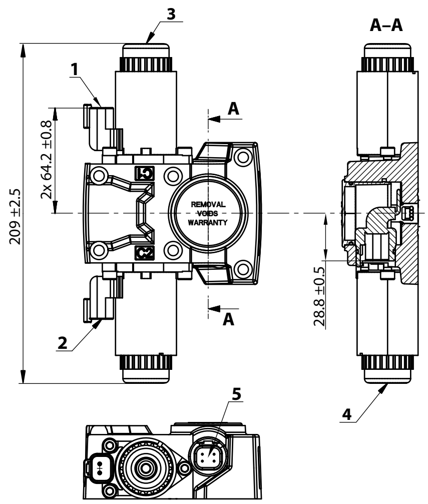
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

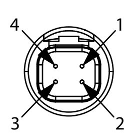
NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V)

Non-Feedback Proportional Electric control with Manual Over Ride and Angle Sensor, options N5 (12 V) and N6 (24 V).



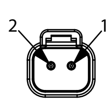
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Angle sensor connector **S2** DEUTSCH DT04-4P, paint free

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

Control solenoid connectors C1/C2 DEUTSCH 2-pin/assignment



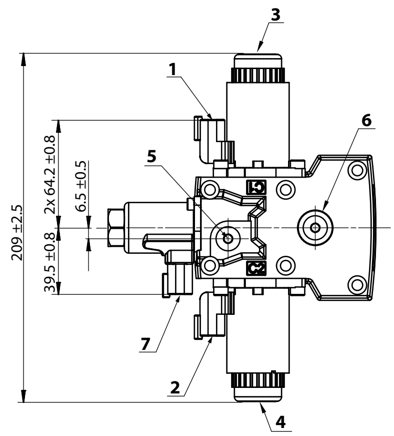
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

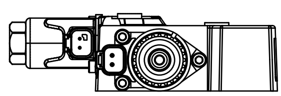
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

NFPE with MOR and CCO, Options: N7, N8 (12/24 V)

Non Feedback Proportional Electric control with Manual Over Ride and Control-Cut-Off valve key C, options N7 (12 V) and N8 (24 V).

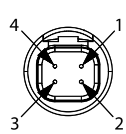




1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
6. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

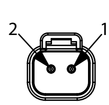
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Control solenoid connectors **C1/C2** DEUTSCH DTM04-2P pin assignment*

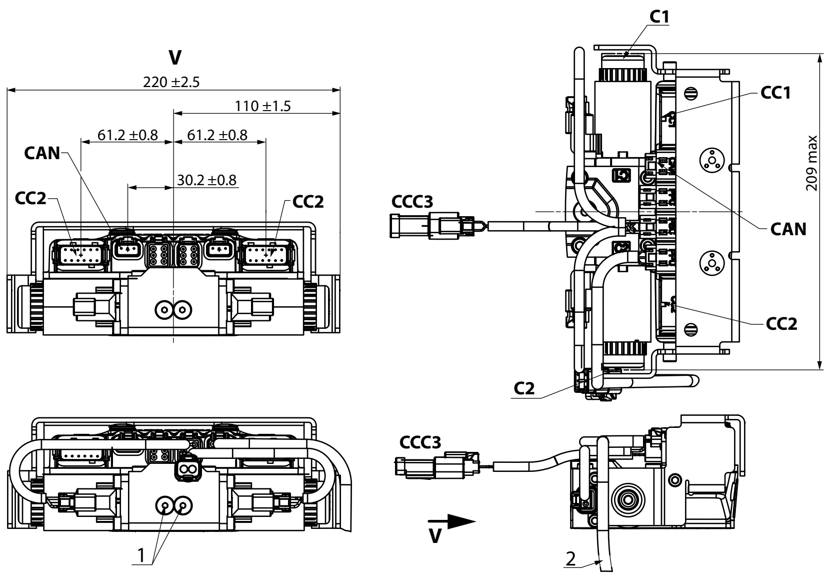


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Automotive control (AC)



1 Plug removing can cause contamination issues

2 PPU wire harness is factory installed to speed sensor

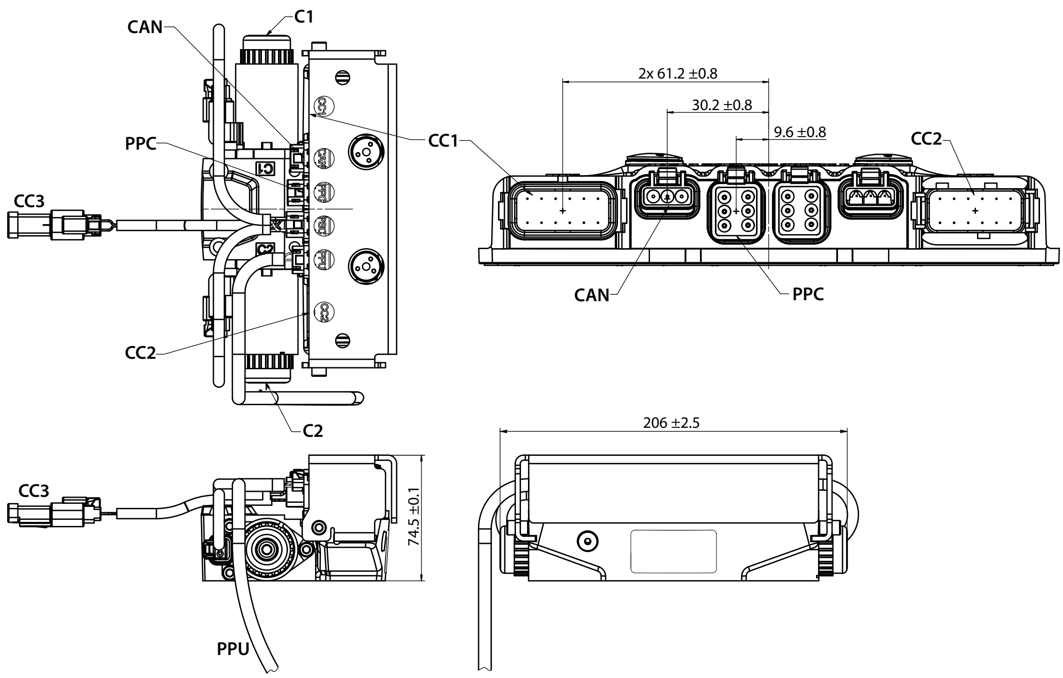
Connectors description

Port	Description
C1 and C2	**1.** Control manual override **C1** **2.** Control Manual Override **C2**
CC1	Port A control connector DEUTSCH DTM04-12P; paint free
CC2	Port B control connector DEUTSCH DTM04-12P; paint free
CC3	Control connector DEUTSCH DT06-2S; paint free; For using connector, the plug may be removed.
CAN	Control connector DEUTSCH DTM04-3P; paint free; For using connector, the plug may be removed.

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

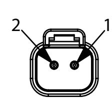
AC connectors dimensions



PPU wire harness is factory installed to speed sensor.

CC3

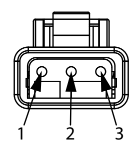
Connector DEUTSCH, 2-pin



1. Digital output A1 (+)
2. Digital output A2 (-)

CAN

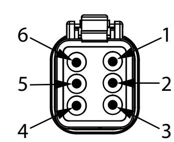
Connector DEUTSCH, 3-pin



1. CAN High
2. CAN Low
3. CAN Shield

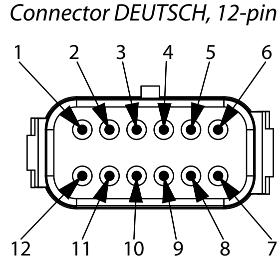
PPC

Connector DEUTSCH, 6-pin



1. Sensor A (+)
2. Analog input A
3. Sensor A (-)
4. Sensor B (-)
5. Analog input B
6. Sensor B (+)

Connector DEUTSCH, 12-pin



CC1

1. Battery (-)
2. Battery (+)
3. Sensor (+)
4. Sensor (-)
5. Motor rpm input (frequency)
6. Forward input (digital)
7. Reverse input (digital)
8. Sensor (+)
9. Sensor (-)
10. Drive pedal input (analog – nominal)
11. Drive pedal input (analog – red)
12. Neural input (digital)

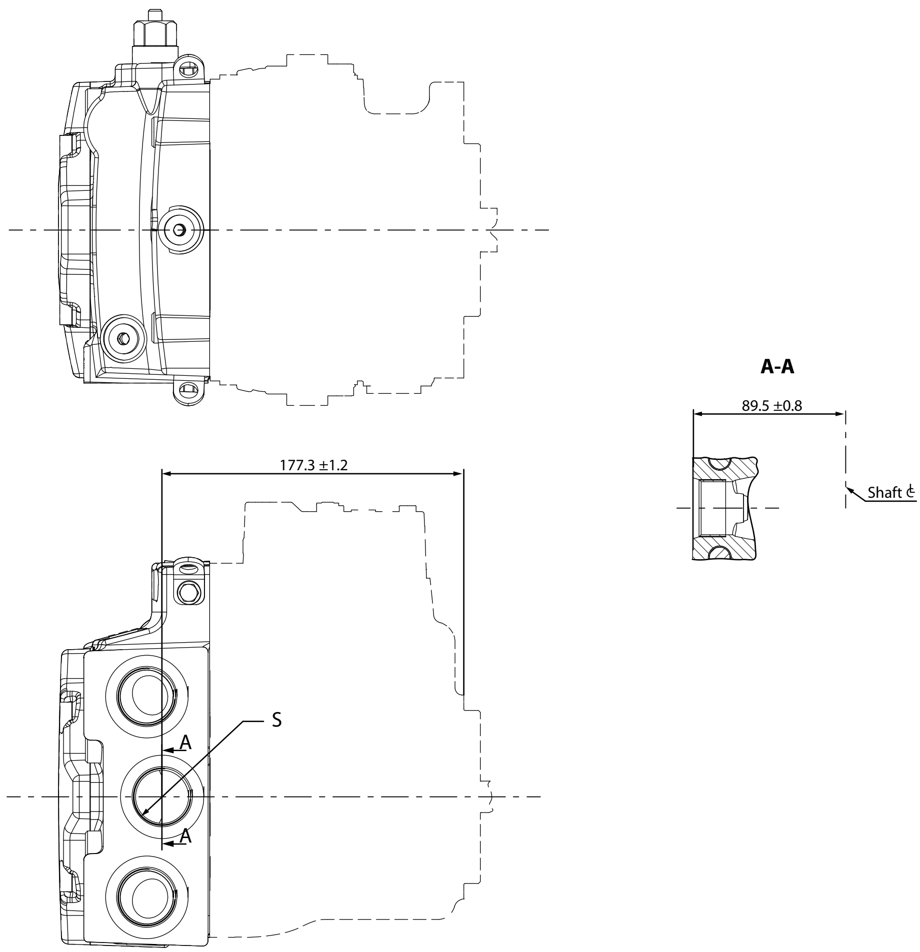
CC2

1. Inch input (analog – red)
2. Mode switch B input (digital – nominal)
3. Motor prop/PCOR driver
4. Motor direction input (analog)
5. Sensor (+)
6. Sensor (-)
7. Inch input (analog – nominal)
8. Motor BPD driver
9. Digital output B2 (-)
10. Digital output B1 (+)
11. Mode switch A input (digital)
12. Mode switch B input (digital – red)

Dimensions and Data

Filtration

H1P 45/53 Suction Filtration Option L

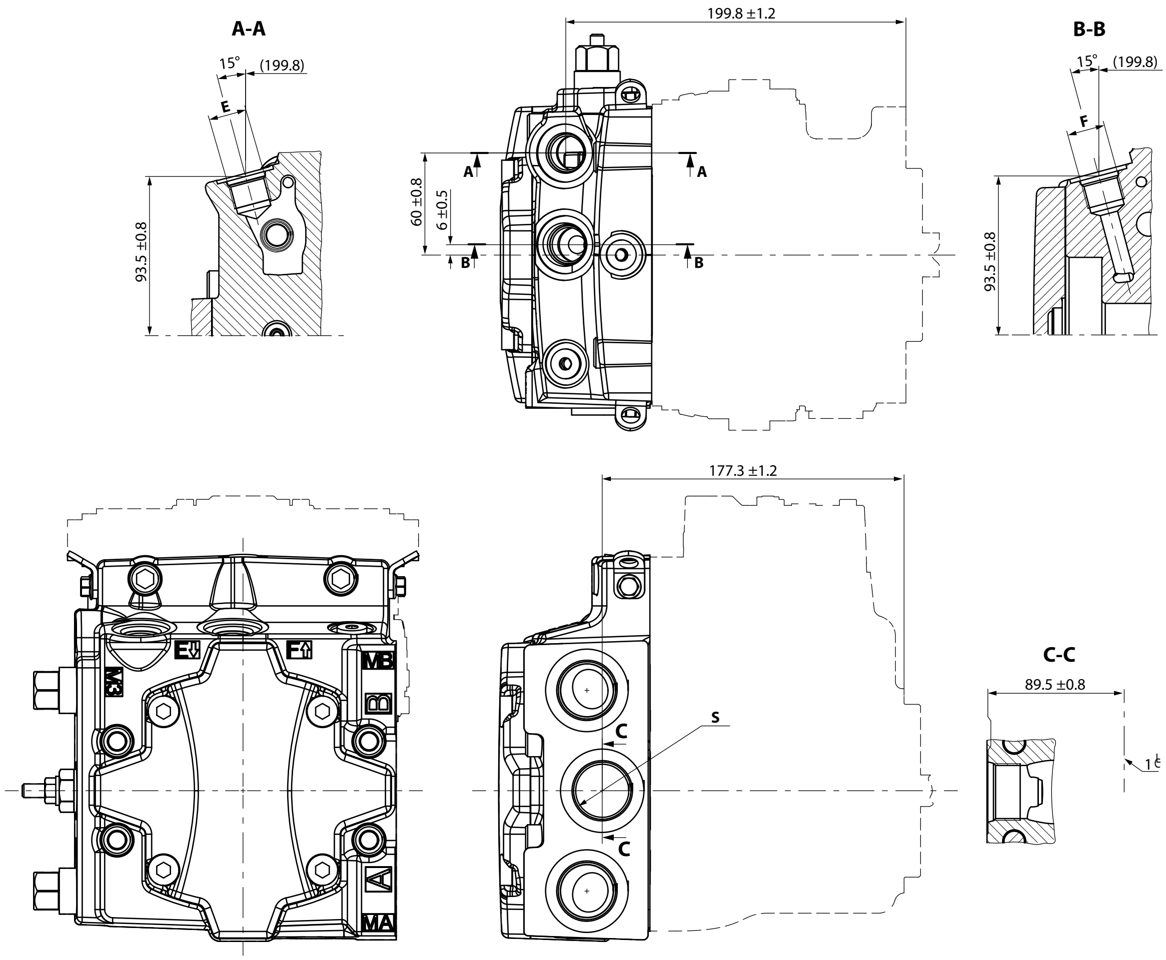


S Charge inlet port per ISO 1926-1; 1 5/16-12

Dimensions and Data

H1P 45/53 Full Flow Charge Pressure Filtration Option P

Remote full flow charge pressure filtration, option P (for endcap option F)



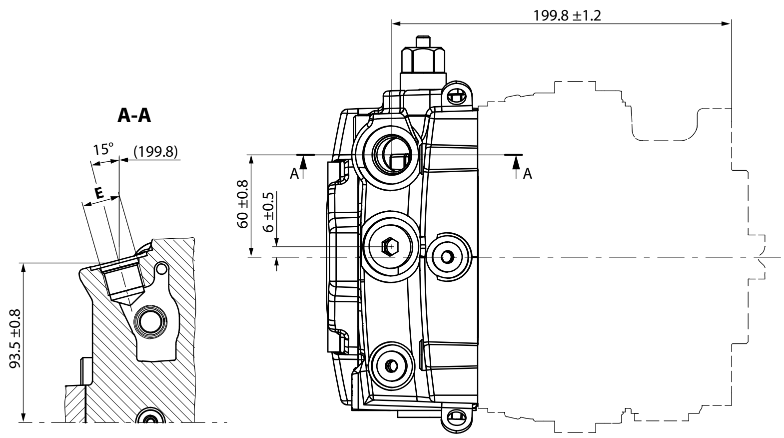
E Charge filtration port per ISO 11926-1; 7/8-14 from filter

F Charge filtration port per ISO 11926-1; 7/8-14 to filter

S Charge inlet port per ISO 11926-1; 5/16-12

Dimensions and Data

External Full Flow Charge Pressure Filtration, Option E



E Charge filtration ports per ISO 11926-1: $^{7}/_{8}$–14 from filter

Please contact Danfoss representative for specific installation drawings.

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ENGINEERING
TOMORROW

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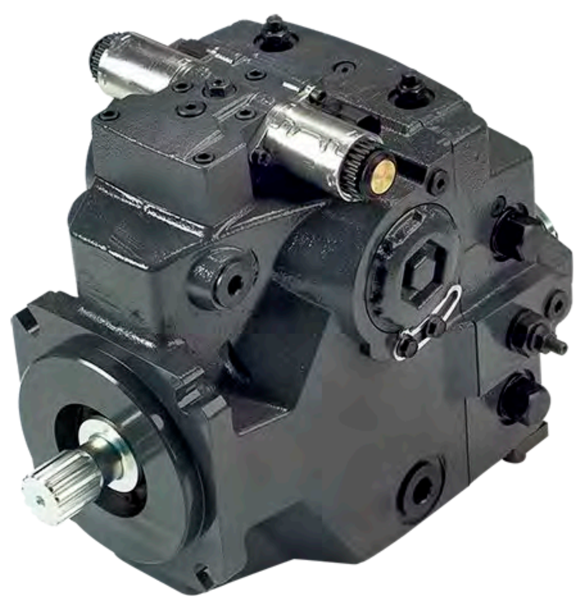
Technical Information

H1P 060/068
Axial Piston Single Pumps



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Revision history

Table of revisions

Date	Changed	Rev
May 2022	Corrected HDC control information	1201
December 2021	Added HDC control	1101
April 2021	Corrected interface with EDU (EDC) graphic	1005
April 2020	Corrected swash plate angle sensor connector and CCO connector descriptions	1004
February 2020	Added NFPE control options and changed the document number from BC00000074	1003
June 2019	Major update.	0901
May 2018	Angle sensor for EDC; FDC note added.	0801
May 2017	NFPE gen. 3 changes.	0701
November 2015	Master Model Code changes.	0600
2010-2014	Various changes.	BA-GB
Nov 2010	First edition	AA

Contents

Technical Specifications

H1 Pumps General Specification......6
H1P 060/068 Technical Data......6
H1P 060/068 Operating Parameters......7
Fluid Specification......8
H1P 060/068 Mounting Flange Loads......8
Bearing Life and External Radial Shaft Loads......9
Charge pump......10
  Charge Pump Selection......10
  14/17 cm^3 Charge Pump – Flow and Power Curves......10

Master Model Code

Displacement, A—Rotation, B—Product Version, Z—Port Configuration......11
D—Controls......12
  Electronic Displacement Controls......12
  Fan Drive Controls......12
  Forward-Neutral-Reverse (FNR) Controls......12
  Non-Feedback Proportional Electric (NFPE) Controls......12
  Automotive Controls......13
  Manual Displacement Control......13
  Hydraulic Displacement Control......13
F—Orifices, E—Displacement Limiters......14
G—Endcap......15
H—Mounting Flange, J—Input Shaft, K—Aux Pad......16
M, N—Overpressure Protection Settings......17
S—Charge Pump, T—Filtration, V—Charge Pressure Relief......18
W—Special Hardware, X—Paint, Y—Special Features......19

Control Options

Electrical Displacement Control (EDC)......20
  Control signal requirements, EDC 060/068......20
  Control Solenoid Data......21
  Single Pump Output Flow Direction......21
  Connector......21
  Control response......22
  Response Time, EDC 060/068......22
Manual Displacement Control (MDC)......23
  MDC operation......23
  MDC shaft rotation......24
  MDC Torque......24
  Control response......25
  Response time, MDC 060/068......25
  Connector......25
  Neutral start switch (NSS)......25
  Case Gauge Port M14......26
  Lever......26
Hydraulic Displacement Control (HDC)......27
  HDC principle......27
  HDC operation......27
  Hydraulic signal pressure range......28
  Pump output flow direction vs. control pressure......28
  Control response......28
  Response time, HDC 069/078......29
Forward-Neutral-Reverse Control (FNR)......30
  Single Pump Output Flow Direction......30
  FNR Solenoid Data......31
  Control response......31
  Connector......31
  Response Time, FNR 060/068......31
Non feedback proportional electric control (NFPE)......32

Contents

- Control Signal Requirements, NFPE 060/068 ... 32
- Control Solenoid Data ... 33
- Single Pump Output Flow Direction ... 33
- Control response ... 34
- Connector ... 34
- Response Time, NFPE 060/068 ... 34

Automotive Control (AC) ... 35
- Mode types ... 35
- Basic functions ... 35
- Performance functions ... 36
- Protection and safety functions ... 36
- Engine control and protection ... 36
- Installation features ... 36

Fan Drive Control (FDC) ... 37
- Control Signal Requirements, FDC 060/068 ... 38
- Control Solenoid Data ... 38
- Single Pump Output Flow Direction ... 39
- Control response ... 39
- Connector ... 39
- Response Time, FDC 060/068 ... 39

Manual Override (MOR) ... 40

Swashplate angle sensor for EDC controls ... 41
- Swash plate angle sensor parameters (EDC) ... 41
- Swashplate Angle Sensor Connector ... 42
- Interface with ECU (EDC) ... 42

Swash Plate Angle Sensor for NFPE and AC2 Controls ... 43
- Swash Plate Angle Characteristic ... 43
- Swash Plate Angle Sensor Parameters (NFPE/AC) ... 44
- Swash Plate Angle Sensor Connector (NFPE) ... 44
- Interface with ECU (NFPE) ... 44

Control Cut Off Valve (CCO) ... 45
- Brake gauge port with MDC ... 45
- CCO Connector (MDC) ... 45
- H1P CCO Connector (EDC, NFPE) ... 46
- CCO solenoid data ... 46

Displacement Limiter ... 47
- H1P 060/068 Displacement Change (approximately) ... 47

Dimensions and Data

H1P 060/068 Input Shaft Option G1 (SAE C, 14 teeth) ... 48

H1P 060/068 Input Shaft Option F1 (SAE C, 21 teeth) ... 49

H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth) ... 50

H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth) ... 51

H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth) ... 52

H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth) ... 53

H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth) ... 54

H1P Displacement Limiter, Option B ... 55

Single Pump Ports ... 56

H1P Dimensions ... 57

Controls ... 60
- EDC Options A2 and A3 (12/24 V) ... 60
- EDC with MOR, Options A4 and A5 (12/24 V) ... 61
- EDC with CCO (key C), Options E7 and E8 (12/24 V) ... 62
- EDC with ASNSR, Options: H2 and H3 (12/24 V) ... 63
- EDC with MOR and ASNSR, Options H6 and H7 (12/24 V) ... 64
- EDC with CCO and ASNSR, Options H8 and H9 (12/24 V) ... 65
- MDC Option: M1 ... 66
- MDC with Neutral Start Switch Option: M2 ... 67
- MDC with CCO, Options: M3, M4 ... 68
- MDC with NSS and CCO Options: M5, M6 ... 69

Contents

HDC, Options: T1, T2....70
NFPE with MOR, Options: N1, N2 (12/24 V)....71
NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V)....72
NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V)....73
NFPE with MOR and CCO, Options: N7, N8 (12/24 V)....74
Automotive control (AC)....75
AC connectors dimensions....76
Filtration....77
Suction Filtration Option L....77
Remote Full Charge Pressure Filtration Option P....78
Internal Filtration Option M (End Cap Option: D3)....79
Internal Filtration Option M (End Cap Option: F4)....80
External Filtration Option E (End Cap Option: D8)....81
External Filtration Option E (End Cap Option: F5)....82

Technical Specifications

H1 Pumps General Specification

Axial piston closed circuit variable displacement pumps of cradle swash-plate design with clockwise or counterclockwise direction of rotation.

Pipe connections

- Main pressure ports: ISO split flange boss
- Remaining ports: SAE straight thread O-ring boss

Recommended installation position

Pump installation position is discretionary, however the recommended control position is on the top or at the side with the top position preferred. If the pump is installed with the control at the bottom, flushing flow must be provided through port M14 located on the EDC, FNR and NFPE control.

Vertical input shaft installation is acceptable. If input shaft is at the top, 1 bar case pressure must be maintained during operation. The housing must always be filled with hydraulic fluid. Recommended mounting for a multiple pump stack is to arrange the highest power flow towards the input source. Consult Danfoss for nonconformance to these guidelines.

Auxiliary cavity pressure

Auxiliary cavity pressure will be inlet pressure with internal charge pump or case pressure with external charge supply. For reference see Operating Parameters. Please verify mating pump shaft seal capability.

H1P 060/068 Technical Data

Feature	Size 060	Size 068
Displacement	60.4 cm^3 [3.69 in^3]	68.0 cm^3 [4.15 in^3]
Flow at rated speed (continuous)	210 l/min [55.5 US gal/min]	238 l/min [62.8 US gal/min]
Torque at maximum displacement (theoretical)	0.96 N•m/bar [590 lbf•in/1000 psi]	1.08 N•m/bar [610 lbf•in/1000 psi]
Mass moment of inertia of rotating components	0.00709 kg•m^2 [0.00523 slug•ft^2]	0.00707 kg•m^2 [0.00522 slug•ft^2]
Mass (dry–no charge pump)	50 kg [110 lb]	50 kg [110 lb]
Oil volume	2.1 l [0.55 US gal]	2.1 l [0.55 US gal]

Shaft, flange and ports description

Input shaft per ISO 3019-1 (outer diameter)	• Outer Ø32 mm – 4 (SAE C, 14 teeth) • Outer Ø35 mm – 4 (SAE C, 21 teeth)
Mounting flange per ISO 3019-1	Flange 127-4 (SAE C)
Auxiliary mounting flange with metric fasteners, with shaft outer diameter	• Flange 82-2 (SAE A, 9 teeth and 11 teeth) • Flange 101-2 (SAE B, 13 teeth and SAE B-B, 15 teeth) • Flange 127-4 (SAE C, 14 teeth)
Suction port per ISO 3019-1	$1\frac{5}{16}$–12 (SAE O-ring boss)
Main configuration port	Ø25.4 mm, 450 bar; Split flange boss per ISO 6162, M12x1.75
Case drain ports L2, L4 per ISO 3019-1	$1\frac{1}{16}$–12 (SAE O-ring boss)
Other ports	SAE O-ring boss
Customer interface threads	Metric fasteners

Technical Specifications

H1P 060/068 Operating Parameters

Parameter		Unit	Size 060	Size 068
Input speed	**Min. for internal[1] and external[2] charge supply**	min^{-1} (rpm)	500	500
	Min. for full performance, internal charge supply		1200	1250
	Rated		3500	3500
	Maximum		4000	4000
System pressure	**Maximum working**	bar [psi]	420 [6090]	380 [5510]
	Maximum		450 [6525]	400 [5800]
	Max./Min. low loop		45/10 [650/145]	
Charge pressure	**Minimum**	bar [psi]	14.5 [210]	
	Maximum		34 [493]	
Control pressure	**Minimum (at corner power for EDC, MDC, FNR)**		18.5 [270]	
	Minimum (at corner power for NFPE, FDC, AC)		26 [377]	
	Maximum		40 [580]	
Charge pump inlet pressure	**Rated**	bar (absolute) [in Hg vacuum]	0.7 [9.0]	
	Minimum (cold start)		0.2 [24.0]	
	Maximum	bar [psi]	4.0 [58.0]	
Case pressure	**Rated**		3.0 [44.0]	
	Maximum		5.0 [73.0]	
Lip seal maximum pressure (external)			0.4 [5.8]	

[1] Performance (displacement and pressure) may be limited due to limited control pressure.

[2] Full performance (displacement and pressure) possible at minimum charge and control pressure supply.

Filtration, cleanliness level and β_x-ratio (recommended minimum)

Cleanliness per ISO 4406	22/18/13
Efficiency β_x (charge pressure filtration)	$\beta_{15-20} = 75$ ($\beta_{10} \geq 10$)
Efficiency β_x (suction and return line filtration)	$\beta_{35-45} = 75$ ($\beta_{10} \geq 2$)
Recommended inlet screen mesh size	100 – 125 µm

Technical Specifications

Fluid Specification

Viscosity

Intermittent[1]	5 mm^2/s [42 SUS]
Minimum	7 mm^2/s [49 SUS]
Recommended range	12 – 80 mm^2/s [66 – 370 SUS]
Maximum	1600 mm^2/s [7500 SUS]

[1] Intermittent = Short term t < 1 min per incident and not exceeding 2 % of duty cycle based load-life.

Temperature

Minimum [1]	-40°C [-40°F]
Rated	104°C [220°F]
Recommended range[2]	60 – 85°C [140 – 185°F]
Maximum Intermittent	115°C [240°F]

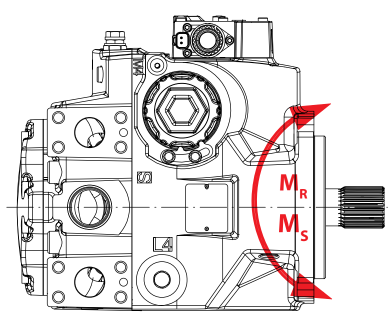
[1] Cold start = Short term t > 3 min, p ≤ 50 bar [725 psi], n ≤ 1000 min-1 (rpm).

[2] At the hottest point, normally case drain port.

H1P 060/068 Mounting Flange Loads

The Rated and Shock load moments apply for top or side orientation of control.

Mounting flange load with control on top



Rated moment	$\mathbf{M_R}$ = 2110 N•m [18 680 lbf•in]
Shock load moment	$\mathbf{M_S}$ = 5275 N•m [46 690 lbf•in]

For more information, see *H1 Axial Piston Pumps, Basic Information*, **BC152886483968**, the section "Mounting flange loads".

Technical Specifications

Bearing Life and External Radial Shaft Loads

All external shaft loads affect bearing life. The pumps are designed with bearings that can accept some external radial loads. The external radial shaft load limits are a function of the load position and orientation, and the operating conditions of the unit.

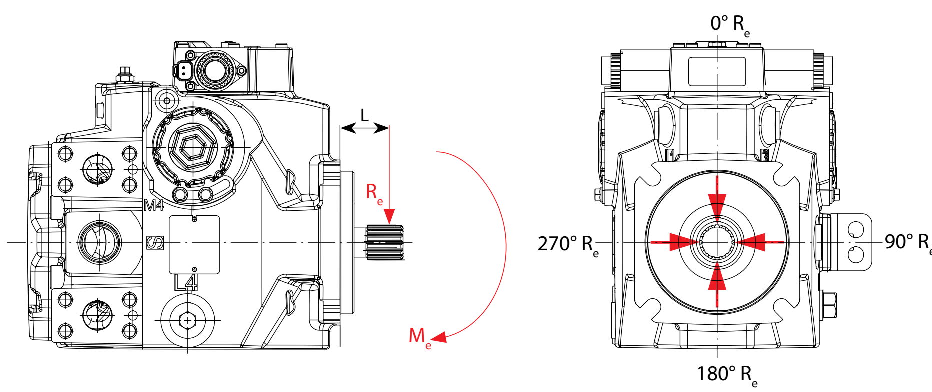
Danfoss recommends clamp-type couplings for applications with radial shaft loads. Contact your Danfoss representative for an evaluation of unit bearing life if you have continuously applied external loads exceeding 25 % of the maximum allowable radial load (R_e) or the pump swash-plate is positioned on one side of center all or most of the time.

Maximum external shaft load based on shaft deflection

External radial moment	Unit	Size 060/068
M_e	N•m [lbf•in]	104 [920]

External radial shaft loads impact lifetime. For lifetime calculations please contact your Danfoss representative. In applications with external shaft loads, minimize the impact by positioning the load at 0° or 180° as shown below.

Radial load position



The maximum allowable radial shaft load (R_e) is based on the maximum external moment (M_e) and the distance (L) from the mounting flange to the load. It may be determined using the following formula:

$$R_e = \frac{M_e}{L}$$

Thrust loads should be avoided. Contact your Danfoss representative in the event thrust loads are anticipated.

Technical Specifications

Charge pump

Charge Pump Selection

In most applications a general guideline is that the charge pump displacement should be at least 10% of the total displacement of all components in the system. Unusual application conditions may require a more detailed review of charge flow requirements. System features and conditions which may invalidate the 10% guideline include (but are not limited to):

- Continuous operation at low input speeds < 1500 min^{-1} (rpm)
- High shock loading and/or long loop lines
- High flushing flow requirements
- Multiple low speed high torque motors
- High input shaft speeds

Contact your Danfoss representative for application assistance if your application includes any of these conditions.

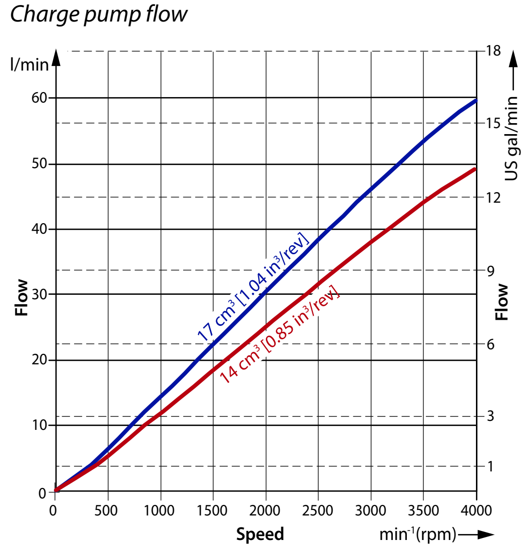
For more information, see *Selection of Drive line Components*, **BC157786484430**.

14/17 cm³ Charge Pump – Flow and Power Curves

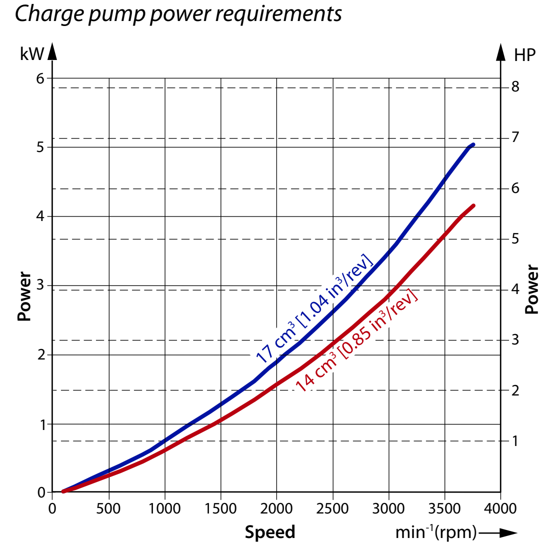
Charge pump flow and power requirements curves shown below at the following conditions:

Charge pressure = 20 bar [290 psi]
Viscosity = 11 mm²/s [63 SUS]
Temperature = 80°C [176°F]

Charge pump flow

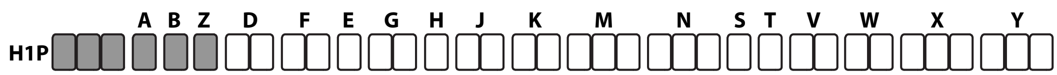


Charge pump power requirements



Master Model Code

Displacement, A—Rotation, B—Product Version, Z—Port Configuration



Displacement

060	60.4 cm^3 [3.69 in^3]
068	68.0 cm^3 [4.15 in^3]

A – Direction of Rotation

L	Left hand (counter clockwise)
R	Right hand (clockwise)

B – Product version

A	Revision code

Z – Port configuration

A	Inch, Customer O-ring port sealing according to ISO 11926-1

Master Model Code

D—Controls

A B Z D F E G H J K M N S T V W X Y

H1P

Electronic Displacement Controls

Code	Control type	Voltage	MOR	CCO with key C	Angle sensor	Connector
A2	EDC	12 V	—	—	—	DEUTSCH
A3	EDC	24 V	—	—	—	DEUTSCH
A4	EDC	12 V	●	—	—	DEUTSCH
A5	EDC	24 V	●	—	—	DEUTSCH
E7	EDC	12 V	—	●	—	DEUTSCH
E8	EDC	24 V	—	●	—	DEUTSCH
H2	EDC	12 V	—	—	●	DEUTSCH
H3	EDC	24 V	—	—	●	DEUTSCH
H6	EDC	12 V	●	—	●	DEUTSCH
H7	EDC	24 V	●	—	●	DEUTSCH
H8	EDC	12 V	—	●	●	DEUTSCH
H9	EDC	24 V	—	●	●	DEUTSCH

● – To be used for the control; — Not to be used for the control

Fan Drive Controls

F1	FDC	12 V	DEUTSCH Connector
F2	FDC	24 V	DEUTSCH Connector

Align with options: **F:** Orifices, **E:** Displacement limiters, **M, N:** Overpressure protection, and **W:** Special hardware.

Forward-Neutral-Reverse (FNR) Controls

A9	FNR	12 V	with MOR	DEUTSCH Connector
B1	FNR	24 V	with MOR	DEUTSCH Connector

Non-Feedback Proportional Electric (NFPE) Controls

Code	Control type	Voltage	MOR	CCO with key C	Angle sensor	Connector
N1	NFPE	12 V	●	—	—	DEUTSCH
N2	NFPE	24 V	●	—	—	DEUTSCH
N3	NFPE	12 V	●	●	●	DEUTSCH
N4	NFPE	24 V	●	●	●	DEUTSCH
N5	NFPE	12 V	●	—	●	DEUTSCH
N6	NFPE	24 V	●	—	●	DEUTSCH
N7	NFPE	12 V	●	●	—	DEUTSCH
N8	NFPE	24 V	●	●	—	DEUTSCH

Align with options: **E:** Displacement limiters and **W:** Special hardware.

Master Model Code

Automotive Controls

Automotive Control (AC)

Code	AC type	Voltage	MOR	Speed sensor	Wire harness	Angle sensor	Connector
P6	AC–1	12 V	●	●	●	—	DEUTSCH
P7	AC–1	24 V	●	●	●	—	DEUTSCH
P8	AC–2	12 V	●	●	●	●	DEUTSCH
P9	AC–2	24 V	●	●	●	●	DEUTSCH
P5	AC–1	12 V	●	—	—	—	DEUTSCH
R3	AC–1	24 V	●	—	—	—	DEUTSCH
R4	AC–2	12 V	●	—	—	●	DEUTSCH
R5	AC–2	24 V	●	—	—	●	DEUTSCH

● – To be used for the control; — Not to be used for the control

Manual Displacement Control

Manual Displacement Control (MDC)

Code	Control type	CCO Voltage	CCO	Neutral Start Switch	Connector
M1	MDC	—	—	—	—
M2	MDC	—	—	●	DEUTSCH
M3	MDC	12 V	●	—	DEUTSCH
M4	MDC	24 V	●	—	DEUTSCH
M5	MDC	12 V	●	●	DEUTSCH
M6	MDC	24 V	●	●	DEUTSCH

Align with options **F:** Orifices and **Y:** Settings for adjustment (if applicable).

Hydraulic Displacement Control

Hydraulic Displacement Control (HDC)

Code	Pressure range	Ports
T1	4.2 - 16.2 bar	Inch ports 9/16-18
T2	3.0 - 11.6 bar	Inch ports 9/16-18

Master Model Code

F—Orifices, E—Displacement Limiters

A B Z D F E G H J K M N S T V W X Y

H1P

F – Orifices Options

Orifices options related to control type

Code	Tank (A+B)	P orifice	A/B orifices	EDC, FNR	MDC	NFPE, AC	FDC
C3	No orifice			●	●	–	–
C1	–	–	0.8 mm	●	●	●	–
C2	–	–	1.3 mm	●	●	●	●
C4	–	–	1.8 mm	●	●	●	–
C6	1.0 mm	–	–	–	●	–	
C7	1.3 mm	–	–	–	●	–	–
D1	0.8 mm	1.0 mm	–	–	●	–	–
D2	0.8 mm	1.3 mm	–	–	●	–	–
D3	1.0 mm	1.3 mm	–	–	●	–	–
D4	1.0 mm	1.3 mm	1.3 mm	–	●	–	–
D5	0.6 mm	0.6 mm	0.8 mm	–	●	–	–
D6	1.3 mm	1.3 mm	–	–	●	–	–
D8	–	–	2.3 mm	–	–	●	–

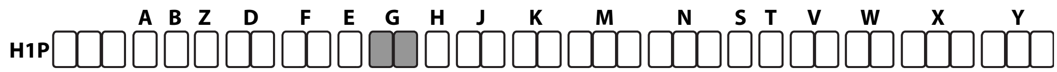
E – Displacement Limiter Options

N	None
B	Adjustable externally
C	No limiters, with nested springs, required for NFPE, AC, FDC*
D	Adjustable externally with nested springs, required for NFPE, AC, FDC*

* Align with option **Y:** Settings for adjustment (if applicable).

Master Model Code

G—Endcap



G – End-cap Options

Split flange twin ports ISO 6162; Align with T: Filtration and K: Auxiliary Pad

D3	Integral pressure filtration, Code 62
D6	Suction filtration, Code 62
D8	Remote filtration, Code 62
F4	Integral pressure filtration with SAE-C Auxiliary Pad, Code 62
F6	Suction filtration with SAE-C Auxiliary Pad, Code 62
F5	Remote filtration with SAE-C Auxiliary Pad, Code 62

Master Model Code

H—Mounting Flange, J—Input Shaft, K—Aux Pad

A B Z D F E G H J K M N S T V W X Y

H1P

H – Mounting options

Mounting to be aligned with option W: Special hardware

H	ISO 3019-1 flange 127–4 (SAE C)
K	ISO 3019-1 flange 127–4 (SAE C), 4-bolt, with speed sensor

J – Input Shaft options

G1	ISO 3019-1, outer Ø32 mm - 4 (14 teeth splined shaft 12/24 pitch)
F1	ISO 3019-1, outer Ø35 mm - 4 (21 teeth splined shaft 16/32 pitch)

K – Auxiliary Mounting Pad options (ISO 3019-1)

NN	None
H1	Flange 82–2 (SAE A, 11 teeth, 16/32 coupling); shipping cover
H2	Flange 82–2 (SAE A, 9 teeth, 16/32 coupling); shipping cover
H3	Flange 101–2 (SAE B, 13 teeth, 16/32 coupling); shipping cover
H5	Flange 101–2 (SAE B-B, 15 teeth, 16/32 coupling); shipping cover
H6	Flange 127–4 (SAE C, 14 teeth, 12/24 coupling); shipping cover

Master Model Code

M, N—Overpressure Protection Settings

A B Z D F E G H J K M N S T V W X Y
H1P

M and N – Overpressure protection options

L	Pressure limiter setting	HPRV with bypass setting[1]
L15	150 bar [2900 psi]	230 bar [3336 psi]
L18	180 bar [2610 psi]	230 bar [3336 psi]
L20	200 bar [2900 psi]	250 bar [3630 psi]
L23	230 bar [3336 psi]	280 bar [4061 psi]
L25	250 bar [3630 psi]	300 bar [4350 psi]
L28	280 bar [4061 psi]	330 bar [4786 psi]
L30	300 bar [4350 psi]	350 bar [5076 psi]
L33	330 bar [4786 psi]	380 bar [5510 psi]
L35	350 bar [5080 psi]	400 bar [5800 psi]
L38	380 bar [5510 psi]	420 bar [6090 psi]
L40	400 bar [5800 psi]	450 bar [6526 psi] (H1P 060 only
L41	410 bar [5946 psi]	450 bar [6526 psi] (H1P 060 only
L42	420 bar [6090 psi]	450 bar [6526 psi] (060 only
Overpressure protection type and setting for FDC		
F01	150 bar [2175 psi]	250 bar [3630 psi]
F02	150 bar [2175 psi]	300 bar [4350 psi] (H1P 060 only
F03	150 bar [2175 psi]	350 bar [5076 psi]

1) Pressure limiter and HPRV with bypass, over-pressure protection type must be the same for both sides “A” and “B”.

K	Pressure setting [1]
K18	180 bar [2610 psi]
K20	200 bar [2900 psi]
K23	230 bar [3336 psi]
K25	250 bar [3630 psi]
K28	280 bar [4061 psi]
K30	300 bar [4350 psi]
K33	330 bar [4786 psi]
K35	350 bar [5076 psi]
K38	380 bar [5510 psi]
K40	400 bar [5800 psi] (available for H1P 060 only
K41	410 bar [5946 psi] (available for H1P 060 only
K42	420 bar [6090 psi] (available for H1P 060 only

1) Pressure limiter and HPRV with bypass, over-pressure protection type must be the same for both sides “A” and “B”.

Please contact Danfoss Power Solutions for pressures not shown or for applied pressure above max. working pressure.

Master Model Code

S—Charge Pump, T—Filtration, V—Charge Pressure Relief

H1P A B Z D F E G H J K M N S T V W X Y

S – Charge pump options

F	14 cm^3/rev [0.85 in^3/rev]
C	17 cm^3/rev [1.03 in^3/rev]
N	No charge pump, external charge supply (*Align with options:* **E, T**)

T – Filtration options

Filtration to be aligned with G: End cap selection

L	Suction filtration
M	Integral full charge flow filtration with bypass sensor, medium filter length **11004918**
P	Remote full charge flow filtration
E	External full charge flow filtration (Align with options **N, S**)

V – Charge pressure relief valve (CPRV) setting

18*	18 bar [261 psi]
20*	20 bar [290 psi]
22*	22 bar [319 psi]
24*	24 bar [348 psi]
26	26 bar [377 psi]
28	28 bar [406 psi]
30	30 bar [435 psi]
32	32 bar [464 psi]

* Not to be used for **NFPE, AC** and **FDC** controls.

Master Model Code

W—Special Hardware, X—Paint, Y—Special Features

H1P A B Z D F E G H J K M N S T V W X Y

W – Special Hardware features

Hardware features to be aligned with options D, E

P1	NFPE/FDC valve plate
P2	NFPE/FDC/AC valve plate and speed ring on the cylinder block
P4	EDC/FNR/MDC valve plate and speed ring on the cylinder block
PN	EDC/FNR/MDC valve plate
H1	MDC/EDC/FNR valve plate with MDC handle

X – Paint and Name-tag

NNN	Black paint and Danfoss name-tag
C08	Paint none and Danfoss name-tag

Y – Special settings (SIL-2 non-certifiable, without customer files)

<table>
<tr><th>Code</th><th>CAN J1939</th><th>ECO fuel saving mode</th><th>Functional option</th><th>Cruise control</th><th>Control</th><th>AC type</th></tr>
<tr><td>D3E</td><td>in/out</td><td>●</td><td>E</td><td>–</td><td rowspan="2">N1 (12 V_{DC})</td><td rowspan="4">AC–1</td></tr>
<tr><td>D3F</td><td>in/out</td><td>–</td><td>F</td><td>–</td></tr>
<tr><td>D4E</td><td>in/out</td><td>●</td><td>E</td><td>–</td><td rowspan="2">N2 (24 V_{DC})</td></tr>
<tr><td>D4F</td><td>in/out</td><td>–</td><td>F</td><td>–</td></tr>
<tr><td>D5F</td><td>in/out</td><td>–</td><td>F</td><td>–</td><td rowspan="2">P8 (12 V_{DC})</td><td rowspan="4">AC–2 (with swash plate angle sensor)</td></tr>
<tr><td>D5J</td><td>in/out</td><td>●</td><td>J</td><td>●</td></tr>
<tr><td>D6F</td><td>in/out</td><td>–</td><td>F</td><td>–</td><td rowspan="2">P9 (24 V_{DC})</td></tr>
<tr><td>D6J</td><td>in/out</td><td>●</td><td>J</td><td>●</td></tr>
<tr><td>M00</td><td colspan="6">MDC handle standard position</td></tr>
<tr><td>NNN</td><td colspan="6">None</td></tr>
</table>

● – To be used for the control; — Not to be used for the control

Control Options

Electrical Displacement Control (EDC)

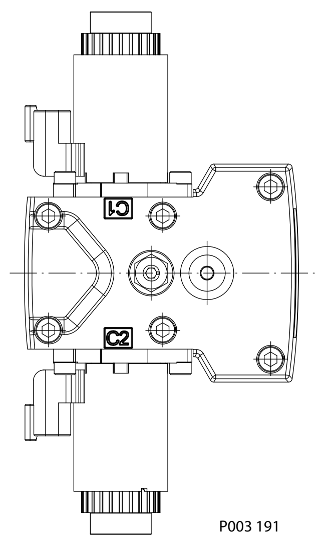
An EDC is a displacement (flow) control. Pump swash plate position is proportional to the input command and therefore vehicle or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The Electrical Displacement Control (**EDC**) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

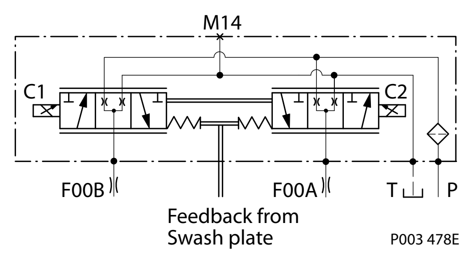
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

Electrical Displacement Control

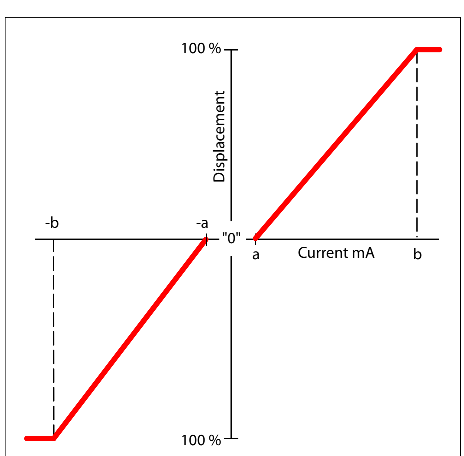


EDC schematic, feedback from swash plate



Control signal requirements, EDC 060/068

Pump displacement vs. control current



Control Options

EDC control current

Voltage		$12\ V_{DC}$	$24\ V_{DC}$
Minimum current to stroke pump	**a**[*]	640 mA	330 mA
	b	1640 mA	820 mA
Pin connections		any order	

[*] Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended[*]	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

[*] PWM signal required for optimum control performance.

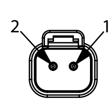
Single Pump Output Flow Direction

Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized[*]	**C1**	**C2**	**C1**	**C2**
Port A	out	in	in	out
Port B	in	out	out	in
Servo port pressurized	M4	M5	M4	M5

[*] For coil location see installation drawings.

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control Options

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, EDC 060/068

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	2.6 s	1.2 s	0.8 s
Full flow to neutral	1.7 s	0.8 s	0.4 s

Control Options

Manual Displacement Control (MDC)

A Manual proportional Displacement Control (**MDC**) consists of a handle on top of a rotary input shaft. The shaft provides an eccentric connection to a feedback link. This link is connected on its one end with a porting spool. On its other end the link is connected the pumps swashplate.

This design provides a travel feedback without spring. When turning the shaft the spool moves thus providing hydraulic pressure to either side of a double acting servo piston of the pump.

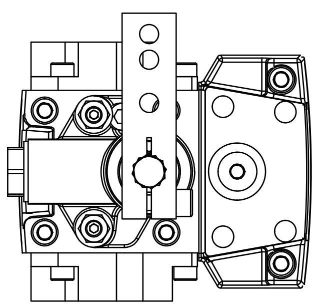
Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement. Simultaneously the swashplate movement is fed back to the control spool providing proportionality between shaft rotation on the control and swash-plate rotation. The MDC changes the pump displacement between no flow and full flow into opposite directions.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

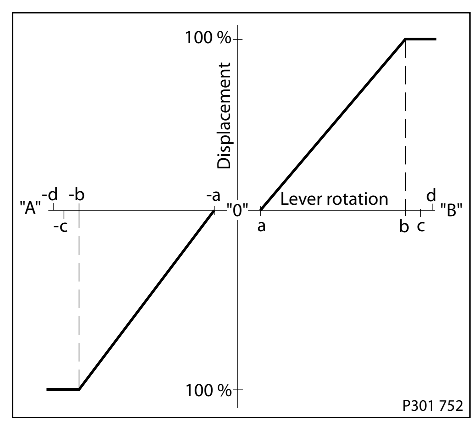
For the MDC with CCO option the brake port (X7) provides charge pressure when the coil is energized to activate static function such as a brake release. The X7 port must not be used for any continuous oil consumption.

The MDC is sealed by means of a static O-ring between the actuation system and the control block. Its shaft is sealed by means of a special O-ring which is applied for low friction. The special O-ring is protected from dust, water and aggressive liquids or gases by means of a special lip seal.

Manual Displacement Control



Pump displacement vs. control lever rotation



Deadband on **B** side: **a = 3° ±1°**
Maximum pump stroke: **b = 30° +2/-1°**
Required customer end stop: **c = 36° ±3°**
Internal end stop: **d = 40°**

MDC operation

The MDC provides a mechanical dead-band required to overcome the tolerances in the mechanical actuation. The MDC contains an internal end stop to prevent turning the handle into any inappropriate position.

The MDC provides a permanent restoring moment appropriate for turning the MDC input shaft back to neutral position only. This is required to take the backlash out of the mechanical connections between the Bowden cable and the control.

High case pressure may cause excessive wear and the NSS to indicate that the control is not in neutral position. In addition, if the case pressure exceeds 5 bar there is a risk of an insufficient restoring moment. The MDC is designed for a maximum case pressure of 5 bar and a rated case pressure of 3 bar.

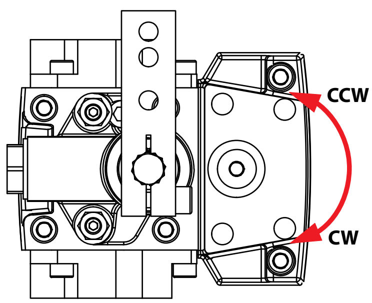
Control Options

- Customers must install some support to limit the setting range of their Bowden cable to avoid an overload of the MDC.
- Customers can apply their own handle design but they must care about a robust clamping connection between their handle and the control shaft and avoid overload of the shaft.
- Customers can connect two MDC's on a tandem unit in such a way that the actuation force will be transferred from the pilot control to the second control. The kinematic of the linkages must ensure that either control shaft is protected from torque overload.

Caution

Using the internal spring force on the input shaft is not an appropriate way to return the customer connection linkage to neutral, or to force a Bowden cable or a joystick back to neutral position. It is not applicable for any limitation of the Bowden cable stroke, except the applied torque to the shaft will never exceed 20 N•m.

MDC shaft rotation



Pump shaft rotation*	Clockwise (CW)		Counter-clockwise (CCW)	
MDC shaft rotation	**CW**	**CCW**	**CW**	**CCW**
Port A	in (low)	out (high)	out (high)	in (low)
Port B	out (high)	in (low)	in (low)	out (high)
Servo port high pressure	M5	M4	M5	M4

* As seen from shaft side.

MDC Torque

Description	Value
Torque required to move handle to maximum displacement	1.4 N•m [12.39 lbf•in]
Torque required to hold handle at given displacement	0.6 N•m [5.31 lbf•in]
Maximum allowable input torque	20 N•m [177 lbf•in]

Caution

Volumetric efficiencies of the system will have impacts on the start and end input commands.

Control Options

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

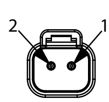
Response time, MDC 060/068

Code	Orifice description (mm)			Stroking direction	
	Tank (A+B)	P	A/B	Neutral to full flow	Full flow to neutral
C3	No orifice			0.4 s	0.4 s
C6	1	–	–	1.1 s	1.0 s
C7	1.3	–	–	0.7 s	0.7 s
D1	0.8	1	–	2.1 s	1.5 s
D2	0.8	1.3	–	1.8 s	1.4 s
D3	1	1.3	–	1.3 s	1.0 s
D4	1	1.3	1.3	1.6 s	1.2 s

For further data please contact your Danfoss representative.

Connector

Connector DEUTSCH, 2-pin



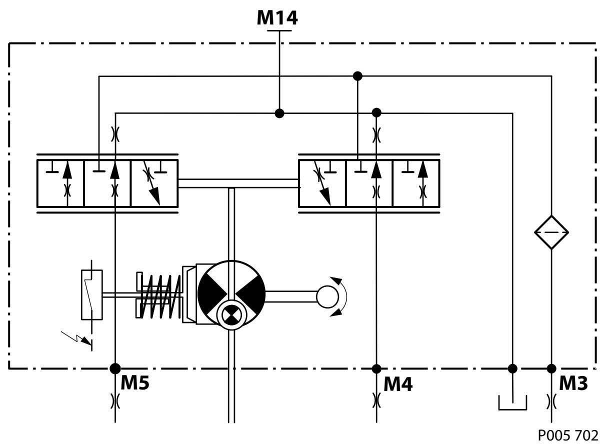
Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Neutral start switch (NSS)

The Neutral Start Switch **(NSS)** contains an electrical switch that provides a signal of whether the control is in neutral. The signal in neutral is Normally Closed **(NC)**.

Control Options

Neutral start switch schematic



Neutral start switch data

Max. continuous current with switching	8.4 A
Max. continuous current without switching	20 A
Max. voltage	36 V_{DC}
Electrical protection class	IP67 / IP69K with mating connector

Case Gauge Port M14

The drain port should be used when the control is mounted on the unit's bottom side to flush residual contamination out of the control.

Lever

MDC-controls are available with an integrated lever.

Control Options

Hydraulic Displacement Control (HDC)

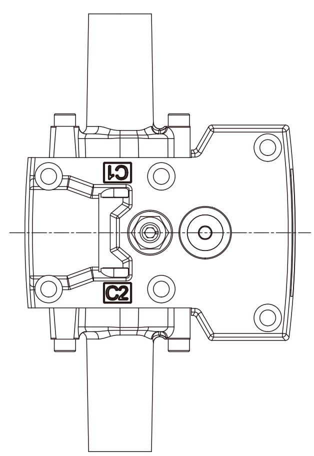
HDC principle

An HDC is a Hydraulic Displacement Control. Pump swashplate position is proportional to the input command and therefore vehicle speed or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The HDC control uses a hydraulic input signal to operate a porting spool, which ports hydraulic pressure to either side of a double acting servo piston. The hydraulic signal applies a force input to the spool which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction. Under some circumstances, such as contamination, the porting spool could stick and cause the pump to stay at some displacement.

A serviceable 175 µm screen is located in the supply line immediately before the control porting spool.

HDC control



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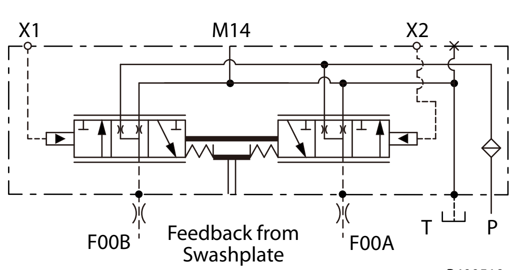
HDC schematic



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HDC operation

HDC's are hydraulically driven control which ports hydraulic pressure to either side of a porting spool, which pressurizes one end of the servo piston, while draining the other end to case. Pressure differential across the servo piston moves the swashplate.

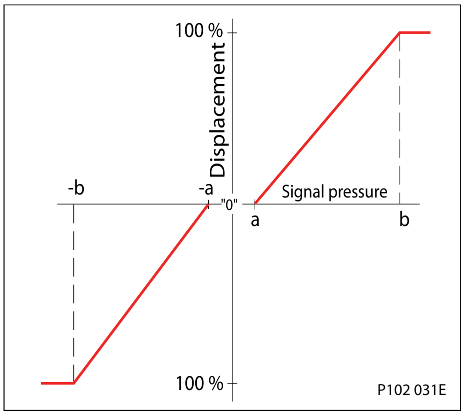
A swashplate feedback link, opposing control linkage, and a linear spring provide swashplate position force feedback to the hydraulic pressure. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

Control Options

The HDC incorporates a positive neutral dead band as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold point is reached, the swashplate is positioned directly proportional to the control pressure.

When the control input is either lost or removed, or if there is a loss of charge pressure, the spring loaded servo piston will automatically return the pump to the neutral position.

Pump displacement vs signal pressure



Hydraulic signal pressure range

Option	Type	a*	b*	Max. pressure
T1	Standard	4.2 bar	16.2 bar	30 bar
T2	Option	3 bar	11.6 bar	30 bar

* Factory test current, for vehicle movement or application actuation expect a higher or lower value.

Pump output flow direction vs. control pressure

Shaft rotation HDC	Clockwise (CW) seen from shaft		Counter Clockwise (CCW) seen from shaft	
Port energized	X1	X2	X1	X2
Port A	Out (high)	In (low)	In (low)	Out (high)
Port B	In (low)	Out (high)	Out (high)	In (low)
Servo port high pressure	M4	M5	M4	M5

For appropriate performance of HDC characteristic, keep the drain pressure of pilot valve to be equal or slightly higher than pump case pressure.

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Control Options

Response time, HDC 069/078

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	2.1s	1s	0.5s
Full flow to neutral	1.2s	0.5s	0.3s

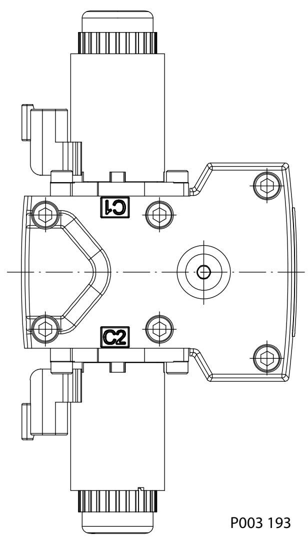
Control Options

Forward-Neutral-Reverse Control (FNR)

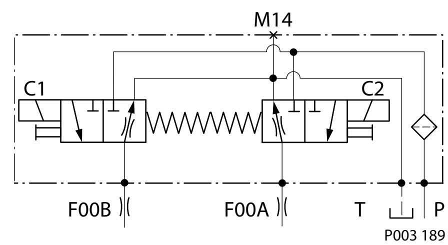
The 3-position FNR control options **A9** (12 V) and **B1** (24 V) uses an electric input signal to switch the pump to a full stroke position. A serviceable 125 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool can stick and cause the pump to stay at some displacement.

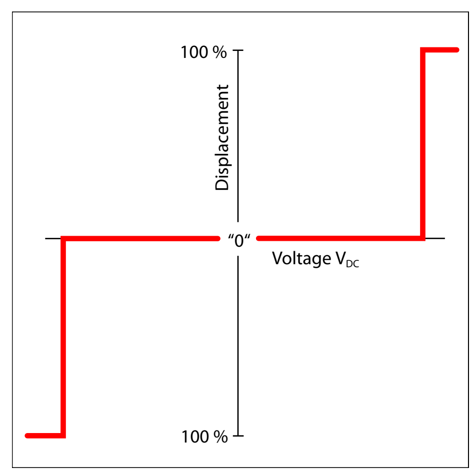
Forward-Neutral-Reverse electric control (FNR)



FNR hydraulic schematic



Pump displacement vs. electrical signal



FNR control current

Voltage	12 V_{DC}	24 V_{DC}
Minimum current to stroke pump	750 mA	380 mA
Pin connections	any order	

Single Pump Output Flow Direction

Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see installation drawings.

Control Options

FNR Solenoid Data

Solenoid data

Voltage	**12 V_{DC}**	**24 V_{DC}**
Minimum supply voltage	9.5 V_{DC}	19 V_{DC}
Maximum supply voltage (continuous)	14.6 V_{DC}	29 V_{DC}
Bi-directional diode cut off voltage	28 V_{DC}	53 V_{DC}
Maximum current	1050 mA	500 mA
Nominal coil resistance @ 20°C	8.4 Ω	34.5 Ω
PWM Range	70 – 200 Hz	
PWM Frequency (preferred)*	100 Hz	

* PWM signal required for optimum control performance.

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

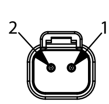
The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Response Time, FNR 060/068

Stroking direction	0.8 [0.03] orifice	1.3 [0.05] orifice	No orifice
Neutral to full flow	2.7 s	0.9 s	0.8 s
Full flow to neutral	2.3 s	1.1 s	0.5 s

Control Options

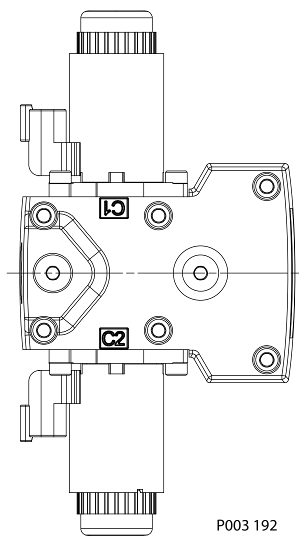
Non feedback proportional electric control (NFPE)

The Non Feedback Proportional Electric (**NFPE**) control is an electrical automotive control in which an electrical input signal activates one of two proportional solenoids that port charge pressure to either side of the pump servo cylinder. The NFPE control has no mechanical feedback mechanism.

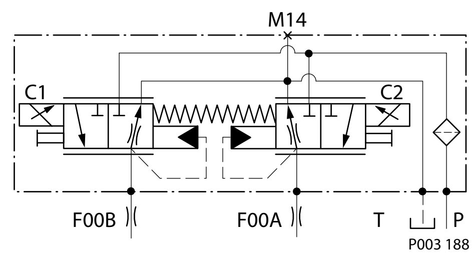
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

NFPE control



NFPE schematic

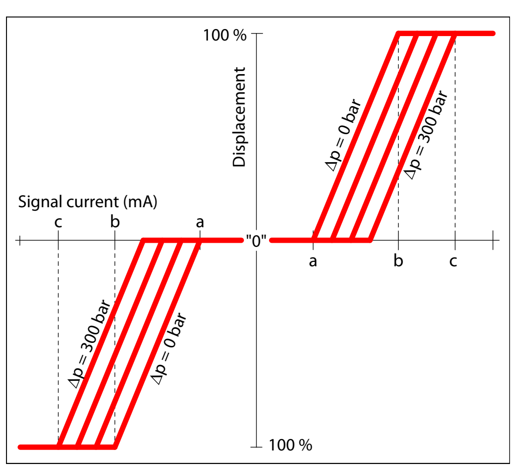


Control Signal Requirements, NFPE 060/068

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash-plate angle as system pressure increases.

A typical response characteristic is shown in the accompanying graph below:

Pump displacement vs. input signal



Control Options

Control current requirements

Voltage*	a	b	c	Pin config.
12 V_{DC}	694 mA	1114 mA	1490 mA	any order
24 V_{DC}	347 mA	583 mA	745 mA	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Single Pump Output Flow Direction

Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see installation drawings.

Control Options

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

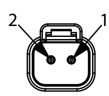
The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

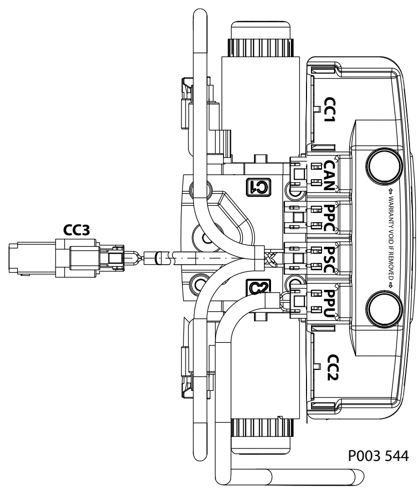
Response Time, NFPE 060/068

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	2.3 mm [0.09 in] orifice
Neutral to full flow	2.5 s	1.1 s	0.6 s
Full flow to neutral	1.9 s	0.6 s	0.3 s

Control Options

Automotive Control (AC)

The H1 **A**automotive **C**ontrol (AC) is an electric NFPE Control with an integrated micro-controller, installed on the pump. The integrated micro-controller enhanced control performance with a flexible, configurable control scheme for an entire single path propel transmission. It can be used in combination with fixed and variable displacement hydraulic-motors. With the pre-installed application software and easily changeable control parameters, it is possible to tailor the vehicle's driving behavior to the individual requirements of the customer.



The H1 Automotive Control is divided into 2 systems:
- AC-1
- AC-2

AC-2 is an extension of AC-1 that features an integrated pump swash plate angle sensor and software enabled functions such as Swash Plate Control.

Mode types

The application software provides 3 different hydrostatic propel methods, defined as mode types, which can be used individually.
- **Automotive Load dependent** (torque controlled) driving behavior. Setpoint for the drive curve is the engine rpm.
- **Non-Automotive Load independent** (speed controlled) driving mode. Setpoint for the drive curve is a Joystick or drive pedal signal, independent of the engine rpm. The best performance will achieved with an AC-2 Swash Plate Angle Sensor.
- **Creep-Automotive Load dependent** (torque controlled) driving behavior (like Automotive). Setpoint for the drive curve is the engine rpm. The setpoint can be reduced by the creep potentiometer if a high engine rpm in combination with low vehicle speed is needed.

Basic functions

- Four selectable system modes, selectable via switch.
- Individual settings for forward and reverse driving direction (4 x 2 curves).
- Independent pump and hydraulic-motor profiling and ramping for each mode.
- Electric drive pedal connection
- Electronic inching function without separate control valve
- Electric creep mode potentiometer

Control Options

- Configurable System Mode & Direction change
- Load independent pump displacement control with integrated Swash Plate Angle Sensor (AC-2)
- Hydraulic-motor displacement control including brake pressure defeat function

Performance functions

- ECO fuel saving mode with automatic reduction of the engine speed during transport (Cruise control)
- Vehicle constant speed drive control
- Vehicle speed limitation
- Dynamic brake light, automatic park brake, reverse buzzer and status LED outputs
- Vehicle speed controlled output function.
- Temperature compensation for predictable performance
- Advanced CAN J1939 interface for the information exchange with the vehicle control system

Protection and safety functions

- Safety controlled vehicle start protection with engine speed check, battery check and FNR must be in neutral, etc..
- Operator presence detection
- Hydraulic system overheat and low-temperature protection
- Hydraulic motor over speed protection
- Park brake test mode for roller applications to fulfill SAE J1472 / EN500-4.
- SIL2 compliant

Engine control and protection

- CAN J1939 engine interface
- Engine speed control via drive pedal with safety controlled monitoring function
- Engine antistall protection
- Engine over speed protection during inching
- Engine speed dependent Retarder control
- Engine cold start protection

Installation features

- Factory calibration for hysteresis compensation.
- Starting current adjustment in the factory
- Pre-installed application software and parameter files

For more information, see *Automotive Control for H1 Single Pumps Technical Information*, **BC152986482596**.

Control Options

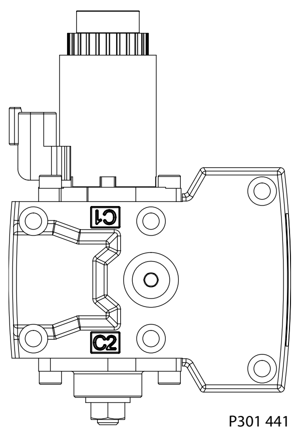
Fan Drive Control (FDC)

The Fan Drive Control (**FDC**) is a non-feedback control in which an electrical input signal activates the proportional solenoid that ports charge pressure to either side of the pump servo cylinder. The single proportional solenoid is used to control pump displacement in the forward or reverse direction.

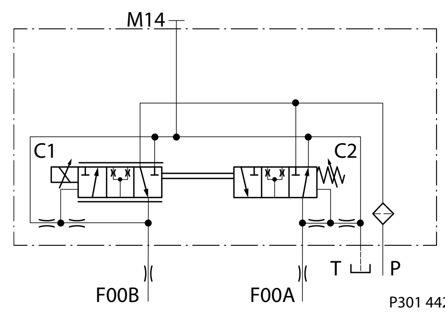
The control spool is spring biased to produce maximum forward pump displacement in the absence of an electrical input signal. Based on the spring bias spool default forward flow for a CW rotation pump is out of port B while default forward flow for a CCW rotation pump is out of port A.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

FDC control



FDC schematic



The pump should be configured with 0.8 mm control orifices to provide slowest response and maximize system stability. Additionally, pressure limiter (PL) valves are used to limit maximum fan trim speed in both (forward and reverse) directions.

H1 pumps with FDC will be delivered from factory with nominal pressure limiter setting of 150 bar [2175 psi]. The PL must be re-adjusted to ensure that the fan reaches the desired fan speed to satisfy the cooling needs of the system. HPRV setting must be always at least 30 bar [435 psi] higher than PL setting.

For more information necessary to properly size and configure a hydraulic fan drive system, see *Hydraulic Fan Drive Design Guidelines* **AB152886482265**.

Warning

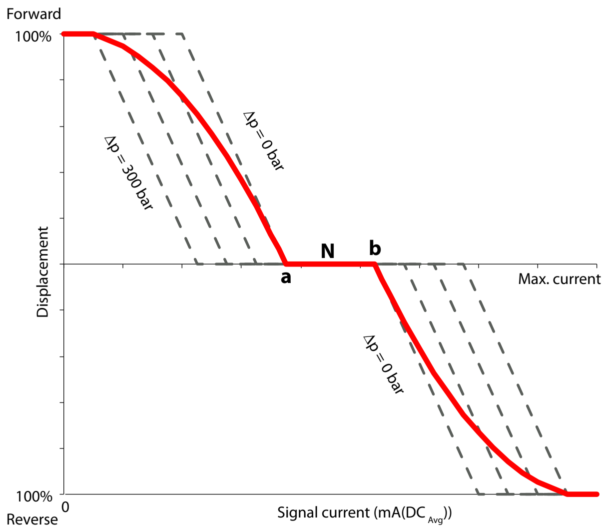
Use in other systems could result in unintended movement of the machine or it's elements. Loss of the input signal to this control will cause the pump to produce maximum flow.
The FDC is for Fan Drive systems only!

Due to the fail-safe functionality of the FDC control the pump will stroke to max. displacement in case the input signal to the pump control and the Diesel engine will be switched off at the same time. In this situation a low loop event can occur which may damage the pump. Therefore, it's strictly recommended to keep the input signal to the pump control alive while switching off the engine.
For further information please contact your Danfoss representative.

Control Options

Control Signal Requirements, FDC 060/068

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash plate angle as system pressure increases. A typical response characteristic is shown in the accompanying graph below:



a – Forward threshold

b – Reverse threshold

N – Neutral override current

Control current requirements

Voltage*	a	N	b	Pin config.
12 V_{DC}	780 mA	1100 mA	1300 mA	any order
24 V_{DC}	400 mA	550 mA	680 mA	

* Factory test current, for fan movement expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Control Options

Single Pump Output Flow Direction

Pump output flow direction vs. control signal

Shaft rotation		ClockWise			CounterClockWise		
Control Logic	**12 V**	**0-780 mA**	**1100 mA**	**1300-1800 mA**	**0-780 mA**	**1100 mA**	**1300-1800 mA**
	24 V	**0-400 mA**	**550 mA**	**680-920 mA**	**0-400 mA**	**550 mA**	**680-920 mA**
Port A		in	no flow	out	out	no flow	in
Port B		out	no flow	in	in	no flow	out
Servo port pressurized		M5	n/a	M4	M5	n/a	M4

Warning

Loss of input signal to the control will cause the pump to produce maximum flow.

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

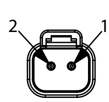
The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Response Time, FDC 060/068

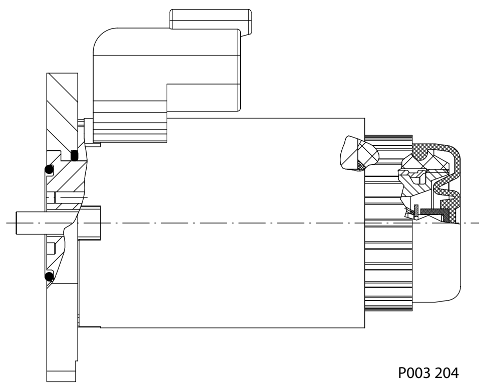
Stroking direction	0.8 mm [0.03 in] orifice
Full flow to neutral	2.6 s
Full forward flow to full reverse flow	3.7 s

Control Options

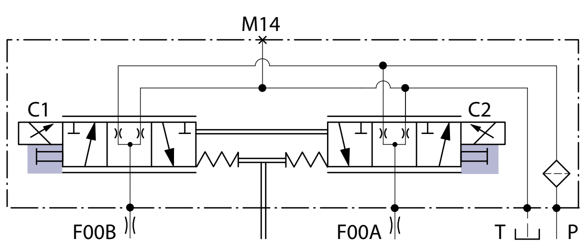
Manual Override (MOR)

All controls are available with a manual override functionality, either as a standard or as an option for temporary actuation of the control to aid in diagnostics.

Control with manual override



MOR schematic (EDC control shown)



Feedback from swash plate.

The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke. The MOR should be engaged anticipating a full stroke response from the pump.

An o-ring seal is used to seal the MOR plunger where initial actuation of the function will require a force of 45 N to engage the plunger. Additional actuation typically require less force to engage the MOR plunger.

Proportional control of the pump using the MOR should not be expected.

Warning

Unintended MOR operation will cause the pump to go into stroke; *example:* vehicle lifted off the ground. The vehicle or device must always be in a safe condition when using the MOR function.

Refer to control flow table for the relationship of solenoid to direction of flow.

Control Options

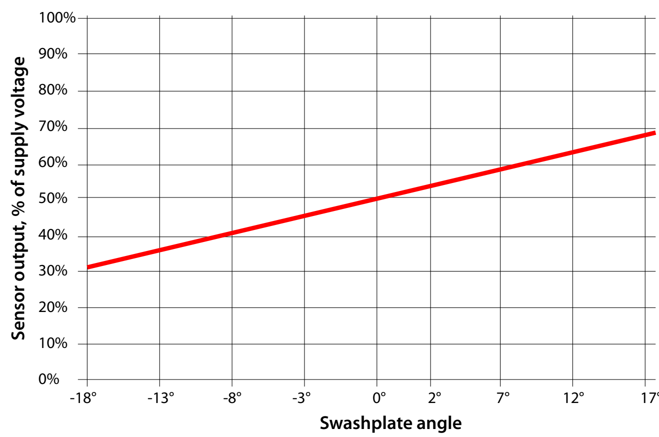
Swashplate angle sensor for EDC controls

The angle sensor detects the swash plate position with an accuracy dependent upon the calibration effort done for the application and direction of rotation from the neutral position. At minimum the sensor can be used for forward, neutral and reverse (FNR) detection.

The sensor works on the hall-effect technology. The implemented technology is based on a measurement of the magnetic field direction in parallel to the chip surface. This field direction is converted to a voltage signal at the output.

Enhanced calibration of the non-linear behavior leads to more exact calculation of the pump swashplate angle. The 4-pin DEUTSCH connector is part of the sensor housing. The swashplate angle sensor is available for all EDC controls for 12 V and 24 V.

Swashplate angle vs. output of supply voltage



Warning

Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

Contact your Danfoss representative in case the angle sensor will be used for safety functions.

Swash plate angle sensor parameters (EDC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.5 V_{DC}	5 V_{DC}	5.5 V_{DC}
Supply protection	–	–	18 V_{DC}
Pump neutral output (% of supply voltage)	–	50%	–
Working range (swash plate angle)	–18°	–	18°
Required supply current	–	–	30 mA
Output current signal	–	9 mA	11 mA
Working temperature	–40 °C	80 °C	115 °C

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector
EMC Immunity	ISO 11452-2	100 V/m

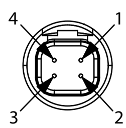
Control Options

Calibration of the sensor output within the software is mandatory. Vehicle neutral thresholds in the software (±0.5°) are vehicle dependent and must consider different conditions, example: system temperature, system pressure and/or shaft speed.

For safety function: If the sensor fails (invalid signal <10% or >90% of supply voltage), it must be sure that the ECU will go into a diagnostic mode and shift into limited mode in order for the driver to take the full control or the mechanical breaks should be activated. Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

H1P Swash Plate Angle Sensor Connector

Connector DEUTSCH, 4-pin

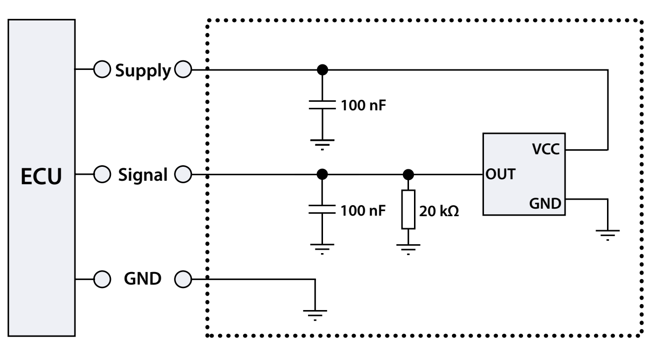


1	Ground (GND)
2	Not connected
3	Output signal 1 (SIG 1)
4	Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Interface with ECU (EDC)

Interface with ECU diagram

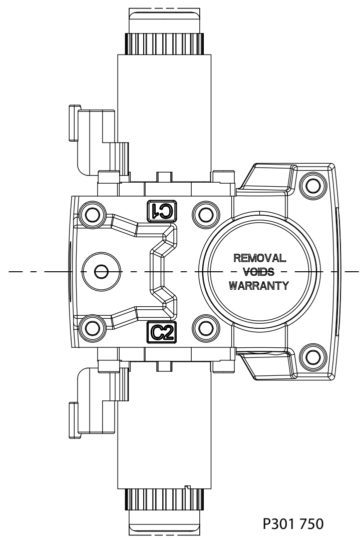


Control Options

Swash Plate Angle Sensor for NFPE and AC2 Controls

The angle sensor detects the swash plate angle position and direction of rotation from the zero position. The swash angle sensor works on the AMR sensing technology. Under the saturated magnetic field, the resistance of the element varies with the magnetic field direction.

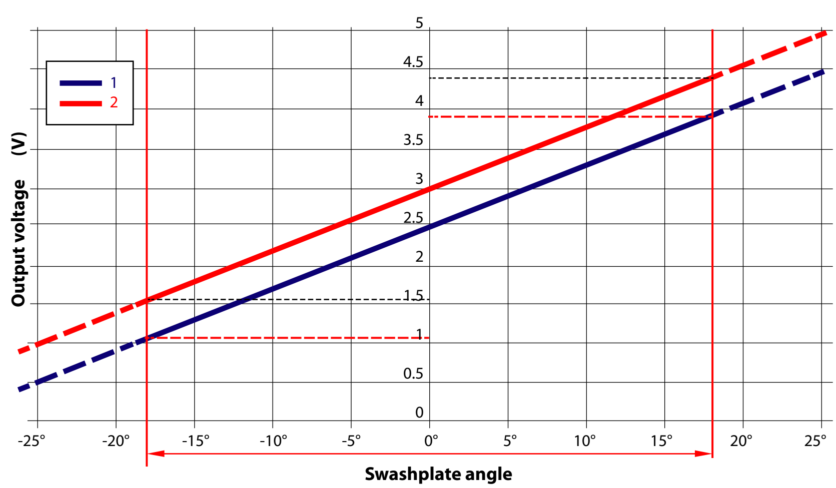
The output signal give a linear output voltage for the various magnet positions in the sensing range.



Swash Plate Angle Characteristic

The volumetric losses depend on pump max. displacement, actual displacement, speed, delta pressure, viscosity and temperature.

Swashplate angle vs. output voltage (calibrated at 50 °C)



1. Signal 1 (nominal)
2. Signal 2 (redundant)

The displacement can be calculated by:

$$V = \frac{\tan \alpha \cdot V}{\tan 18°} \ (cm^3)$$

The corresponding flow is:

$$Q = \frac{V \cdot n \cdot \eta_{vol}}{1000} \ (l/min)$$

Control Options

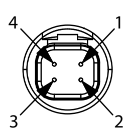
Swash Plate Angle Sensor Parameters (NFPE/AC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.75 V	5 V	5.25 V
Supply protection	–	–	28 V
Supply current	–	22 mA	25 mA
Output current (Signal 1, 2)	–	0.1 mA	–
Short circuit output current to supply or GND[1)]	–	–	7.5 mA
Sensitivity	70.0 mV/deg	78.0 mV/deg	85.8 mV/deg
Working range (swash plate angle)	−18°	0°	18°
Correlation between signals 1 and 2[2)]	475 mV	500 mV	525 mV

[1)] Up to duration of 2.5 seconds at 25°C

[2)] Signal 1 (nominal) is lower than signal 2 (redundant)

H1P Swash Plate Angle Sensor Connector (NFPE)



1 Ground (GND)

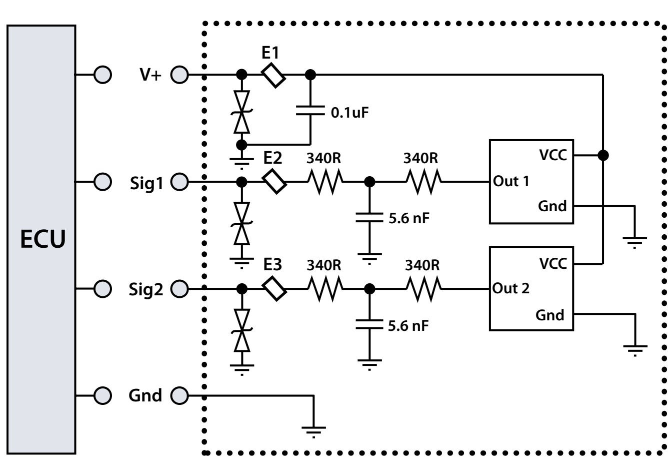
2 Output Signal 2 (SIG 2) – Secondary (redundant)

3 Output signal 1 (SIG 1)

4 Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Interface with ECU (NFPE)



Minimum recommended load resistance is 100 kΩ.

Control Options

Control Cut Off Valve (CCO)

The H1 pump offers an optional control cut off valve integrated into the control. All EDC, NFPE and MDC controls are available with a CCO valve. This valve will block charge pressure to the control, allowing the servo springs to de-stroke both pumps regardless of the pump´s primary control input.

There is also a hydraulic logic port, X7, which can be used to control other machine functions, such as spring applied pressure release brakes. The pressure at X7 is controlled by the control cut off solenoid. The X7 port would remain plugged if not needed.

In the normal (de-energized) state of the solenoid charge flow is prevented from reaching the controls. At the same time the control passages and the X7 logic port are connected and drained to the pump case. The pump will remain in neutral, or return to neutral, independent of the control input signal. Return to neutral time will be dependent on oil viscosity, pump speed, swashplate angle, and system pressure.

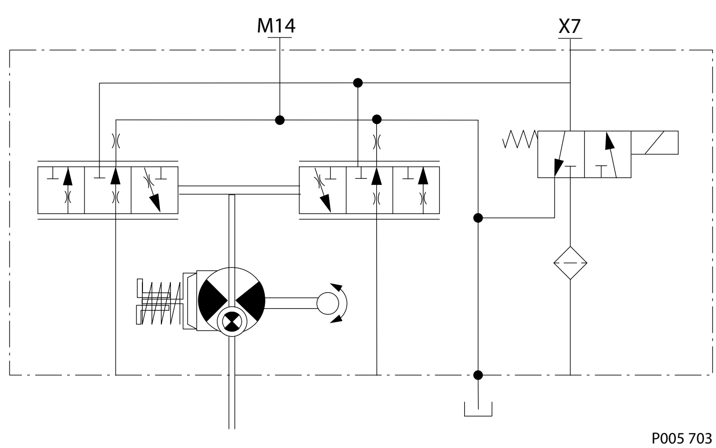
When the solenoid is energized, charge flow and pressure is allowed to reach the pump control. The X7 logic port will also be connected to charge pressure and flow.

The solenoid control is intended to be independent of the primary pump control making the control cut off an override control feature. It is however recommended that the control logic of the CCO valve be maintained such that the primary pump control signal is also disabled whenever the CCO valve is de-energized. Other control logic conditions may also be considered.

The CCO valve is available with 12 V or 24 V solenoid.

The response time of the unit depends on the control type and the used control orifices.

CCO schematic (MDC shown)



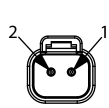
Brake gauge port with MDC

Caution

It is not recommended to use brake port for any external flow consumption to avoid malfunction of CCO function.

CCO Connector (MDC)

Connector DEUTSCH, 2-pin

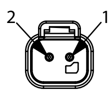


Control Options

Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

H1P CCO Connector (EDC, NFPE)

Connector CCO DEUTSCH, 2-pin with key C



Description	Quantity	Order number
Mating connector	1	DEUTSCH DT06-2S-C015
Wedge lock	1	DEUTSCH W2SC-P012
Socket contact	4	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	11212714

CCO solenoid data

Nominal supply voltage		12 V	24 V
Supply voltage	Maximum	14.6 V	29 V
	Minimum	9.5 V	19 V
Bi-directional diode cut off voltage		28 V	53 V
Nominal coil resistance at 20 °C		10.7 Ω	41.7 Ω
Supply current	Maximum	850 mA	430 mA
	Minimum	580 mA	300 mA
PWM frequency	Range	50 – 200 Hz	
	Preferred	100 Hz	
Electrical protection class		IP67 / IP69K with mating connector	

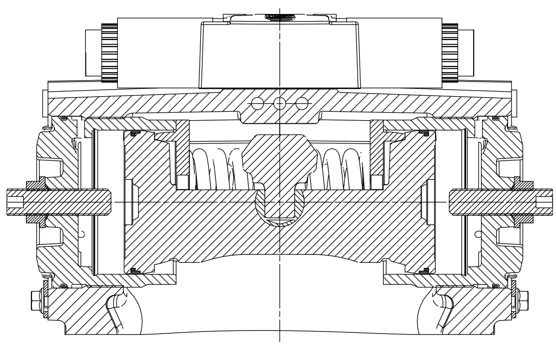
CCO solenoids are design for battery voltage application within the voltage range in the table above, in consideration of a wide range of environmental temperature common for known hydraulic applications. Closed loop PWM current supply can be also applied and is helpful in case that the voltage range is exceeded, or ambient temperature could rise in an unusual manner.

Control Options

Displacement Limiter

H1 pumps are designed with optional mechanical displacement (stroke) limiters factory set to max. displacement. The maximum displacement of the pump can be set independently for forward and reverse using the two adjustment screws to mechanically limit the travel of the servo piston down to 50% displacement.

Adjustments under operating conditions may cause leakage. The adjustment screw can be completely removed from the threaded bore if backed out to far.



P003 266

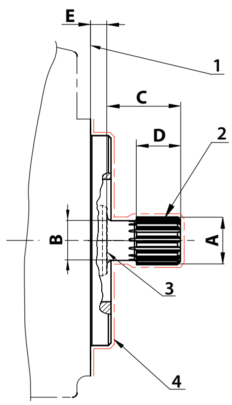
H1P 060/068 Displacement Change (approximately)

Parameter	Size 060	Size 068
1 turn of displacement limiter screw	5.9 cm^3 [0.36 in^3]	6.6 cm^3 [0.40 in^3]
Internal wrench size	4 mm	
External wrench size	13 mm	
Torque for external hex seal lock nut	23 N•m [204 lbf•in]	

For more information, see *H1 Axial Piston Pumps, Service Manual,* **AX152886482551**, the section “Displacement Limiter Adjustment”.

Dimensions and Data

H1P 060/068 Input Shaft Option G1 (SAE C, 14 teeth)



1. Surface of mounting flange 127 – 4 per ISO 3019-1 (SAE C); to be paint free
2. **Spline Data:** 14 teeth, Pressure angle: 30°, Pitch: 12/24, Ø29.633 [1.167]; Fillet root side fit per ANSI B92.1-1996, Class 6
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1]	E
Ø31.58 ±0.09 [1.243 ±0.004]	Ø25.72 ±0.12 [1.024 ±0.005]	48.0 ±0.68 [1.89 ±0.003]	28.8 ±1.0 [1.134 ±0.039]	8.0 ±0.8 [0.315 ±0.03]

[1] Minimum active spline length for the specified torque ratings.

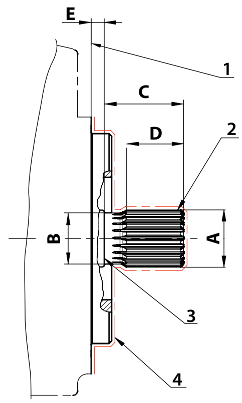
Torque rating

Rated torque	Maximum torque
534 N•m [4720 lb•in]	592 N•m [5240 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P 060/068 Input Shaft Option F1 (SAE C, 21 teeth)



1. Surface of mounting flange 127 – 4 per ISO 3019-1 (SAE C); to be paint free
2. **Spline Data:** 21 teeth, Pressure angle: 30°, Pitch: 16/32, Ø33.338 [1.313]; Fillet root side fit per ANSI B92.1-1996, Class 6
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø34.42 ±0.09 [1.335 ±0.004]	Ø31.0 ±0.12 [1.22 ±0.005]	48.0 ±0.5 [1.89 ±0.02]	34.5 ±0.15 [1.433 ±0.01]	8.0 ±0.8 [0.315 ±0.03]

1) Minimum active spline length for the specified torque ratings.

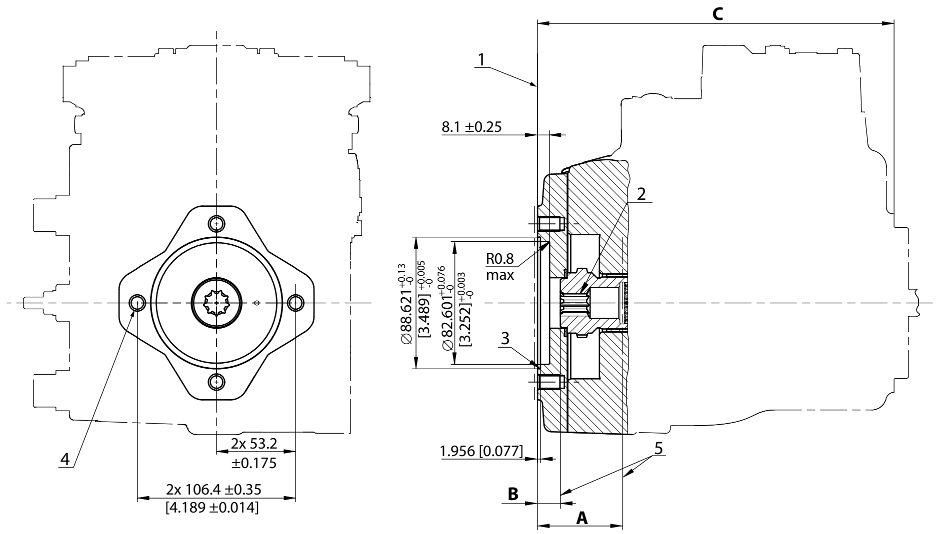
Torque rating

Rated torque	Maximum torque
760 N•m [6730 lbf•in]	1137 N•m [10 060 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth)



1. Auxiliary mounting pad for mating flange 82-2 per ISO 3019-1 (SAE A); Paint free
2. **Spline Data:** 11 teeth, Pressure angle: 30°, Pitch: 16/32, Ø17.463 [0.688]; Fillet root side fit per ANSI B92.1b, Class 7e
3. O-ring seal required; Ref. Ø82.22 ID x 2.62, cross section
4. Thread: M10x1.5-6H; 15 [0.59] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Dimensions and torque

A	B	C	Max. Torque
68.4 [2.693] min.; Shaft clearance	19.4 [0.764] min.; Shaft clearance	258.5 ±2.5 [10.177 ±0.003]	296 N•m [2620 lbf•in]

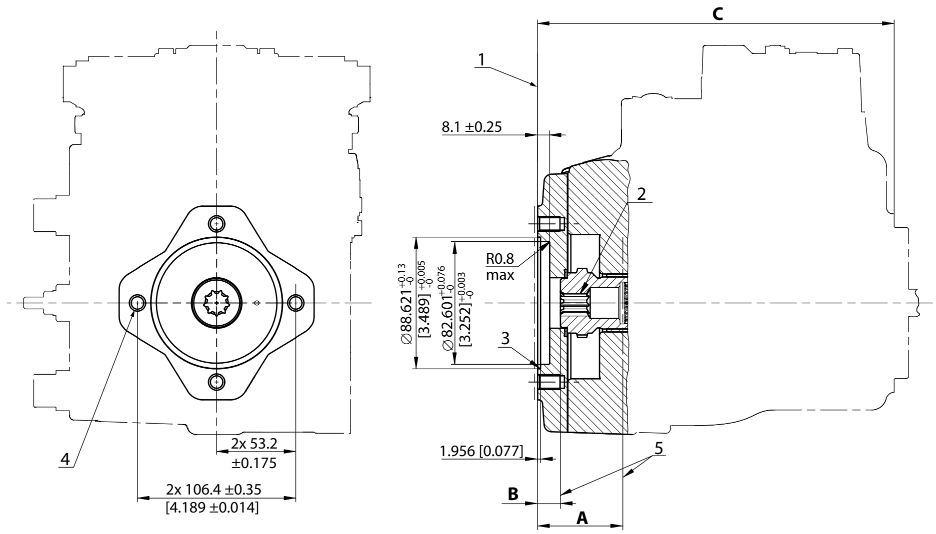
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth)



1. **1.** Auxiliary mounting pad for mating flange 82-2 per ISO 3019-1 (SAE A); Paint free
2. **Spline Data:** 9 teeth, Pressure angle: 30°, Pitch: 16/32, Ø14.288 [0.563]; Fillet root side fit per ANSI B92.1b, Class 7e
3. O-ring seal required; Ref. Ø82.22 ID x 2.62, cross section
4. Thread: M10x1.5-6H; 15 [0.59] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Dimensions and torque

A	B	C	Max. Torque
68.4 [2.693] min.; Shaft clearance	19.4 [0.764] min.; Shaft clearance	258.5 ±2.5 [10.177 ±0.003]	162 N•m [1430 lbf•in]

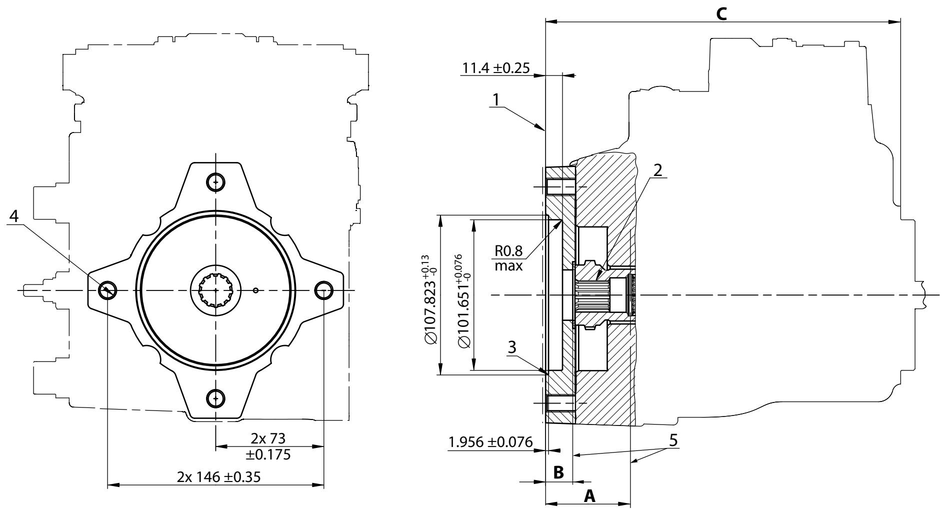
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 16/32, Ø20.638 [0.813]; Fillet root side fit per ANSI B92.1-1996, Class 6
3. O-ring seal required; Ref. Ø94.92 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 19.75 [0.778] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Bolt length > 19.75 mm could result in a leak or damage to the unit.

Dimensions and torque

A	B	C	Max. Torque
68.4 [2.693] min.; Shaft clearance	19.4 [0.764] min.; Shaft clearance	258.5 ±2.5 [10.177 ±0.003]	395 N•m [3500 lbf•in]

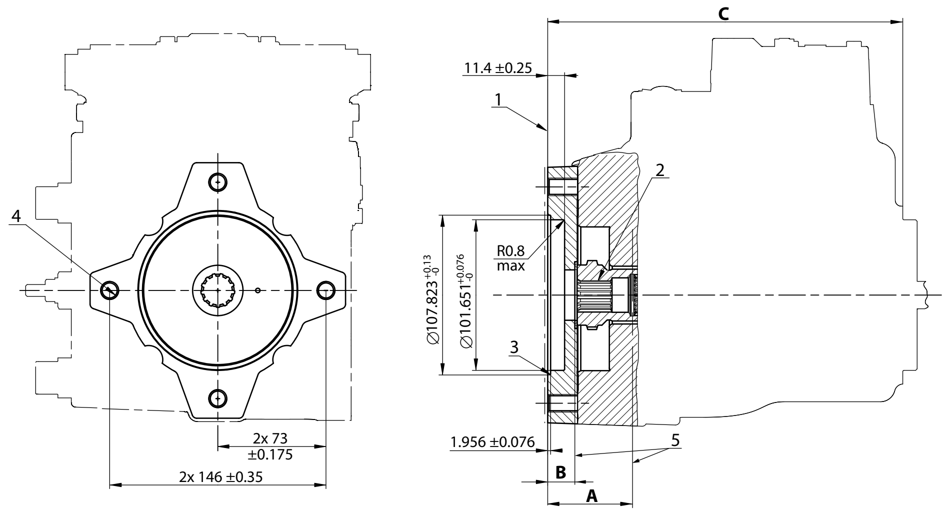
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 15 teeth, Pressure angle: 30°, Pitch: 16/32, Ø23.813 [0.938]; Fillet root side fit per ANSI B92.1b, Class 7e
3. O-ring seal required; Ref. Ø94.92 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 19.75 [0.778] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Bolt length > 19.75 mm could result in a leak or damage to the unit.

Dimensions and torque

A	B	C	Max. Torque
68.4 [2.693] min.; Shaft clearance	19.4 [0.764] min.; Shaft clearance	258.5 ±2.5 [10.177 ±0.003]	693 N•m [6130 lbf•in]

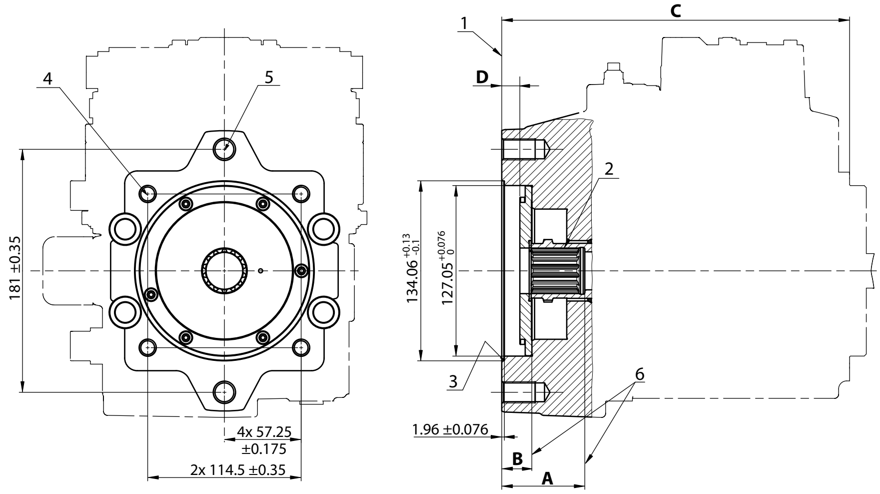
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth)



1. Auxiliary mounting pad for mating flanges: 127-2, 127-4 per ISO 3019-1 (SAE C); Paint free
2. **Spline Data:** 14 teeth, Pressure angle: 30°, Pitch: 12/24, Ø29.6334 [0.813]; Fillet root side fit per ANSI B92.1-1996, Class 7
3. O-ring seal required; Ref. Ø120.32 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 21 [0.827] min. depth (4x)
5. Thread: M16x2-6H; 25 [0.984] min. depth (2x)
6. Mating shaft and shaft shoulder must not protrude beyond this point

Bolt length > 19.75 mm could result in a leak or damage to the unit.

Dimensions and torque

A	B	C	D	Torque
61.25 [2.41] min.; Shaft clearance	21.75 [0.856] min.; Shaft clearance	259.6 ±2.5 [10.22 ±0.003]	13.5 ±0.5 [0.532 ±0.02]	816 N•m [7220 lbf•in]

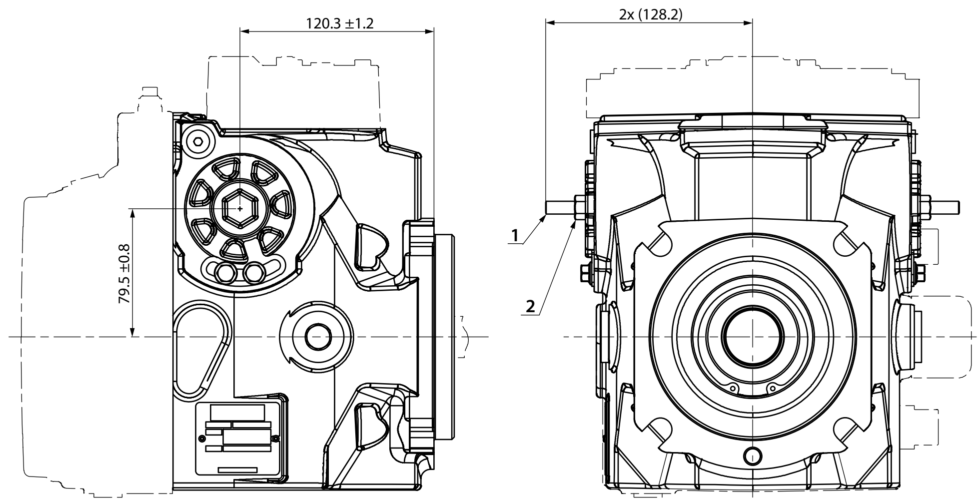
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Displacement Limiter, Option B



1. Displacement limiter screw (2x)
2. Displacement limiter seal nut (2x)

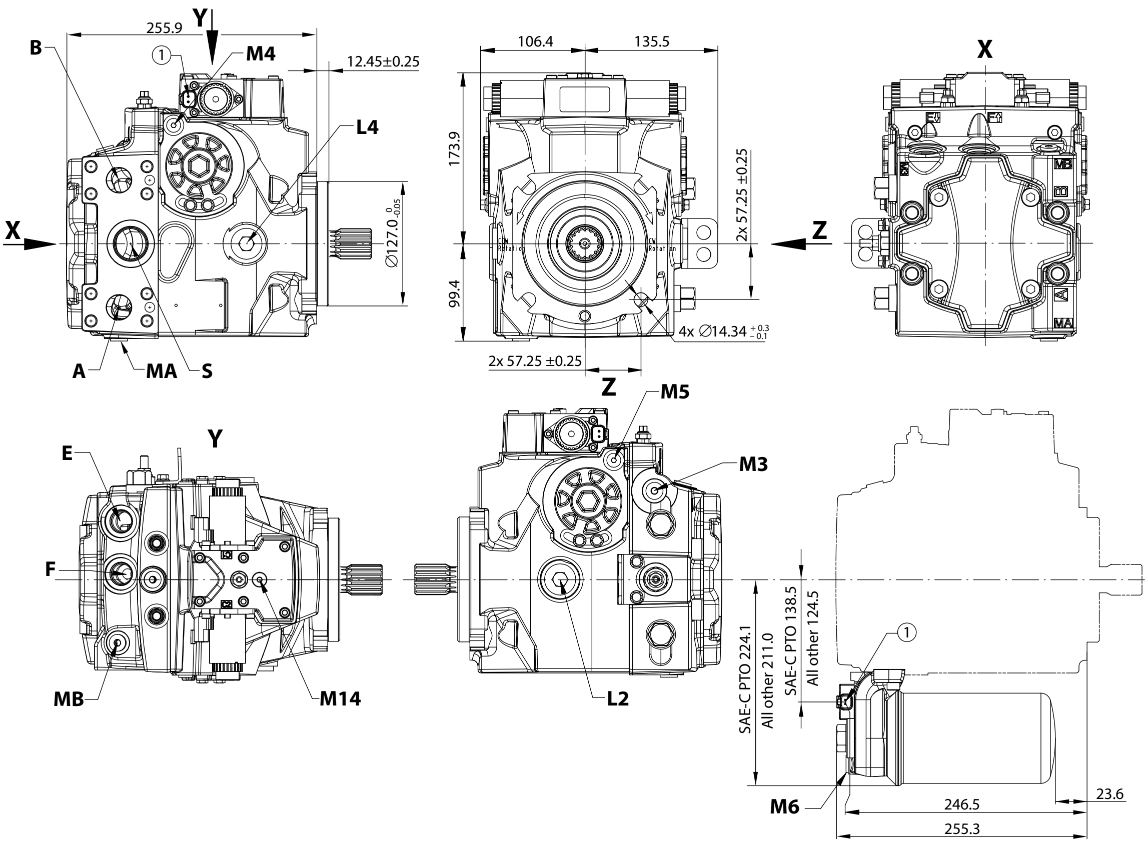
Wrench size, torque

Wrench size for DL screw	Wrench size for DL seal nut	Torque
4 internal hex	13 external hex	24 N•m [18 lb•ft]

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Single Pump Ports



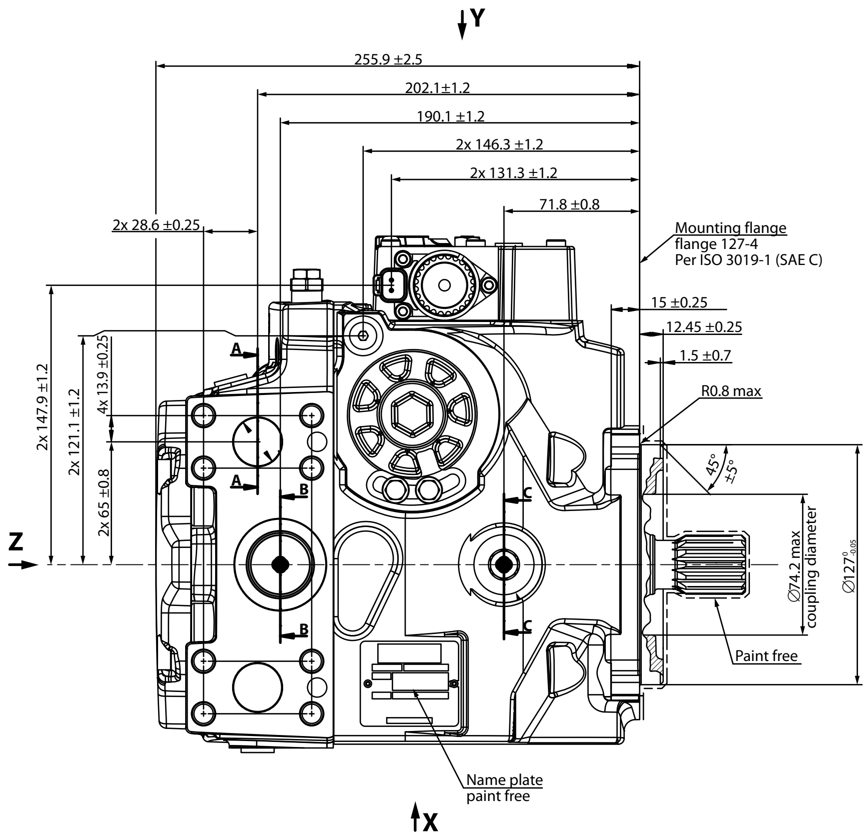
Ports per ISO 11 926-1

Port	Description	Size
A, B	System ports	Ø25.4–450 bar; Split flange boss per ISO 6162
L2, L4	Case drain ports	1 1/16–12
MA, MB	System **A/B** gauge ports	9/16–18
E/F	Charge filtration ports	7/8–14
M3	Charge pressure gauge port	9/16–18
M4, M5	Servo gauge port	7/16–20
M14	Case gauge port (EDC, FNR, NFPE)	7/16–20
S	Charge inlet port	1 5/16–12
1	Connector DEUTSCH DT04-2P, to be paint free	

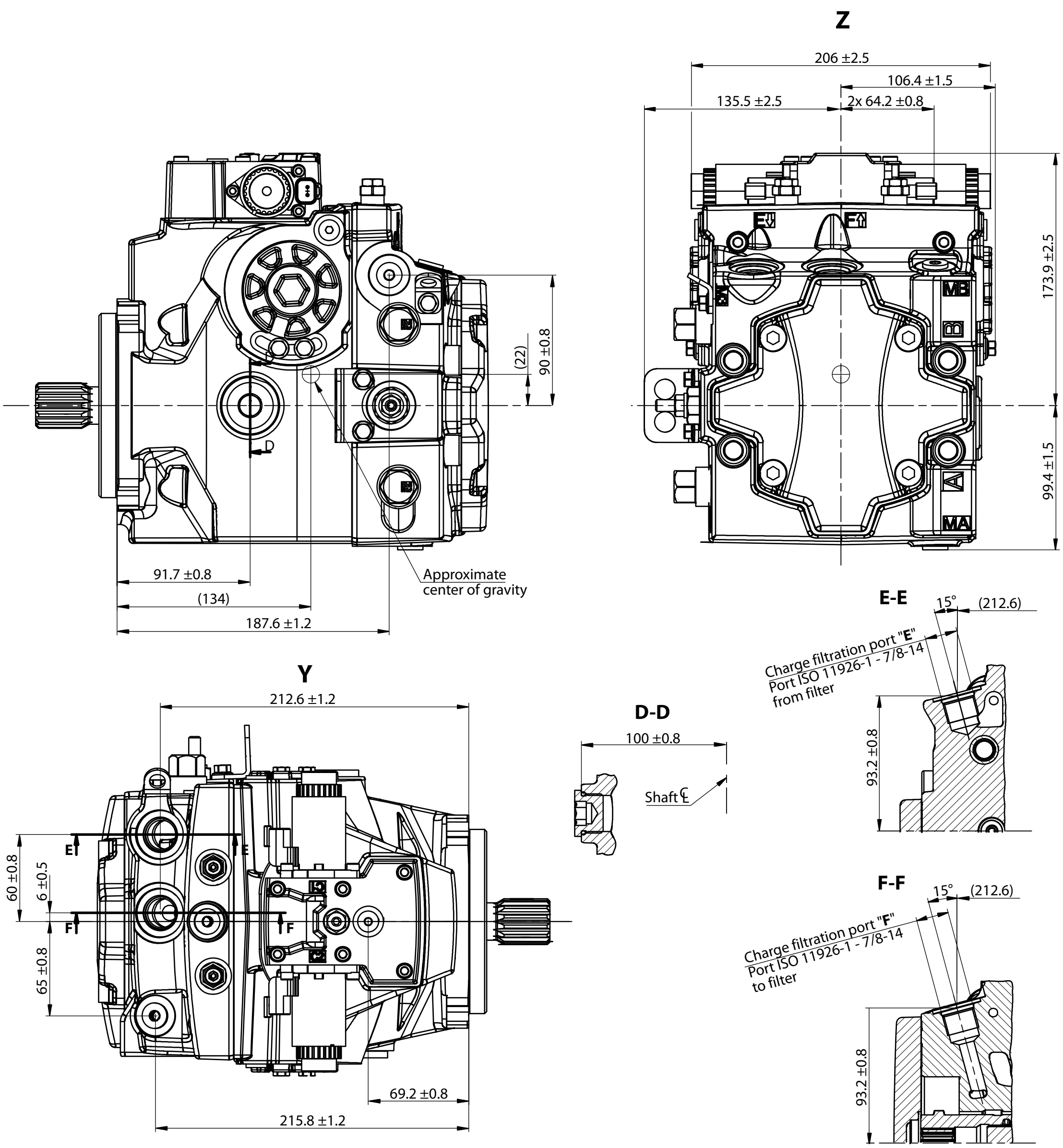
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

H1P Dimensions

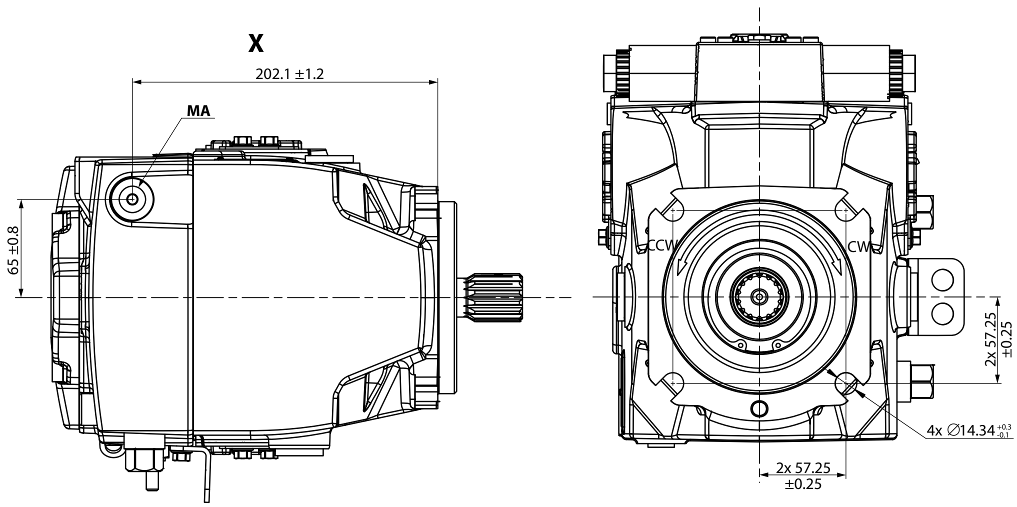


Dimensions and Data



1 — Approximate center of gravity

Dimensions and Data

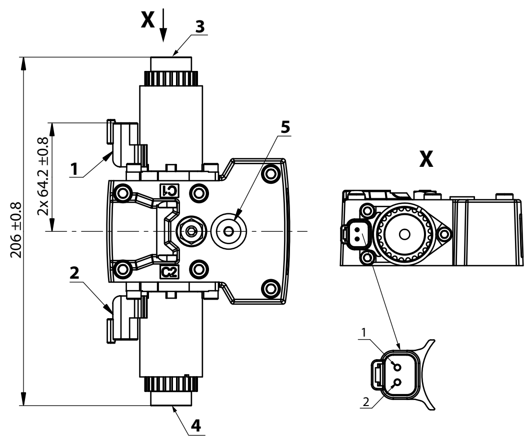


1 — Other side screw head space

Dimensions and Data

Controls

EDC Options A2 and A3 (12/24 V)



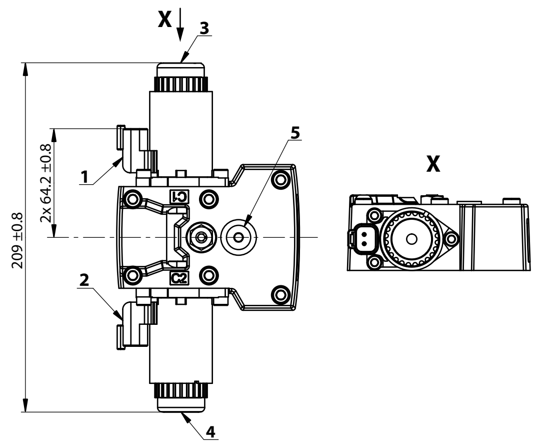
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

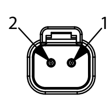
EDC with MOR, Options A4 and A5 (12/24 V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector C1/C2: DEUTSCH DTM04-2P

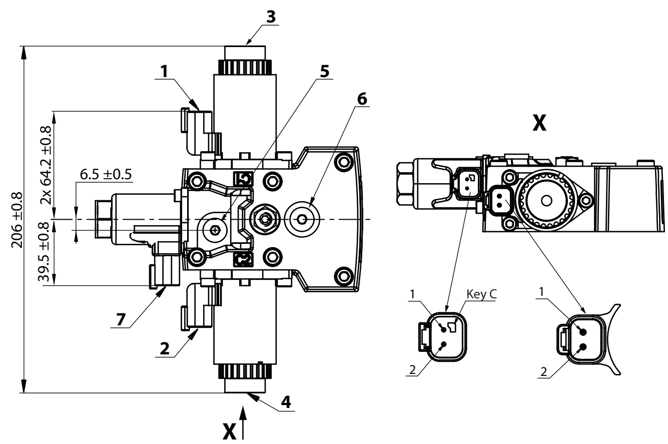


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

EDC with CCO (key C), Options E7 and E8 (12/24 V)



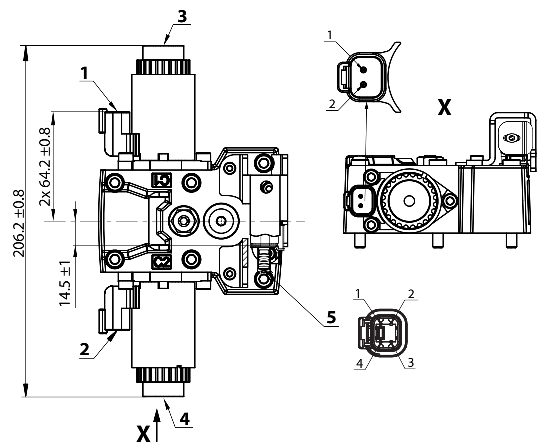
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
6. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

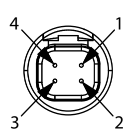
Dimensions and Data

EDC with ASNSR, Options: H2 and H3 (12/24 V)



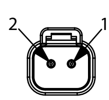
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Angle sensor connector **S2** DEUTSCH DT04-4P, paint free

Connector DEUTSCH, 4-pin



4-pin assignment:
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Connector **C1/C2**: DEUTSCH DTM04-2P*

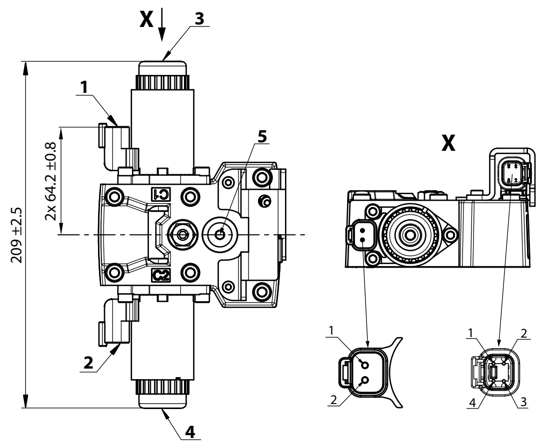


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

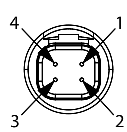
Dimensions and Data

EDC with MOR and ASNSR, Options H6 and H7 (12/24 V)



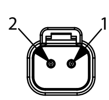
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Connector DEUTSCH, 4-pin



4-pin assignment:
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Connector **C1/C2**: DEUTSCH DTM04-2P*

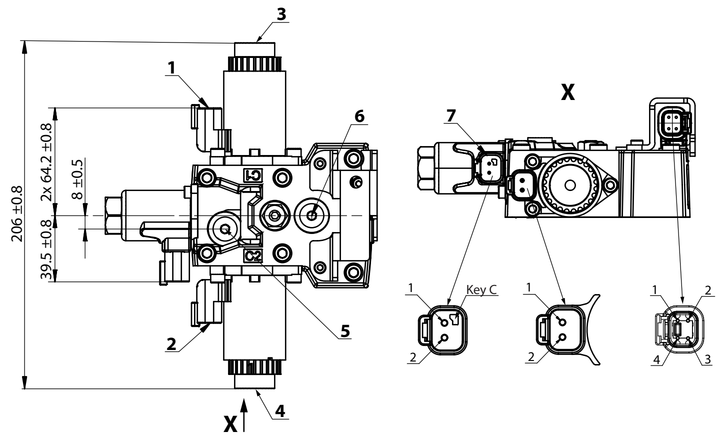


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

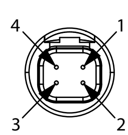
EDC with CCO and ASNSR, Options H8 and H9 (12/24 V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
6. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

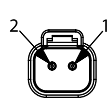
Connector DEUTSCH, 4-pin



Angle sensor connector S2: DEUTSCH DTM04-4P

1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connectors C1/C2/C4: DEUTSCH DTM04-2P

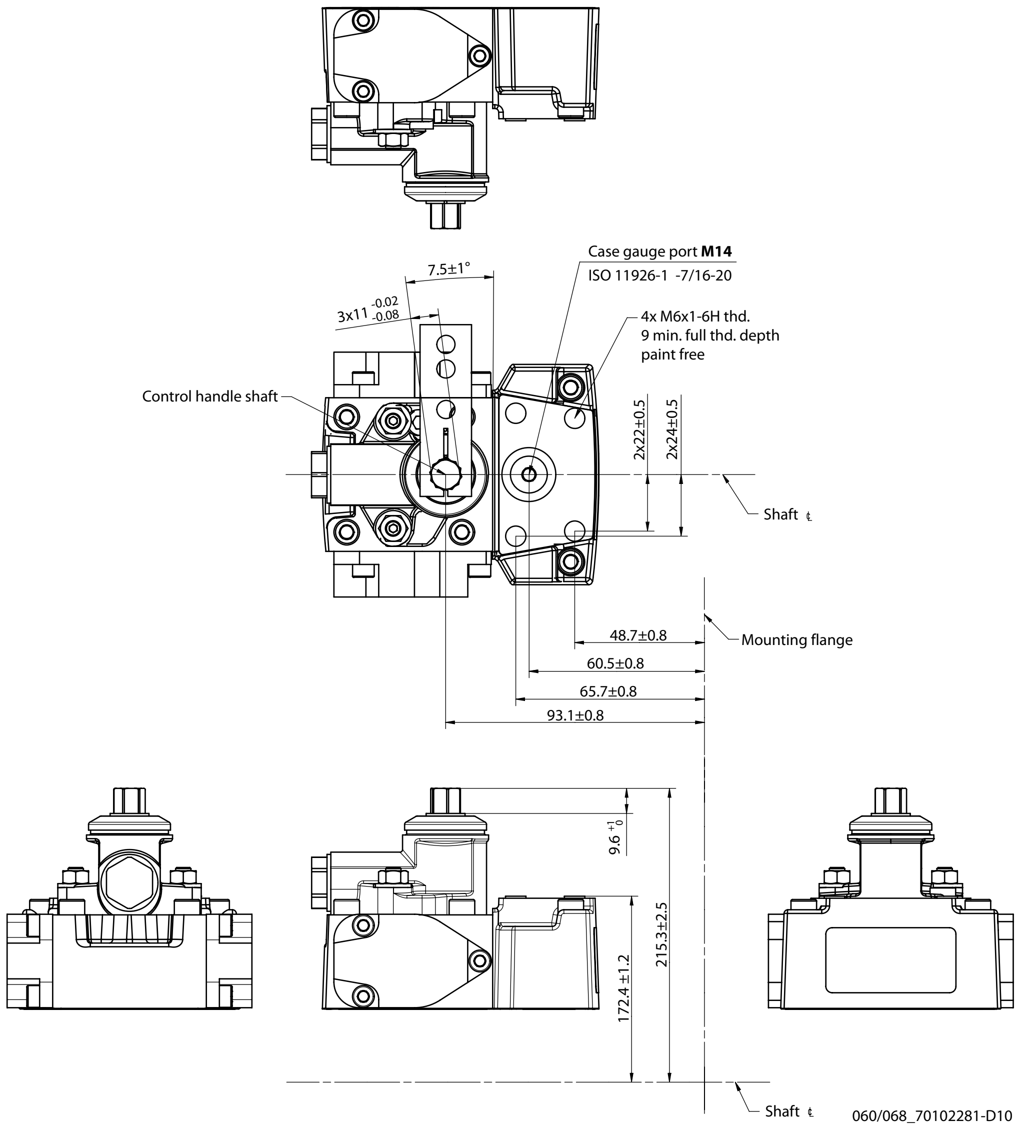


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

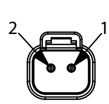
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC Option: M1



Connector DEUTSCH, 2-pin

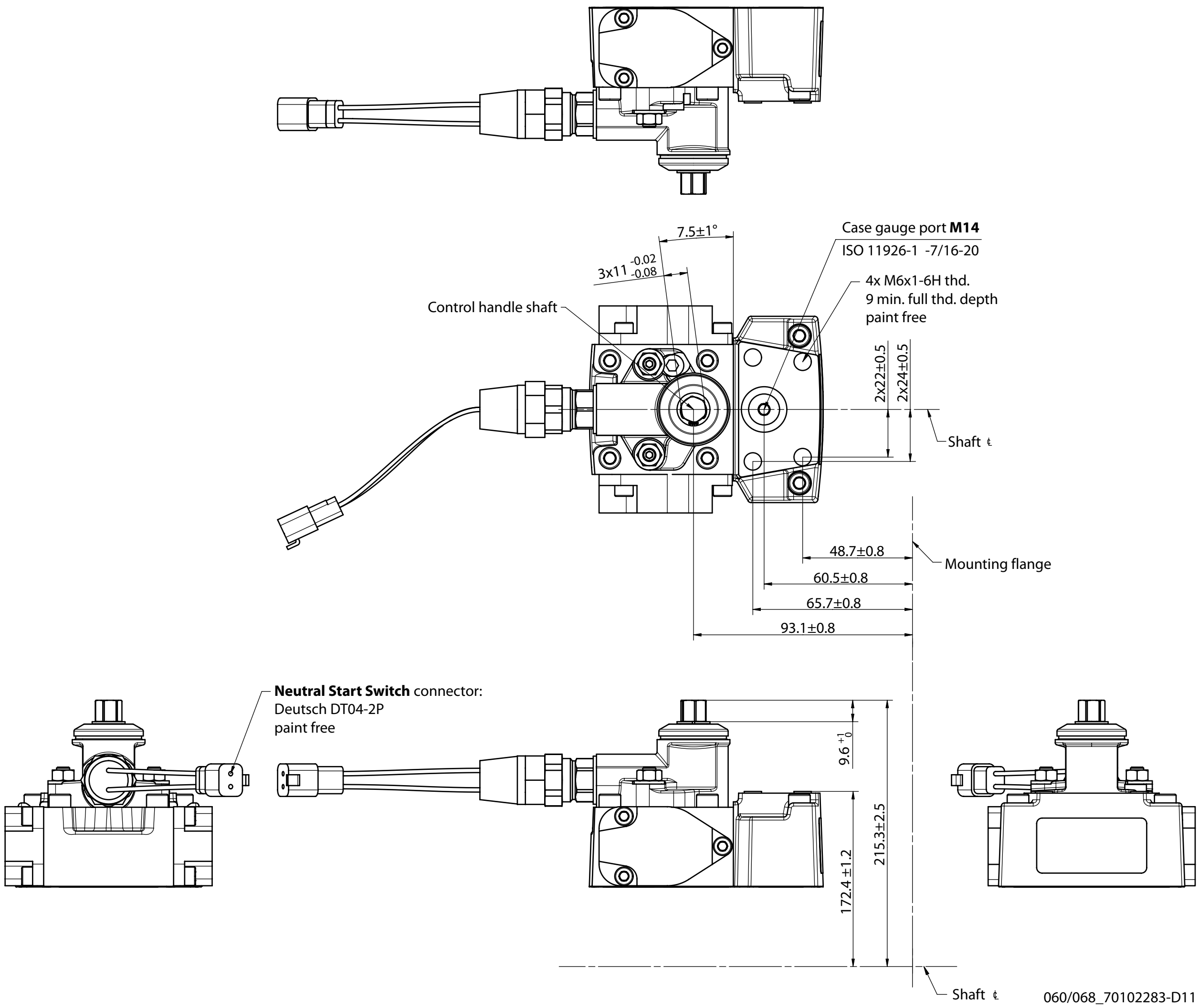


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

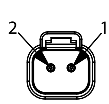
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with Neutral Start Switch Option: M2



Connector DEUTSCH, 2-pin

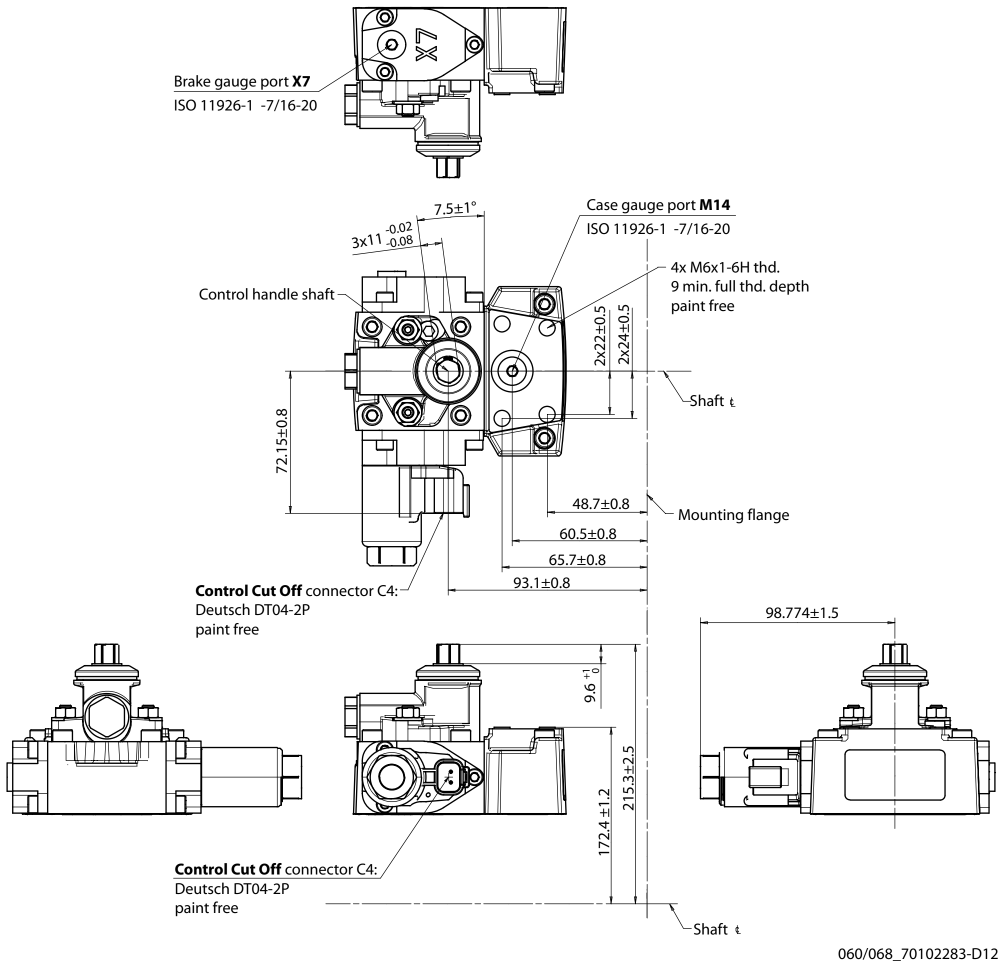


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

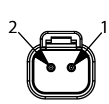
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with CCO, Options: M3, M4



Connector DEUTSCH, 2-pin

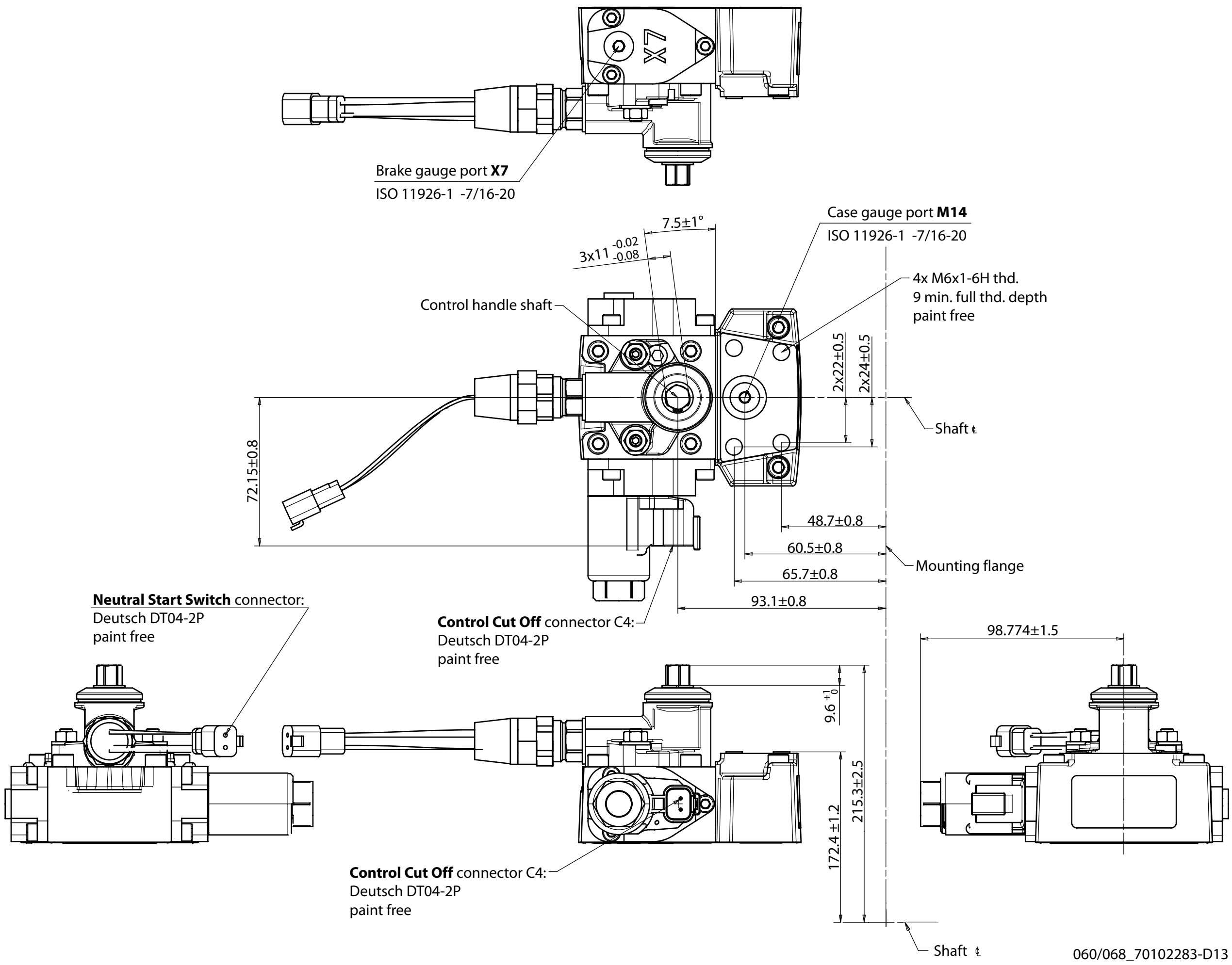


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

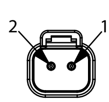
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with NSS and CCO Options: M5, M6



Connector DEUTSCH, 2-pin



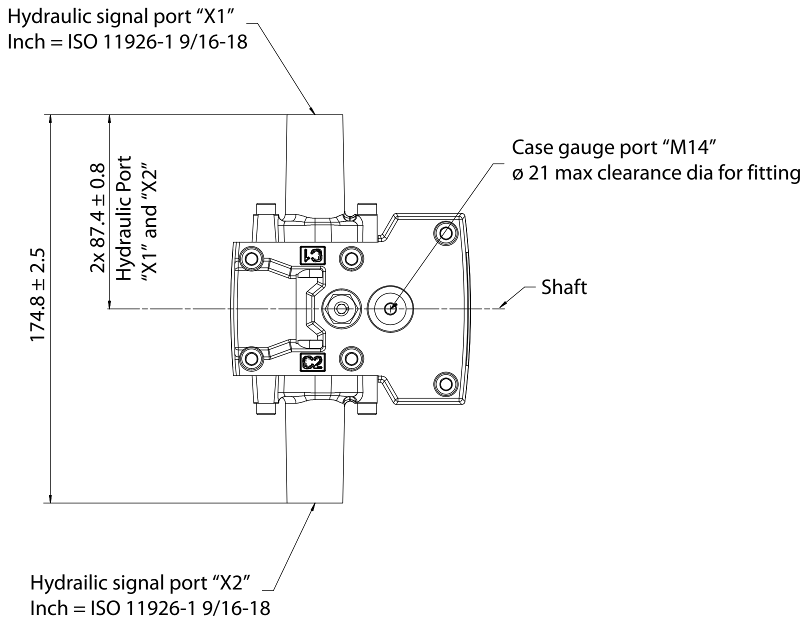
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

H1P HDC, Options: T1, T2

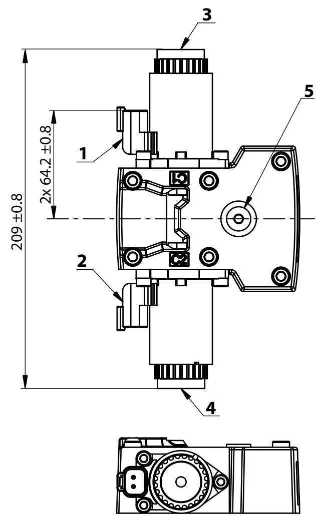
Dimensions in mm



Dimensions and Data

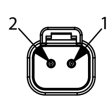
NFPE with MOR, Options: N1, N2 (12/24 V)

Non-Feedback Proportional Electric control with Manual Over Ride options N1 (12 V) and N2 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

*Control solenoid connectors **C1/C2** DEUTSCH DTM04-2P pin/assignment*



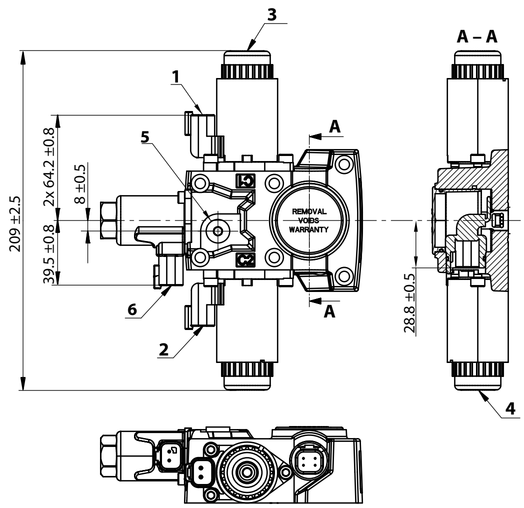
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V)

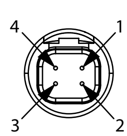
Non-Feedback Proportional Electric control with Control-Cut-Off valve with key C, Manual Over Ride and Angle Sensor, options N3 (12 V) and N4 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
6. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

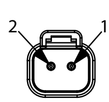
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Control solenoid connectors **C1/C2/C4** DEUTSCH DTM04-2P pin/assignment*



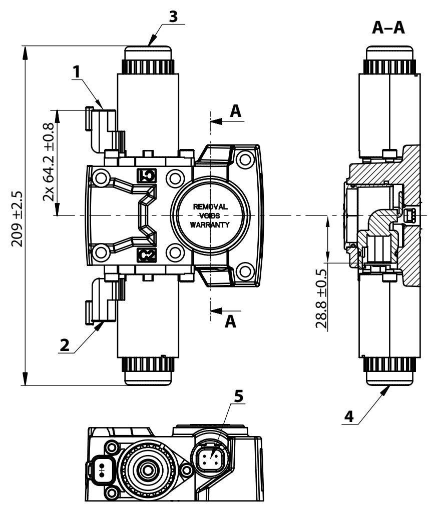
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

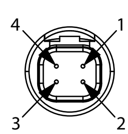
NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V)

Non-Feedback Proportional Electric control with Manual Over Ride and Angle Sensor, options N5 (12 V) and N6 (24 V).



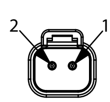
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Angle sensor connector **S2** DEUTSCH DT04-4P, paint free

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

Control solenoid connectors C1/C2 DEUTSCH 2-pin/assignment



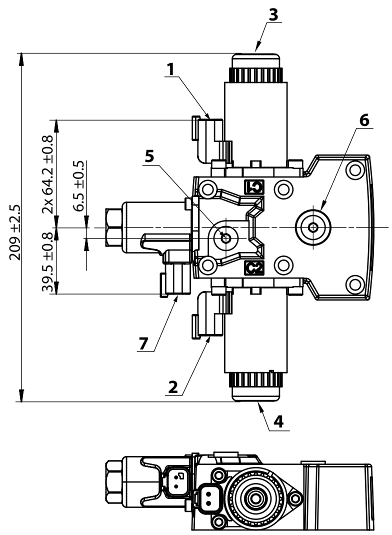
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

NFPE with MOR and CCO, Options: N7, N8 (12/24 V)

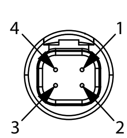
Non Feedback Proportional Electric control with Manual Over Ride and Control-Cut-Off valve key C, options N7 (12 V) and N8 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
6. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

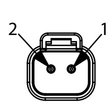
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

Control solenoid connectors C1/C2 DEUTSCH DTM04-2P pin assignment

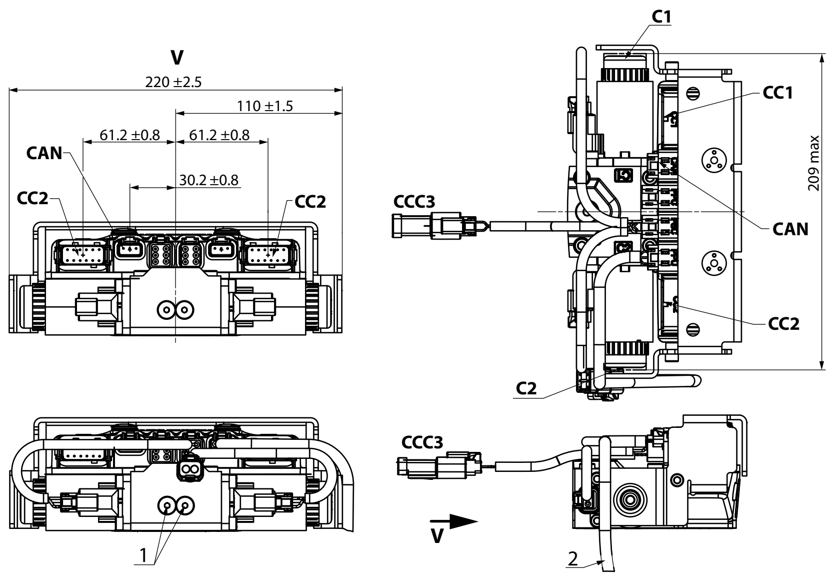


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Automotive control (AC)



1 Plug removing can cause contamination issues

2 PPU wire harness is factory installed to speed sensor

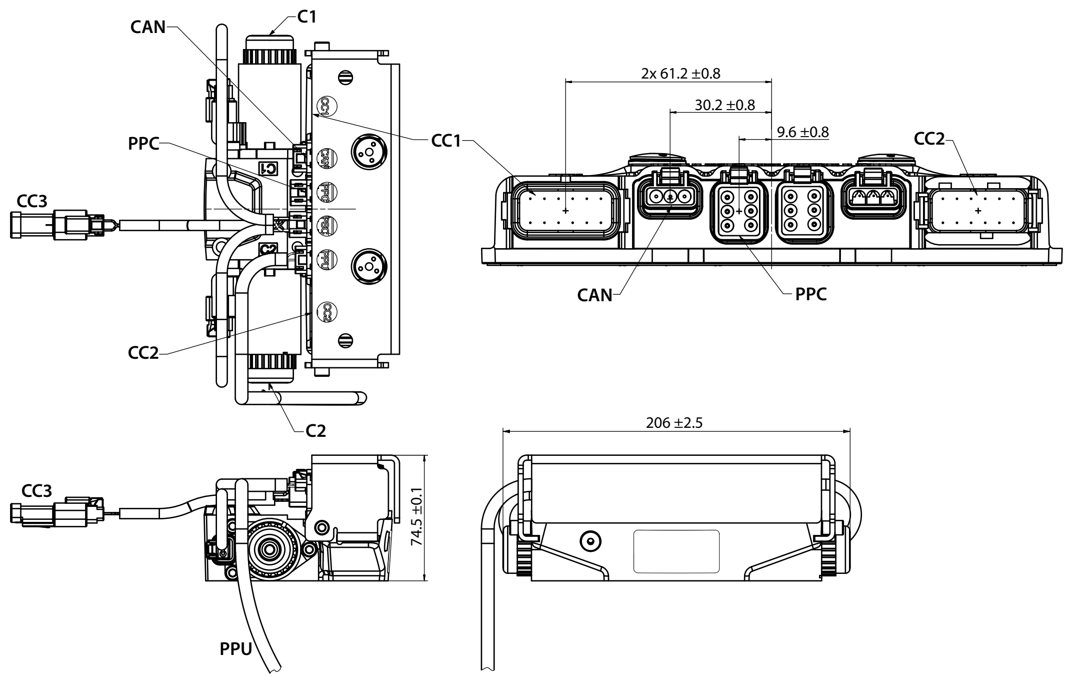
Connectors description

Port	Description
C1 and C2	**1.** Control manual override **C1** **2.** Control Manual Override **C2**
CC1	Port A control connector DEUTSCH DTM04-12P; paint free
CC2	Port B control connector DEUTSCH DTM04-12P; paint free
CC3	Control connector DEUTSCH DT06-2S; paint free; For using connector, the plug may be removed.
CAN	Control connector DEUTSCH DTM04-3P; paint free; For using connector, the plug may be removed.

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

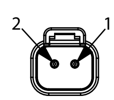
AC connectors dimensions



PPU wire harness is factory installed to speed sensor.

CC3

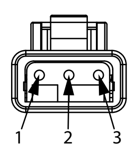
Connector DEUTSCH, 2-pin



1. Digital output A1 (+)
2. Digital output A2 (-)

CAN

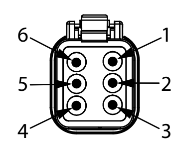
Connector DEUTSCH, 3-pin



1. CAN High
2. CAN Low
3. CAN Shield

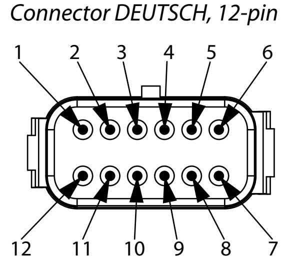
PPC

Connector DEUTSCH, 6-pin



1. Sensor A (+)
2. Analog input A
3. Sensor A (-)
4. Sensor B (-)
5. Analog input B
6. Sensor B (+)

Connector DEUTSCH, 12-pin



CC1

1. Battery (-)
2. Battery (+)
3. Sensor (+)
4. Sensor (-)
5. Motor rpm input (frequency)
6. Forward input (digital)
7. Reverse input (digital)
8. Sensor (+)
9. Sensor (-)
10. Drive pedal input (analog – nominal)
11. Drive pedal input (analog – red)
12. Neural input (digital)

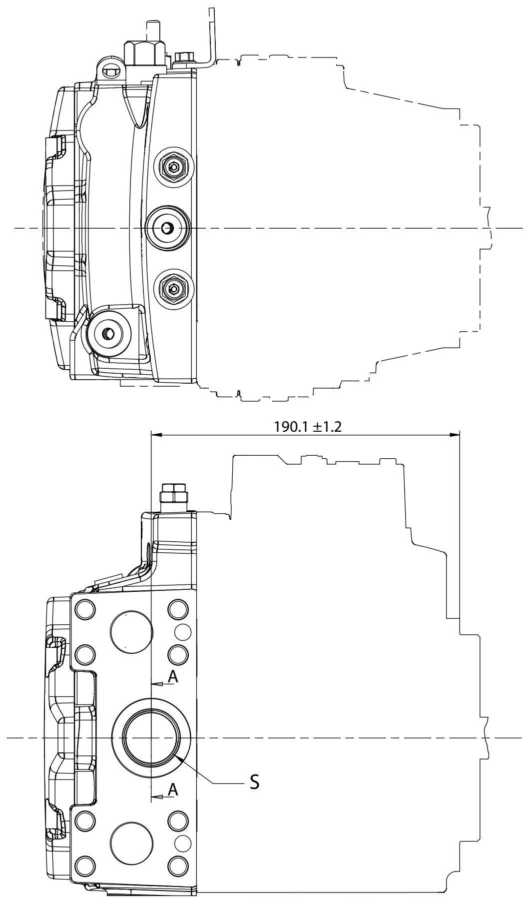
CC2

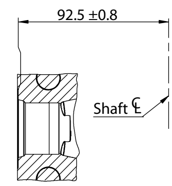
1. Inch input (analog – red)
2. Mode switch B input (digital – nominal)
3. Motor prop/PCOR driver
4. Motor direction input (analog)
5. Sensor (+)
6. Sensor (-)
7. Inch input (analog – nominal)
8. Motor BPD driver
9. Digital output B2 (-)
10. Digital output B1 (+)
11. Mode switch A input (digital)
12. Mode switch B input (digital – red)

Dimensions and Data

Filtration

H1P 60/68 Suction Filtration Option L



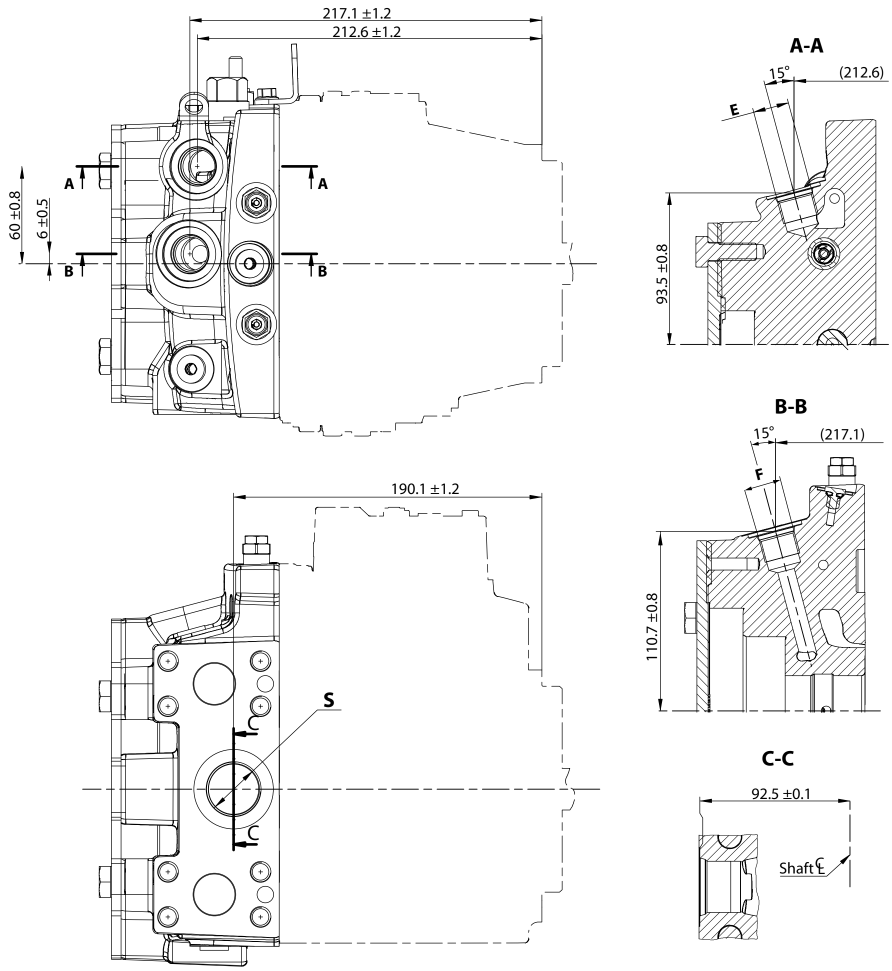


S Charge inlet port per ISO 11926-1; 1 5/16-12

Dimensions and Data

H1P 60/68 Remote Full Charge Pressure Filtration Option P

Remote Filtration for end cap option F5 (SAE-C PTO)



E Charge filtration port per ISO 11926-1; 7/8-14 from filter

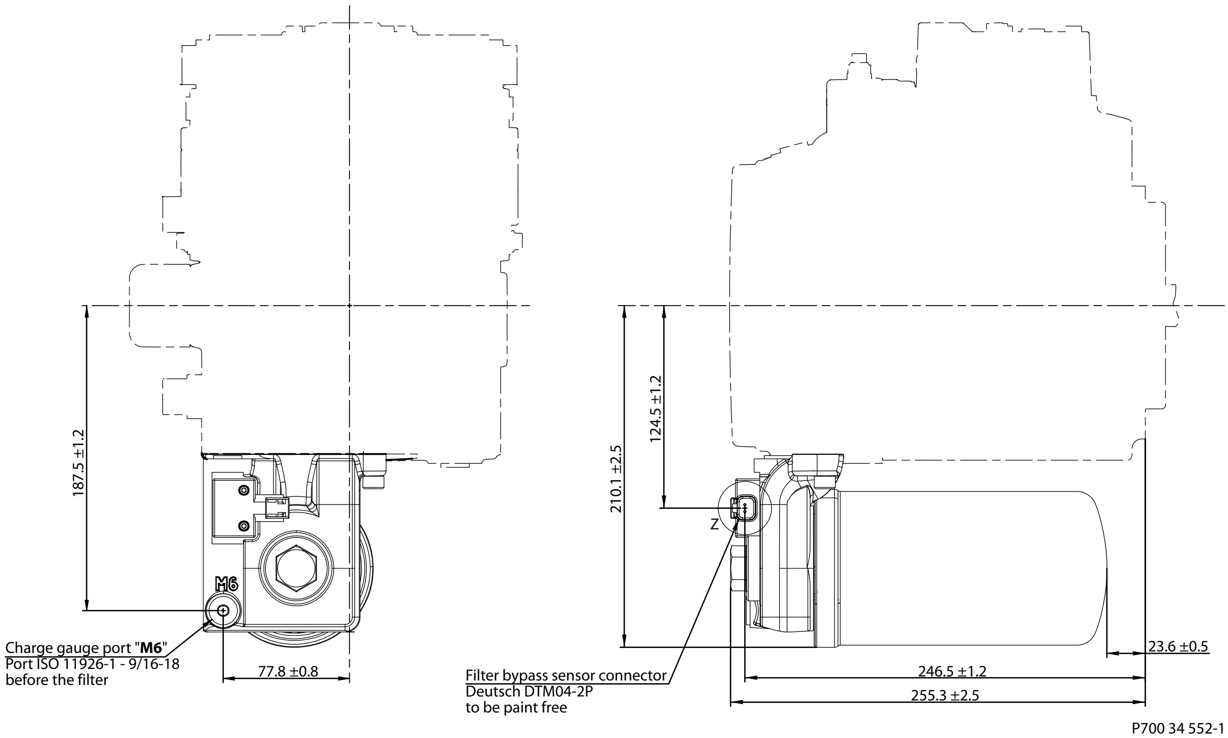
F Charge filtration port per ISO 11926-1; 7/8-14 to filter

S Charge inlet port per ISO 11926-1; 1 5/16-12

Dimensions and Data

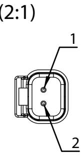
Internal Filtration Option M (End Cap Option: D3)

The Filtration option M for end cap option D3 – Internal full flow charge pressure filtration with filter bypass sensor.



Z (2:1)

FILTER BYPASS SENSOR CONNECTOR				
PIN	ASSIGNMENT	OR	PIN	ASSIGNMENT
1	SUPPLY		1	GROUND
2	GROUND		2	SUPPLY

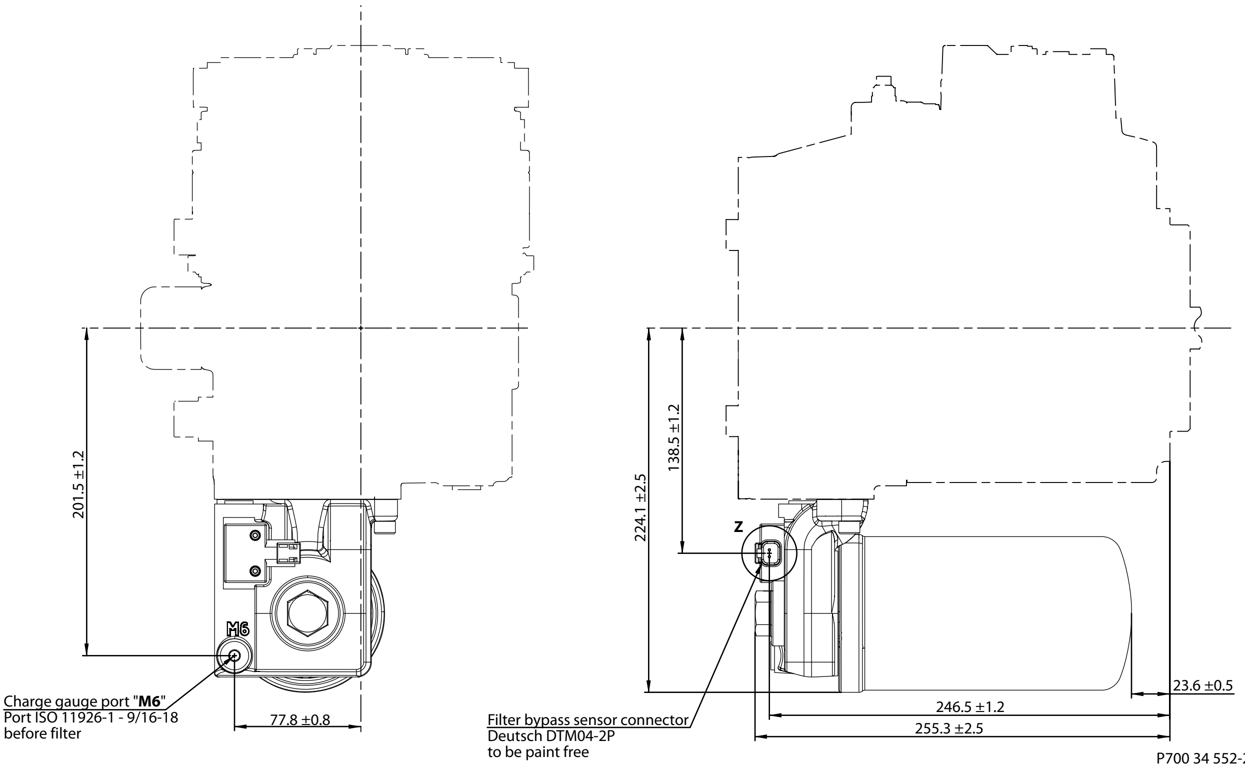


Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

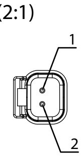
Internal Filtration Option M (End Cap Option: F4)

The Filtration option M for end cap option F4 – Internal full flow charge pressure filtration with filter bypass sensor.



Z (2:1)

FILTER BYPASS SENSOR CONNECTOR				
PIN	ASSIGNMENT	OR	PIN	ASSIGNMENT
1	SUPPLY		1	GROUND
2	GROUND		2	SUPPLY

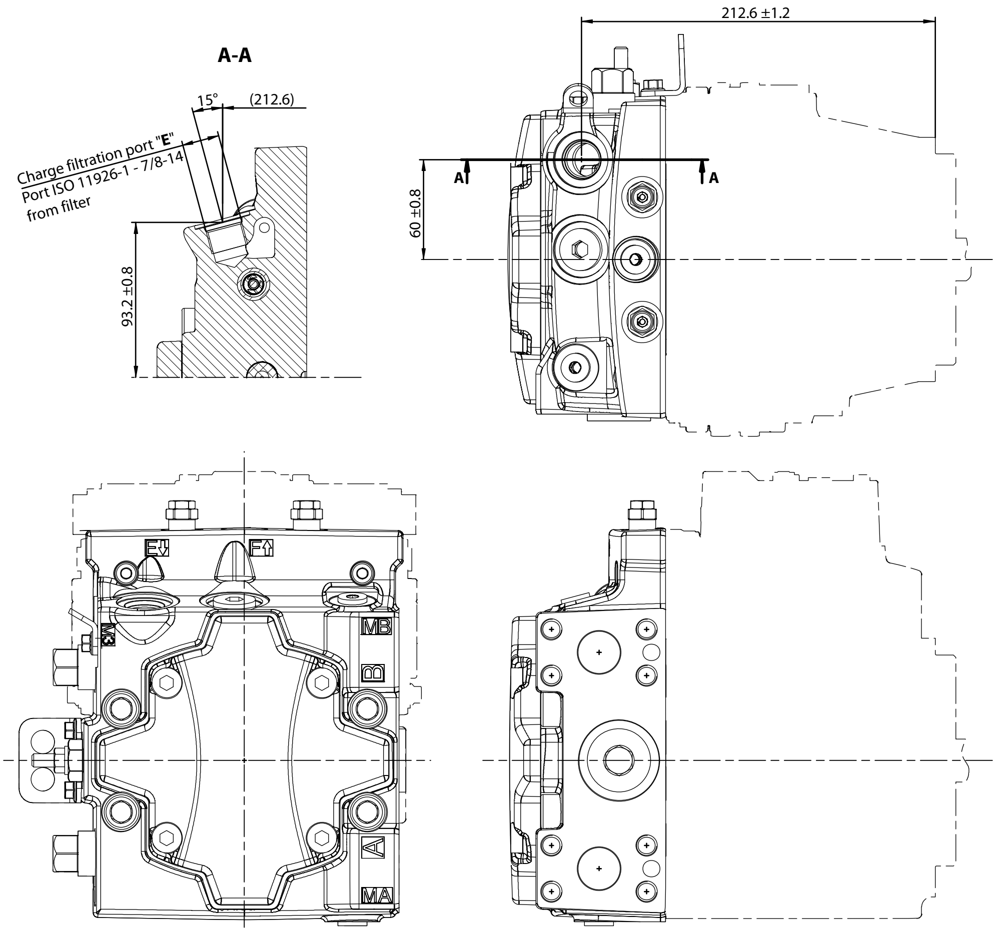


Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

External Filtration Option E (End Cap Option: D8)

The outlines of External full flow charge pressure filtration option E for end cap option D8.



P700 45 736-1

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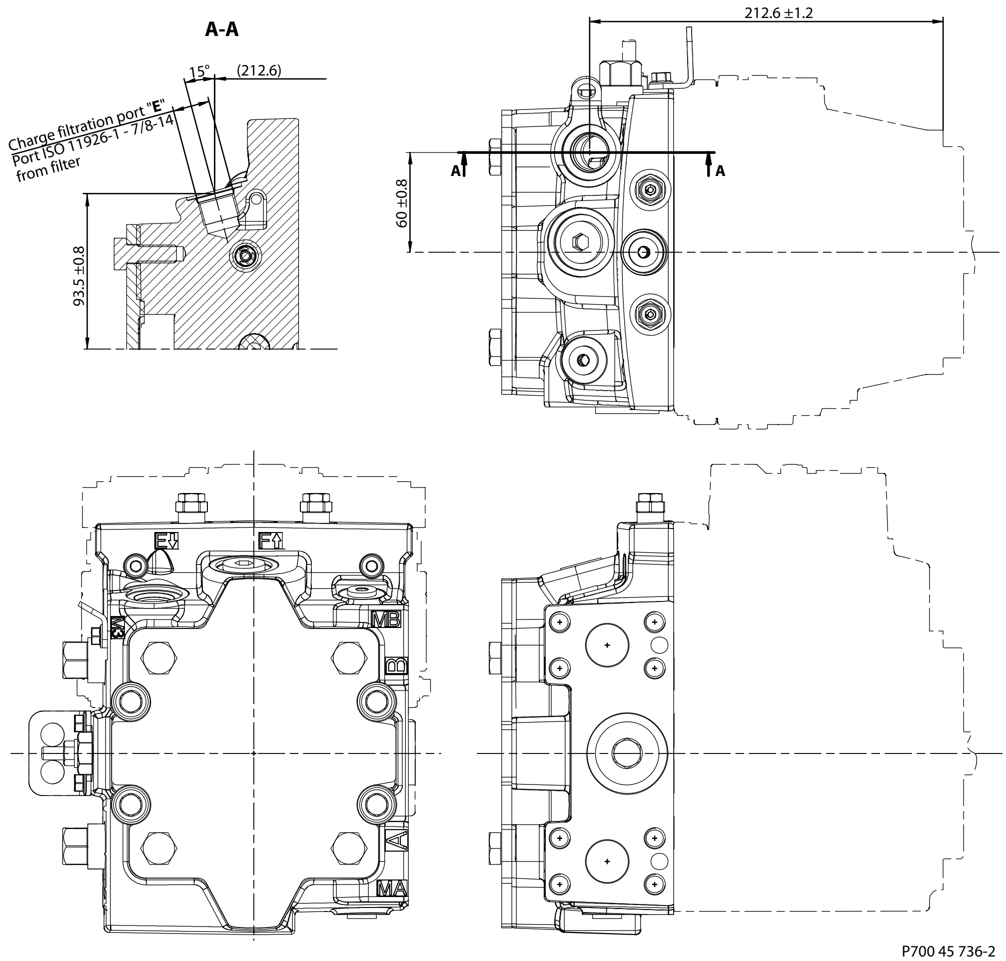
Dimensions and Data

External Filtration Option E (End Cap Option: F5)

The outlines of External full flow charge pressure filtration option E for end cap option F5 (SAE-C PTO).



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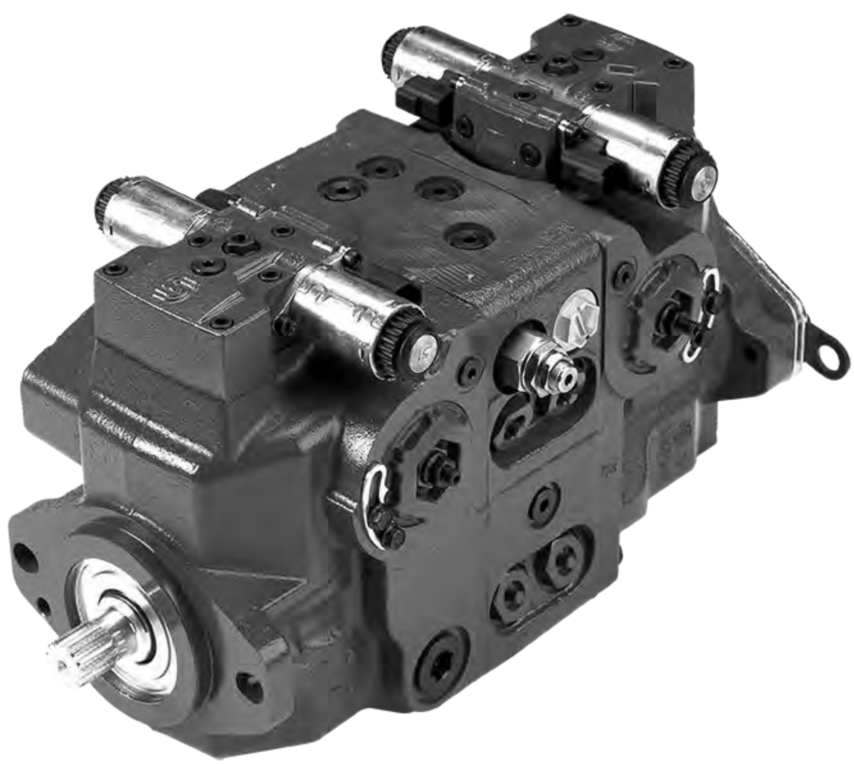
Technical Information

H1T 045/053/060/068
Axial Piston Tandem Pumps



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Revision history

Table of revisions

Date	Changed	Rev
December 2021	Added HDC control	1001
April 2021	Corrected interface with ECU graphic	0905
June 2020	Added section title in ports chapter for clarity	0904
March 2020	Updated port information and changed document number from BC00000060	0903
July 2018	Major revision.	0801
June 2018	Angle sensor chapters added.	0701
September 2017	add G6 option	0603
June 2017	minor edit page 40	0602
April 2017	add 60-68	0601
November 2015	Master Model Code changes	0501
2010-2014	Various changes.	BA-EA
Jul 2009	First edition	AA

Contents

Technical Specifications

H1 Pumps General Specification....5
Technical Data for H1 Tandem Pumps....5
Operating parameters for H1 Tandem Pumps....6
Fluid Specification....7
External radial shaft loads H1 Tandem....7
Bearing Life....8
Mounting flange loads H1T 045/053....8
Mounting flange loads H1T 060/068....9
Case drain....9

Master Model Code

H1T rotation, ports, and second pump options....10
H1T Controls Options....10
H1T Orifice and Displacement Limiter Options....11
H1T Endcap and Mounting Options....11
H1T Input Shaft and Aux Mounting Options....12
H1T High Pressure Relief Valve Options....12
H1T Pressure Limiter, Charge Pump, and Filtration Options....13
H1T Charge Pressure Relief, Special Hardware and Settings....14

Control Options

Electrical Displacement Control (EDC)....15
  Control Solenoid Data....16
Manual Displacement Control (MDC)....17
Hydraulic Displacement Control (HDC)....21
  HDC principle....21
  HDC operation....21
  Hydraulic signal pressure range....22
  Pump output flow direction vs. control pressure....22
  Control response....22
  Response time, HDC 047/053, 060/068....23
Forward-Neutral-Reverse Control (FNR)....24
  Control response....25
Non feedback proportional electric control (NFPE)....26
Manual Override (MOR)....28
Swashplate angle sensor for EDC controls....29
  Swash plate angle sensor parameters (EDC)....29
  Swash plate angle sensor connector....30
  Interface with ECU (EDC)....30
Swash Plate Angle Sensor for NFPE and AC2 Controls....31
  Swash Plate Angle Sensor Parameters (NFPE/AC)....31
  Swash-plate Angle Sensor Connector (NFPE/AC2)....32
  Interface with ECU (NFPE)....32
Control-Cut-Off (CCO) and Brake Release Valves....33
Displacement Limiter....35

Port Locations

Port Locations H1T 045/053 Tandem....36
Port Locations H1T 060/068 Tandem....38

Dimensions

Dimensions H1T 045/053 Tandem....39
Dimensions H1T 060/068 Tandem....42
Input shaft, option G1 (SAE C, 14 teeth) (045/053/060/068)....43
Input shaft, option G5 (SAE B-B, 15 teeth) (045/053 only)....44
Input shaft, option G6, (19 teeth-long) (045/053 only)....45
Input shaft, option F1, (060/068 only)....46
Auxiliary mounting pads....47
060/068 Control dimensions....53
045/053 Control dimensions....56

Contents

Hydraulic Displacement Control (HDC), options T1, T2 62
Center section coupling, torque rating 63
Control Cut Off (CCO) 64
045/053 CCO 64
060/068 CCO 65
Displacement limiter, H1 Tandem, option B 66

Technical Specifications

H1 Pumps General Specification

Axial piston closed circuit variable displacement pumps of cradle swash-plate design with clockwise or counterclockwise direction of rotation.

Pipe connections

- Main pressure ports H1P 045/053: SAE straight thread O-ring boss
- Main pressure ports H1P 060/068: ISO split flange boss
- Remaining ports: SAE straight thread O-ring boss

Recommended installation position

Pump installation position is discretionary, however the recommended control position is on the top or at the side with the top position preferred. If the pump is installed with the control at the bottom, flushing flow must be provided through port M14 located on the EDC, FNR and NFPE control.

Vertical input shaft installation is acceptable. If input shaft is at the top, 1 bar case pressure must be maintained during operation. The housing must always be filled with hydraulic fluid. Recommended mounting for a multiple pump stack is to arrange the highest power flow towards the input source. Consult Danfoss for nonconformance to these guidelines.

Auxiliary cavity pressure

Auxiliary cavity pressure will be inlet pressure with internal charge pump or case pressure with external charge supply. For reference see Operating Parameters. Please verify mating pump shaft seal capability.

Technical Data for H1 Tandem Pumps

Technical Data

Feature	Unit	045	053	060	068
Displacement	cm^3 [in^3]	45.0 [2.75]	53.8 [3.28]	60.4 [3.69]	68.0 [4.15]
Flow at rated (continuous) speed*	l/min [US gal/min]	153 [40]	183 [48]	210 [55.5]	238 [62.8]
Torque at maximum displacement (theoretical)	N•m/bar [lb•in/1000 psi]	0.8 [488]	0.9 [549]0.0078 [0.00575]	0.96 [590]	1.08 [610]
Mass moment of inertia of rotating components	kg•m^2 [slug•ft^2]	0.0077 [0.00568]	0.0078 [0.00575	0.0143 [0.01055]	0.0143 [0.01052]
Mass (weight dry, without charge pump or auxiliary flange)	kg [lb]	65 [143]	65 [143]	96.2 [212]	96.2 [212]
Oil volume	l [US gal]	2.3 [0.61]	2.3 [0.61]	4.2 [1.1]	4.2 [1.1]

* Applies for each rotating group.

Physical properties

Description	045/053	060/068
Mounting flange per ISO 3019-1	Flange 101-2 (SAE B), special bolt	Flange 127-4 (SAE C)
Input shaft outer diameter, splines per ISO 3019-1	• Ø25 mm - 4 (SAE B-B, 15 teeth) • Ø32 mm - 4 (SAE-C, 14 teeth) • Ø31 mm - 4 (19 teeth)	• Ø32 mm - 4 (SAE C, 14 teeth) • Ø35 mm - 4 (SAE C, 21 teeth)

Technical Specifications

Physical properties (continued)

Description	045/053	060/068
Auxiliary mounting flange with metric fasteners, shaft outer diameter and splines per ISO 3019-1	Flange **82–2** outer dia: • Ø16 mm - 4 (SAE A, 9 teeth) • Ø19 mm - 4 (SAE A, 11 teeth) Flange **101–2** outer dia: • Ø22 mm - 4 (SAE B, 13 teeth) • Ø25 mm - 4 (SAE B-B, 15 teeth)	Flange **101–2** outer dia: • Ø22 mm - 4 (SAE B, 13 teeth) • Ø25 mm - 4 (SAE B-B, 15 teeth)
Charge inlet port per ISO 11926-1	$^7/_8$ -14 (SAE O-ring boss)	1 $^1/_{16}$ -14 (SAE O-ring boss)
Main port configuration	ISO 11926-1: 1 $^5/_{16}$ -12 (SAE O-ring boss)	ISO 6162: M12 x 1.75 (Split flange)
Other ports	SAE O-ring boss	
Customer interface threads	Metric fasteners	

Operating parameters for H1 Tandem Pumps

Input Speed (at minimum charge/control pressure)

Description	Size 045/053	Size 060/068
Minimum for **external** charge supply[1]	min^{-1} (rpm)	500 min^{-1} (rpm)
Rated	3400 min^{-1} (rpm)	3500 min^{-1} (rpm)
Maximum	3500 min^{-1} (rpm)	4000 min^{-1} (rpm)

[1] Full performance (pressure and displacement) possible at minimum charge and control pressure supply.

System pressure

Description		Size 045	Size 053	Size 060	Size 068
System pressure	Max. working	420 bar [6092 psi]	380 bar [5511 psi]	420 bar [6090 psi]	380 bar [5510 psi]
	Maximum (peak)	450 bar [6527 psi]	400 bar [5802 psi]	450 bar [6525 psi]	400 bar [5800 psi]
	Max. low loop	45 bar [653 psi]		45 bar [650 psi]	
	Min. low loop	10 bar [145 psi]		10 bar [145 psi]	
Control pressure	Min. at corner power (EDC, MDC, FNR)	21.5 bar [312 psi]		18.5 bar [270 psi]	
	Maximum	40 bar [580 psi]		40 bar [580 psi]	

Other pressure type for all tandem pumps

Description		045–068
Charge pressure	Minimum **without** CCO valve	14.5 bar [210 psi]
	Minimum **with** CCO valve	18 bar [265 psi]
	Maximum	34 bar [493 psi]
Case pressure	Rated	3.0 bar [44.0 psi]
	Maximum	5.0 bar [73.0 psi]
Lip seal external	Maximum	0.4 bar [5.8 psi]

Technical Specifications

Fluid Specification

Viscosity

Intermittent[1]	5 mm^2/s [42 SUS]
Minimum	7 mm^2/s [49 SUS]
Recommended range	12 – 80 mm^2/s [66 – 370 SUS]
Maximum	1600 mm^2/s [7500 SUS]

[1] Intermittent = Short term t < 1 min per incident and not exceeding 2 % of duty cycle based load-life.

Temperature

Minimum [1]	-40°C [-40°F]
Rated	104°C [220°F]
Recommended range[2]	60 – 85°C [140 – 185°F]
Maximum Intermittent	115°C [240°F]

[1] Cold start = Short term t > 3 min, p ≤ 50 bar [725 psi], n ≤ 1000 min-1 (rpm).

[2] At the hottest point, normally case drain port.

External radial shaft loads H1 Tandem

External radial shaft loads

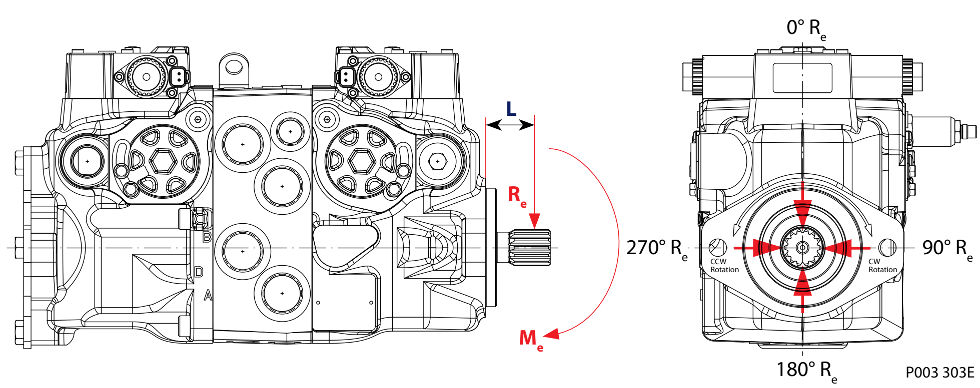
H1 pumps are designed with bearings that can accept some external radial loads. The external radial shaft load limits are a function of the load position and orientation, and the operating conditions of the unit. External radial shaft loads impact lifetime. For lifetime calculations please contact Danfoss representative.

The **maximum allowable radial load (R_e)** is based on the maximum external moment (M_e) and the distance (L) from the mounting flange to the load.

It may be determined using the following formula:

$$R_e = \frac{M_e}{L}$$

Radial load position (045/053 shown)



M_e = shaft moment

L = flange distance

R_e = external force to the shaft

Thrust loads should be avoided. Contact factory in the event thrust loads are anticipated.

Technical Specifications

Bearing Life

Maximum external shaft load based on shaft deflection

External radial moment	Unit	Size 045 / 053	Size 060 / 068
M_e	N•m [lbf•in]	104 [920]	104 [920]

All external shaft loads affect bearing life. In applications with external shaft loads, minimize the impact by positioning the load at 0° or 180° as shown in the figure.

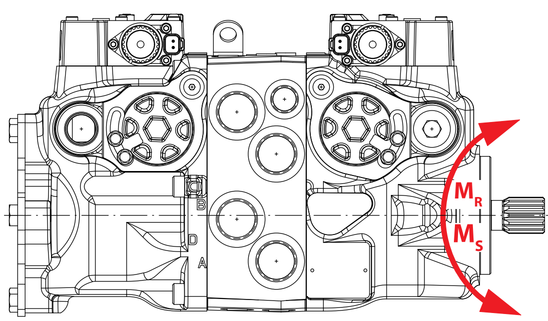
Danfoss recommends clamp-type couplings for applications with radial shaft loads.

Contact your Danfoss representative for an evaluation of unit bearing life if you have continuously applied external loads exceeding 25 % of the maximum allowable radial load (Re) or the pump swashplate is positioned on one side of center all or most of the time.

Mounting flange loads H1T 045/053

H1 tandem pump front flange load

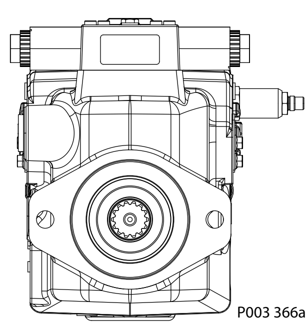
Mounting flange loads H1T 045/053, Controls on top



P003 367

The moments shown below apply for the control orientation on top or side.

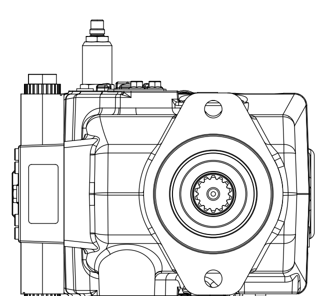
Mounting flange loads, Control on top



P003 366a

Rated moment:
M_R = 2020 N•m [17 880 lbf•in]
Shock load moment:
M_S = 4110 N•m [36 380 lbf•in]

Mounting flange loads, Control on side



P003 366b

Rated moment:
M_R = 1300 N•m [11 510 lbf•in]
Shock load moment:
M_S = 2930 N•m [25 935 lbf•in]

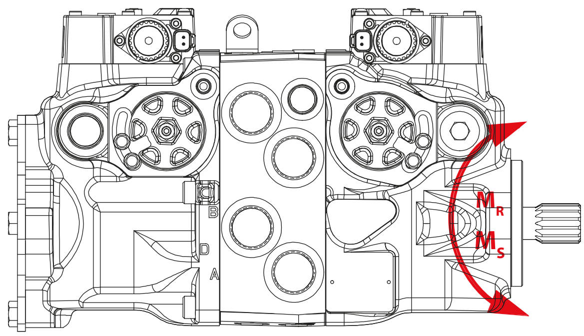
For more information, see *H1 Axial Piston Pumps, Basic Information,* **BC152886483968**, the section "Mounting flange loads".

Technical Specifications

Mounting flange loads H1T 060/068

H1 tandem pump front flange load

Mounting flange loads H1T 060/068, Controls on top



Rated moment:
$\mathbf{M_R}$ = 2190 N•m [19 380 lbf•in]

Shock load moment:
$\mathbf{M_S}$ = 6560 N•m [58 060 lbf•in]

P109515

The moments shown apply for the control orientation on top or side.

For more information, see *H1 Axial Piston Pumps, Basic Information,* **BC152886483968**, the section “Mounting flange loads”.

Case drain

The tandem housings are connected through the center section via a drilled hole. The charge relief valve discharges oil into the front housing. In order to provide positive flow through both housings, use of the rear housing case drain is required. The front housing case pressure ports should only be used if the pump is used as a common drain manifold for the vehicle where external drain flow is brought into the rear housing and discharged out the front.

The allowable case pressures must be met accordingly.

Master Model Code

H1T rotation, ports, and second pump options

Displacement (Front pump, second pump see "C")

Code	Description
045	45 cm^3 [2.75 in^3]
053	53.8 cm^3 [3.28 in^3]
060	60 cm^3 [3.66 in^3]
068	68 cm^3 [4.15 in^3]

A – Rotation

L	Left hand (counter clockwise)
R	Right hand (clockwise)

B – Product version

A	Revision code

Z – Port configuration

A	Inch, Customer O-ring port sealing according to ISO 11926-1

C – Second pump size

N	Frame size of rear stage equal front stage (default)
A	Rear stage kit 45cc/rev (only use with 53cc/rev front stage)
B	Rear stage kit 60cc/rev (only use with 68cc/rev front stage)

H1T Controls Options

D – Controls

Code	Control type	Input	Miscellaneous options	Connector
A2	EDC	12 V	—	DEUTSCH
A3	EDC	24 V	—	DEUTSCH
A4	EDC	12 V	MOR	DEUTSCH
A5	EDC	24 V	MOR	DEUTSCH
A9	FNR	12 V	MOR	DEUTSCH
H3	EDC	24 V	Angle sensor	DEUTSCH
H4	MDC front unit	—	Gain 0.52 with NSS	—
	FNR rear unit	12 V	Gain 0.52 with MOR	DEUTSCH
H6	EDC	12 V	Angle sensor + MOR	DEUTSCH
H7	EDC	24 V	Angle sensor + MOR	DEUTSCH
B1	FNR	24 V	MOR	DEUTSCH
B6	FNR front unit	12 V	—	DEUTSCH
	EDC rear unit	12 V	Gain 0.52	DEUTSCH
D7	EDC front unit	12 V	MOR	DEUTSCH
	FNR rear unit	12 V	MOR	DEUTSCH
D9	MDC front unit	—	Gain 0.52 with NSS	—
	MDC rear unit	—	Gain 0.52	DEUTSCH
N1	NFPE[1]	12 V	MOR	DEUTSCH

Master Model Code

D – Controls (continued)

Code	Control type	Input	Miscellaneous options	Connector
N2	NFPE[1]	24 V	MOR	DEUTSCH
N5	NFPE[1]	12 V	Angle sensor + MOR	DEUTSCH
N6	NFPE[1]	24 V	Angle sensor + MOR	DEUTSCH
M1	MDC	—	—	—
M2	MDC	—	NSS	—
T1	HDC	4.2 - 11.6 bar	—	—
T2	HDC	3.0 - 11.6 bar	—	—

[1] *Align with options:* E: Displacement limiters and W: Special hardware.

H1T Orifice and Displacement Limiter Options

F – Orifices (mm)

Code	Tank (A+B)	P	A / B	Note
C3	No orifice			Not to be used for FDC controls and mobile applications.
C1	–	–	0.8	Not to be used for FDC controls.
C6	1	–	–	To be used for MDC controls only.
C7	1.3	–	–	
C8	0.6	0.8	–	
C9	0.6	1	–	
D1	0.8	1	–	
D2	0.8	1.3	–	
D3	1	1.3	–	
D4	1	1.3	1.3	
D5	0.6	0.6	0.8	

E – Displacement limiter

N	None
C	No limiters, with nested springs, required for NFPE
B	Adjustable externally
D	Adjustable externally with nested springs, required for NFPE

H1T Endcap and Mounting Options

G – Endcap options

Code	Description	045/053	060/068
E7	Tandem same-sided SAE O-ring boss ports, (HPRV only) standard	●	—
D1	Tandem same-sided SAE O-ring boss ports with Control Cut Off (HPRV only), 12 V	●	—
F7	Tandem same-sided SAE O-ring boss ports with Control Cut Off (HPRV only), 24 V	●	—
H3	Tandem Opp. Port Code 62, 12V CCO & Brake	—	●
H4	Tandem Opp. Port Code 62, 24V CCO & Brake	—	●
H5	Tandem Opp. Port Code 62, 12V CCO	—	●
H6	Tandem Opp. Port Code 62, 24V CCO	—	●

Master Model Code

G – Endcap options (continued)

Code	Description	045/053	060/068
H7	Tandem Opp. Port Code 62	—	●
H8	Tandem Opp Port Code 62, Opposite Charge Inlet	—	●

H – Mounting

F	ISO 3019-1, flange 101-2 SAE B (045/053)
H	ISO 3019-1, flange 127-4 SAE C (060/068)
J	ISO 3019-1, flange 101-2 SAE B and speed sensor (045/053)

H1T Input Shaft and Aux Mounting Options

J – Input shaft

Code	Description	045/053	060/068
G1	ISO 3019-1, outer Ø32 mm - 4 (SAE C, 14 teeth splined shaft 12/24 pitch)	●	●
G5	ISO 3019-1, outer Ø25 mm - 4 (SAE B-B, 15 teeth splined shaft 16/32 pitch)	●	—
G6	ISO 3019-1, outer Ø31 mm - 4 (19 teeth splined shaft 16/32 pitch) (45/53 only)	●	—
F1	ISO 3019-1 outer diameter 35mm -4 (SAE C, 21 teeth splined shaft 16/32 pitch) (60/68 only)	—	●

K – Auxiliary mounting pad ISO 3019-1 without charge pump, with shipping cover

Code	Description	045/053	060/068
NN	No auxiliary mounting pad, No shipping cover	●	—
H2	Flange 82 - 2, outer Ø16 mm - 4 (SAE A, 9 teeth 16/32 coupling) (45/53)	●	●
H1	Flange 82 - 2, outer Ø19 mm - 4 (SAE A, 11 teeth 16/32 coupling) (45/53)	●	●
H3	Flange 101 - 2, outer Ø22 mm - 4 (SAE B, 13 teeth 16/32 coupling)	●	●
H5	Flange 101 - 2, outer Ø25 mm - 4 (SAE B-B, 15 teeth 16/32 coupling)	●	●

Align with options: S – Charge pump and Y – Special settings.

H1T High Pressure Relief Valve Options

M – High pressure relief valve setting

Code	Pressure setting (Use the selection for ports A, B, C and D)	045	053	60	68
13	130 bar [1885 psi]	●	●	—	—
15	150 bar [2175 psi]	●	●	—	—
18	180 bar [2610 psi]	●	●	●	●
20	200 bar [2900 psi]	●	●	●	●
23	230 bar [3336 psi]	●	●	●	●
25	250 bar [3630 psi]	●	●	●	●
28	280 bar [4061 psi]	●	●	●	●
30	300 bar [4350 psi]	●	●	●	●

Master Model Code

M – High pressure relief valve setting (continued)

Code	Pressure setting (Use the selection for ports A, B, C and D)	045	053	60	68
33	330 bar [4786 psi]	●	●	●	●
35	350 bar [5080 psi]	●	●	●	●
38	380 bar [5510 psi]	●	●	●	●
40	400 bar [5800 psi]	●	—	●	—
41	410 bar [5946 psi]	●	—	—	—
42	420 bar [6090 psi]	●	—	●	—

NO bypass, side "A" (front pump) N – High pressure relief valve setting, NO bypass side "B" (front pump) P – High pressure relief valve setting, NO bypass, side "C" (rear pump) R – High pressure relief valve setting, NO bypass, side "D" (rear pump).

H1T Pressure Limiter, Charge Pump, and Filtration Options

Pressure limiter 060/068

Code	Pressure setting (Use the selection for ports A, B, C and D)	060	068
AE	150 bar PL / 200 bar HPRV	●	●
AH	180 bar PL / 250 bar HPRV	●	●
BK	200 bar PL / 250 bar HPRV	●	●
BC	230 bar PL / 280 bar HPRV	●	●
BE	250 bar PL / 300 bar HPRV	●	●
BH	280 bar PL / 330 bar HPRV	●	●
CK	300 bar PL / 350 bar HPRV	●	●
CC	330 bar PL / 380 bar HPRV	●	●
CE	350 bar PL / 400 bar HPRV	●	●
CH	380 bar PL / 430 bar HPRV	●	●
DK	400 bar PL / 450 bar HPRV	●	-
DA	410 bar PL / 450 bar HPRV	●	-
DB	420 bar PL / 450 bar HPRV	●	-

S – Charge pump

N	No charge pump, external charge supply (Align with options: T – Filtration)

T – Filtration

P	Remote full charge flow filtration (045/053 only)
E	External charge filtration (060/068 only)

Master Model Code

H1T Charge Pressure Relief, Special Hardware and Settings

V – Charge pressure relief setting

Code	Description	
18	18 bar [261 psi]	Not to be used for **NFPE** controls.
20	20 bar [290 psi]	
22	22 bar [319 psi]	
24	24 bar [348 psi]	
26	26 bar [377 psi]	
28	28 bar [406 psi]	
30	30 bar [435 psi]	
32	32 bar [464 psi]	
34	34 bar [493 psi]	

W – Special hardware features

PN	EDC/FNR/MDC valve plate (without a handle)
P1	NFPE valve plate (Align with options: D – Control selection and E – Displacement limiters)
P4	EDC/FNR/MDC Valve Plate and Speed Ring (045/053 only)
H1	EDC/FNR/MDC Valve Plate, included MDC Handle (All frames)
H2	EDC/FNR/MDC Valve Plate, MDC Handle Front, System Loop Bypass (045/053 only)

X – Paint and nametag

NNN	Black paint and Danfoss nametag

Y – Special settings

NNN	None
M00	MDC (handle in standard position)

Control Options

Electrical Displacement Control (EDC)

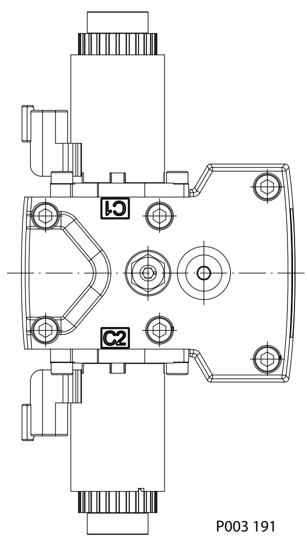
An EDC is a displacement (flow) control. Pump swash plate position is proportional to the input command and therefore vehicle or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The Electrical Displacement Control (**EDC**) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

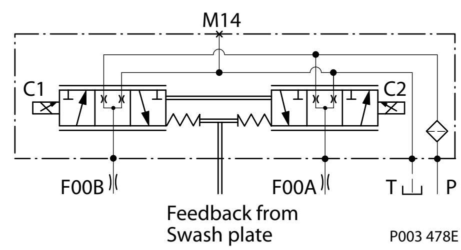
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

Electrical Displacement Control

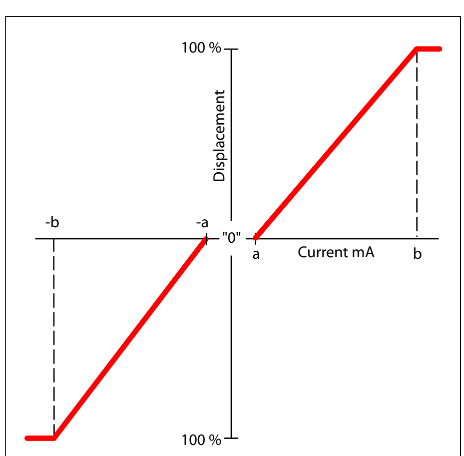


EDC schematic, feedback from swash plate



Control signal requirements, EDC H1T

Pump displacement vs. control current



Control Options

EDC control current

Voltage		$12\ V_{DC}$	$24\ V_{DC}$
Minimum current to stroke pump	**a***	640 mA	330 mA
	b	1640 mA	820 mA
Pin connections		any order	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Control response

H1T controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response time, EDC 045/053

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	1.7 s	0.9 s	0.5 s
Full flow to neutral	1.1 s	0.6 s	0.3 s

Response time, EDC 060/068

Stroking direction	0.8 mm [0.03 in] Orifice	1.3 mm [0.05 in] Orifice	No orifice
Neutral to full flow	2.6 s	1.2 s	0.8 s
Full flow to neutral	1.7 s	0.8 s	0.4 s

Control Options

Manual Displacement Control (MDC)

A Manual proportional Displacement Control (**MDC**) consists of a handle on top of a rotary input shaft. The shaft provides an eccentric connection to a feedback link. This link is connected on its one end with a porting spool. On its other end the link is connected the pumps swashplate.

This design provides a travel feedback without spring. When turning the shaft the spool moves thus providing hydraulic pressure to either side of a double acting servo piston of the pump.

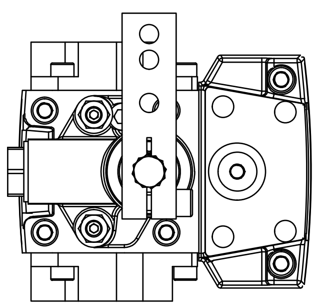
Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement. Simultaneously the swashplate movement is fed back to the control spool providing proportionality between shaft rotation on the control and swash-plate rotation. The MDC changes the pump displacement between no flow and full flow into opposite directions.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

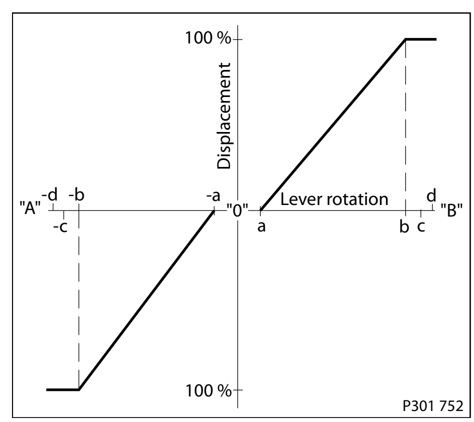
For the MDC with CCO option the brake port (X7) provides charge pressure when the coil is energized to activate static function such as a brake release. The X7 port must not be used for any continuous oil consumption.

The MDC is sealed by means of a static O-ring between the actuation system and the control block. Its shaft is sealed by means of a special O-ring which is applied for low friction. The special O-ring is protected from dust, water and aggressive liquids or gases by means of a special lip seal.

Manual Displacement Control



Pump displacement vs. control lever rotation



Deadband on **B** side: **a = 3° ±1°**
Maximum pump stroke: **b = 30° +2/-1°**
Required customer end stop: **c = 36° ±3°**
Internal end stop: **d = 40°**

MDC operation

The MDC provides a mechanical dead-band required to overcome the tolerances in the mechanical actuation. The MDC contains an internal end stop to prevent turning the handle into any inappropriate position.

The MDC provides a permanent restoring moment appropriate for turning the MDC input shaft back to neutral position only. This is required to take the backlash out of the mechanical connections between the Bowden cable and the control.

High case pressure may cause excessive wear and the NSS to indicate that the control is not in neutral position. In addition, if the case pressure exceeds 5 bar there is a risk of an insufficient restoring moment. The MDC is designed for a maximum case pressure of 5 bar and a rated case pressure of 3 bar.

Control Options

- Customers must install some support to limit the setting range of their Bowden cable to avoid an overload of the MDC.
- Customers can apply their own handle design but they must care about a robust clamping connection between their handle and the control shaft and avoid overload of the shaft.
- Customers can connect two MDC's on a tandem unit in such a way that the actuation force will be transferred from the pilot control to the second control. The kinematic of the linkages must ensure that either control shaft is protected from torque overload.

Caution

Using the internal spring force on the input shaft is not an appropriate way to return the customer connection linkage to neutral, or to force a Bowden cable or a joystick back to neutral position. It is not applicable for any limitation of the Bowden cable stroke, except the applied torque to the shaft will never exceed 20 N•m.

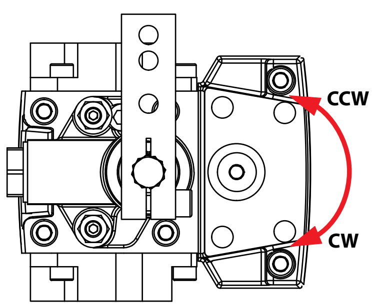
MDC Torque

Description	Value
Torque required to move handle to maximum displacement	1.4 N•m [12.39 lbf•in]
Torque required to hold handle at given displacement	0.6 N•m [5.31 lbf•in]
Maximum allowable input torque	20 N•m [177 lbf•in]

Caution

Volumetric efficiencies of the system will have impacts on the start and end input commands.

MDC shaft rotation



Pump shaft rotation*	Clockwise (CW)		Counter-clockwise (CCW)	
MDC shaft rotation	**CW**	**CCW**	**CW**	**CCW**
Port A	in (low)	out (high)	out (high)	in (low)
Port B	out (high)	in (low)	in (low)	out (high)
Servo port high pressure	M5	M4	M5	M4

* As seen from shaft side.

Control response

H1T controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]

Control Options

Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response time, MDC 045/053

Code	Orifice description (mm)				Stroking direction (sec)	
	P	A	B	Tank (A+B)	Neutral to full flow	Full flow to neutral
C3	–	–	–	–	0.3	0.4
C6	–	–	–	1	0.9	0.8
C7	–	–	–	1.3	0.6	0.6
C8	0.8	–	–	0.6	2.9	2.0
C9	1	–	–	0.6	2.7	1.9
D1	1	–	–	0.8	1.7	1.2
D2	1.3	–	–	0.8	1.5	1.1
D3	1.3	–	–	1	1.1	0.8
D4	1.3	1.3	1.3	1	1.3	1.0
D5	0.6	0.8	0.8	0.6	5.4	2.8

Response time, MDC H1T

Code	Orifice description (mm)			Stroking direction	
	Tank (A+B)	P	A/B	Neutral to full flow	Full flow to neutral
C3	No orifice			s	s
C6	1	–	–	s	s
C7	1.3	–	–	s	s
D1	0.8	1	–	s	s
D2	0.8	1.3	–	s	s
D3	1	1.3	–	s	s
D4	1	1.3	1.3	s	s

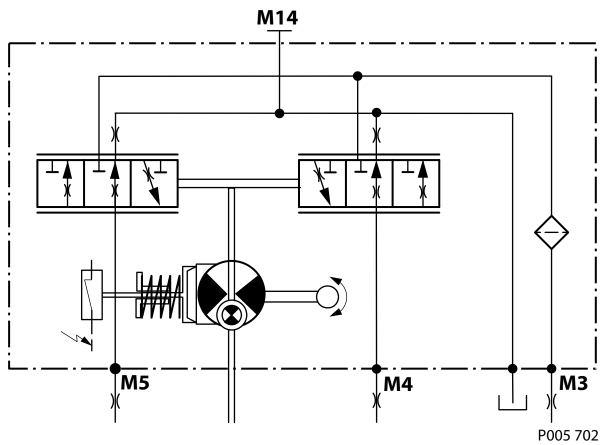
For further data please contact your Danfoss representative.

Neutral start switch (NSS)

The Neutral Start Switch **(NSS)** contains an electrical switch that provides a signal of whether the control is in neutral. The signal in neutral is Normally Closed **(NC)**.

Control Options

Neutral start switch schematic



Neutral start switch data

Max. continuous current with switching	8.4 A
Max. continuous current without switching	20 A
Max. voltage	36 V_{DC}
Electrical protection class	IP67 / IP69K with mating connector

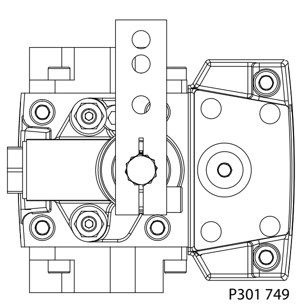
Case Gauge Port M14

The drain port should be used when the control is mounted on the unit's bottom side to flush residual contamination out of the control.

Lever

MDC controls are available with optional lever/handle. Align with Settings: Y module in the model code.

Standard orientation 90° from input shaft



Control Options

Hydraulic Displacement Control (HDC)

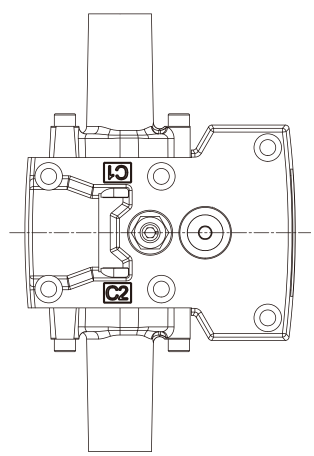
HDC principle

An HDC is a Hydraulic Displacement Control. Pump swashplate position is proportional to the input command and therefore vehicle speed or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The HDC control uses a hydraulic input signal to operate a porting spool, which ports hydraulic pressure to either side of a double acting servo piston. The hydraulic signal applies a force input to the spool which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction. Under some circumstances, such as contamination, the porting spool could stick and cause the pump to stay at some displacement.

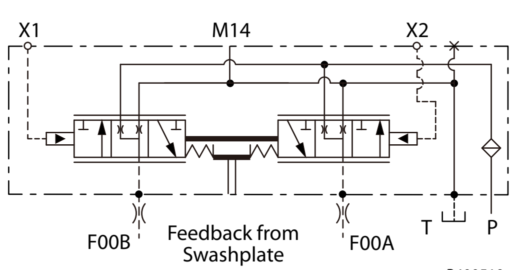
A serviceable 175 µm screen is located in the supply line immediately before the control porting spool.

HDC control



P400520

HDC schematic



P400519

HDC operation

HDC's are hydraulically driven control which ports hydraulic pressure to either side of a porting spool, which pressurizes one end of the servo piston, while draining the other end to case. Pressure differential across the servo piston moves the swashplate.

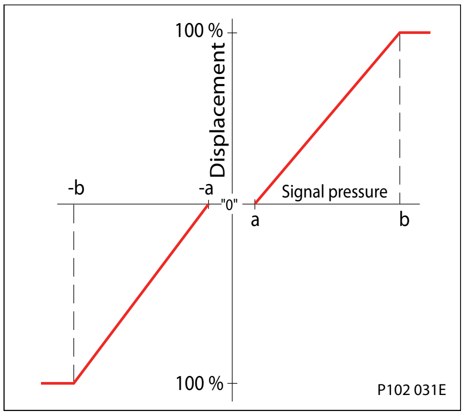
A swashplate feedback link, opposing control linkage, and a linear spring provide swashplate position force feedback to the hydraulic pressure. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

Control Options

The HDC incorporates a positive neutral dead band as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold point is reached, the swashplate is positioned directly proportional to the control pressure.

When the control input is either lost or removed, or if there is a loss of charge pressure, the spring loaded servo piston will automatically return the pump to the neutral position.

Pump displacement vs signal pressure



Hydraulic signal pressure range

Type	Unit	Start of control	End of control
Option	bar	3.0	11.6
Standard		4.2	16.2

Pump output flow direction vs. control pressure

Shaft rotation HDC	Clockwise (CW) seen from shaft		Counter Clockwise (CCW) seen from shaft	
Port energized	X1	X2	X1	X2
Port A	Out (high)	In (low)	In (low)	Out (high)
Port B	In (low)	Out (high)	Out (high)	In (low)
Servo port high pressure	M4	M5	M4	M5

For appropriate performance of HDC characteristic, keep the drain pressure of pilot valve to be equal or slightly higher than pump case pressure.

Control response

H1T controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Control Options

Response time, HDC 047/053, 060/068

HDC 047/053

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	1.6s	0.7s	0.4s
Full flow to neutral	0.9s	0.4s	0.2s

HDC 060/068

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	2.1s	1s	0.5s
Full flow to neutral	1.2s	0.5s	0.3s

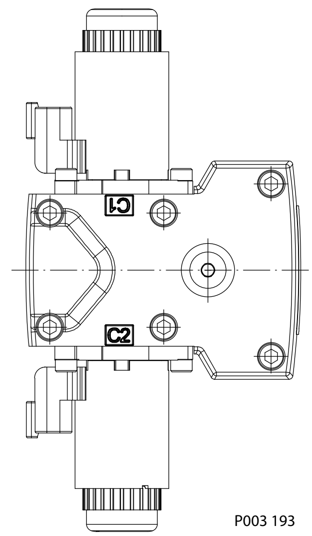
Control Options

Forward-Neutral-Reverse Control (FNR)

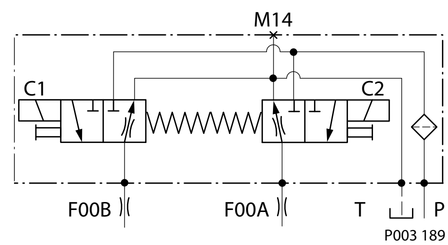
The 3-position FNR control options **A9** (12 V) and **B1** (24 V) uses an electric input signal to switch the pump to a full stroke position. A serviceable 125 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool can stick and cause the pump to stay at some displacement.

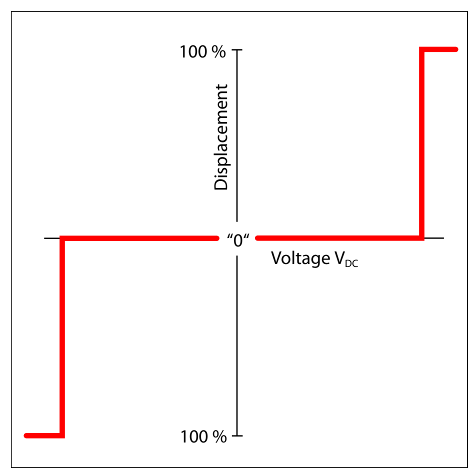
Forward-Neutral-Reverse electric control (FNR)



FNR hydraulic schematic



Pump displacement vs. electrical signal



FNR control current

Voltage	12 V_{DC}	24 V_{DC}
Minimum current to stroke pump	750 mA	380 mA
Pin connections	any order	

Control Options

Control response

H1T controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, FNR

Stroking direction	Size combo	0.8 [0.03] orifice	1.3 [0.05] orifice	No orifice
Neutral to full flow	045/053	1.8 s	0.9 s	0.5 s
	060/068	2.7 s	1.3 s	0.8 s
Full flow to neutral	045/053	1.6 s	0.8 s	0.4 s
	060/068	2.3 s	1.1 s	0.5 s

Control Options

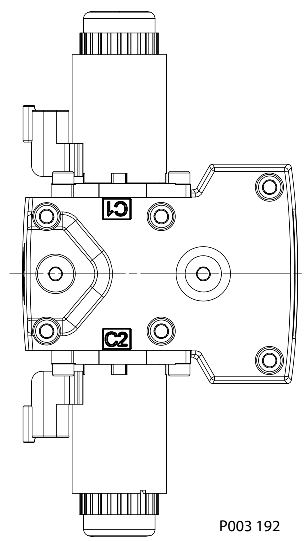
Non feedback proportional electric control (NFPE)

The Non Feedback Proportional Electric (**NFPE**) control is an electrical automotive control in which an electrical input signal activates one of two proportional solenoids that port charge pressure to either side of the pump servo cylinder. The NFPE control has no mechanical feedback mechanism.

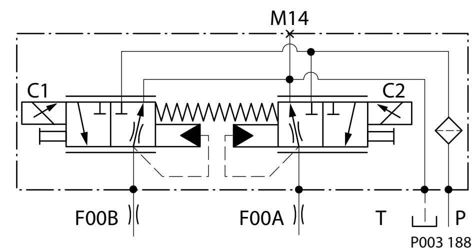
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

NFPE control



NFPE schematic



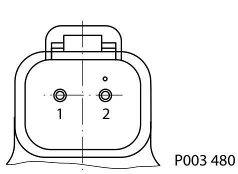
Control signal requirements, NFPE 045/053 Tandem

Control current

Voltage	a* mA	b mA	c mA	Pin connections
12 V	870	1290	1550	any order
24 V	440	670	775	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

DEUTSCH connector, 2-pin



Connector ordering data

Description	Quantity	Ordering data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16 and 18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control Options

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Pump output flow direction vs. control signal

Shaft rotation	CW		CCW	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see Installation drawings.

Control response

H1T controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, NFPE

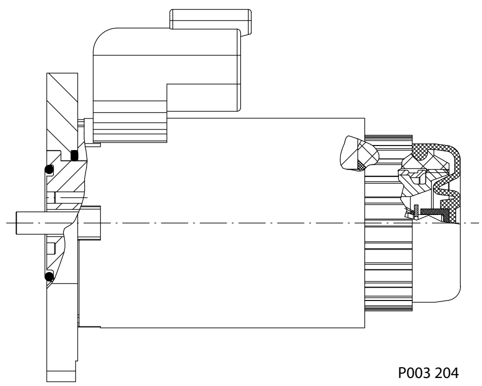
Stroking direction	Size combo	0.8 [0.03] orifice	1.3 [0.05] orifice	No orifice
Neutral to full flow	045/053	2.2 s	1.2 s	0.8 s
	060/068	3.3 s	1.6 s	1.0 s
Full flow to neutral	045/053	1.5 s	0.7 s	0.4 s
	060/068	1.9 s	0.8 s	0.4 s

Control Options

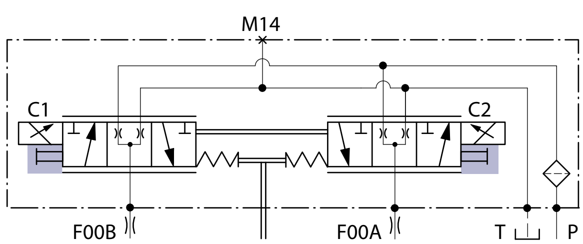
Manual Override (MOR)

All controls are available with a manual override functionality, either as a standard or as an option for temporary actuation of the control to aid in diagnostics.

Control with manual override



MOR schematic (EDC control shown)



Feedback from swash plate.

The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke. The MOR should be engaged anticipating a full stroke response from the pump.

An o-ring seal is used to seal the MOR plunger where initial actuation of the function will require a force of 45 N to engage the plunger. Additional actuation typically require less force to engage the MOR plunger.

Proportional control of the pump using the MOR should not be expected.

Warning

Unintended MOR operation will cause the pump to go into stroke; *example:* vehicle lifted off the ground. The vehicle or device must always be in a safe condition when using the MOR function.

Refer to control flow table for the relationship of solenoid to direction of flow.

Control Options

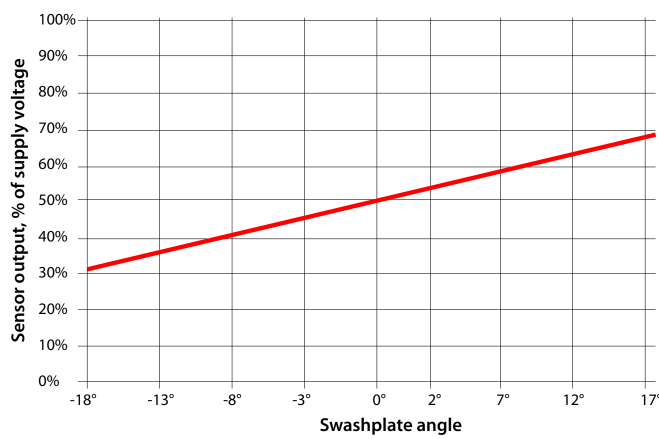
Swashplate angle sensor for EDC controls

The angle sensor detects the swash plate position with an accuracy dependent upon the calibration effort done for the application and direction of rotation from the neutral position. At minimum the sensor can be used for forward, neutral and reverse (FNR) detection.

The sensor works on the hall-effect technology. The implemented technology is based on a measurement of the magnetic field direction in parallel to the chip surface. This field direction is converted to a voltage signal at the output.

Enhanced calibration of the non-linear behavior leads to more exact calculation of the pump swashplate angle. The 4-pin DEUTSCH connector is part of the sensor housing. The swashplate angle sensor is available for all EDC controls for 12 V and 24 V.

Swashplate angle vs. output of supply voltage



Warning

Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

Contact your Danfoss representative in case the angle sensor will be used for safety functions.

Swash plate angle sensor parameters (EDC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.5 V_{DC}	5 V_{DC}	5.5 V_{DC}
Supply protection	–	–	18 V_{DC}
Pump neutral output (% of supply voltage)	–	50%	–
Working range (swash plate angle)	–18°	–	18°
Required supply current	–	–	30 mA
Output current signal	–	9 mA	11 mA
Working temperature	–40 °C	80 °C	115 °C

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector
EMC Immunity	ISO 11452-2	100 V/m

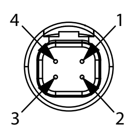
Control Options

Calibration of the sensor output within the software is mandatory. Vehicle neutral thresholds in the software (±0.5°) are vehicle dependent and must consider different conditions, example: system temperature, system pressure and/or shaft speed.

For safety function: If the sensor fails (invalid signal <10% or >90% of supply voltage), it must be sure that the ECU will go into a diagnostic mode and shift into limited mode in order for the driver to take the full control or the mechanical breaks should be activated. Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

Swash plate angle sensor connector

Connector DEUTSCH, 4-pin



Pin assignment:

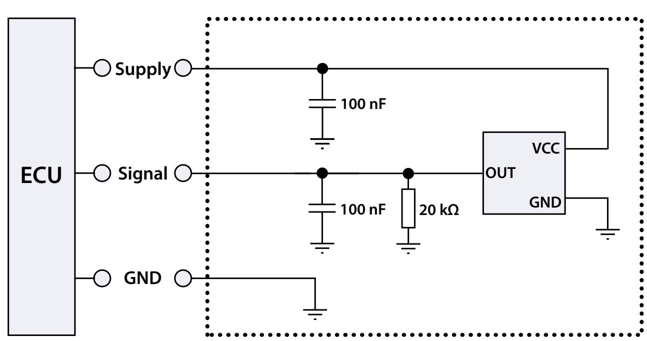
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connector order numbers

Description	Quantity	Order number
Mating connector DEUTSCH DTM06-4S-E004	1	**11105824**
Wedge lock WM-4S	1	not available
Socket contact 0462-201-2031	3	
Mating connector kit	1	**11212713**

Interface with ECU (EDC)

Interface with ECU diagram

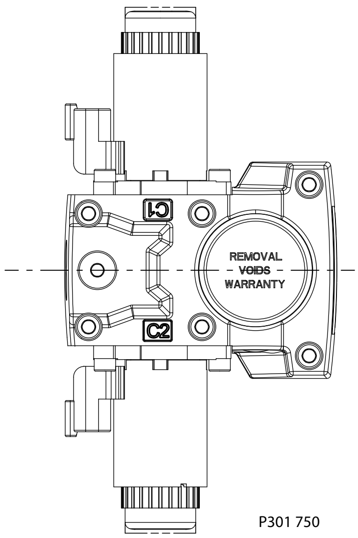


Control Options

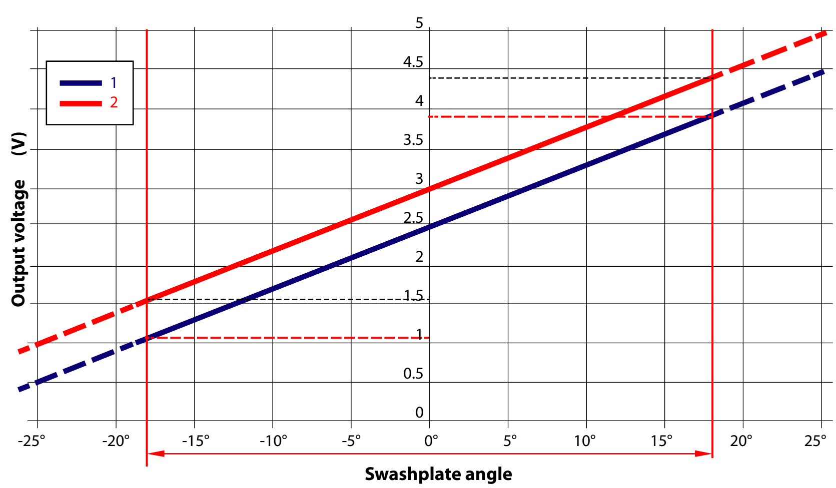
Swash Plate Angle Sensor for NFPE and AC2 Controls

The angle sensor detects the swash plate angle position and direction of rotation from the zero position. The swash angle sensor works on the AMR sensing technology. Under the saturated magnetic field, the resistance of the element varies with the magnetic field direction.

The output signal give a linear output voltage for the various magnet positions in the sensing range.



Swash plate angle vs. output voltage



Swash Plate Angle Sensor Parameters (NFPE/AC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.75 V	5 V	5.25 V
Supply protection	–	–	28 V
Supply current	–	22 mA	25 mA
Output current (Signal 1, 2)	–	0.1 mA	–
Short circuit output current to supply or GND[1)]	–	–	7.5 mA
Sensitivity	70.0 mV/deg	78.0 mV/deg	85.8 mV/deg

Control Options

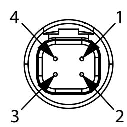
Parameter	Minimum	Typical	Maximum
Working range (swash plate angle)	–18°	0°	18°
Correlation between signals 1 and 2[2)]	475 mV	500 mV	525 mV

[1)] Up to duration of 2.5 seconds at 25°C

[2)] Signal 1 (nominal) is lower than signal 2 (redundant)

Swash-plate Angle Sensor Connector (NFPE/AC2)

Connector DEUTSCH, 4-pin



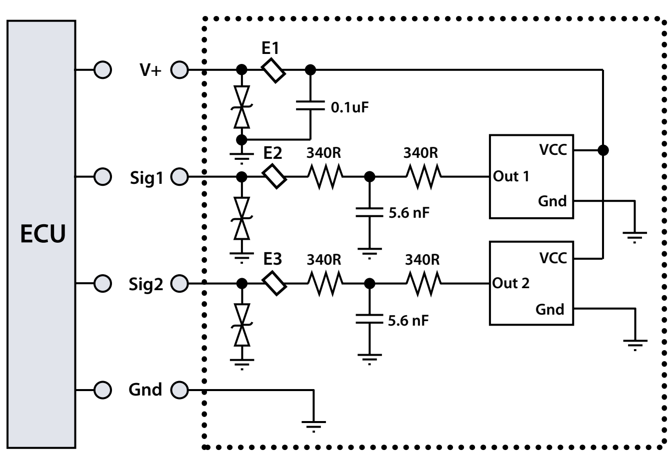
Pin assignment:

1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connector order numbers

Description	Quantity	Order number
Mating connector DEUTSCH DTM06-4S-E004	1	**11105824**
Wedge lock W4S	1	**11084558**
Socket contact DEUTSCH 0462-201-16141 (16–18 AWG)	2	**K02325**

Interface with ECU (NFPE)



Minimum recommended load resistance is 100 kΩ.

Control Options

Control-Cut-Off (CCO) and Brake Release Valves

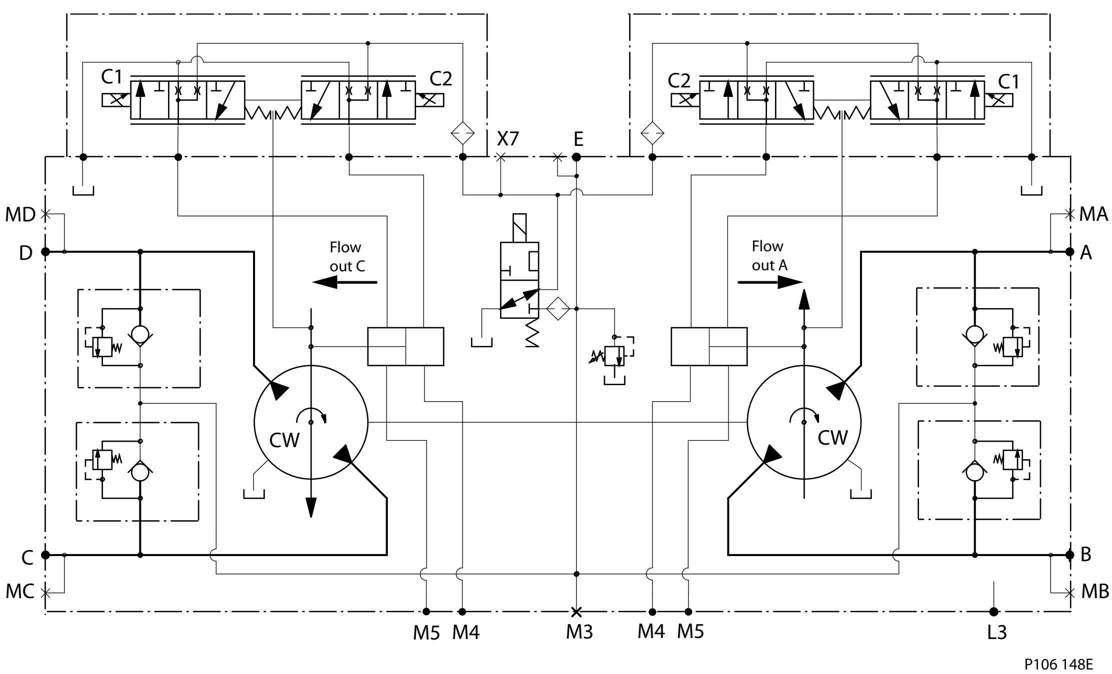
The H1 tandem pumps offer an optional **Control-Cut-Off** valve integrated into the pump center section and a separate brake release valve allowing the controls to be activated before activating any auxiliary functions.

The CCO valve shunts charge pressure from the pump controls allowing the servo springs to de-stroke both pumps. The valve is normally open for fail-safe operation. The solenoid must be energized for the pump to operate. When the machine control circuits energize the CCO solenoid, it connects charge supply from the charge gallery to the pump controls.

The 045/053 tandem also supplies charge pressure to the port X7 for auxiliary operation of devices such as spring applied/pressure released brakes. The control cut off valve also shunts pressure away from port X7.

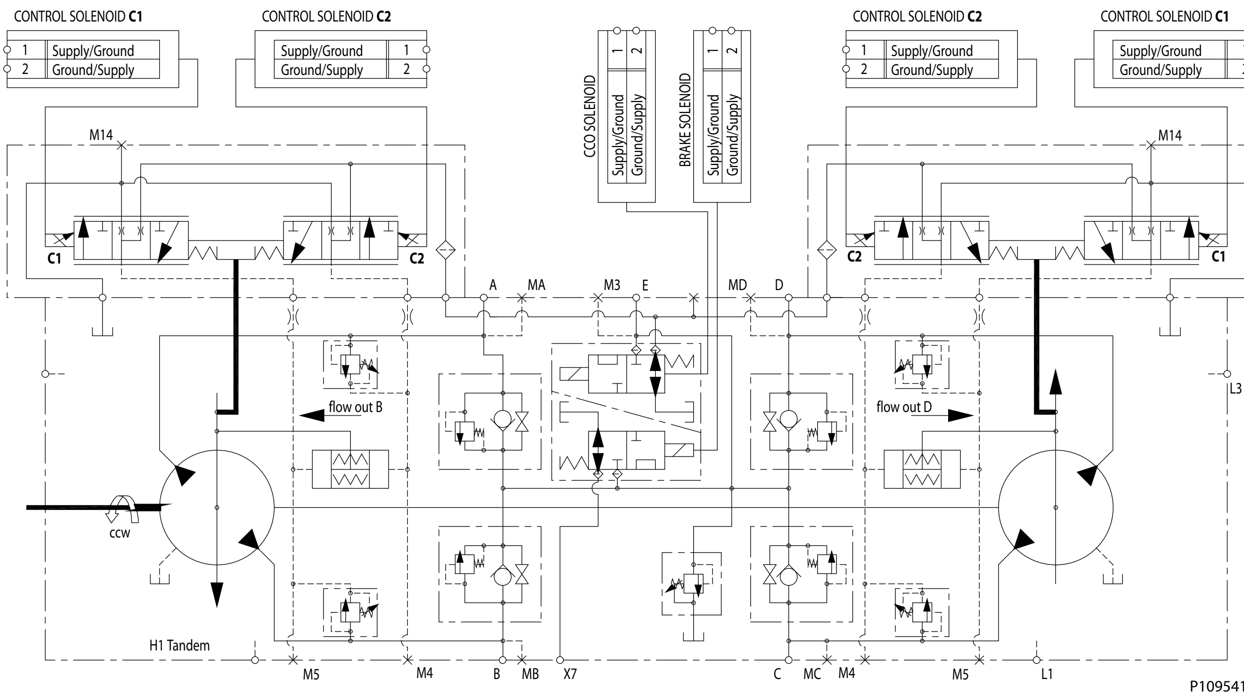
The 060/068 tandem offers a separate brake release valve that operates independently of the CCO valve allowing the controls to be activated before activating any auxiliary functions. When the 60/68 brake valve is deactivated the X7 port shunts to case.

045/053 Tandem



Control Options

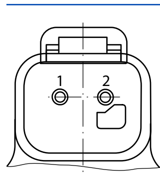
060/068 Tandem



Solenoid data

Description		12 V	24 V
Minimum supply voltage		9 V_{DC}	18 V_{DC}
Maximum supply voltage (continuous)		16 V_{DC}	32 V_{DC}
IP Rating	**IEC 60 529**	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Pin connector		any order	

For additional information, please contact Danfoss.

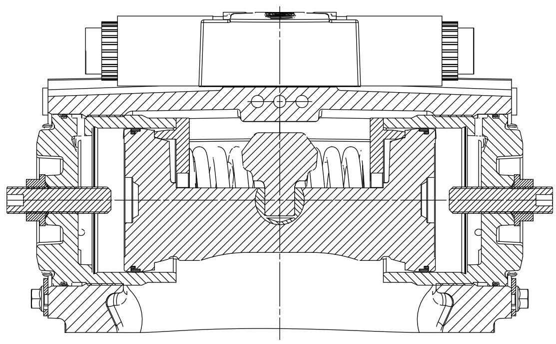


Control Options

Displacement Limiter

H1 pumps are designed with optional mechanical displacement (stroke) limiters factory set to max. displacement. The maximum displacement of the pump can be set independently for forward and reverse using the two adjustment screws to mechanically limit the travel of the servo piston down to 50% displacement.

Adjustments under operating conditions may cause leakage. The adjustment screw can be completely removed from the threaded bore if backed out to far.



P003 266

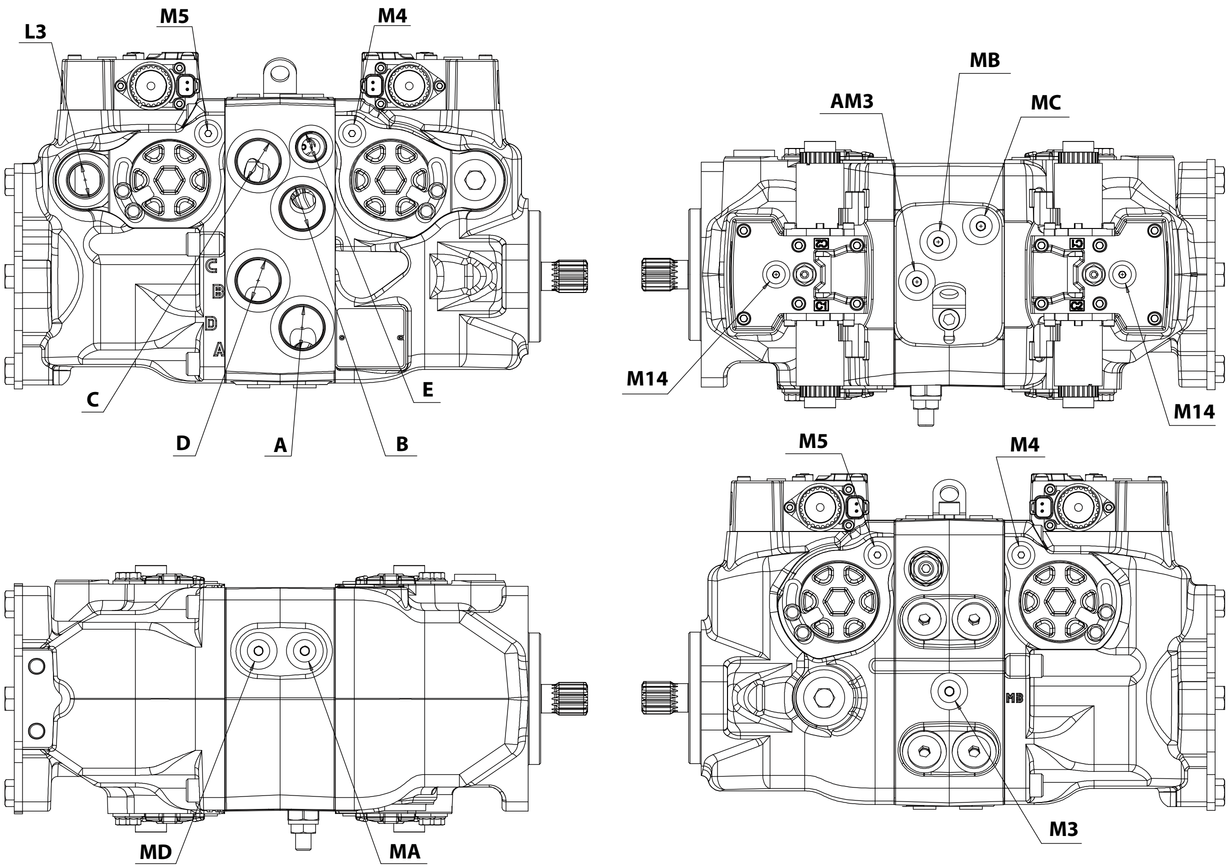
Displacement change (approximately)

Parameter	Size 045	Size 053	Size 060	Size 068
1 Turn of displacement limiter screw	5.1 cm^3 [0.31 in^3]	6.0 cm^3 [0.37 in^3]	5.9 cm^3 [0.36 in^3]	6.6 cm^3 [0.40 in^3]
Internal wrench size	4 mm			
External wrench size	13 mm			
Torque for external hex seal lock nut	23 N•m [204 lbf•in]			

For more information, see *H1 Axial Piston Pumps, Service Manual,* **AX152886482551**, the section “Displacement Limiter Adjustment”.

Port Locations

Port Locations H1T 045/053 Tandem



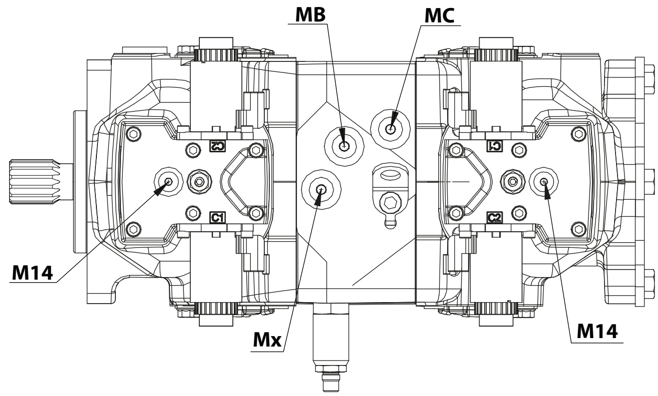
Mounting flange, shaft and connector surfaces to be paint free.

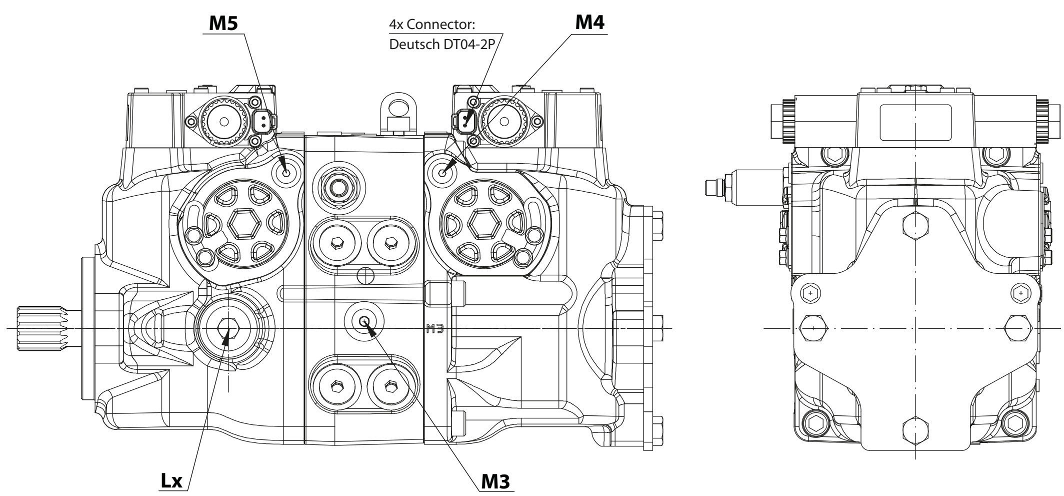
Ports description, ISO 11926-1

Ports	Description	Sizes
A, B, C, D	System ports: A, B, C and D; Ø48.5 max. clearance for fitting	$1\,{}^{5}/_{16}$ –12
MA, MB, MC, MD	System gauge ports A, B, C and D; Ø28 max. clearance for fitting	${}^{9}/_{16}$ – 18
E	Charge filtration inlet port from filter; Ø36 max. clearance for fitting	${}^{7}/_{8}$ –14
L3	Case drain port; Ø48.5 max. clearance for fitting	$1\,{}^{1}/_{16}$ –12
M3	Charge gauge / constr. port; Ø28 max. clearance for fitting	${}^{9}/_{16}$ – 18
M4, M5	Servo gauge ports; Ø24.5 max. clearance for fitting	${}^{7}/_{16}$ – 20
M14	Case gauge port; Ø21 max. clearance for fitting (EDC, MDC, FNR, NFPE)	${}^{7}/_{16}$ – 20
AM3	Alternate charge pressure port	${}^{9}/_{16}$ –18

Port Locations

Port Locations H1T 045/053 Tandem





Mounting flange, shaft and connector surfaces to be paint free.

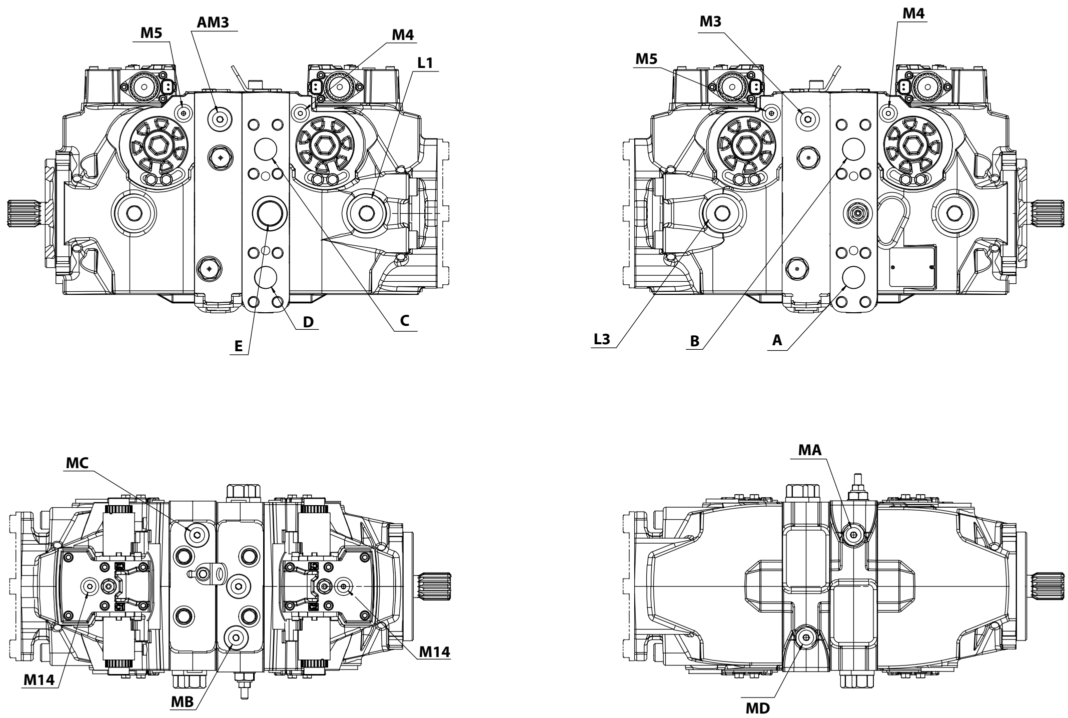
Ports description, ISO 11926-1

Ports	Description	Sizes
MA, MB, MC, MD	System gauge ports A, B, C and D; Ø28 max. clearance for fitting	9⁄16 – 18
M3, Mx	Charge gauge / constr. port; Ø28 max. clearance for fitting	9⁄16 – 18
M4, M5	Servo gauge ports; Ø24.5 max. clearance for fitting	7⁄16 – 20
M14	Case gauge port; Ø21 max. clearance for fitting (EDC, MDC, FNR, NFPE)	7⁄16 – 20

Please contact Danfoss representative for specific installation drawings.

Port Locations

Port Locations H1T 060/068 Tandem

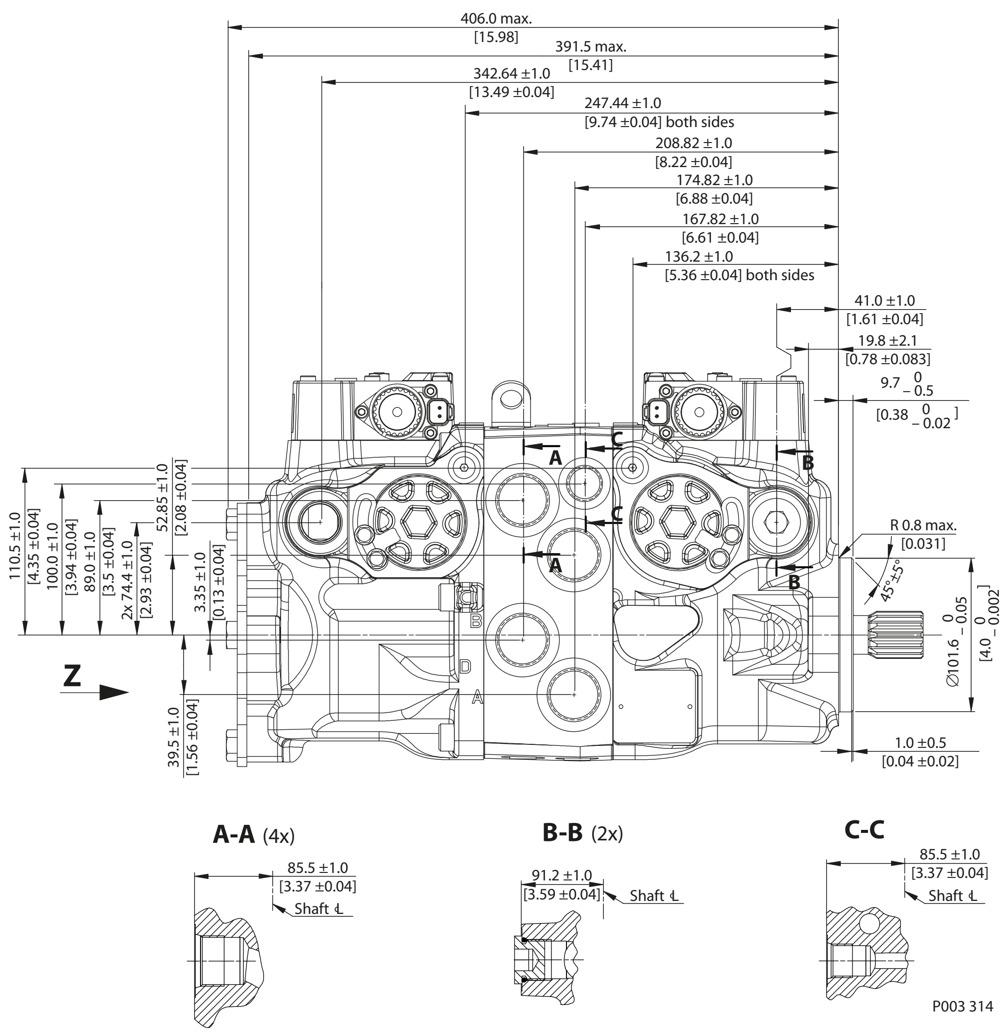


Ports description, ISO 11926-1

Ports	Description	Size
A, B, C, D	System ports: A, B, C and D	Split flange, M12 x 1.75
MA, MB, MC, MD	System gauge ports A, B, C and D	$^{9}/_{16}$ – 18
E	Charge filtration inlet port from filter	$1^{1}/_{16}$ –12
L1, L3	Case drain port	$1^{5}/_{16}$ –12
M3, Mx	Charge gauge / constr. port	$^{9}/_{16}$ – 18
M4, M5	Servo gauge ports	$^{7}/_{16}$ – 20
M14	Case gauge port; (EDC, MDC, FNR, NFPE)	$^{7}/_{16}$ – 20
AM3	Alternate charge pressure port	$^{9}/_{16}$ – 18

Dimensions

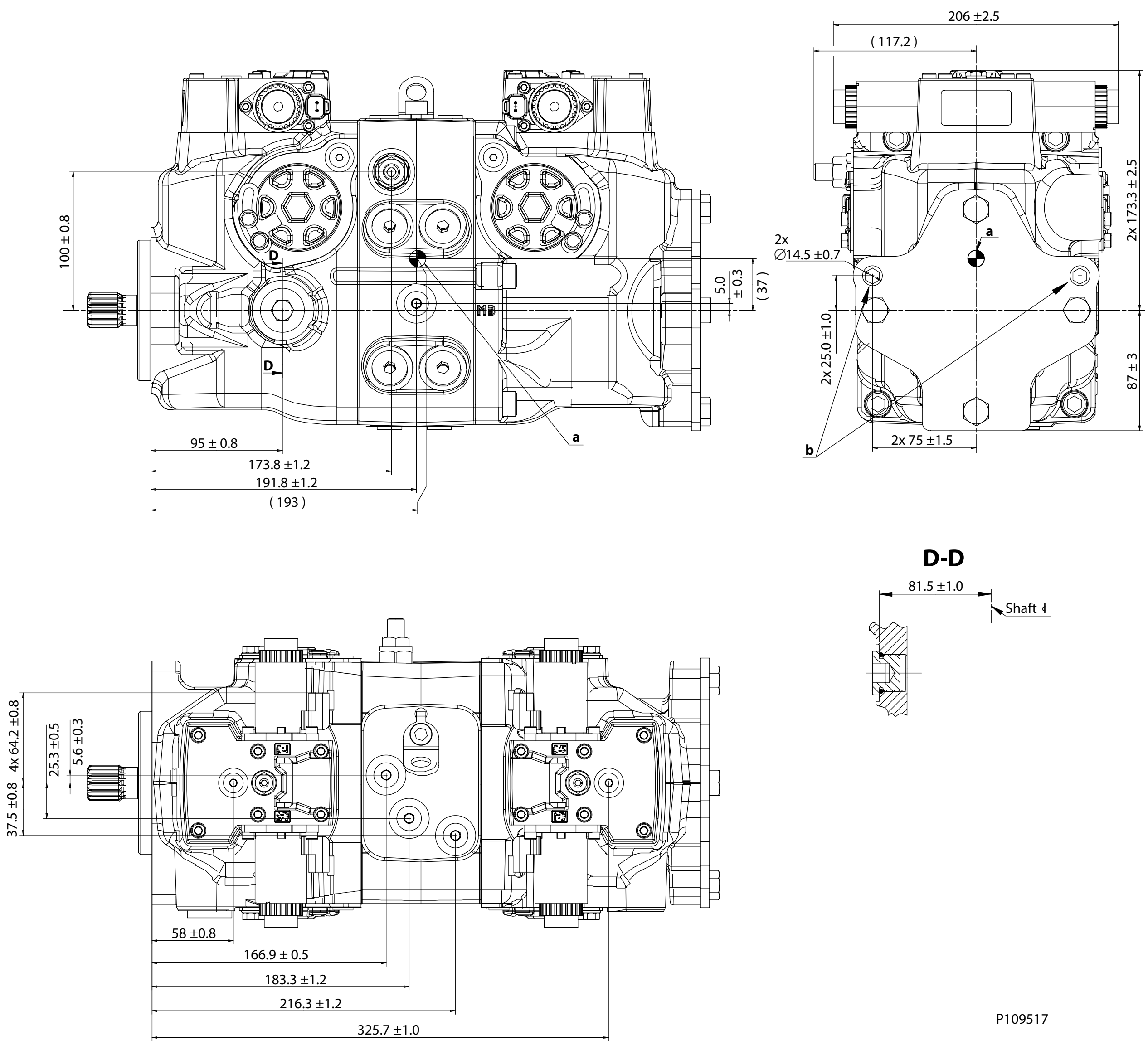
Dimensions H1T 045/053 Tandem



L3 case drain port must be used (see the section *Case drain* on page 9 for more details).

Please contact Danfoss representative for specific installation drawings.

Dimensions



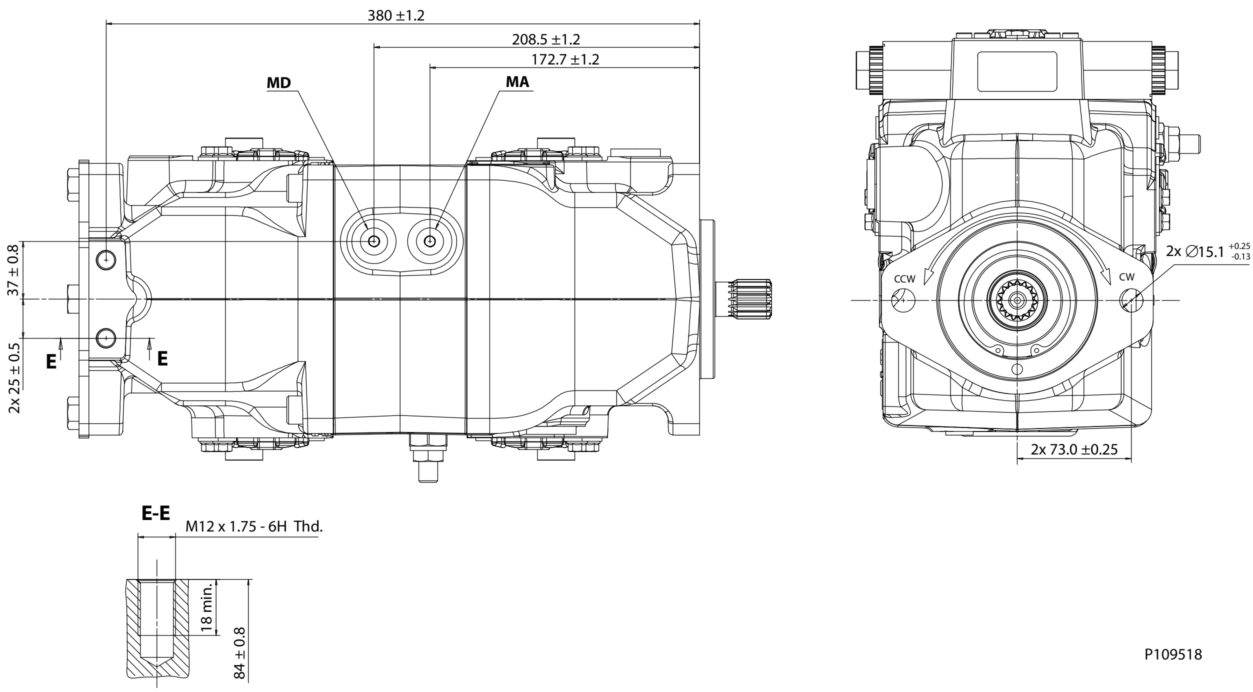
Notes in the drawing:

a – Approximate center of gravity

b – Lifting holes weight limit not to exeed 75 kg [165 lb]

Please contact Danfoss representative for specific installation drawings.

Dimensions

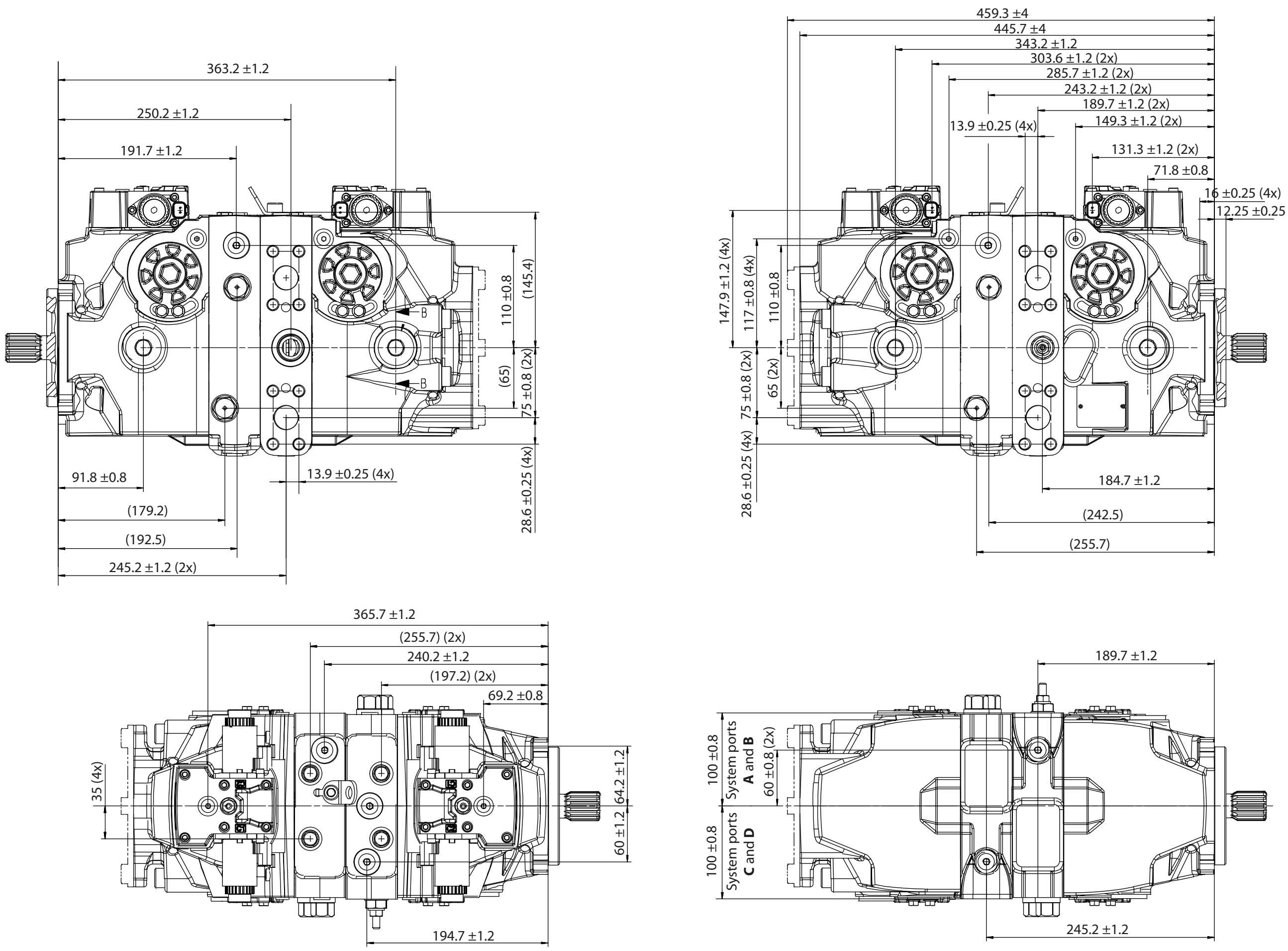


Mounting bolt holes are sized for 14 mm fasteners. M12 or ½ inch can be used, but require a hardened washer.

Please contact Danfoss representative for specific installation drawings.

Dimensions

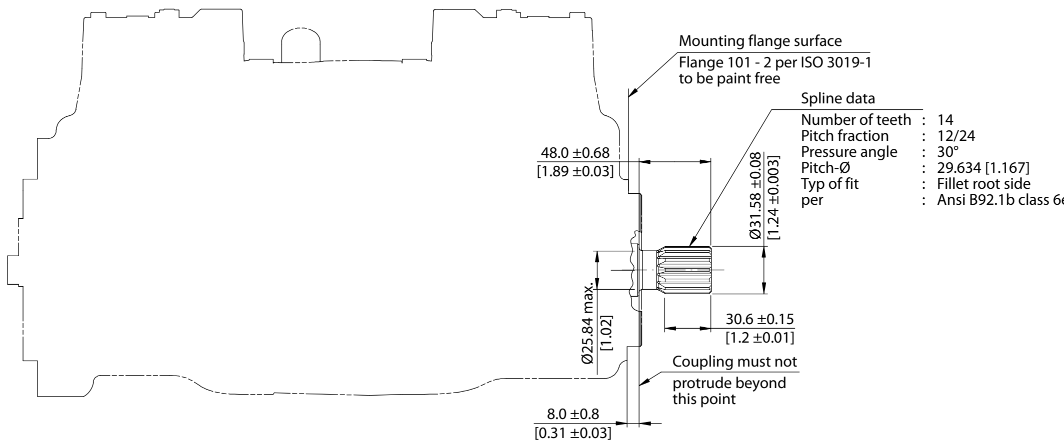
Dimensions H1T 060/068 Tandem



Dimensions

Input shaft, option G1 (SAE C, 14 teeth) (045/053/060/068)

Option G1



Specifications

Option		G1
Spline		14 teeth, 12/24 pitch
Min. active spline length[1)]		30.6 mm [1.205 in]
Torque rating[2)]	**Rated**	534 N•m [4720 lbf•in]
	Maximum	592 N•m [5240 lbf•in]

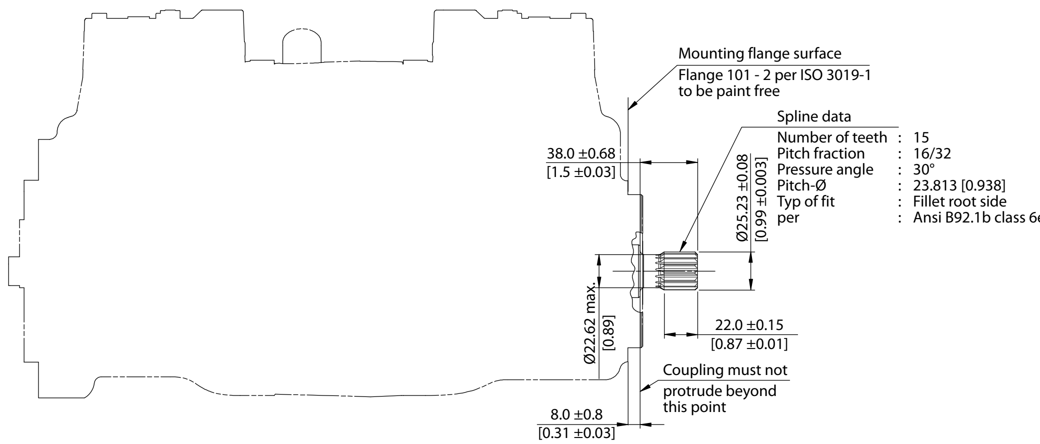
[1)] Minimum active spline length for the specified torque ratings.

[2)] For definitions of maximum and rated torque values, refer to *Basic Information* **BC152886483968**, section Shaft Torque Ratings and Spline Lubrication.

Dimensions

Input shaft, option G5 (SAE B-B, 15 teeth) (045/053 only)

Option G5



Specifications

Option		G5
Spline		15 teeth, 16/32 pitch
Min. active spline length1)		22 mm [0.866 in]
Torque rating2)	**Rated**	277 N•m [2450 lbf•in]
	Maximum	370 N•m [3270 lbf•in]

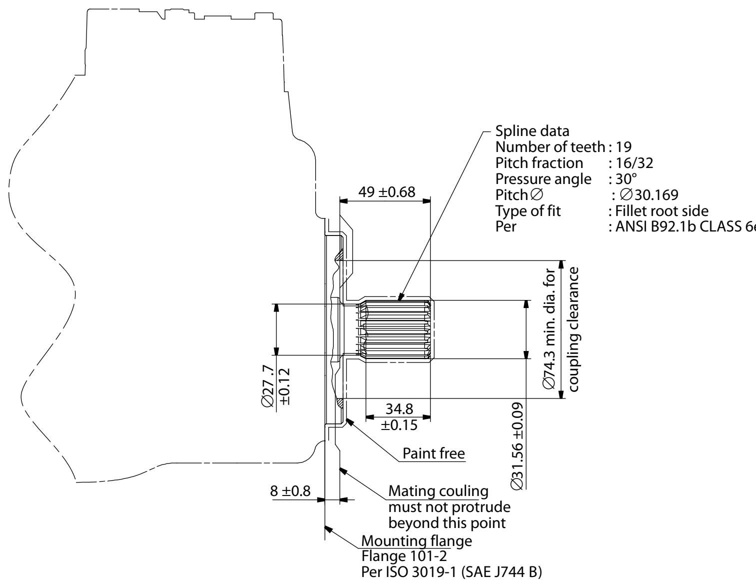
1) Minimum active spline length for the specified torque ratings.

2) For definitions of maximum and rated torque values, refer to *Basic Information* **BC152886483968**, section Shaft Torque Ratings and Spline Lubrication.

Dimensions

Input shaft, option G6, (19 teeth-long) (045/053 only)

Option G6, 045/053



Specifications

Option		**G6**
Spline		19 teeth, 16/32 pitch
Min. active spline length[1)]		34.8 mm [1.370 in]
Torque rating[2)]	**Rated**	563 N•m [4980 lbf•in]
	Maximum	732 N•m [6478 lbf•in]

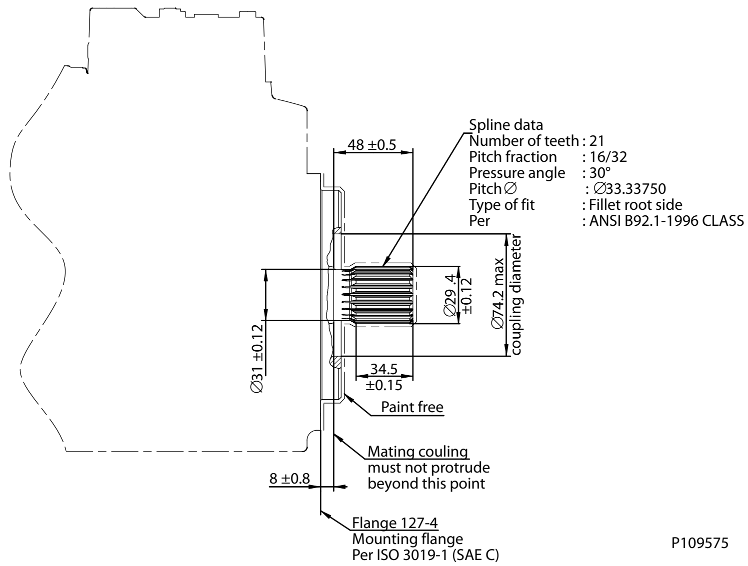
1) Minimum active spline length for the specified torque ratings.

2) For definitions of maximum and rated torque values, refer to *Basic Information* **BC152886483968**, section Shaft Torque Ratings and Spline Lubrication.

Dimensions

Input shaft, option F1, (060/068 only)

Option F1, ISO 3019-1, outer dia 32 mm-4 (SAE C, 21 teeth)



Specifications

Option		F1
Spline		21 teeth, 16/32 pitch
Min. active spline length[1)]		31.5 mm [1.358 in]
Torque rating[2)]	**Rated**	760 N•m [6730 lb•in]
	Maximum	1137 N•m [10060 lb•in]

[1)] Minimum active spline length for the specified torque ratings.

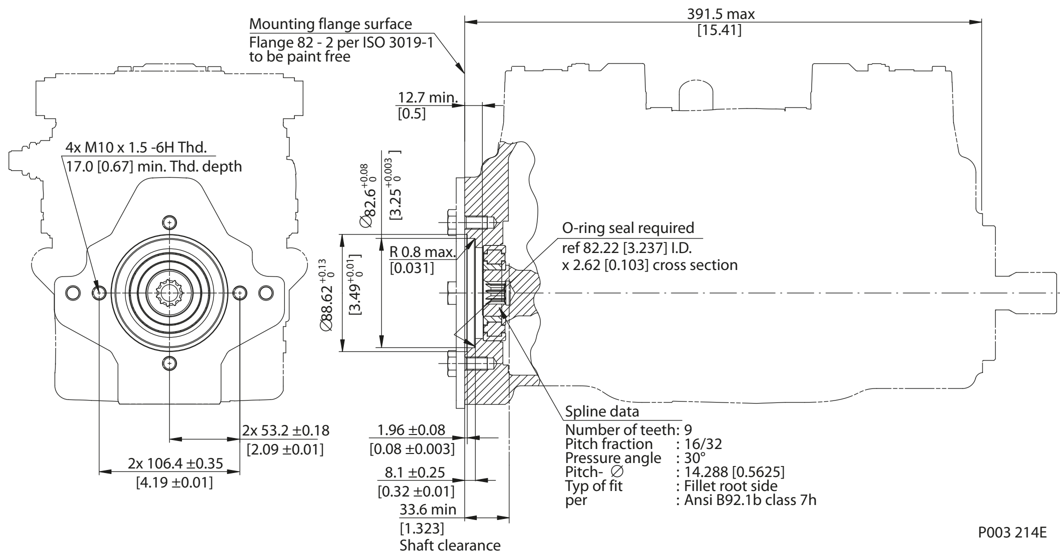
[2)] For definitions of maximum and rated torque values, refer to *Basic Information* **BC152886483968**, section Shaft Torque Ratings and Spline Lubrication.

Dimensions

Auxiliary mounting pads

Option H2 (SAE A, 9 teeth) 045/053

Option H2, ISO 3019-1, flange 82-2 (SAE A, 9 teeth)



Specifications

Option	H2
Spline	9 teeth, 16/32 pitch
Maximum torque[1]	162 N•m [1430 lbf•in]

[1] For definitions of maximum and rated torque values, refer to *Basic Information* **BC152886483968**, section Shaft Torque Ratings and Spline Lubrication.

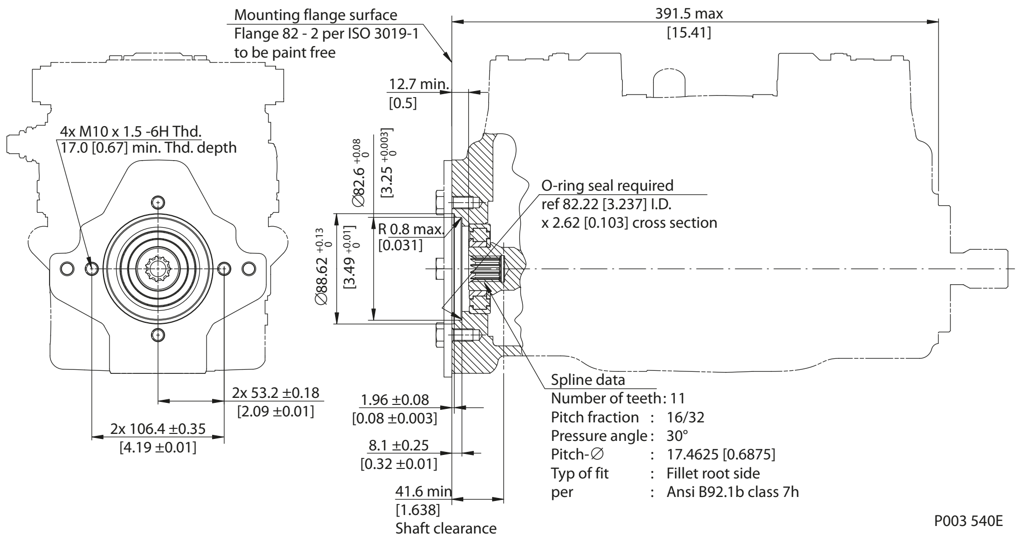
Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions

Option H1 (SAE A, 11 teeth) 045/053

Option H1, ISO 3019-1, Flange 82-2 (SAE A, 11 Teeth)



Specifications

Option	**H1**
Spline	11 teeth, 16/32 pitch
Maximum torque[1)]	296 N•m [2620 lbf•in]

[1)] For definitions of maximum and rated torque values, refer to *Basic Information* **BC152886483968**, section Shaft Torque Ratings and Spline Lubrication.

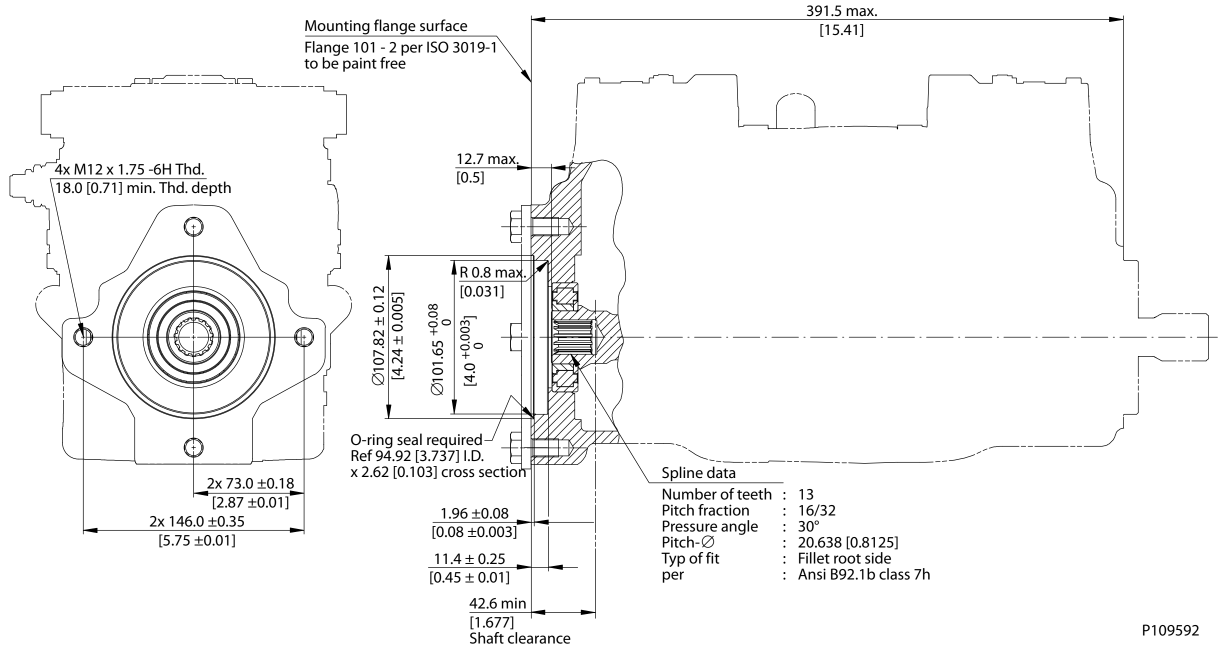
Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions

Option H3 (SAE B, 13 teeth) 045/053

Option H3, ISO 3019-1, Flange 101-2 (SAE B, 13 Teeth)



Specifications

Option	**H3**
Spline	13 teeth, 16/32 pitch
Maximum torque1)	395 N•m [3500 lbf•in]

1) For definitions of maximum and rated torque values, refer to *Basic Information* **BC152886483968**, section Shaft Torque Ratings and Spline Lubrication.

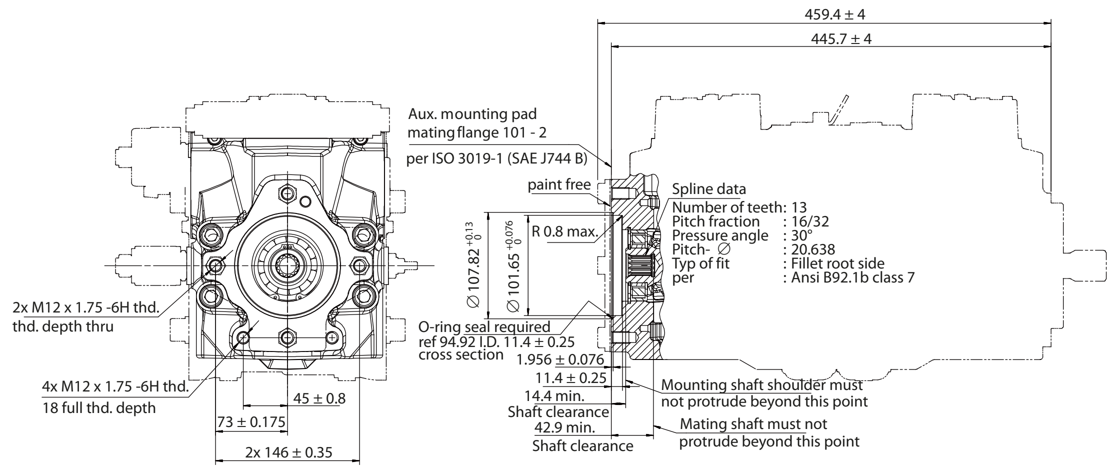
Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions

Option H3 (SAE B, 13 teeth) 060/068

Option H3, ISO 3019-1, Flange 101-2 (SAE B, 13 Teeth)



Specifications

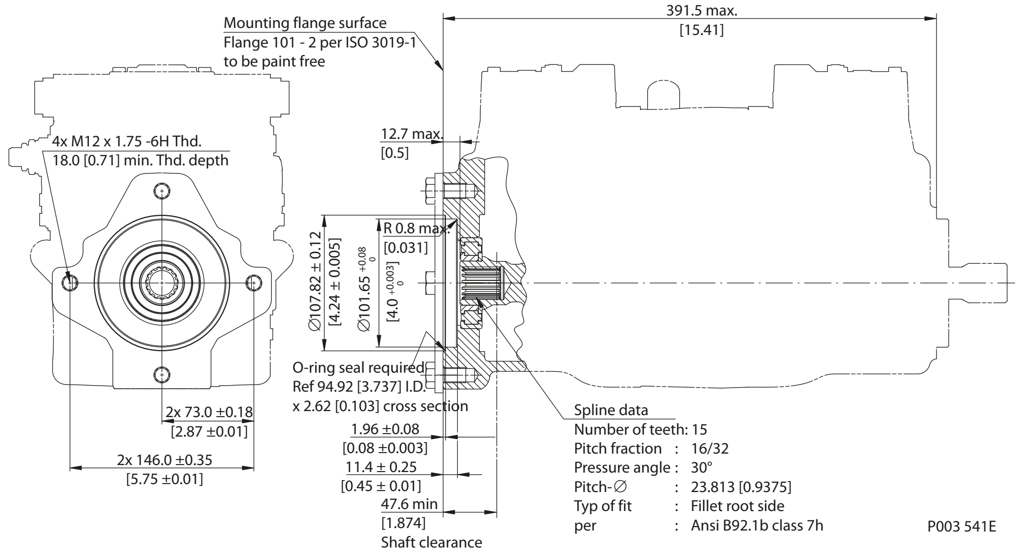
Option	H3
Spline	13 teeth, 16/32 pitch
Maximum torque[1)]	395 N•m [3500 lbf•in]

[1)] For definitions of maximum and rated torque values, refer to *Basic Information* **BC152886483968**, section Shaft Torque Ratings and Spline Lubrication.

Dimensions

Option H5 (SAE B-B, 15 teeth) 045/053

Option H5, ISO 3019-1, Flange 101-2 (SAE B-B, 15 Teeth)



Specifications

Option	H5
Spline	15 teeth, 16/32 pitch
Maximum torque[1)]	405 N•m [3580 lbf•in]

[1)] For definitions of maximum and rated torque values, refer to *Basic Information* **BC152886483968**, section Shaft Torque Ratings and Spline Lubrication.

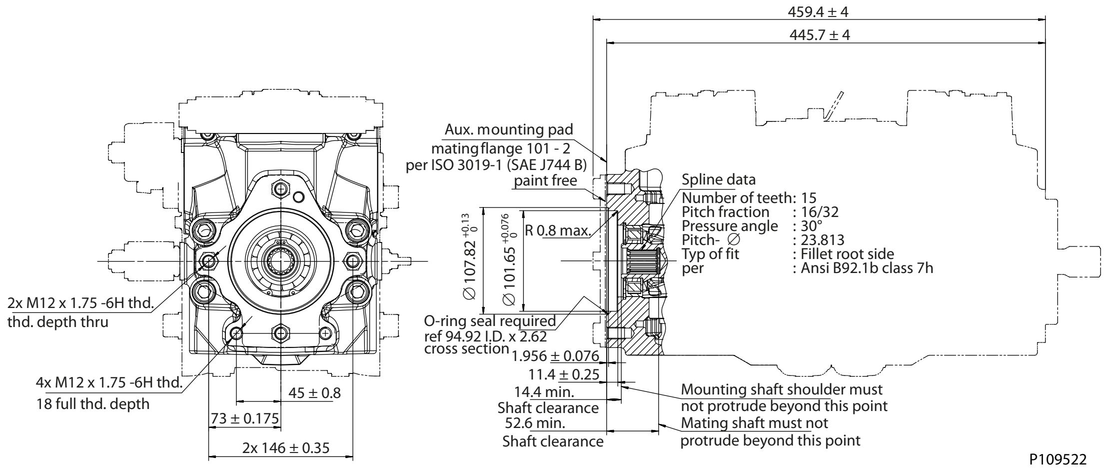
Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions

Option H5 (SAE B-B, 15 teeth) 060/068

Option H5, ISO 3019-1, Flange 101-2 (SAE B-B, 15 Teeth)



Specifications

Option	H5
Spline	15 teeth, 16/32 pitch
Maximum torque[1)]	592 N•m [5240 lbf•in]

[1)] For definitions of maximum and rated torque values, refer to *Basic Information* **BC152886483968**, section Shaft Torque Ratings and Spline Lubrication.

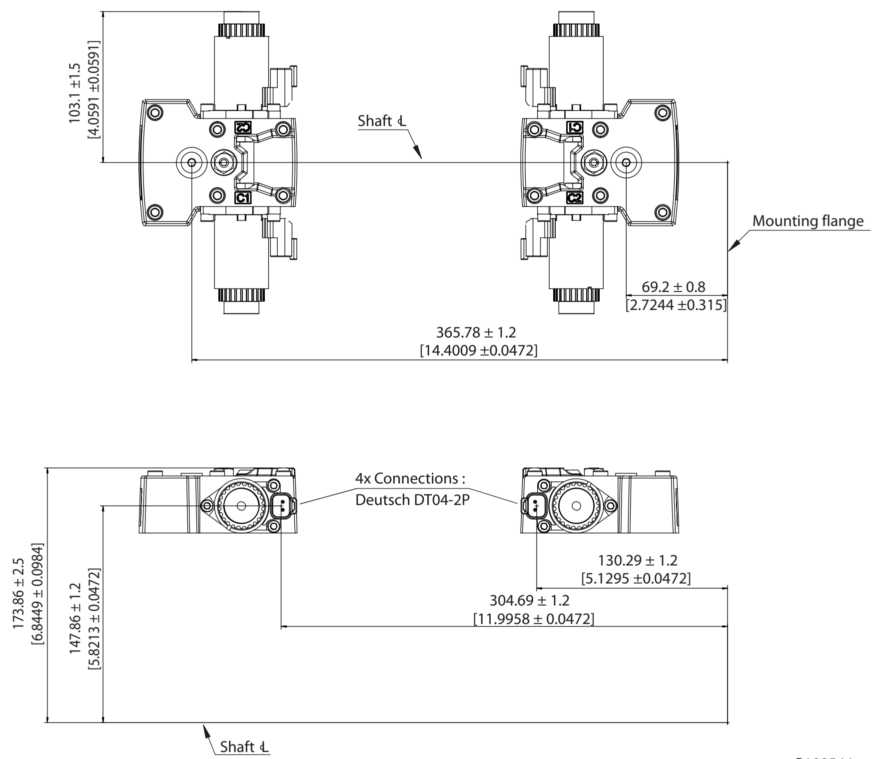
Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions

060/068 Control dimensions

Electric Displacement Control (EDC), option A2 (12V) / A3 (24V) (060/068)



P109544

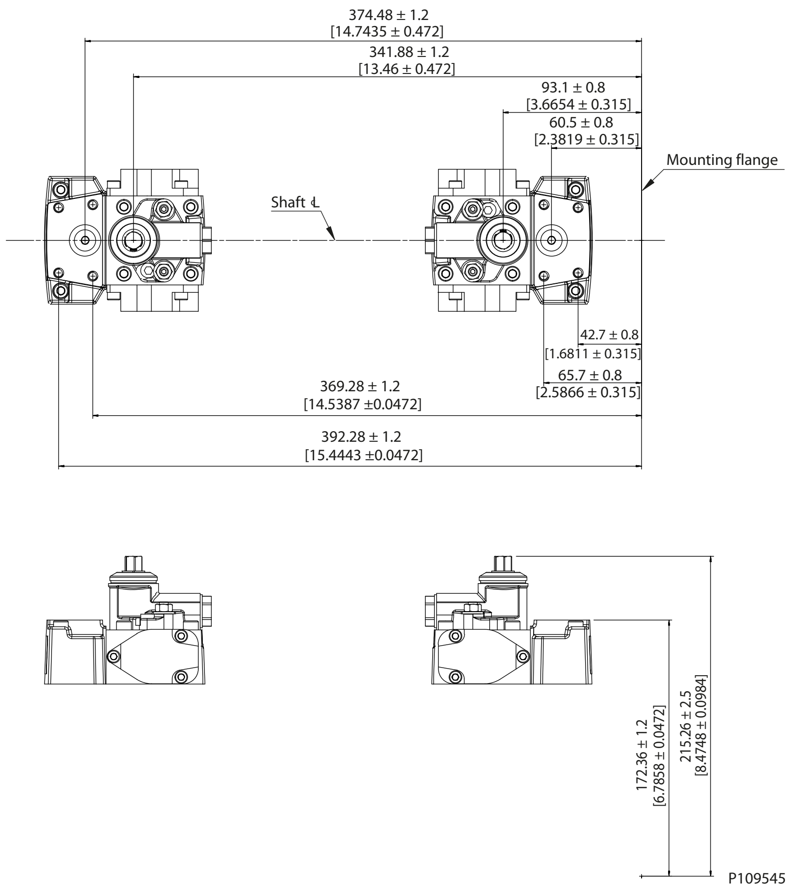
2x Case gauge port **M14:** ISO 11926-1 – 7/16 -20; Ø21.0 max clearance dia for fitting

4x Connectors Deutsch DT04-2P to be paint free

Please contact Danfoss representative for specific installation drawings.

Dimensions

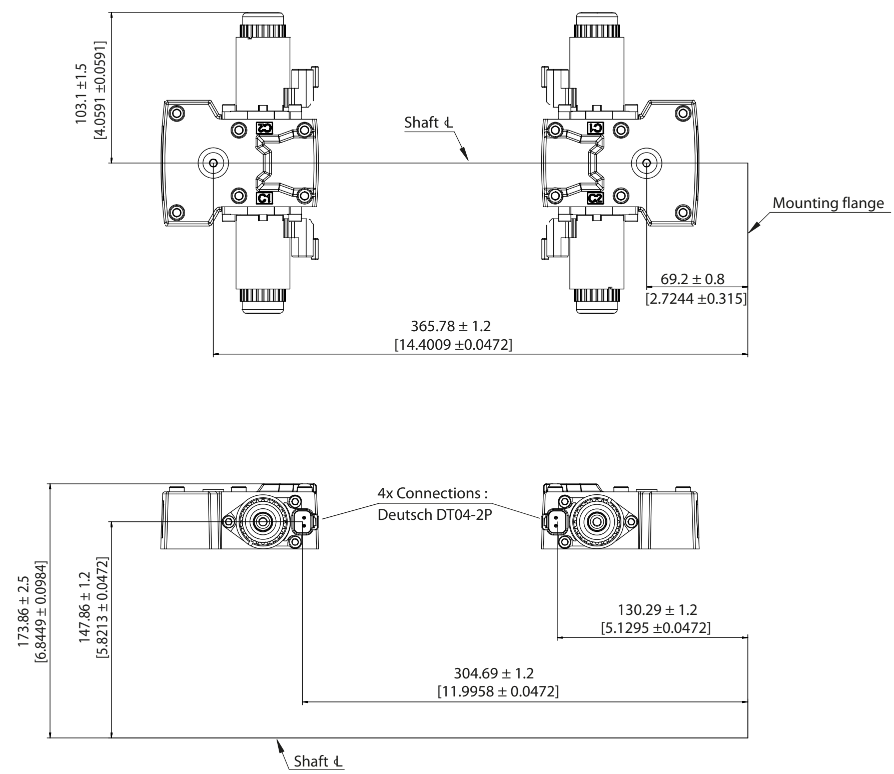
Manual Displacement Control (MDC), option M1 (060/068)



Please contact Danfoss representative for specific installation drawings.

Dimensions

Forward-Neutral-Reverse (FNR) with MOR, option A9 (12 V)/ B1 (24 V) (060/068)



P109546

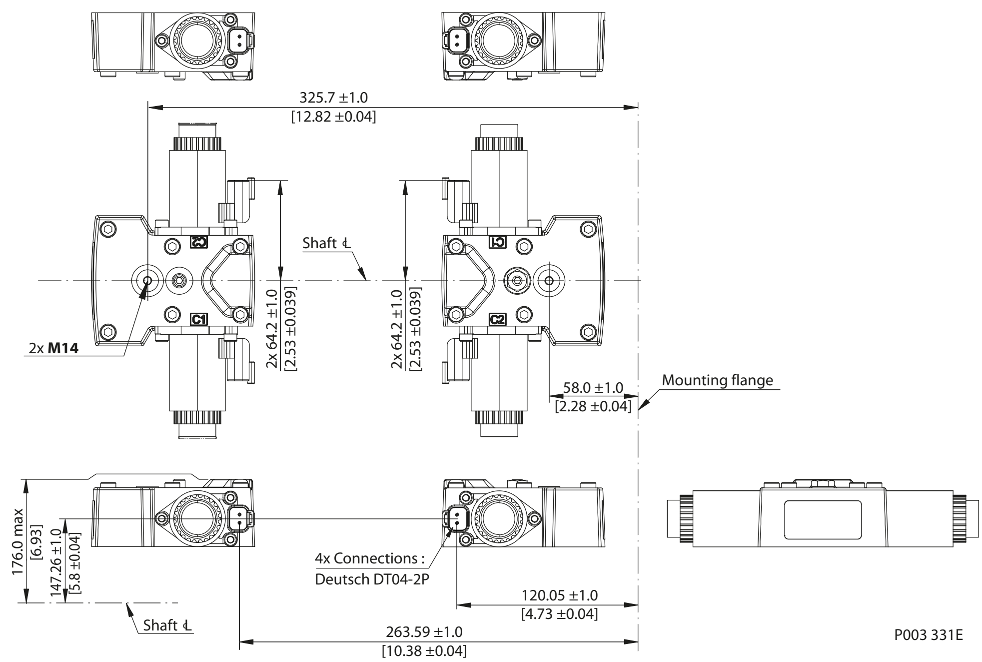
2x Case gauge port **M14:** ISO 11926-1; $^{7}/_{16}$–20; Ø21.0 max clearance dia for fitting.
4x Connectors Deutsch DT04-2P to be paint free.

Please contact Danfoss representative for specific installation drawings.

Dimensions

045/053 Control dimensions

Electric Displacement Control (EDC), option A2 (12V) / A3 (24V) H1T (045/053)



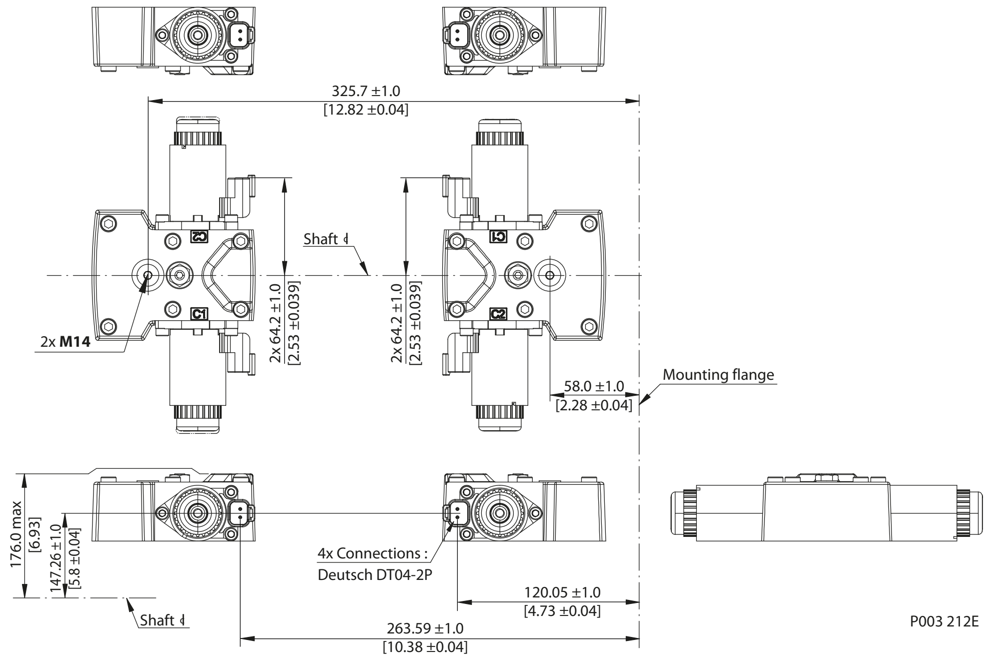
2x Case gauge port **M14:** ISO 11926-1 – 7/16 -20; Ø21.0 max clearance dia for fitting

4x Connectors Deutsch DT04-2P to be paint free

Please contact Danfoss representative for specific installation drawings.

Dimensions

Electric Displacement Control (EDC) with MOR, option A4 (12 V) / A5 (24 V) H1T (045/053)



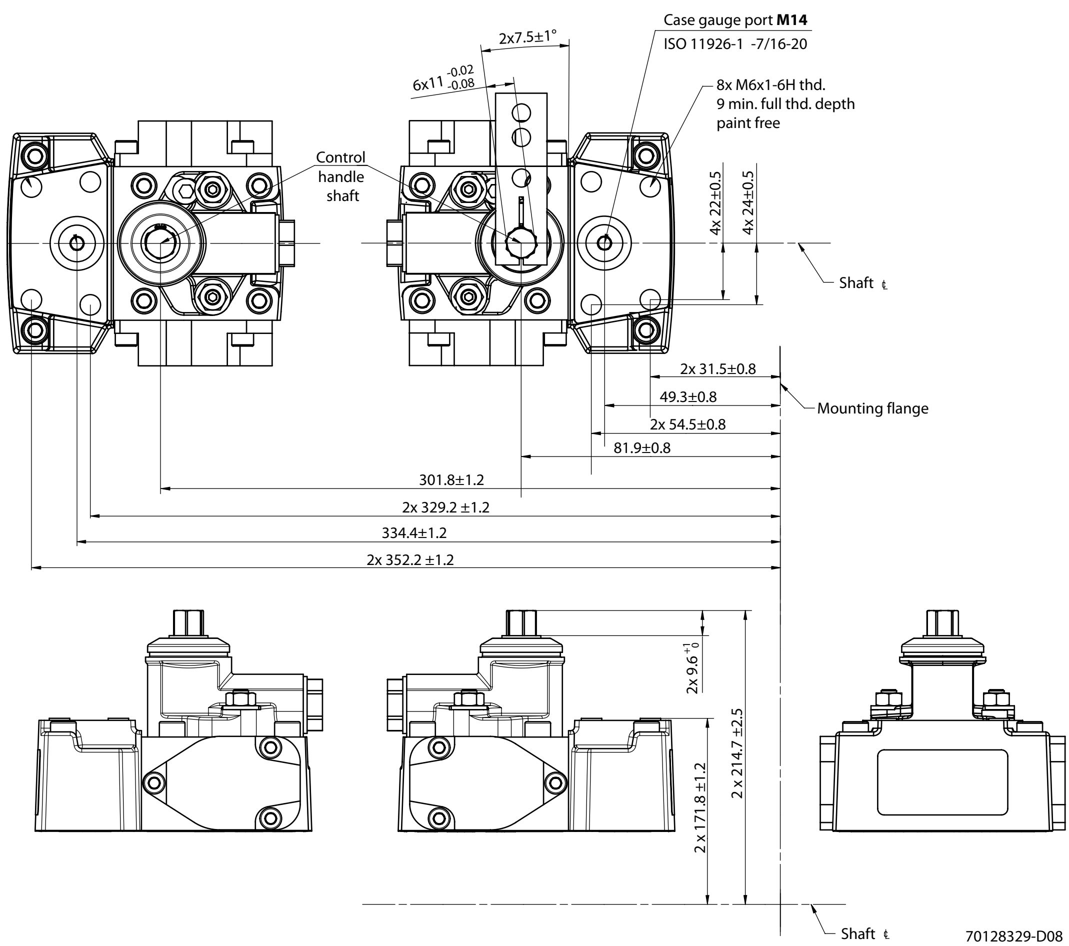
2x Case gauge port **M14:** ISO 11926-1 – 7/16 -20; Ø21.0 max clearance dia for fitting

4x Connectors Deutsch DT04-2P to be paint free

Please contact Danfoss representative for specific installation drawings.

Dimensions

Manual Displacement Control (MDC), option M1, H1T (045/053)

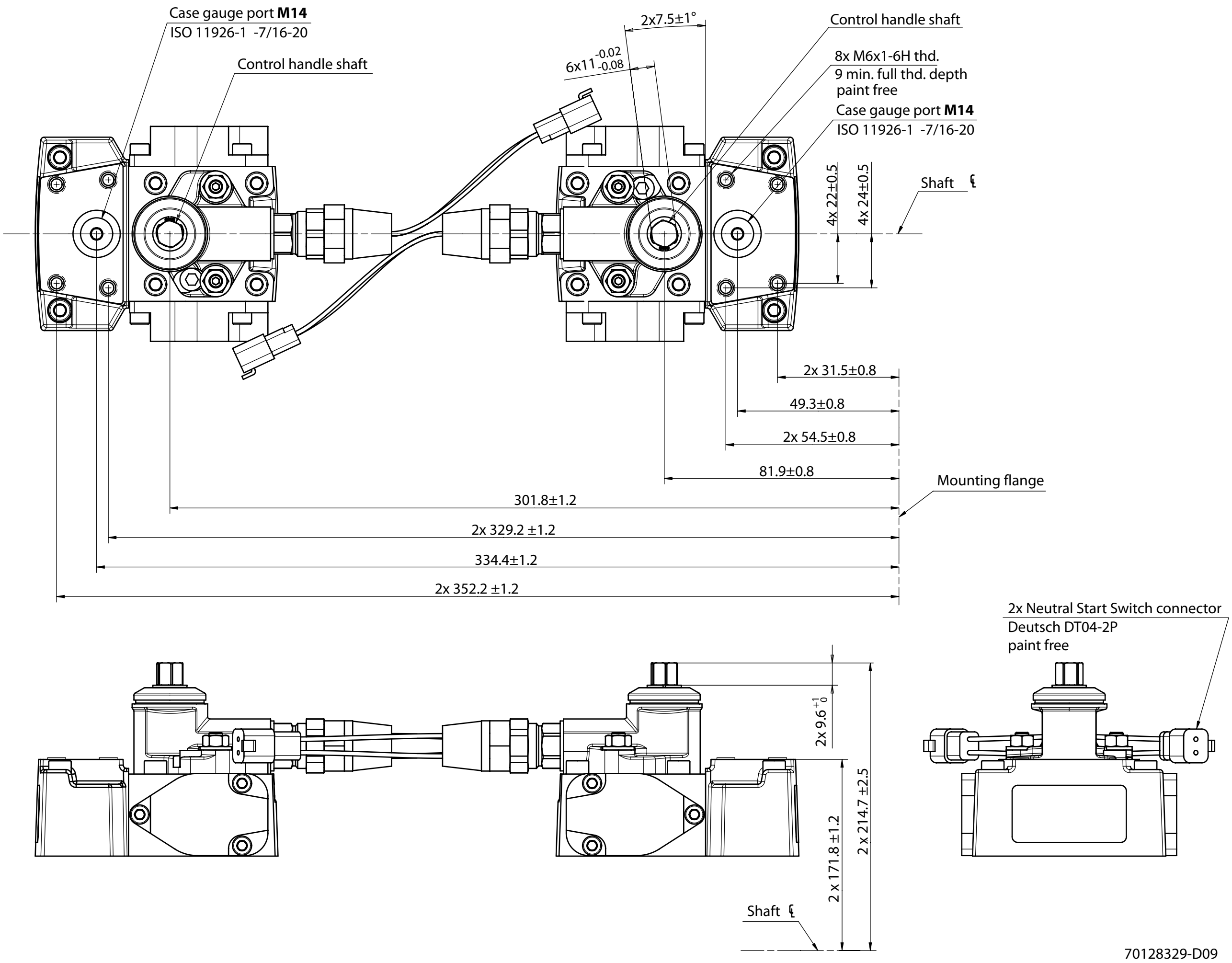


Please contact Danfoss representative for specific installation drawings.

Dimensions

Manual Displacement Control (MDC) with NSS, option M2, H1T (045/053)

H1 Tandem 045/053 Manual Displacement Control (MDC) with NSS, option M2



Neutral Start Switch connector:

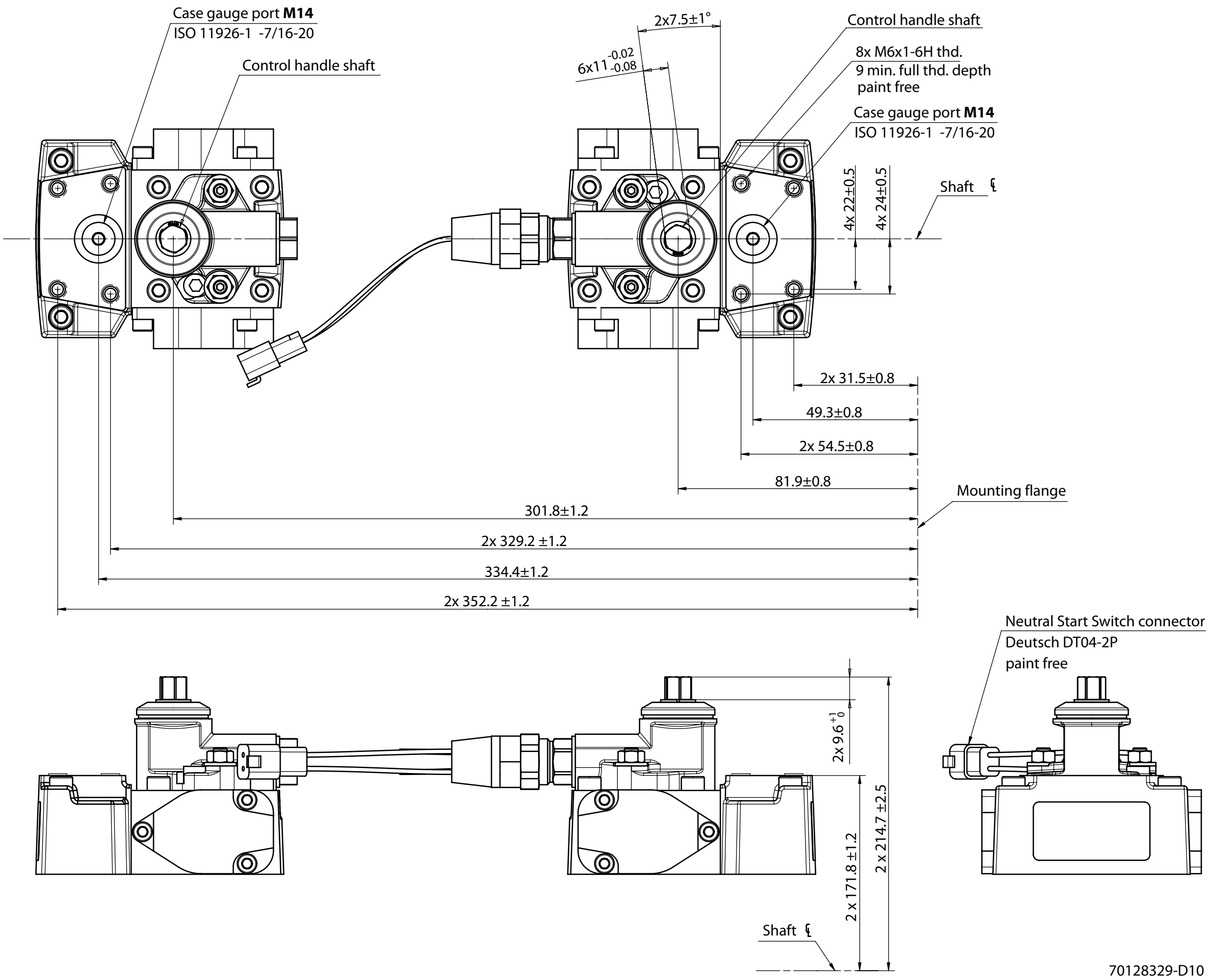
Pin	Assignment		Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions

Manual Displacement Control (MDC) with NSS, option D9, H1T (045/053)

H1 Tandem 045/053 Manual Displacement Control (MDC) with NSS, option D9



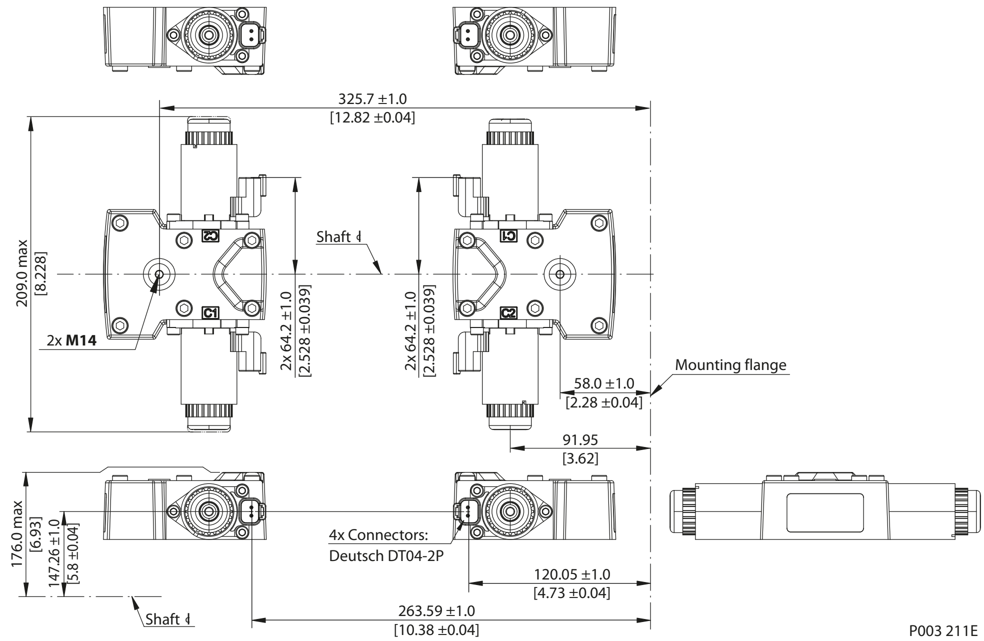
Neutral Start Switch connector:

Pin	Assignment		Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions

Forward-Neutral-Reverse (FNR) with MOR, option A9 (12 V) / B1 (24 V) H1T (045/053)

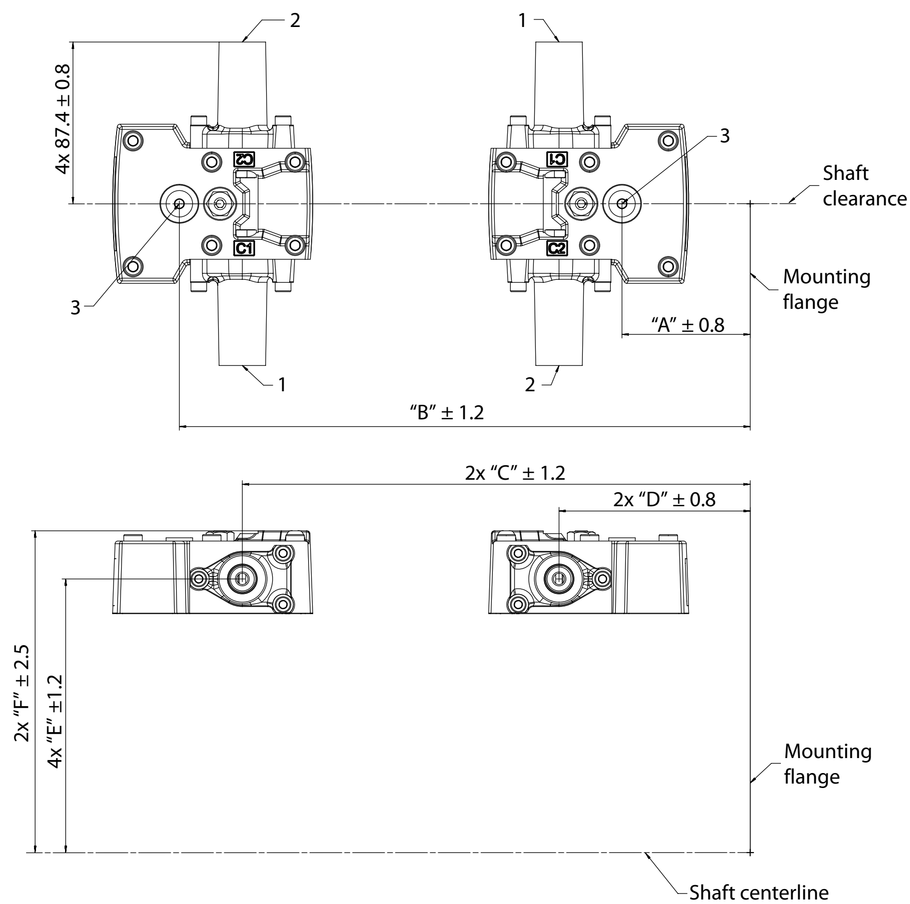


2x Case gauge port **M14:** ISO 11926-1; $^7/_{16}$–20; Ø21.0 max clearance dia for fitting.
4x Connectors Deutsch DT04-2P to be paint free.

Please contact Danfoss representative for specific installation drawings.

Dimensions

HDC, Options: T1, T2



Ports

Item	Description
1	Control signal pressure inlet port "X1" Port ISO 11926-1 - 9/16-18UNF-2B
2	Control signal pressure inlet port "X2" Port ISO 11926-1 - 9/16-18UNF-2B
3	Case gauge port "M14" Port ISO 11926-1 - 7/16-20UNF-2

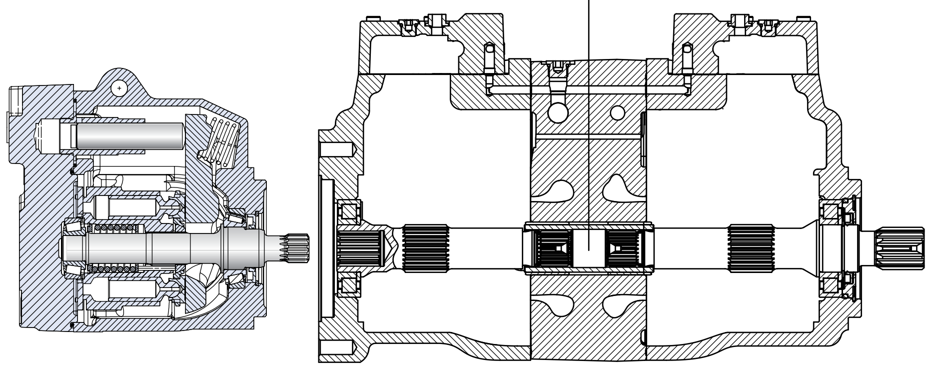
Dimensions in mm [in]

Size	A	B	C	D	E	F
H1T 45/53	58 [2.3]	325.7 [12.8]	291.7 [11.5]	92 [3.6]	147.3 [5.8]	173.3 [6.8]
H1T 60/68	69.2 [2.7]	365.8 [14.4]	331.8 [13.1]	103.2 [4.1]	147.9 [5.8]	173.9 [6.8]

Dimensions

Center section coupling, torque rating

Torque rating for center section coupling



Maximum torque for center coupling

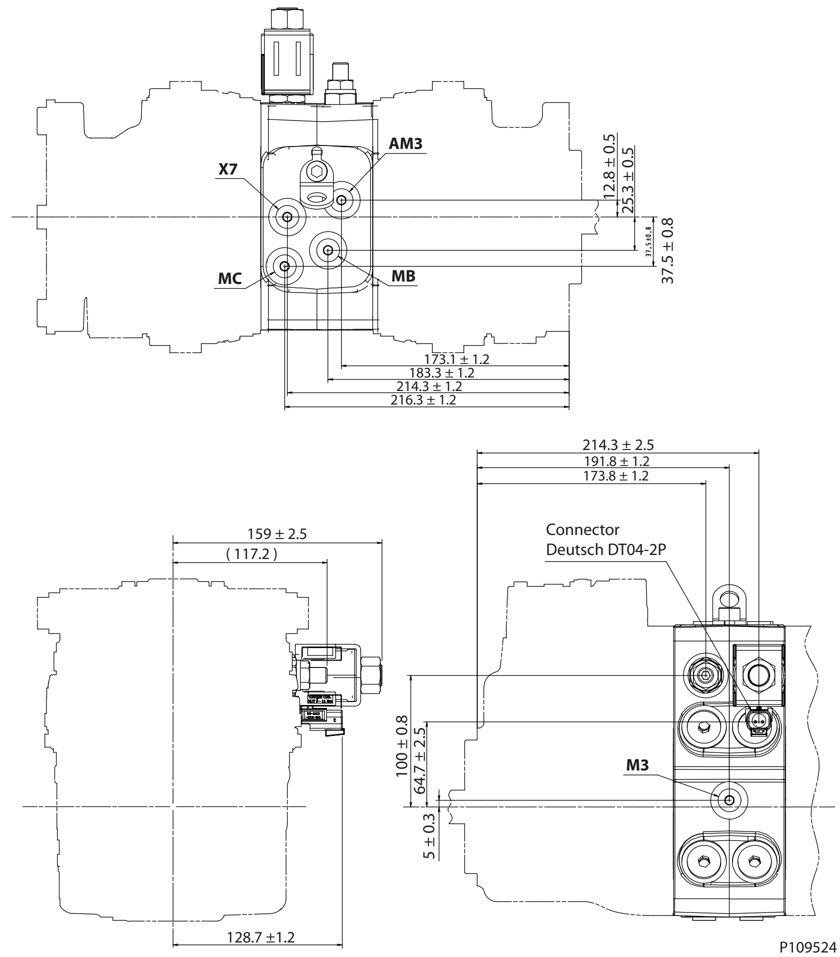
Model	Max. torque
045/053	**405 N•m [3580 lbf•in]**
060/068	**592 N•m [5040 lbf•in]**

For definitions of maximum and rated torque values, refer to *Basic Information* **BC152886483968**, section *Shaft Torque Ratings and Spline Lubrication*.

Dimensions

Control Cut Off (CCO)

045/053 CCO



Mounting flange, shaft and connector surfaces to be paint free.

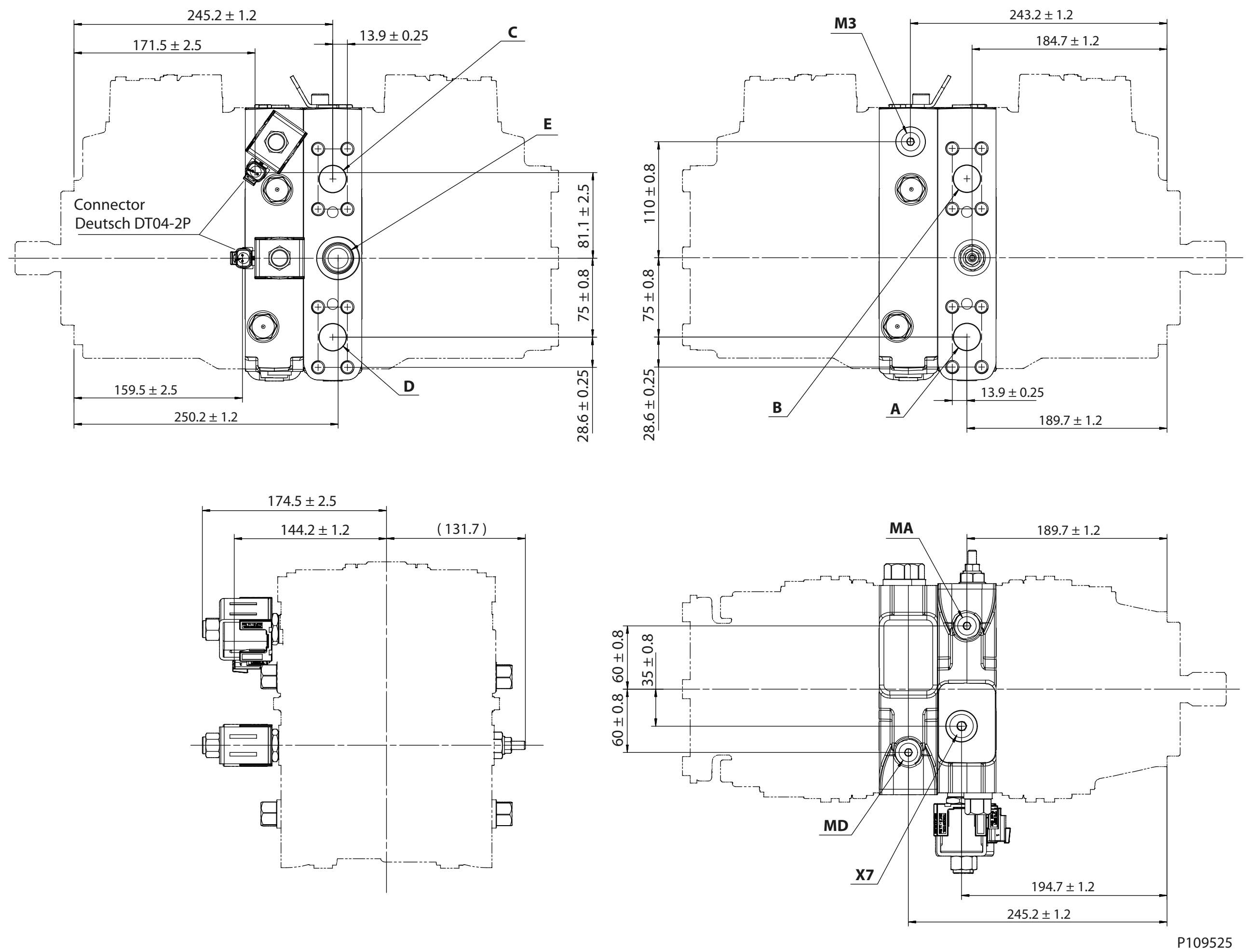
Ports description, ISO 11926-1

Ports	Description	Size
MB, MC	System gauge ports **B, C**; Ø28 max. clearance for fitting	9⁄16 – 18
AM3	Charge constr. port; Ø28 max. clearance for fitting	9⁄16 – 18
X7	Brake gauge port	9⁄16 –18
M3	Charge Gauge Port	9⁄16 –18

Please contact Danfoss representative for specific installation drawings.

Dimensions

060/068 CCO



Mounting flange, shaft and connector surfaces to be paint free.

Ports description, ISO 11926-1

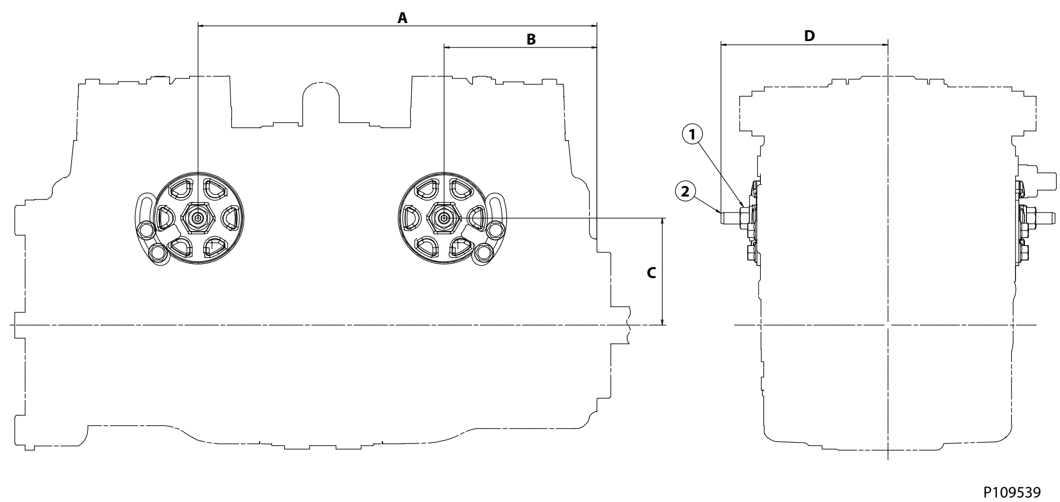
Ports	Description	Size
A, B, C, D	System ports	Split flange, M12 x 1.75
MA, MD	System gauge ports A, D	9⁄16 – 18
E	Charge inlet port	1 1⁄16 – 12
X7	Brake gauge port	3⁄4 –16
M3	Charge Gauge Port	9⁄16 –18

Please contact Danfoss representative for specific installation drawings.

Dimensions

Displacement limiter, H1 Tandem, option B

045/053 shown



	Description	Wrench size	Torque
1	Seal nut	13 mm external hex	23 Nm [17 lbf•ft]
2	Adjustment screw	4 mm internal hex	-

Dimensions

	045/053	060/068
A	277.4 ± 1.2	314 ± 1.2
B	106.2 ± 0.8	120 ± 1.2
C	74.4 ± 0.8	79.5 ± 0.8
D	(116.1)	128.2

Please contact Danfoss representative for specific installation drawings.

ENGINEERING
TOMORROW

Products we offer:

- Cartridge valves
- DCV directional control valves
- Electric converters
- Electric machines
- Electric motors
- Gear motors
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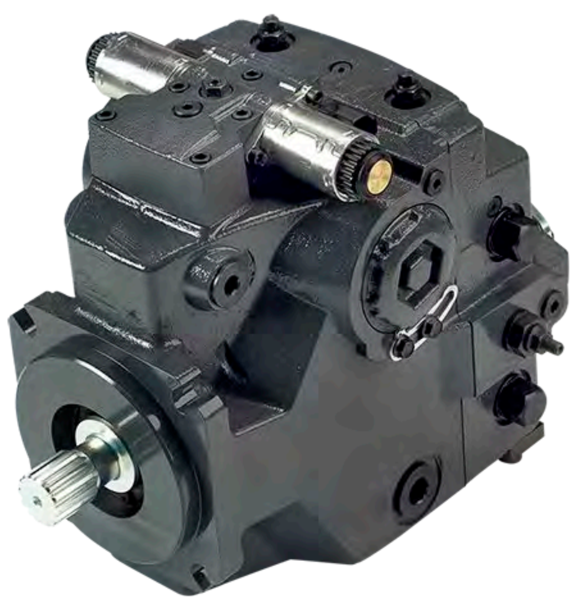
Technical Information

H1P 069/078
Axial Piston Single Pumps



Revision history

Table of revisions

Date	Changed	Rev
May 2022	Corrected HDC control information	1301
December 2021	Added HDC control	1201
April 2021	Removed case pressure ports	1105
April 2020	Corrected swash plate angle sensor connector and CCO connector descriptions	1104
February 2020	Added NFPE control options and changed document number from BC00000058	1103
June 2019	Major revision.	1001
June 2018	FDC topic added.	0902
May 2018	Angle sensor for EDC; FDC note added.	0901
May 2017	NFPE gen. 3 changes.	0801
November 2015	Master Model Code changes.	0700
2010-2014	Various changes.	BA-GB
Jul 2009	First edition	AA

Contents

Technical Specifications

H1 Pumps General Specification....6
H1P 069/078 Technical Data.... 6
H1P 069/078 Operating Parameters 7
Fluid Specification....8
H1P 069/078 Mounting Flange Loads 8
Bearing Life and External Radial Shaft Loads.... 9
Charge pump....10
  Charge Pump Selection....10
  14/17 cm^3 Charge Pump – Flow and Power Curves....10

Master Model Code

Displacement, A—Rotation, B—Product Version, Z—Port Configuration....11
D—Controls.... 12
  Electronic Displacement Controls.... 12
  Fan Drive Controls....12
  Forward-Neutral-Reverse (FNR) Controls....12
  Non-Feedback Proportional Electric (NFPE) Controls.... 12
  Automotive Controls....13
  Manual Displacement Control....13
  Hydraulic Displacement Control....13
F—Orifices, E—Displacement Limiters....14
G—Endcap.... 15
H—Mounting Flange, J—Input Shaft, K—Aux Pad....16
M, N—Overpressure Protection Settings....17
S—Charge Pump, T—Filtration, V—Charge Pressure Relief....18
W—Special Hardware, X—Paint, Y—Special Features.... 19

Control Options

Electrical Displacement Control (EDC).... 20
  EDC Operation....20
  Control signal requirements, EDC 069/078....21
  Control Solenoid Data....21
  Single Pump Output Flow Direction....21
  Connector....22
  Control response....22
  Response Time, EDC 069/078....22
Manual Displacement Control (MDC) 23
  MDC operation.... 23
  MDC shaft rotation....24
  MDC Torque....24
  Control response....24
  Response time, MDC 069/078.... 25
  Neutral start switch (NSS).... 25
  Connector....25
  Case Gauge Port M14....26
  Lever....26
Hydraulic Displacement Control (HDC).... 27
  HDC principle....27
  HDC operation....27
  Hydraulic signal pressure range....28
  Pump output flow direction vs. control pressure.... 28
  Control response....28
  Response time, HDC 069/078....29
Forward-Neutral-Reverse Control (FNR)....30
  FNR Solenoid Data....30
  Single Pump Output Flow Direction....31
  Connector....31
  Control response....31
  Response Time, FNR 069/078....31

Contents

Non feedback proportional electric control (NFPE)....32
Control Signal Requirements, NFPE 069/078....32
Control Solenoid Data....33
Single Pump Output Flow Direction....33
Connector....33
Control response....34
Response Time, NFPE 069/078....34
Automotive Control (AC)....34
Mode types....34
Basic functions....35
Performance functions....35
Protection and safety functions....35
Engine control and protection....35
Installation features....36
Fan Drive Control (FDC)....37
Control Signal Requirements, FDC 069/078....38
Control Solenoid Data....38
Single Pump Output Flow Direction....39
Connector....39
Control response....39
Response Time, FDC 069/078....39
Manual Override (MOR)....40
Swashplate angle sensor for EDC controls....41
Swash plate angle sensor parameters (EDC)....41
Swashplate Angle Sensor Connector....42
Interface with ECU (EDC)....42
Swash Plate Angle Sensor for NFPE and AC2 Controls....43
Swash Plate Angle Characteristic....43
Swash Plate Angle Sensor Parameters (NFPE/AC)....44
Swash Plate Angle Sensor Connector (NFPE)....44
Interface with ECU (NFPE)....44
Control Cut Off Valve (CCO)....45
Brake gauge port with MDC....45
CCO Connector (MDC)....46
H1P CCO Connector (EDC, NFPE)....46
CCO solenoid data....46
Displacement Limiter....47
H1P 069/078 Displacement Change (approximately)....47

Dimensions and Data

H1P 069/078 Input Shaft Option G1 (SAE C, 14 teeth)....48
H1P 069/078 Input Shaft Option G9 (SAE C-C, 23 teeth)....49
H1P 069/078 Input Shaft Option F1 (SAE C, 21 teeth)....50
H1P 069/078 Input Shaft Option F4, Code 38–3....51
Tapered shaft customer acknowledgement....51
H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth)....52
H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth)....53
H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth)....54
H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth)....55
H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth)....56
H1P Displacement Limiter, Option B....57
Single Pump Ports....58
H1P Dimensions....59
Controls....62
EDC Options A2 and A3 (12/24 V)....62
EDC with MOR, Options A4 and A5 (12/24 V)....63
EDC with CCO (key C), Options E7 and E8 (12/24 V)....64
EDC with ASNSR, Options: H2 and H3 (12/24 V)....65
EDC with MOR and ASNSR, Options H6 and H7 (12/24 V)....66
EDC with CCO and ASNSR, Options H8 and H9 (12/24 V)....67

Contents

- MDC Option: M1 68
- MDC with Neutral Start Switch Option: M2 69
- MDC with CCO, Options: M3, M4 70
- MDC with NSS and CCO Options: M5, M6 71
- HDC, Options: T1, T2 72
- NFPE with MOR, Options: N1, N2 (12/24 V) 73
- NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V) 74
- NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V) 75
- NFPE with MOR and CCO, Options: N7, N8 (12/24 V) 76
- Automotive control (AC) 77
  - AC connectors dimensions 78

Filtration 79
- Suction Filtration Option L 79
- Remote Full Charge Pressure Filtration Option P 79
- Integral Full Flow Charge Pressure Filtration, Option M 80
- External Full Flow Charge Pressure Filtration, Option S 81

Technical Specifications

H1 Pumps General Specification

Axial piston closed circuit variable displacement pumps of cradle swash-plate design with clockwise or counterclockwise direction of rotation.

Pipe connections

- Main pressure ports: ISO split flange boss
- Remaining ports: SAE straight thread O-ring boss

Recommended installation position

Pump installation position is discretionary, however the recommended control position is on the top or at the side with the top position preferred. If the pump is installed with the control at the bottom, flushing flow must be provided through port M14 located on the EDC, FNR and NFPE control.

Vertical input shaft installation is acceptable. If input shaft is at the top, 1 bar case pressure must be maintained during operation. The housing must always be filled with hydraulic fluid. Recommended mounting for a multiple pump stack is to arrange the highest power flow towards the input source. Consult Danfoss for nonconformance to these guidelines.

Auxiliary cavity pressure

Auxiliary cavity pressure will be inlet pressure with internal charge pump or case pressure with external charge supply. For reference see Operating Parameters. Please verify mating pump shaft seal capability.

H1P 069/078 Technical Data

Feature	Size 069	Size 078
Displacement	69.2 cm^3 [4.22 in^3]	78.1 cm^3 [4.77 in^3]
Flow at rated speed (continuous)	243 l/min [53.5 US gal/min]	273 l/min [72 US gal/min]
Torque at maximum displacement (theoretical)	1.1 N•m/bar [672 lbf•in/1000 psi]	1.24 N•m/bar [758 lbf•in/1000 psi]
Mass moment of inertia of rotating components	0.0077 kg•m^2 [0.0057 slug•ft^2]	0.0094 kg•m^2 [0.0069 slug•ft^2]
Mass (dry–no charge pump)	56 kg [123 lb]	56 kg [123 lb]
Oil volume	2.0 l [0.5 US gal]	2.0 l [0.5 US gal]

Shaft, flange and ports description

Input shaft per ISO 3019-1 (outer diameter)	• Outer Ø32 mm – 4 (SAE C, 14 teeth) • Outer Ø35 mm – 4 (SAE C, 21 teeth) • Outer Ø38 mm – 4 (SAE C-C, 23 teeth) • Conical key code 38-3, taper 1:8
Mounting flange per ISO 3019-1	Flange 127-4 (SAE C)
Auxiliary mounting flange with metric fasteners, with shaft outer diameter	• Flange 82-2 (SAE A, 9 teeth and 11 teeth) • Flange 101-2 (SAE B, 13 teeth and SAE B-B, 15 teeth) • Flange 127-4 (SAE C, 14 teeth)
Suction port per ISO 3019-1	$1\frac{5}{16}$–12 (SAE O-ring boss)
Main configuration port	Ø25.4 mm – 450 bar; Split flange boss per ISO 6162; M12x1.75; 20 min. full thread depth
Case drain ports L2, L4 per ISO 3019-1	$1\frac{1}{16}$–12 (SAE O-ring boss)
Other ports	SAE O-ring boss
Customer interface threads	Metric fasteners

Technical Specifications

H1P 069/078 Operating Parameters

Parameter		Unit	Size 069/078
Input speed	**Min. for internal[1] and external[2] charge supply**	min^{-1} (rpm)	500
	Min. for full performance, internal charge supply		1200
	Rated		3500
	Maximum		4000
System pressure	**Maximum working**	bar [psi]	450 [6527]
	Maximum		480 [6962]
	Max./Min. low loop		45/10 [650/145]
Charge pressure	**Minimum**	bar [psi]	16 [232]
	Maximum		35 [508]
Control pressure	**Minimum (at corner power for EDC, MDC, FNR)**		14 [203]
	Minimum (at corner power for NFPE, FDC, AC)		25 [363]
	Maximum		40 [580]
Charge pump inlet pressure	**Rated**	bar (absolute) [in Hg vacuum]	0.7 [9.0]
	Minimum (cold start)		0.2 [24.0]
	Maximum	bar [psi]	4.0 [58.0]
Case pressure	**Rated**		3.0 [44.0]
	Maximum		5.0 [73.0]
Lip seal maximum pressure (external)			0.4 [5.8]

[1] Performance (displacement and pressure) may be limited due to limited control pressure.

[2] Full performance (displacement and pressure) possible at minimum charge and control pressure supply.

Filtration, cleanliness level and β_x-ratio (recommended minimum)

Cleanliness per ISO 4406	22/18/13
Efficiency β_x (charge pressure filtration)	$\beta_{15-20} = 75$ ($\beta_{10} \geq 10$)
Efficiency β_x (suction and return line filtration)	$\beta_{35-45} = 75$ ($\beta_{10} \geq 2$)
Recommended inlet screen mesh size	100 – 125 µm

Technical Specifications

Fluid Specification

Viscosity

Intermittent[1]	5 mm^2/s [42 SUS]
Minimum	7 mm^2/s [49 SUS]
Recommended range	12 – 80 mm^2/s [66 – 370 SUS]
Maximum	1600 mm^2/s [7500 SUS]

[1] Intermittent = Short term t < 1 min per incident and not exceeding 2 % of duty cycle based load-life.

Temperature

Minimum [1]	-40°C [-40°F]
Rated	104°C [220°F]
Recommended range[2]	60 – 85°C [140 – 185°F]
Maximum Intermittent	115°C [240°F]

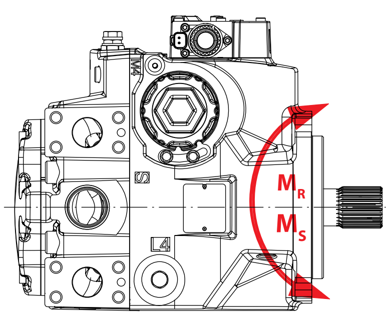
[1] Cold start = Short term t > 3 min, p ≤ 50 bar [725 psi], n ≤ 1000 min-1 (rpm).

[2] At the hottest point, normally case drain port.

H1P 069/078 Mounting Flange Loads

The Rated and Shock load moments apply for top or side orientation of control.

Mounting flange load with control on top



Rated moment	$\mathbf{M_R}$ = 3700 N•m [32 750 lbf•in]
Shock load moment	$\mathbf{M_S}$ = 7900 N•m [69920 lbf•in]

For more information, see *H1 Axial Piston Pumps, Basic Information,* **BC152886483968**, the section “Mounting flange loads”.

Technical Specifications

Bearing Life and External Radial Shaft Loads

All external shaft loads affect bearing life. The pumps are designed with bearings that can accept some external radial loads. The external radial shaft load limits are a function of the load position and orientation, and the operating conditions of the unit.

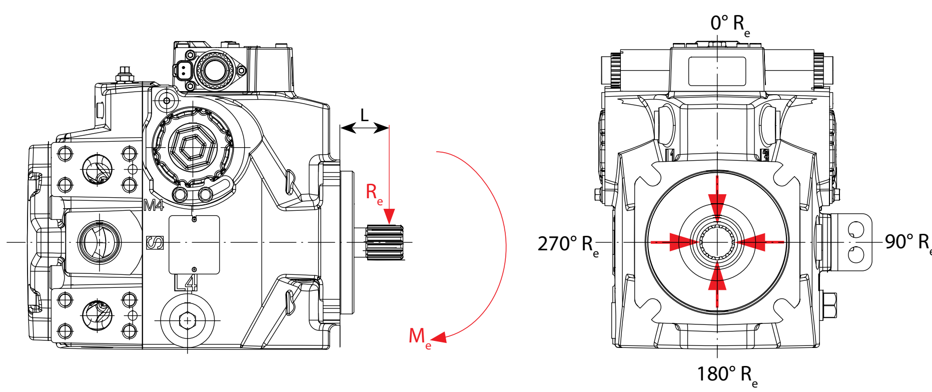
Danfoss recommends clamp-type couplings for applications with radial shaft loads. Contact your Danfoss representative for an evaluation of unit bearing life if you have continuously applied external loads exceeding 25 % of the maximum allowable radial load (R_e) or the pump swash-plate is positioned on one side of center all or most of the time.

Maximum external shaft load based on shaft deflection

External radial moment	Unit	Size 069/078
M_e	N•m [lbf•in]	109 [965]

External radial shaft loads impact lifetime. For lifetime calculations please contact your Danfoss representative. In applications with external shaft loads, minimize the impact by positioning the load at 0° or 180° as shown below.

Radial load position



The maximum allowable radial shaft load (R_e) is based on the maximum external moment (M_e) and the distance (L) from the mounting flange to the load. It may be determined using the following formula:

$$\mathbf{R_e} = \frac{\mathbf{M_e}}{\mathbf{L}}$$

Thrust loads should be avoided. Contact your Danfoss representative in the event thrust loads are anticipated.

Technical Specifications

Charge pump

Charge Pump Selection

In most applications a general guideline is that the charge pump displacement should be at least 10% of the total displacement of all components in the system. Unusual application conditions may require a more detailed review of charge flow requirements. System features and conditions which may invalidate the 10% guideline include (but are not limited to):

- Continuous operation at low input speeds < 1500 min^{-1} (rpm)
- High shock loading and/or long loop lines
- High flushing flow requirements
- Multiple low speed high torque motors
- High input shaft speeds

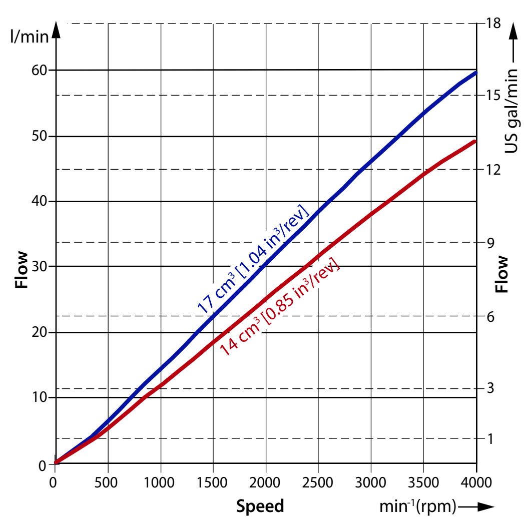
Contact your Danfoss representative for application assistance if your application includes any of these conditions.

14/17 cm^3 Charge Pump – Flow and Power Curves

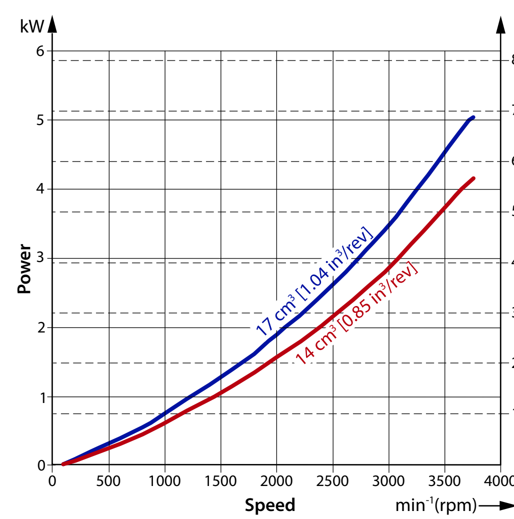
Charge pump flow and power requirements curves shown below at the following conditions:

Charge pressure = 20 bar [290 psi]
Viscosity = 11 mm^2/s [63 SUS]
Temperature = 80°C [176°F]

Charge pump flow



Charge pump power requirements



Master Model Code

Displacement, A—Rotation, B—Product Version, Z—Port Configuration

A B Z D F E G H J K M N S T V W X Y

H1P

Displacement

069	69.2 cm^3 [4.22 in^3]
078	78.1 cm^3 [4.77 in^3]

A – Direction of Rotation

L	Left hand (counter clockwise)
R	Right hand (clockwise)

B – Product version

A	Revision code

Z – Port configuration

A	Inch, Customer O-ring port sealing according to ISO 11926-1

Master Model Code

D—Controls

A B Z D F E G H J K M N S T V W X Y
H1P

Electronic Displacement Controls

Code	Control type	Voltage	MOR	CCO with key C	Angle sensor	Connector
A2	EDC	12 V	—	—	—	DEUTSCH
A3	EDC	24 V	—	—	—	DEUTSCH
A4	EDC	12 V	●	—	—	DEUTSCH
A5	EDC	24 V	●	—	—	DEUTSCH
E7	EDC	12 V	—	●	—	DEUTSCH
E8	EDC	24 V	—	●	—	DEUTSCH
H2	EDC	12 V	—	—	●	DEUTSCH
H3	EDC	24 V	—	—	●	DEUTSCH
H6	EDC	12 V	●	—	●	DEUTSCH
H7	EDC	24 V	●	—	●	DEUTSCH
H8	EDC	12 V	—	●	●	DEUTSCH
H9	EDC	24 V	—	●	●	DEUTSCH

● – To be used for the control; — Not to be used for the control

Fan Drive Controls

F1	FDC	12 V	DEUTSCH Connector
F2	FDC	24 V	DEUTSCH Connector

Align with options: **F:** Orifices, **E:** Displacement limiters, **M, N:** Overpressure protection, and **W:** Special hardware.

Forward-Neutral-Reverse (FNR) Controls

A9	FNR	12 V	with MOR	DEUTSCH Connector
B1	FNR	24 V	with MOR	DEUTSCH Connector

Non-Feedback Proportional Electric (NFPE) Controls

Code	Control type	Voltage	MOR	CCO with key C	Angle sensor	Connector
N1	NFPE	12 V	●	—	—	DEUTSCH
N2	NFPE	24 V	●	—	—	DEUTSCH
N3	NFPE	12 V	●	●	●	DEUTSCH
N4	NFPE	24 V	●	●	●	DEUTSCH
N5	NFPE	12 V	●	—	●	DEUTSCH
N6	NFPE	24 V	●	—	●	DEUTSCH
N7	NFPE	12 V	●	●	—	DEUTSCH
N8	NFPE	24 V	●	●	—	DEUTSCH

Align with options: **E:** Displacement limiters and **W:** Special hardware.

Master Model Code

Automotive Controls

Automotive Control (AC)

Code	AC type	Voltage	MOR	Speed sensor	Wire harness	Angle sensor	Connector
P6	AC–1	12 V	●	●	●	—	DEUTSCH
P7	AC–1	24 V	●	●	●	—	DEUTSCH
P8	AC–2	12 V	●	●	●	●	DEUTSCH
P9	AC–2	24 V	●	●	●	●	DEUTSCH
P5	AC–1	12 V	●	—	—	—	DEUTSCH
R3	AC–1	24 V	●	—	—	—	DEUTSCH
R4	AC–2	12 V	●	—	—	●	DEUTSCH
R5	AC–2	24 V	●	—	—	●	DEUTSCH

● – To be used for the control; — Not to be used for the control

Manual Displacement Control

Manual Displacement Control (MDC)

Code	Control type	CCO Voltage	CCO	Neutral Start Switch	Connector
M1	MDC	—	—	—	—
M2	MDC	—	—	●	DEUTSCH
M3	MDC	12 V	●	—	DEUTSCH
M4	MDC	24 V	●	—	DEUTSCH
M5	MDC	12 V	●	●	DEUTSCH
M6	MDC	24 V	●	●	DEUTSCH

Align with options **F:** Orifices and **Y:** Settings for adjustment (if applicable).

Hydraulic Displacement Control

Hydraulic Displacement Control (HDC)

Code	Pressure range	Ports
T1	4.2 - 16.2 bar	Inch ports 9/16-18
T2	3.0 - 11.6 bar	Inch ports 9/16-18

Master Model Code

F—Orifices, E—Displacement Limiters

A B Z D F E G H J K M N S T V W X Y

H1P

F – Orifices Options

Orifices options related to control type

Code	Tank (A+B)	P orifice	A/B orifices	EDC, FNR	MDC	NFPE, AC	FDC
C3	No orifice			●	●	–	–
C1	–	–	0.8 mm	●	●	●	–
C2	–	–	1.3 mm	●	●	●	●
C4	–	–	1.8 mm	●	●	●	–
C6	1.0 mm	–	–	–	●	–	
C7	1.3 mm	–	–	–	●	–	–
D1	0.8 mm	1.0 mm	–	–	●	–	–
D2	0.8 mm	1.3 mm	–	–	●	–	–
D3	1.0 mm	1.3 mm	–	–	●	–	–
D4	1.0 mm	1.3 mm	1.3 mm	–	●	–	–
D5	0.6 mm	0.6 mm	0.8 mm	–	●	–	–
D6	1.3 mm	1.3 mm	–	–	●	–	–
D7	–	–	3.0 mm	–	–	●	–

E – Displacement Limiter Options

N	None
B	Adjustable externally
C	No limiters, with nested springs, required for NFPE, AC, FDC*
D	Adjustable externally with nested springs, required for NFPE, AC, FDC*

* Align with option **Y:** Settings for adjustment (if applicable).

Master Model Code

G—Endcap

A B Z D F E G H J K M N S T V W X Y
H1P

G – End-cap Options

Split flange twin ports ISO 6162; Align with T: Filtration and K: Auxiliary Pad

D3	Integral pressure filtration, Code 62
D6	Suction filtration, Code 62
D8	Remote filtration, Code 62
F4	Integral pressure filtration with SAE-C Auxiliary Pad, Code 62
F6	Suction filtration with SAE-C Auxiliary Pad, Code 62
F5	Remote filtration with SAE-C Auxiliary Pad, Code 62

Master Model Code

H—Mounting Flange, J—Input Shaft, K—Aux Pad

A B Z D F E G H J K M N S T V W X Y

H1P

H – Mounting options

Mounting to be aligned with option W: Special hardware

H	ISO 3019-1 flange 127–4 (SAE C)
K	ISO 3019-1 flange 127–4 (SAE C), 4-bolt, with speed sensor

J – Input Shaft options

G1	ISO 3019-1, outer Ø32 mm - 4 (14 teeth splined shaft 12/24 pitch)
G9	ISO 3019-1, outer Ø38 mm - 4 (23 teeth splined shaft 16/32 pitch
F1	ISO 3019-1, outer Ø35 mm - 4 (21 teeth splined shaft 16/32 pitch)
F4	Conical keyed shaft end, code 38-3 (similar to ISO 3019-1), taper 1:8 (key not supplied with pump)

K – Auxiliary Mounting Pad options (ISO 3019-1)

NN	None
H1	Flange 82–2 (SAE A, 11 teeth, 16/32 coupling); shipping cover
H2	Flange 82–2 (SAE A, 9 teeth, 16/32 coupling); shipping cover
H3	Flange 101–2 (SAE B, 13 teeth, 16/32 coupling); shipping cover
S1	Flange 101–2 (SAE B, 14 teeth, 12/24 coupling); shipping cover
H5	Flange 101–2 (SAE B-B, 15 teeth, 16/32 coupling); shipping cover
H6	Flange 127–4 (SAE C, 14 teeth, 12/24 coupling); shipping cover

Master Model Code

M, N—Overpressure Protection Settings

A B Z D F E G H J K M N S T V W X Y
H1P

M and N – Overpressure protection options

L	Pressure limiter setting	HPRV with bypass setting[1]
L15	150 bar [2900 psi]	230 bar [3336 psi]
L18	180 bar [2610 psi]	230 bar [3336 psi]
L20	200 bar [2900 psi]	250 bar [3630 psi]
L23	230 bar [3336 psi]	280 bar [4061 psi]
L25	250 bar [3630 psi]	300 bar [4350 psi]
L28	280 bar [4061 psi]	330 bar [4786 psi]
L30	300 bar [4350 psi]	350 bar [5076 psi]
L33	330 bar [4786 psi]	380 bar [5510 psi]
L35	350 bar [5080 psi]	400 bar [5800 psi]
L38	380 bar [5510 psi]	420 bar [6090 psi]
L40	400 bar [5800 psi]	450 bar [6526 psi]
L42	420 bar [6090 psi]	450 bar [6526 psi]
L43	430 bar [6237 psi]	480 bar [6962 psi]
L44	440 bar [6382 psi]	480 bar [6962 psi]
L45	450 bar [6526 psi]	480 bar [6962 psi]
Overpressure protection type and setting for FDC		
F01	150 bar [2175 psi]	250 bar [3630 psi]
F02	150 bar [2175 psi]	300 bar [4350 psi]
F03	150 bar [2175 psi]	350 bar [5076 psi]

[1] Pressure limiter and HPRV with bypass, over-pressure protection type must be the same for both sides “A” and “B”.

K	Pressure setting [1]
K18	180 bar [2610 psi]
K20	200 bar [2900 psi]
K23	230 bar [3336 psi]
K25	250 bar [3630 psi]
K28	280 bar [4061 psi]
K30	300 bar [4350 psi]
K33	330 bar [4786 psi]
K35	350 bar [5076 psi]
K38	380 bar [5510 psi]
K40	400 bar [5800 psi]
K42	420 bar [6090 psi]
K45	450 bar [6526 psi]

[1] Pressure limiter and HPRV with bypass, over-pressure protection type must be the same for both sides “A” and “B”.

Master Model Code

Please contact Danfoss Power Solutions for pressures not shown or for applied pressure above max. working pressure.

S—Charge Pump, T—Filtration, V—Charge Pressure Relief

A B Z D F E G H J K M N S T V W X Y

H1P

S – Charge pump options

F	14 cm^3/rev [0.85 in^3/rev]
C	17 cm^3/rev [1.03 in^3/rev]
N	No charge pump, external charge supply (*Align with options:* **E, T**)

T – Filtration options

Filtration to be aligned with G: End cap selection

L	Suction filtration
M	Integral full charge flow filtration with bypass sensor, medium filter length **11004918**
N	Integral full charge flow filtration with bypass sensor, without filter
P	Remote full charge flow filtration
E	External full charge flow filtration (Align with options **N, S**)

V – Charge pressure relief valve (CPRV) setting

20*	20 bar [290 psi]
22*	22 bar [319 psi]
24*	24 bar [348 psi]
26	26 bar [377 psi]
28	28 bar [406 psi]
30	30 bar [435 psi]
32	32 bar [464 psi]
34	34 bar [493 psi]

* Not to be used for **NFPE, AC** and **FDC** controls.

Master Model Code

W—Special Hardware, X—Paint, Y—Special Features

A B Z D F E G H J K M N S T V W X Y

H1P

W – Special Hardware features

Hardware features to be aligned with options D, E

P1	NFPE/FDC valve plate
P2	NFPE/FDC/AC valve plate and speed ring on the cylinder block
P4	EDC/FNR/MDC valve plate and speed ring on the cylinder block
PN	EDC/FNR/MDC valve plate
H1	MDC/EDC/FNR valve plate with MDC handle

X – Paint and Name-tag

NNN	Black paint and Danfoss name-tag
C08	Paint none and Danfoss name-tag

Y – Special settings (SIL-2 non-certifiable, without customer files)

Code	CAN J1939	ECO fuel saving mode	Functional option	Cruise control	Control	AC type
D3E	in/out	●	E	–	N1 (12 V_{DC})	AC–1
D3F	in/out	–	F	–		
D4E	in/out	●	E	–	N2 (24 V_{DC})	
D4F	in/out	–	F	–		
D5F	in/out	–	F	–	P8 (12 V_{DC})	AC–2 (with swash plate angle sensor)
D5J	in/out	●	J	●		
D6F	in/out	–	F	–	P9 (24 V_{DC})	
D6J	in/out	●	J	●		
M00	MDC handle standard position					
NNN	None					

● – To be used for the control; — Not to be used for the control

Control Options

Electrical Displacement Control (EDC)

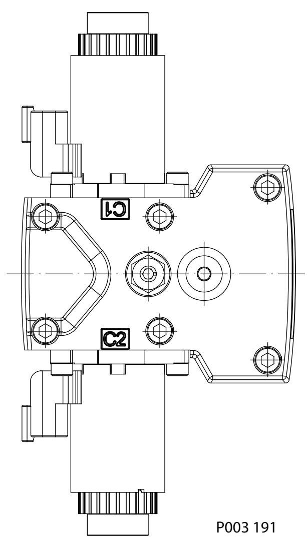
An EDC is a displacement (flow) control. Pump swash plate position is proportional to the input command and therefore vehicle or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The Electrical Displacement Control (**EDC**) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

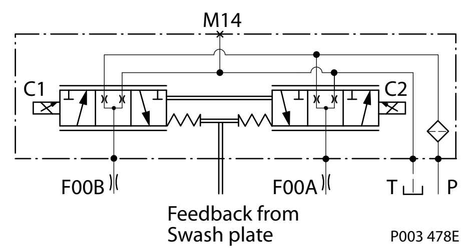
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

Electrical Displacement Control



EDC schematic, feedback from swash plate



EDC Operation

H1 EDC's are current driven controls requiring a Pulse Width Modulated (PWM) signal. Pulse width modulation allows more precise control of current to the solenoids.

The PWM signal causes the solenoid pin to push against the porting spool, which pressurizes one end of the servo piston, while draining the other. Pressure differential across the servo piston moves the swashplate.

A swashplate feedback link, opposing control links, and a linear spring provide swashplate position force feedback to the solenoid. The control system reaches equilibrium when the position of the swashplate spring feedback force exactly balances the input command solenoid force from the operator. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

The EDC incorporates a positive neutral deadband as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold current is reached, the swashplate is positioned directly proportional to the control current. To minimize the effect of the control neutral deadband, we recommend the transmission controller or operator input device incorporate a jump up current to offset a portion of the neutral deadband.

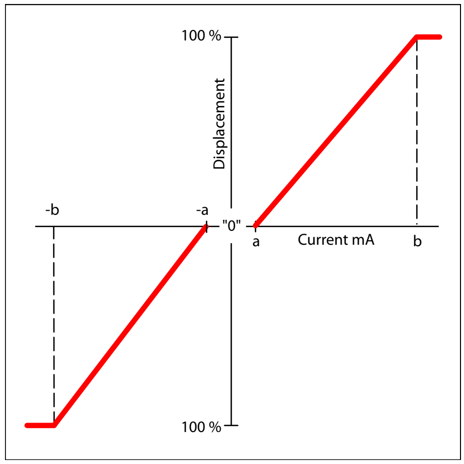
The neutral position of the control spool does provide a positive preload pressure to each end of the servo piston assembly.

When the control input signal is either lost or removed, or if there is a loss of charge pressure, the spring-loaded servo piston will automatically return the pump to the neutral position.

Control Options

Control signal requirements, EDC 069/078

Pump displacement vs. control current



EDC control current

Voltage		12 V_{DC}	24 V_{DC}
Minimum current to stroke pump	**a***	640 mA	330 mA
	b	1640 mA	820 mA
Pin connections		any order	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Single Pump Output Flow Direction

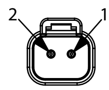
Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	out	in	in	out
Port B	in	out	out	in
Servo port pressurized	M4	M5	M4	M5

* For coil location see installation drawings.

Control Options

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, EDC 069/078

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	1.9 s	0.9 s	0.6 s
Full flow to neutral	1.6 s	0.9 s	0.5 s

Control Options

Manual Displacement Control (MDC)

A Manual proportional Displacement Control (**MDC**) consists of a handle on top of a rotary input shaft. The shaft provides an eccentric connection to a feedback link. This link is connected on its one end with a porting spool. On its other end the link is connected the pumps swashplate.

This design provides a travel feedback without spring. When turning the shaft the spool moves thus providing hydraulic pressure to either side of a double acting servo piston of the pump.

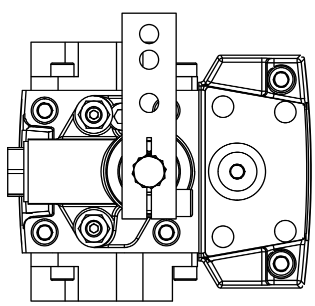
Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement. Simultaneously the swashplate movement is fed back to the control spool providing proportionality between shaft rotation on the control and swash-plate rotation. The MDC changes the pump displacement between no flow and full flow into opposite directions.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

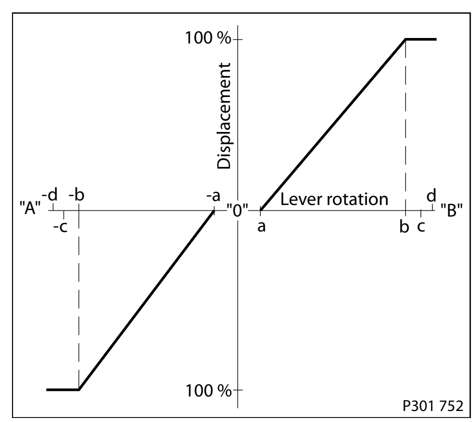
For the MDC with CCO option the brake port (X7) provides charge pressure when the coil is energized to activate static function such as a brake release. The X7 port must not be used for any continuous oil consumption.

The MDC is sealed by means of a static O-ring between the actuation system and the control block. Its shaft is sealed by means of a special O-ring which is applied for low friction. The special O-ring is protected from dust, water and aggressive liquids or gases by means of a special lip seal.

Manual Displacement Control



Pump displacement vs. control lever rotation



Deadband on **B** side: **a = 3° ±1°**
Maximum pump stroke: **b = 30° +2/-1°**
Required customer end stop: **c = 36° ±3°**
Internal end stop: **d = 40°**

MDC operation

The MDC provides a mechanical dead-band required to overcome the tolerances in the mechanical actuation. The MDC contains an internal end stop to prevent turning the handle into any inappropriate position.

The MDC provides a permanent restoring moment appropriate for turning the MDC input shaft back to neutral position only. This is required to take the backlash out of the mechanical connections between the Bowden cable and the control.

High case pressure may cause excessive wear and the NSS to indicate that the control is not in neutral position. In addition, if the case pressure exceeds 5 bar there is a risk of an insufficient restoring moment. The MDC is designed for a maximum case pressure of 5 bar and a rated case pressure of 3 bar.

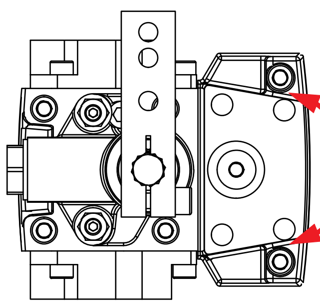
Control Options

- Customers must install some support to limit the setting range of their Bowden cable to avoid an overload of the MDC.
- Customers can apply their own handle design but they must care about a robust clamping connection between their handle and the control shaft and avoid overload of the shaft.
- Customers can connect two MDC's on a tandem unit in such a way that the actuation force will be transferred from the pilot control to the second control. The kinematic of the linkages must ensure that either control shaft is protected from torque overload.

Caution

Using the internal spring force on the input shaft is not an appropriate way to return the customer connection linkage to neutral, or to force a Bowden cable or a joystick back to neutral position. It is not applicable for any limitation of the Bowden cable stroke, except the applied torque to the shaft will never exceed 20 N•m.

MDC shaft rotation



Pump shaft rotation*	Clockwise (CW)		Counter-clockwise (CCW)	
MDC shaft rotation	**CW**	**CCW**	**CW**	**CCW**
Port A	in (low)	out (high)	out (high)	in (low)
Port B	out (high)	in (low)	in (low)	out (high)
Servo port high pressure	M5	M4	M5	M4

* As seen from shaft side.

MDC Torque

Description	Value
Torque required to move handle to maximum displacement	1.4 N•m [12.39 lbf•in]
Torque required to hold handle at given displacement	0.6 N•m [5.31 lbf•in]
Maximum allowable input torque	20 N•m [177 lbf•in]

Caution

Volumetric efficiencies of the system will have impacts on the start and end input commands.

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]

Control Options

Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm²/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response time, MDC 069/078

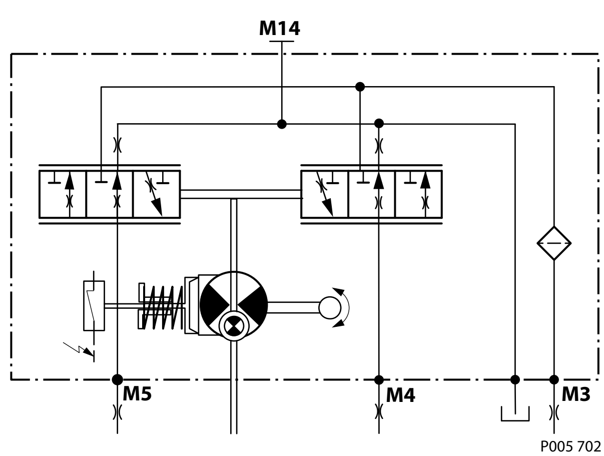
Code	Orifice description (mm)			Stroking direction	
	Tank (A+B)	P	A/B	Neutral to full flow	Full flow to neutral
C3	No orifice			0.4 s	0.5 s
C6	1	–	–	1.4 s	1.1 s
C7	1.3	–	–	0.9 s	0.8 s
D1	0.8	1	–	2.5 s	1.9 s
D2	0.8	1.3	–	2.2 s	1.7 s
D3	1	1.3	–	1.6 s	1.2 s
D4	1	1.3	1.3	1.9 s	1.5 s

For further data please contact your Danfoss representative.

Neutral start switch (NSS)

The Neutral Start Switch **(NSS)** contains an electrical switch that provides a signal of whether the control is in neutral. The signal in neutral is Normally Closed **(NC)**.

Neutral start switch schematic

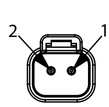


Neutral start switch data

Max. continuous current with switching	8.4 A
Max. continuous current without switching	20 A
Max. voltage	36 V_{DC}
Electrical protection class	IP67 / IP69K with mating connector

Connector

Connector DEUTSCH, 2-pin



Control Options

Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Case Gauge Port M14

The drain port should be used when the control is mounted on the unit's bottom side to flush residual contamination out of the control.

Lever

MDC-controls are available with an integrated lever.

Control Options

Hydraulic Displacement Control (HDC)

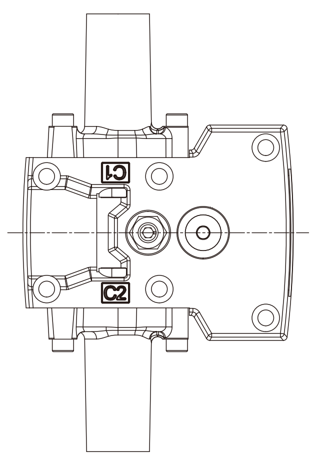
HDC principle

An HDC is a Hydraulic Displacement Control. Pump swashplate position is proportional to the input command and therefore vehicle speed or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

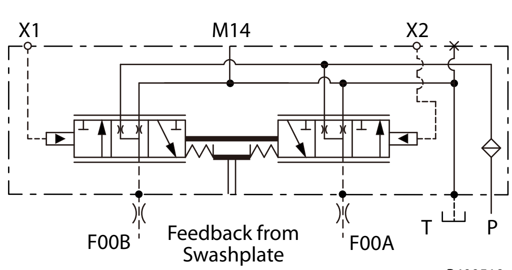
The HDC control uses a hydraulic input signal to operate a porting spool, which ports hydraulic pressure to either side of a double acting servo piston. The hydraulic signal applies a force input to the spool which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction. Under some circumstances, such as contamination, the porting spool could stick and cause the pump to stay at some displacement.

A serviceable 175 µm screen is located in the supply line immediately before the control porting spool.

HDC control



HDC schematic



HDC operation

HDC's are hydraulically driven control which ports hydraulic pressure to either side of a porting spool, which pressurizes one end of the servo piston, while draining the other end to case. Pressure differential across the servo piston moves the swashplate.

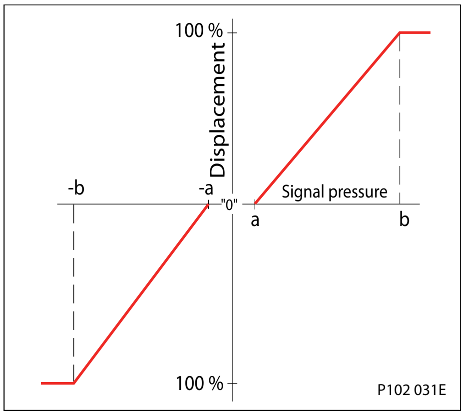
A swashplate feedback link, opposing control linkage, and a linear spring provide swashplate position force feedback to the hydraulic pressure. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

Control Options

The HDC incorporates a positive neutral dead band as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold point is reached, the swashplate is positioned directly proportional to the control pressure.

When the control input is either lost or removed, or if there is a loss of charge pressure, the spring loaded servo piston will automatically return the pump to the neutral position.

Pump displacement vs signal pressure



Hydraulic signal pressure range

Option	Type	a*	b*	Max. pressure
T1	Standard	4.2 bar	16.2 bar	30 bar
T2	Option	3 bar	11.6 bar	30 bar

* Factory test current, for vehicle movement or application actuation expect a higher or lower value.

Pump output flow direction vs. control pressure

Shaft rotation HDC	Clockwise (CW) seen from shaft		Counter Clockwise (CCW) seen from shaft	
Port energized	X1	X2	X1	X2
Port A	Out (high)	In (low)	In (low)	Out (high)
Port B	In (low)	Out (high)	Out (high)	In (low)
Servo port high pressure	M4	M5	M4	M5

For appropriate performance of HDC characteristic, keep the drain pressure of pilot valve to be equal or slightly higher than pump case pressure.

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Control Options

Response time, HDC 069/078

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	2.1s	1s	0.7s
Full flow to neutral	1.5s	0.7s	0.4s

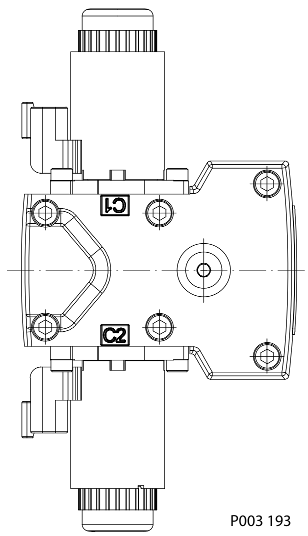
Control Options

Forward-Neutral-Reverse Control (FNR)

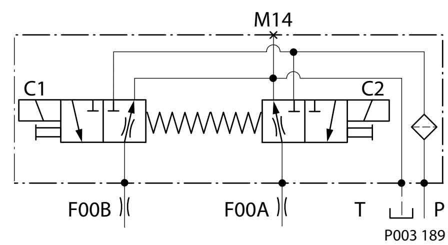
The 3-position FNR control options **A9** (12 V) and **B1** (24 V) uses an electric input signal to switch the pump to a full stroke position. A serviceable 125 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool can stick and cause the pump to stay at some displacement.

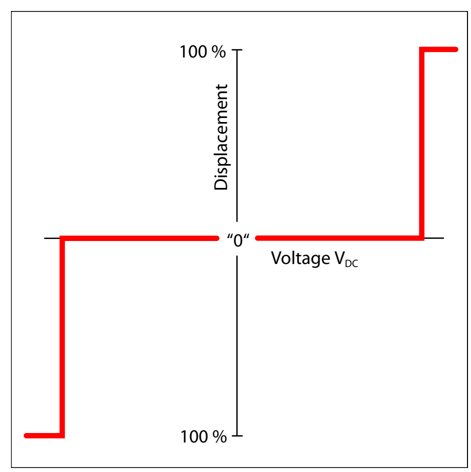
Forward-Neutral-Reverse electric control (FNR)



FNR hydraulic schematic



Pump displacement vs. electrical signal



FNR control current

Voltage	$12\ V_{DC}$	$24\ V_{DC}$
Minimum current to stroke pump	750 mA	380 mA
Pin connections	any order	

FNR Solenoid Data

Solenoid data

Voltage	$12\ V_{DC}$	$24\ V_{DC}$
Minimum supply voltage	$9.5\ V_{DC}$	$19\ V_{DC}$
Maximum supply voltage (continuous)	$14.6\ V_{DC}$	$29\ V_{DC}$
Bi-directional diode cut off voltage	$28\ V_{DC}$	$53\ V_{DC}$
Maximum current	1050 mA	500 mA
Nominal coil resistance @ 20°C	8.4 Ω	34.5 Ω

Control Options

Solenoid data (continued)

Voltage	12 V_{DC}	24 V_{DC}
PWM Range	70 – 200 Hz	
PWM Frequency (preferred)*	100 Hz	

* PWM signal required for optimum control performance.

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector

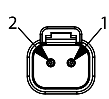
Single Pump Output Flow Direction

Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see installation drawings.

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, FNR 069/078

Stroking direction	0.8 [0.03] orifice	1.3 [0.05] orifice	No orifice
Neutral to full flow	0.9 s	1.0 s	1.1 s
Full flow to neutral	0.8 s	0.9 s	0.8 s

Control Options

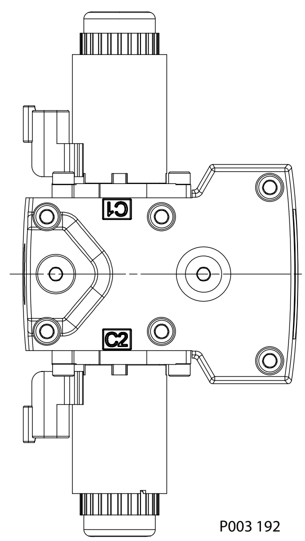
Non feedback proportional electric control (NFPE)

The Non Feedback Proportional Electric (**NFPE**) control is an electrical automotive control in which an electrical input signal activates one of two proportional solenoids that port charge pressure to either side of the pump servo cylinder. The NFPE control has no mechanical feedback mechanism.

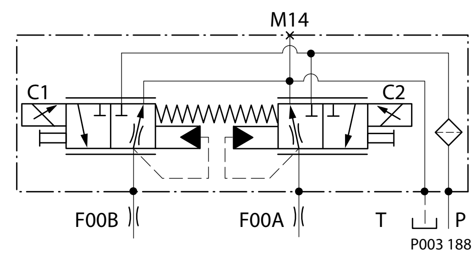
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

NFPE control



NFPE schematic

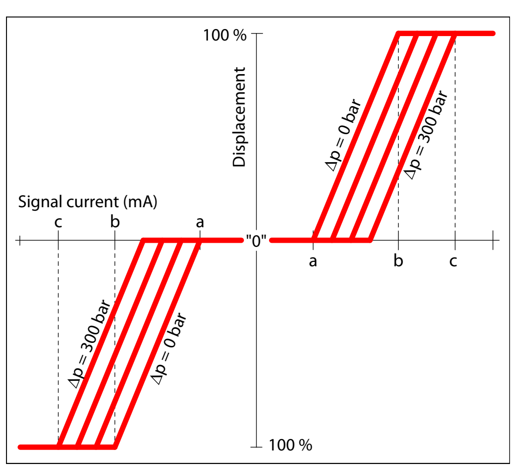


Control Signal Requirements, NFPE 069/078

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash-plate angle as system pressure increases.

A typical response characteristic is shown in the accompanying graph below:

Pump displacement vs. input signal



Control Options

Control current requirements

Voltage*	a	b	c	Pin config.
12 V_{DC}	694 mA	1168 mA	1540 mA	any order
24 V_{DC}	347 mA	600 mA	770 mA	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

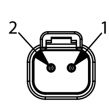
Single Pump Output Flow Direction

Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	C1	C2	C1	C2
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see installation drawings.

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control Options

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

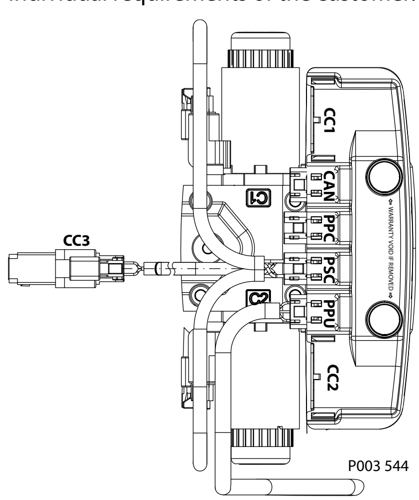
Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, NFPE 069/078

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	2.3 mm [0.09 in] orifice
Neutral to full flow	2.9 s	1.3 s	0.6 s
Full flow to neutral	1.6 s	0.8 s	0.3 s

Automotive Control (AC)

The H1 **A**automotive **C**ontrol (AC) is an electric NFPE Control with an integrated micro-controller, installed on the pump. The integrated micro-controller enhanced control performance with a flexible, configurable control scheme for an entire single path propel transmission. It can be used in combination with fixed and variable displacement hydraulic-motors. With the pre-installed application software and easily changeable control parameters, it is possible to tailor the vehicle's driving behavior to the individual requirements of the customer.



The H1 Automotive Control is divided into 2 systems:

- AC-1
- AC-2

AC-2 is an extension of AC-1 that features an integrated pump swash plate angle sensor and software enabled functions such as Swash Plate Control.

Mode types

The application software provides 3 different hydrostatic propel methods, defined as mode types, which can be used individually.

Control Options

- **Automotive Load dependent** (torque controlled) driving behavior. Setpoint for the drive curve is the engine rpm.
- **Non-Automotive Load independent** (speed controlled) driving mode. Setpoint for the drive curve is a Joystick or drive pedal signal, independent of the engine rpm. The best performance will achieved with an AC-2 Swash Plate Angle Sensor.
- **Creep-Automotive Load dependent** (torque controlled) driving behavior (like Automotive). Setpoint for the drive curve is the engine rpm. The setpoint can be reduced by the creep potentiometer if a high engine rpm in combination with low vehicle speed is needed.

Basic functions

- Four selectable system modes, selectable via switch.
- Individual settings for forward and reverse driving direction (4 x 2 curves).
- Independent pump and hydraulic-motor profiling and ramping for each mode.
- Electric drive pedal connection
- Electronic inching function without separate control valve
- Electric creep mode potentiometer
- Configurable System Mode & Direction change
- Load independent pump displacement control with integrated Swash Plate Angle Sensor (AC-2)
- Hydraulic-motor displacement control including brake pressure defeat function

Performance functions

- ECO fuel saving mode with automatic reduction of the engine speed during transport (Cruise control)
- Vehicle constant speed drive control
- Vehicle speed limitation
- Dynamic brake light, automatic park brake, reverse buzzer and status LED outputs
- Vehicle speed controlled output function.
- Temperature compensation for predictable performance
- Advanced CAN J1939 interface for the information exchange with the vehicle control system

Protection and safety functions

- Safety controlled vehicle start protection with engine speed check, battery check and FNR must be in neutral, etc..
- Operator presence detection
- Hydraulic system overheat and low-temperature protection
- Hydraulic motor over speed protection
- Park brake test mode for roller applications to fulfill SAE J1472 / EN500-4.
- SIL2 compliant

Engine control and protection

- CAN J1939 engine interface
- Engine speed control via drive pedal with safety controlled monitoring function
- Engine antistall protection
- Engine over speed protection during inching
- Engine speed dependent Retarder control
- Engine cold start protection

Control Options

Installation features

- Factory calibration for hysteresis compensation.
- Starting current adjustment in the factory
- Pre-installed application software and parameter files

For more information, see *Automotive Control for H1 Single Pumps Technical Information*, **BC152986482596**.

Control Options

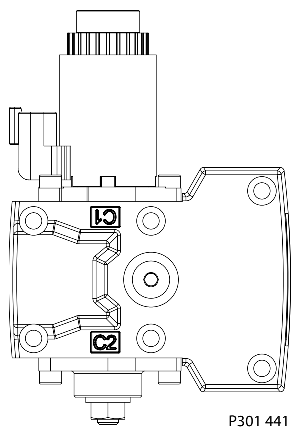
Fan Drive Control (FDC)

The Fan Drive Control (**FDC**) is a non-feedback control in which an electrical input signal activates the proportional solenoid that ports charge pressure to either side of the pump servo cylinder. The single proportional solenoid is used to control pump displacement in the forward or reverse direction.

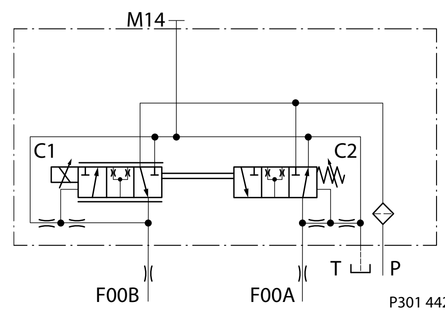
The control spool is spring biased to produce maximum forward pump displacement in the absence of an electrical input signal. Based on the spring bias spool default forward flow for a CW rotation pump is out of port B while default forward flow for a CCW rotation pump is out of port A.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

FDC control



FDC schematic



The pump should be configured with 0.8 mm control orifices to provide slowest response and maximize system stability. Additionally, pressure limiter (PL) valves are used to limit maximum fan trim speed in both (forward and reverse) directions.

H1 pumps with FDC will be delivered from factory with nominal pressure limiter setting of 150 bar [2175 psi]. The PL must be re-adjusted to ensure that the fan reaches the desired fan speed to satisfy the cooling needs of the system. HPRV setting must be always at least 30 bar [435 psi] higher than PL setting.

For more information necessary to properly size and configure a hydraulic fan drive system, see *Hydraulic Fan Drive Design Guidelines* **AB152886482265**.

Warning

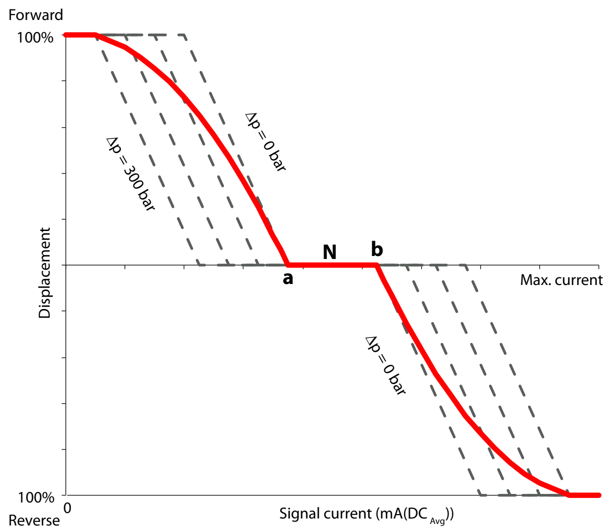
Use in other systems could result in unintended movement of the machine or it's elements. Loss of the input signal to this control will cause the pump to produce maximum flow.
The FDC is for Fan Drive systems only!

Due to the fail-safe functionality of the FDC control the pump will stroke to max. displacement in case the input signal to the pump control and the Diesel engine will be switched off at the same time. In this situation a low loop event can occur which may damage the pump. Therefore, it's strictly recommended to keep the input signal to the pump control alive while switching off the engine.
For further information please contact your Danfoss representative.

Control Options

Control Signal Requirements, FDC 069/078

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash plate angle as system pressure increases. A typical response characteristic is shown in the accompanying graph below:



a – Forward threshold

b – Reverse threshold

N – Neutral override current

Control current requirements

Voltage*	a	N	b	Pin config.
12 V_{DC}	780 mA	1100 mA	1300 mA	any order
24 V_{DC}	400 mA	550 mA	680 mA	

* Factory test current, for fan movement expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Control Options

Single Pump Output Flow Direction

Pump output flow direction vs. control signal

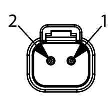
Shaft rotation		ClockWise			CounterClockWise		
Control Logic	**12 V**	**0-780 mA**	**1100 mA**	**1300-1800 mA**	**0-780 mA**	**1100 mA**	**1300-1800 mA**
	24 V	**0-400 mA**	**550 mA**	**680-920 mA**	**0-400 mA**	**550 mA**	**680-920 mA**
Port A		in	no flow	out	out	no flow	in
Port B		out	no flow	in	in	no flow	out
Servo port pressurized		M5	n/a	M4	M5	n/a	M4

Warning

Loss of input signal to the control will cause the pump to produce maximum flow.

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, FDC 069/078

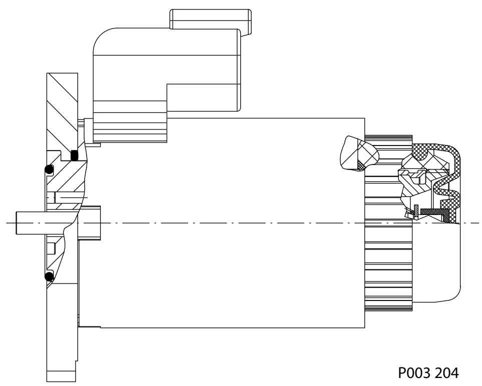
Stroking direction	0.8 mm [0.03 in] orifice
Full flow to neutral	2.9 s
Full forward flow to full reverse flow	4.3 s

Control Options

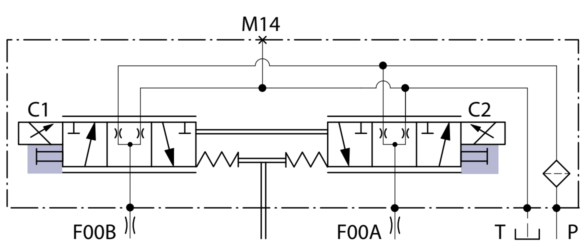
Manual Override (MOR)

All controls are available with a manual override functionality, either as a standard or as an option for temporary actuation of the control to aid in diagnostics.

Control with manual override



MOR schematic (EDC control shown)



Feedback from swash plate.

The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke. The MOR should be engaged anticipating a full stroke response from the pump.

An o-ring seal is used to seal the MOR plunger where initial actuation of the function will require a force of 45 N to engage the plunger. Additional actuation typically require less force to engage the MOR plunger.

Proportional control of the pump using the MOR should not be expected.

Warning

Unintended MOR operation will cause the pump to go into stroke; *example:* vehicle lifted off the ground. The vehicle or device must always be in a safe condition when using the MOR function.

Refer to control flow table for the relationship of solenoid to direction of flow.

Control Options

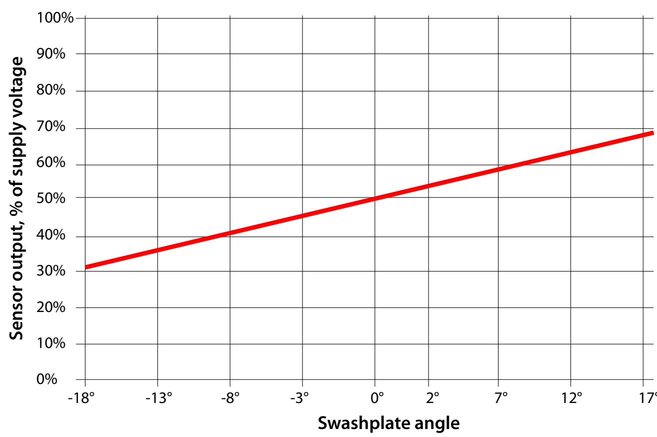
Swashplate angle sensor for EDC controls

The angle sensor detects the swash plate position with an accuracy dependent upon the calibration effort done for the application and direction of rotation from the neutral position. At minimum the sensor can be used for forward, neutral and reverse (FNR) detection.

The sensor works on the hall-effect technology. The implemented technology is based on a measurement of the magnetic field direction in parallel to the chip surface. This field direction is converted to a voltage signal at the output.

Enhanced calibration of the non-linear behavior leads to more exact calculation of the pump swashplate angle. The 4-pin DEUTSCH connector is part of the sensor housing. The swashplate angle sensor is available for all EDC controls for 12 V and 24 V.

Swashplate angle vs. output of supply voltage



Warning

Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

Contact your Danfoss representative in case the angle sensor will be used for safety functions.

Swash plate angle sensor parameters (EDC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.5 V_{DC}	5 V_{DC}	5.5 V_{DC}
Supply protection	–	–	18 V_{DC}
Pump neutral output (% of supply voltage)	–	50%	–
Working range (swash plate angle)	–18°	–	18°
Required supply current	–	–	30 mA
Output current signal	–	9 mA	11 mA
Working temperature	–40 °C	80 °C	115 °C

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector
EMC Immunity	ISO 11452-2	100 V/m

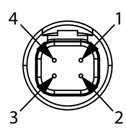
Control Options

Calibration of the sensor output within the software is mandatory. Vehicle neutral thresholds in the software (±0.5°) are vehicle dependent and must consider different conditions, example: system temperature, system pressure and/or shaft speed.

For safety function: If the sensor fails (invalid signal <10% or >90% of supply voltage), it must be sure that the ECU will go into a diagnostic mode and shift into limited mode in order for the driver to take the full control or the mechanical breaks should be activated. Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

H1P Swash Plate Angle Sensor Connector

Connector DEUTSCH, 4-pin

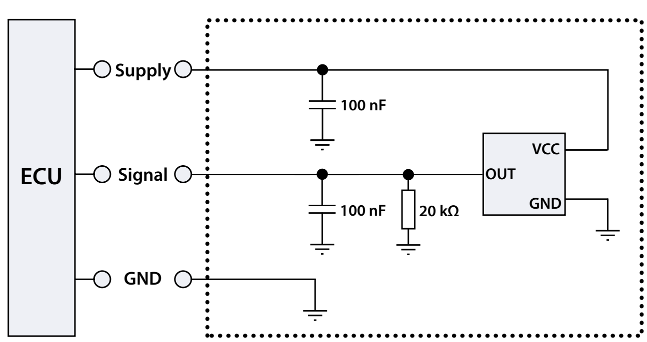


1	Ground (GND)
2	Not connected
3	Output signal 1 (SIG 1)
4	Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Interface with ECU (EDC)

Interface with ECU diagram

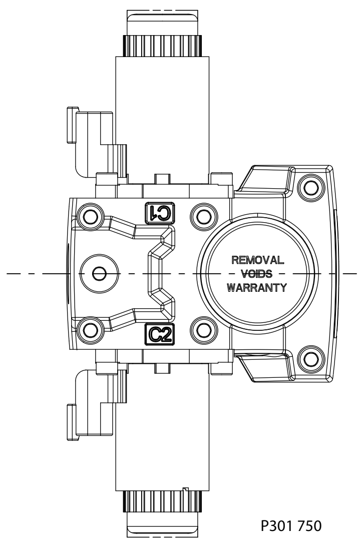


Control Options

Swash Plate Angle Sensor for NFPE and AC2 Controls

The angle sensor detects the swash plate angle position and direction of rotation from the zero position. The swash angle sensor works on the AMR sensing technology. Under the saturated magnetic field, the resistance of the element varies with the magnetic field direction.

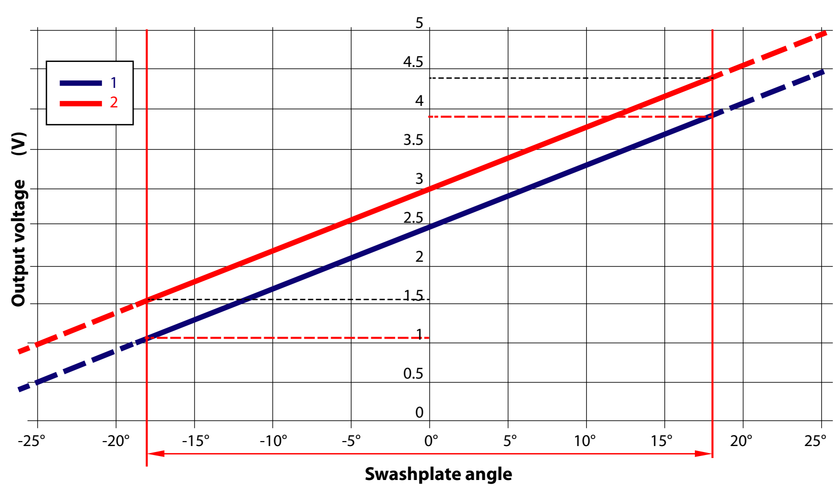
The output signal give a linear output voltage for the various magnet positions in the sensing range.



Swash Plate Angle Characteristic

The volumetric losses depend on pump max. displacement, actual displacement, speed, delta pressure, viscosity and temperature.

Swashplate angle vs. output voltage (calibrated at 50 °C)



1. Signal 1 (nominal)
2. Signal 2 (redundant)

The displacement can be calculated by:

$$V = \frac{\tan\alpha \cdot V}{\tan 18°} \quad (cm^3)$$

The corresponding flow is:

$$Q = \frac{V \cdot n \cdot \eta_{vol}}{1000} \quad (l/min)$$

Control Options

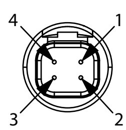
Swash Plate Angle Sensor Parameters (NFPE/AC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.75 V	5 V	5.25 V
Supply protection	–	–	28 V
Supply current	–	22 mA	25 mA
Output current (Signal 1, 2)	–	0.1 mA	–
Short circuit output current to supply or GND[1)]	–	–	7.5 mA
Sensitivity	70.0 mV/deg	78.0 mV/deg	85.8 mV/deg
Working range (swash plate angle)	−18°	0°	18°
Correlation between signals 1 and 2[2)]	475 mV	500 mV	525 mV

[1)] Up to duration of 2.5 seconds at 25°C

[2)] Signal 1 (nominal) is lower than signal 2 (redundant)

H1P Swash Plate Angle Sensor Connector (NFPE)



1 Ground (GND)

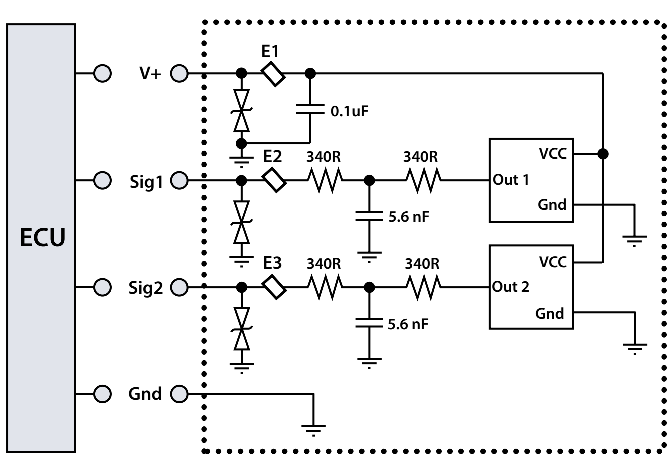
2 Output Signal 2 (SIG 2) – Secondary (redundant)

3 Output signal 1 (SIG 1)

4 Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Interface with ECU (NFPE)



Minimum recommended load resistance is 100 kΩ.

Control Options

Control Cut Off Valve (CCO)

The H1 pump offers an optional control cut off valve integrated into the control. All EDC, NFPE and MDC controls are available with a CCO valve. This valve will block charge pressure to the control, allowing the servo springs to de-stroke both pumps regardless of the pump´s primary control input.

There is also a hydraulic logic port, X7, which can be used to control other machine functions, such as spring applied pressure release brakes. The pressure at X7 is controlled by the control cut off solenoid. The X7 port would remain plugged if not needed.

In the normal (de-energized) state of the solenoid charge flow is prevented from reaching the controls. At the same time the control passages and the X7 logic port are connected and drained to the pump case. The pump will remain in neutral, or return to neutral, independent of the control input signal. Return to neutral time will be dependent on oil viscosity, pump speed, swashplate angle, and system pressure.

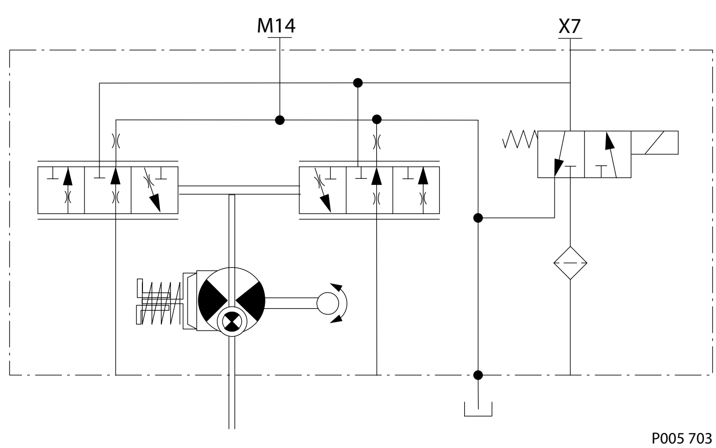
When the solenoid is energized, charge flow and pressure is allowed to reach the pump control. The X7 logic port will also be connected to charge pressure and flow.

The solenoid control is intended to be independent of the primary pump control making the control cut off an override control feature. It is however recommended that the control logic of the CCO valve be maintained such that the primary pump control signal is also disabled whenever the CCO valve is de-energized. Other control logic conditions may also be considered.

The CCO valve is available with 12 V or 24 V solenoid.

The response time of the unit depends on the control type and the used control orifices.

CCO schematic (MDC shown)



Brake gauge port with MDC

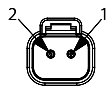
Caution

It is not recommended to use brake port for any external flow consumption to avoid malfunction of CCO function.

Control Options

CCO Connector (MDC)

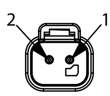
Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

H1P CCO Connector (EDC, NFPE)

Connector CCO DEUTSCH, 2-pin with key C



Description	Quantity	Order number
Mating connector	1	DEUTSCH DT06-2S-C015
Wedge lock	1	DEUTSCH W2SC-P012
Socket contact	4	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	11212714

CCO solenoid data

Nominal supply voltage		**12 V**	**24 V**
Supply voltage	**Maximum**	14.6 V	29 V
	Minimum	9.5 V	19 V
Bi-directional diode cut off voltage		28 V	53 V
Nominal coil resistance at 20 °C		10.7 Ω	41.7 Ω
Supply current	**Maximum**	850 mA	430 mA
	Minimum	580 mA	300 mA
PWM frequency	**Range**	50 – 200 Hz	
	Preferred	100 Hz	
Electrical protection class		IP67 / IP69K with mating connector	

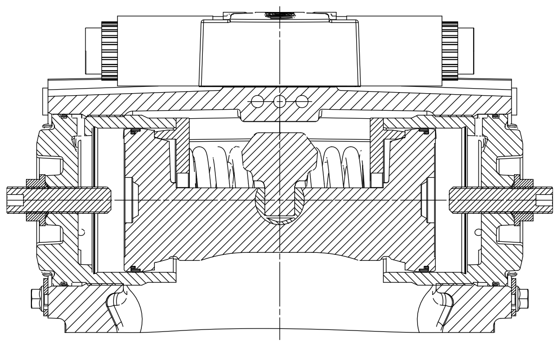
CCO solenoids are design for battery voltage application within the voltage range in the table above, in consideration of a wide range of environmental temperature common for known hydraulic applications. Closed loop PWM current supply can be also applied and is helpful in case that the voltage range is exceeded, or ambient temperature could rise in an unusual manner.

Control Options

Displacement Limiter

H1 pumps are designed with optional mechanical displacement (stroke) limiters factory set to max. displacement. The maximum displacement of the pump can be set independently for forward and reverse using the two adjustment screws to mechanically limit the travel of the servo piston down to 50% displacement.

Adjustments under operating conditions may cause leakage. The adjustment screw can be completely removed from the threaded bore if backed out to far.



P003 266

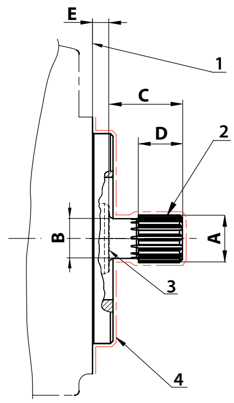
H1P 069/078 Displacement Change (approximately)

Parameter	Size 069	Size 078
1 turn of displacement limiter screw	7.4 cm^3 [0.45 in^3]	7.4 cm^3 [0.45 in^3]
Internal wrench size	4 mm	
External wrench size	13 mm	
Torque for external hex seal lock nut	24 N•m [212 lbf•in]	

For more information, see *H1 Axial Piston Pumps, Service Manual,* **AX152886482551**, the section “Displacement Limiter Adjustment”.

Dimensions and Data

H1P 069/078 Input Shaft Option G1 (SAE C, 14 teeth)



1. Surface of mounting flange 127 – 4 per ISO 3019-1; to be paint free
2. **Spline Data:** 14 teeth, Pressure angle: 30°, Pitch: 12/24, Ø29.633 [1.167]; Fillet root side fit per ANSI B92.1-1996, Class 6H; minimum active spline length 31.45 mm [1.238 in]
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø31.14 ±0.08 [1.226 ±0.003]	Ø26.0 ±0.25 [1.024 ±0.01]	48.0 ±1.0 [1.89 ±0.039]	31.5 ±0.5 [1.24 ±0.02]	8.05 ±0.08 [0.317 ±0.003]

[1)] Minimum active spline length for the specified torque ratings.

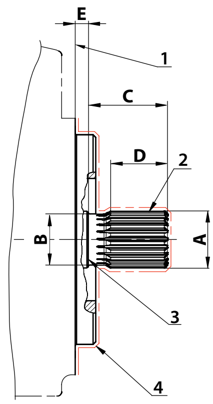
Torque rating

Rated torque	Maximum torque
534 N•m [4720 lb•in]	816 N•m [7220 lb•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P 069/078 Input Shaft Option G9 (SAE C-C, 23 teeth)



1. Surface of mounting flange 127 – 4 per ISO 3019-1 (SAE C); to be paint free
2. **Spline Data:** 23 teeth, Pressure angle: 30°, Pitch: 16/32, Ø36.513 [1.438]; Fillet root side fit per ANSI B92.1-1996, Class 6H
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø37.59 ±0.08 [1.746 ±0.004]	Ø33.6 ±0.13 [1.323 ±0.005]	54.0 ±1.0 [2.126 ±0.039]	40.5 ±1.0 [1.594 ±0.039]	8.05 ±0.8 [0.317 ±0.03]

[1)] Minimum active spline length for the specified torque ratings.

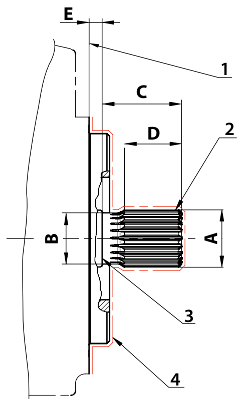
Torque rating

Rated torque	Maximum torque
999 N•m [8840 lb•in]	1818 N•m [16 090 lb•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P 069/078 Input Shaft Option F1 (SAE C, 21 teeth)



1. Surface of mounting flange 127 – 4 per ISO 3019-1; to be paint free
2. **Spline Data:** 21 teeth, Pressure angle: 30°, Pitch: 16/32, Ø33.337 [1.313]; Fillet root side fit per ANSI B92.1-1996, Class 6H; minimum active spline length 34.5 mm [1.358 in]
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø34.42 ±0.09 [1.355 ±0.004]	Ø30.4 ±0.25 [1.197 ±0.01]	48.0 ±1 [1.89 ±0.039]	34.5 ±1 [1.358 ±0.0039]	8.05 ±0.8 [0.317 ±0.03]

[1)] Minimum active spline length for the specified torque ratings.

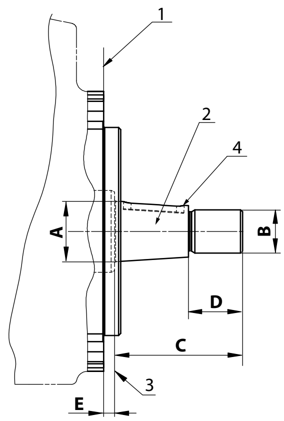
Torque rating

Rated torque	Maximum torque
760 N•m [6730 lbf•in]	1137 N•m [10 060 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section "Shaft Torque Ratings and Spline Lubrication".

Dimensions and Data

H1P 069/078 Input Shaft Option F4, Code 38–3



1. Surface of mounting flange 127 – 4 per ISO 3019-1; to be paint free
2. **Tapered shaft:** Conical keyed shaft end, code 38–3 similar to ISO 3019-1; Cone 125 ±10.5 : 1000; Suitable key: ⅜ x ⅜ x 1½ per ANSI B17.1
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D	E
Ø38.1 ±0.09 [1.5 ±0.004]	1⅛ –12UNF	81.9 ±1.0 [3.224 ±0.039]	34.9 ±1.0 [1.374 ±0.039]	7.88 ±0.8 [0.31 ±0.03]

Torque rating

Rated torque[1)]	Maximum torque[2)]
1116 N•m [9880 lbf•in]	1488 N•m [13 170 lbf•in]

[1)] Rated torque includes just the capability of the press-fit in accordance with an assumed fastener grade 5

[2)] Mating part must maintain a minimum gap width of 1.0 mm with the shaft shoulder after installation of the part. Transmittable torque will be reduced if the minimum gap requirement is not met.

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Tapered shaft customer acknowledgement

The Danfoss H1 tapered shaft has been designed using the industry standard ISO 3019-1, minus the through-hole in the end of the shaft. Danfoss guarantees the design and manufactured quality of the tapered shaft.

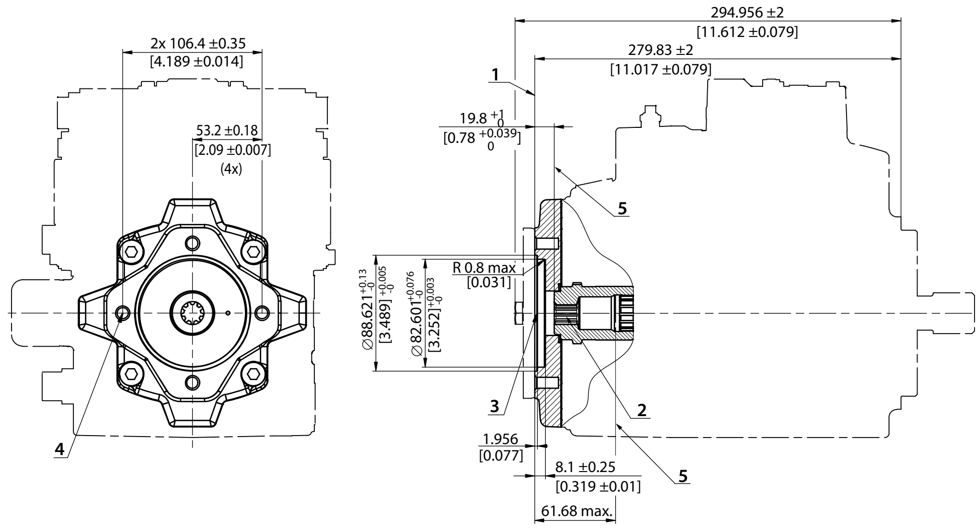
Danfoss recommends a self-locking nut instead of a castle nut and pin. The nut and mating square-cut key are customer supplied. The specified torque rating of the tapered shaft is based on the cross-sectional diameter of the shaft, through the keyway, and assumes the proper clamp and fit between shaft and coupling. The customer is responsible for the design and manufactured quality of the mating female coupling and key and applied torque on the nut. Danfoss has made provisions for the key in accordance to the ISO specification with the understanding that the key is solely to assist in the installation of the mating coupling.

Caution

Possible hazard because torque or loading inadvertently transmitted by the customer supplied key may lead to premature shaft failure. Torque must be transmitted by the taper fit between the shaft and it’s mating coupling, not the key.

Dimensions and Data

H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth)



1. Auxiliary mounting pad for mating flange 82-2 per ISO 3019-1 (SAE A); Paint free
2. **Spline Data:** 11 teeth, Pressure angle: 30°; Pitch: 16/32, Ø17.463 [0.6875]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 10.5 mm
3. O-ring seal required; Ref. Ø82.22 ID x 2.62, cross section
4. Thread: M10x1.5-6H; 15 [0.59] min. depth; Recommended screw in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	296 N•m [2620 lbf•in]

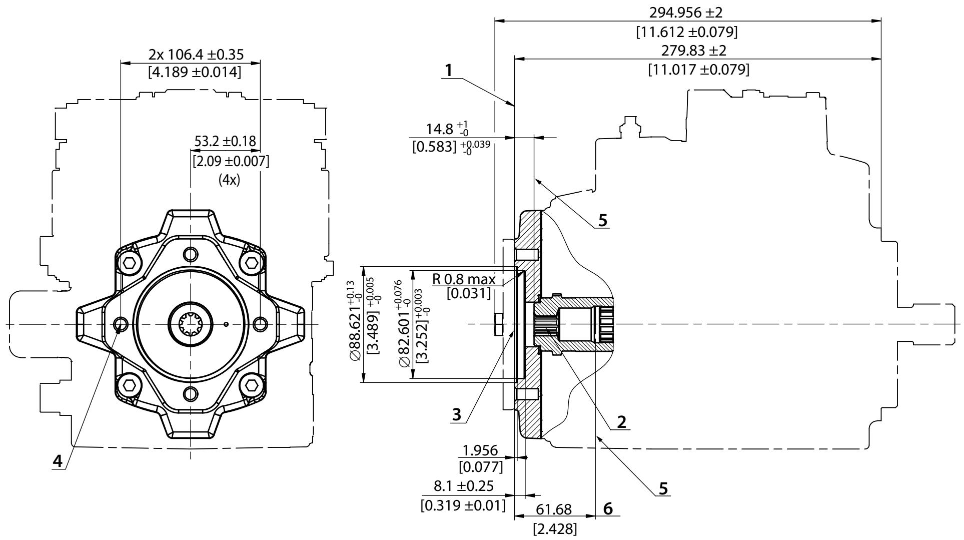
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth)



1. Auxiliary mounting pad for mating flange 82-2 per ISO 3019-1 (SAE A); Paint free
2. **Spline Data:** 9 teeth, Pressure angle: 30°; Pitch: 16/32, Ø14.288 [0.5625]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 8.6 mm
3. O-ring seal required; Ref. Ø82.22 ID x 2.62, cross section
4. Thread: M10x1.5-6H; 15 [0.59] min. depth; Recommended screw in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	162 N•m [1430 lbf•in]

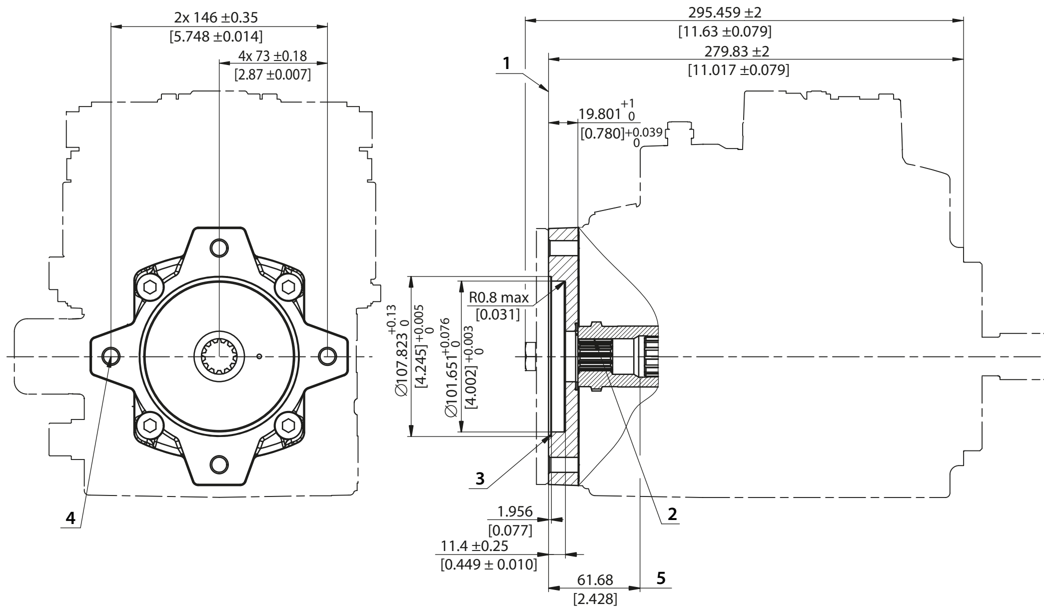
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°; Pitch: 16/32, Ø20.638 [0.813]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 12.4 mm
3. O-ring seal required; Ref. Ø94.92 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 20 [0.787] min. depth; Recommended screw in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	395 N•m [3500 lbf•in]

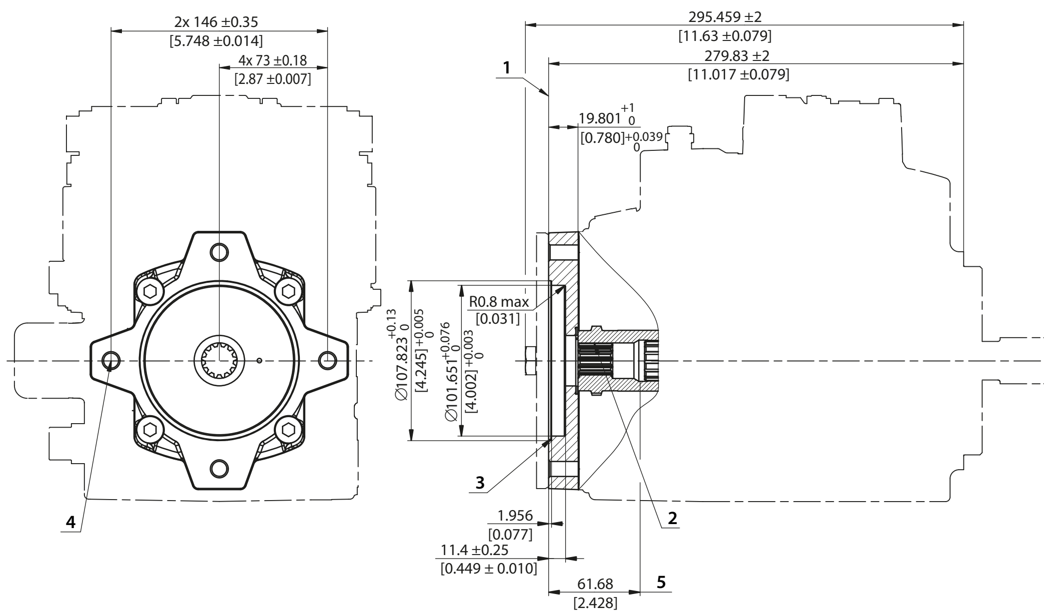
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 15 teeth, Pressure angle: 30°; Pitch: 16/32, Ø23.813 [0.938]; Fillet root side fit per ANSI B92.1b, Class 6
3. O-ring seal required; Ref. Ø94.92 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 20 [0.787] min. depth; Recommended screw in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	693 N•m [6130 lbf•in]

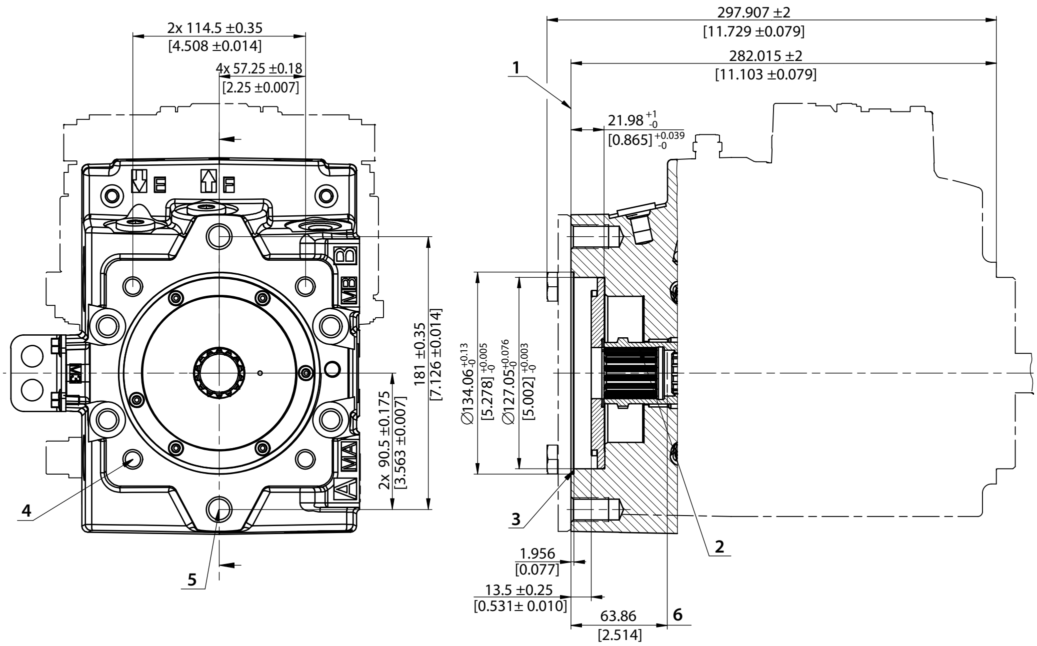
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth)



1. Auxiliary mounting pad for mating flange 127-4 per ISO 3019-1 (SAE C); Paint free
2. **Spline Data:** 14 teeth, Pressure angle: 30°; Pitch: 12/24, Ø29.633 [1.667]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 14.3 mm
3. O-ring seal required; Ref. Ø120.32 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 21 [0.827] min. depth; Recommended screw in depth 1.5 x thread dia (4x)
5. Thread: M16x2-6H; 25 [0.984] min. depth; Recommended screw in depth 1.5 x thread dia (2x)
6. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum torque	816 N•m [7220 lbf•in]

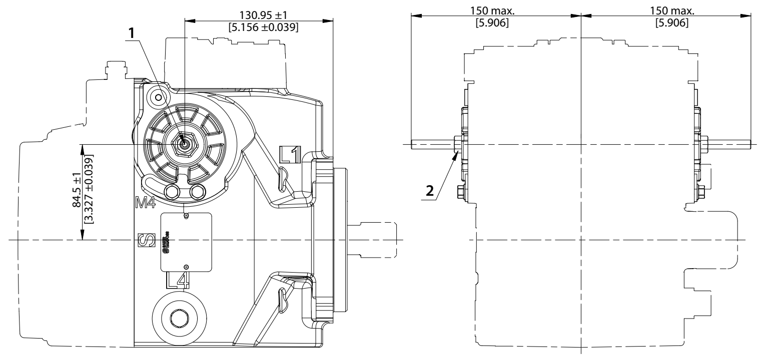
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Displacement Limiter, Option B



1. Displacement limiter screw (2x)
2. Displacement limiter seal nut (2x)

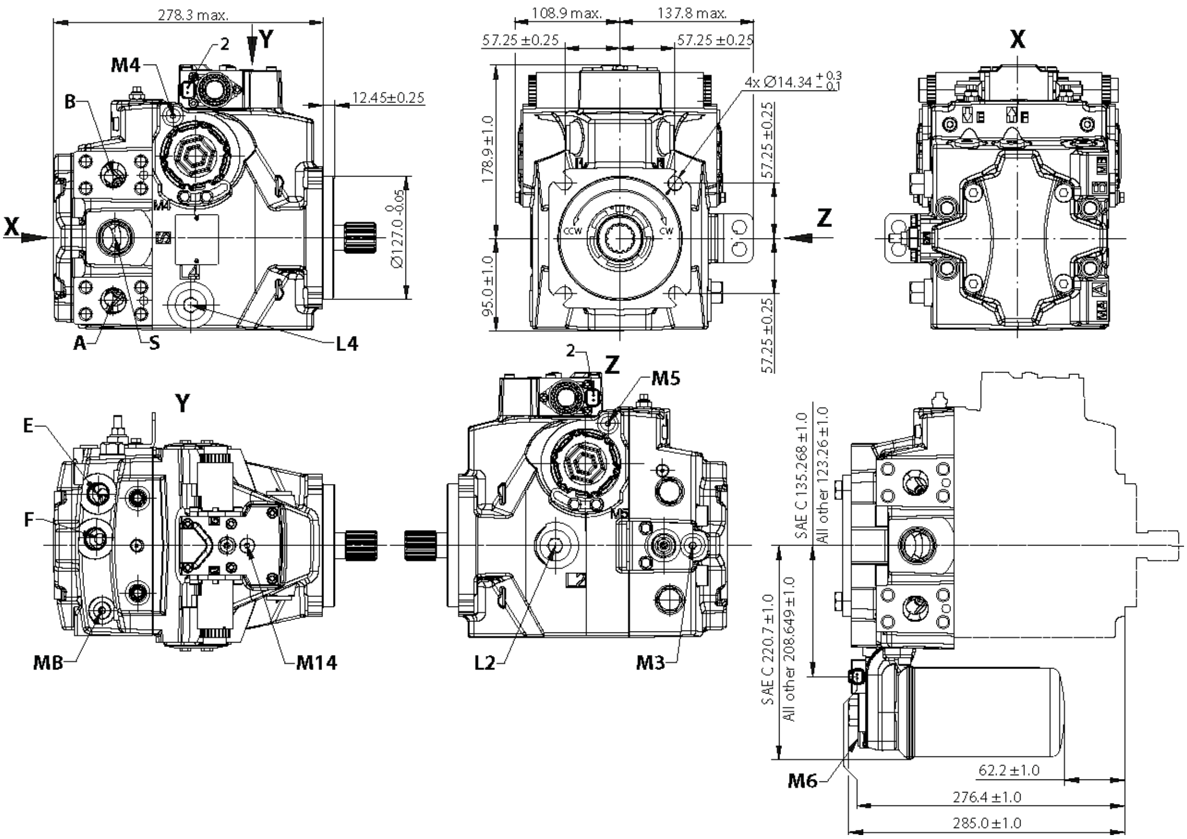
Wrench size, torque

Wrench size for DL screw	Wrench size for DL seal nut	Torque
4 internal hex	13 external hex	24 N•m [18 lb•ft]

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Single Pump Ports



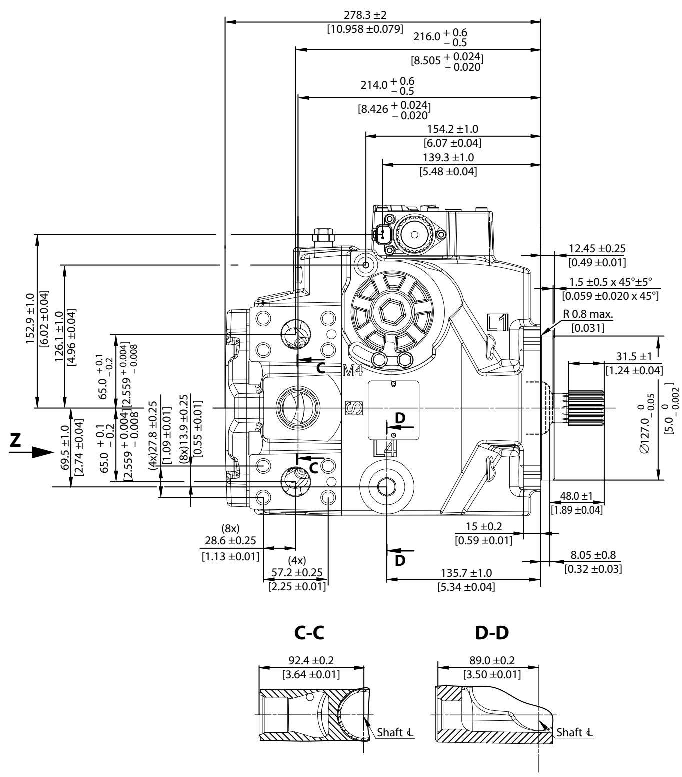
Ports per ISO 11 926-1

Port	Description	Size
A, B	System ports	Ø25.4 – 450 bar, Split flange boss ISO 6162; M1 2x 1.75, 20 min full thread depth Recommended screw in depth 1.5 x thread dia
L2, L4	Case drain ports	$1\frac{1}{16}$–12
MA, MB	System **A/B** gauge ports	$\frac{9}{16}$–18
E/F	Charge filtration ports	$\frac{7}{8}$–14
M3	Charge pressure gauge port	$\frac{9}{16}$–18
M4, M5	Servo gauge port	$\frac{7}{16}$–20
M14	Case gauge port (EDC, FNR, NFPE)	$\frac{7}{16}$–20
S	Charge inlet port	$1\frac{5}{16}$–12
2	Connector DEUTSCH DTM04-2P, to be paint free	

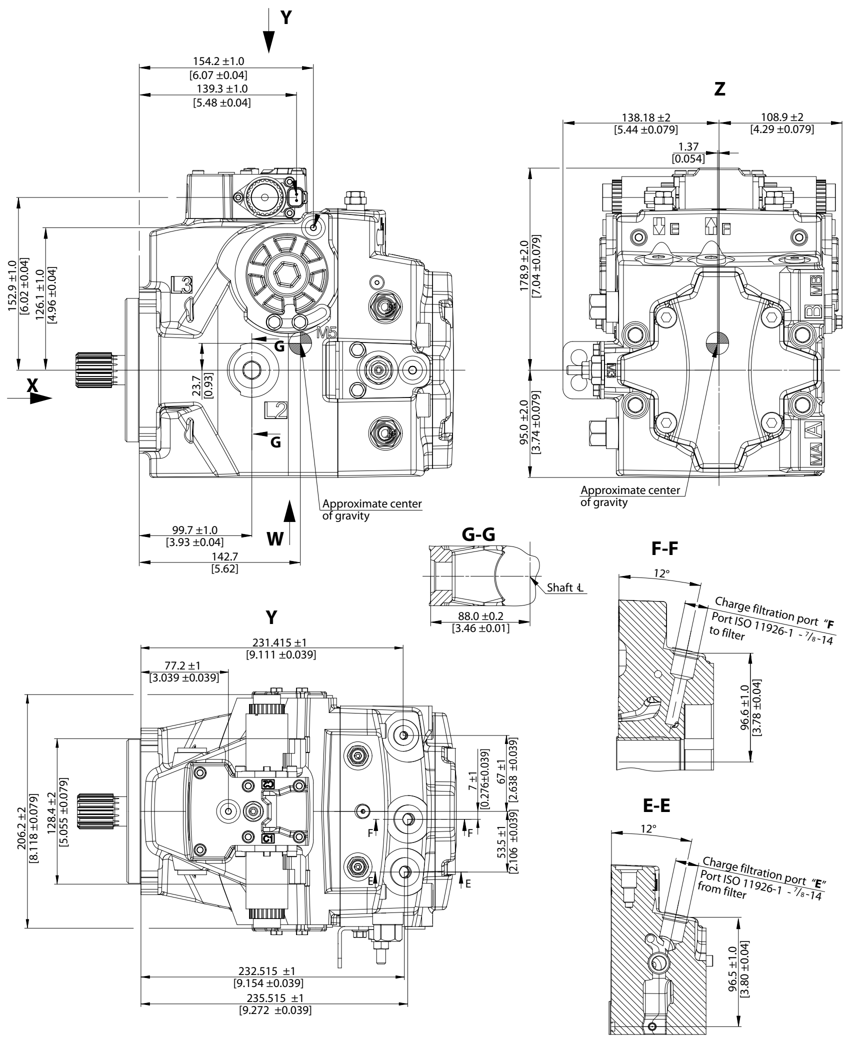
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

H1P Dimensions



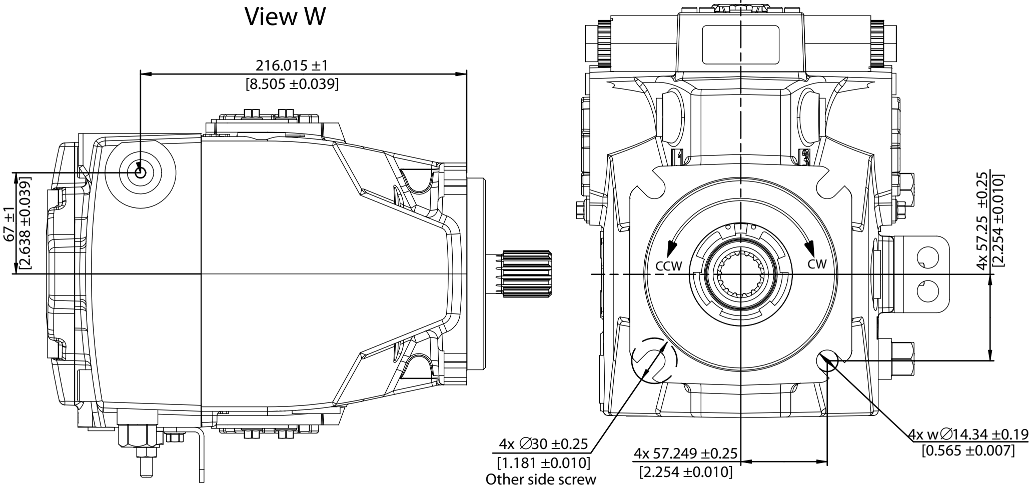
Dimensions and Data



1 — Approximate center of gravity

View X

View W



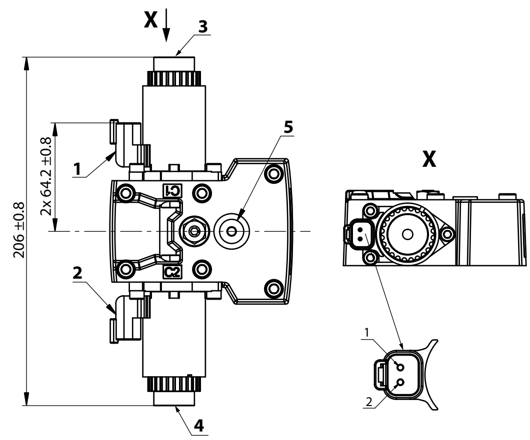
1 — Other side screw head space

Dimensions and Data

Dimensions and Data

Controls

EDC Options A2 and A3 (12/24 V)



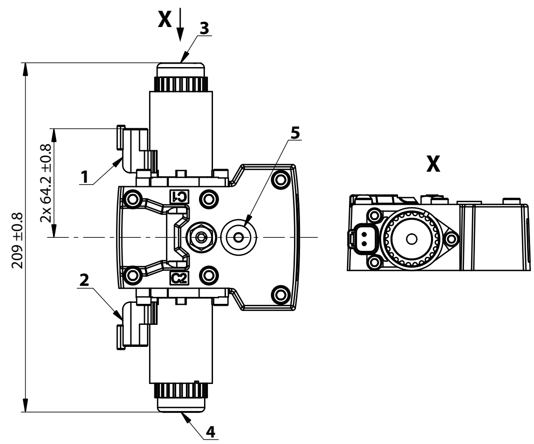
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

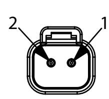
EDC with MOR, Options A4 and A5 (12/24 V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector C1/C2: DEUTSCH DTM04-2P

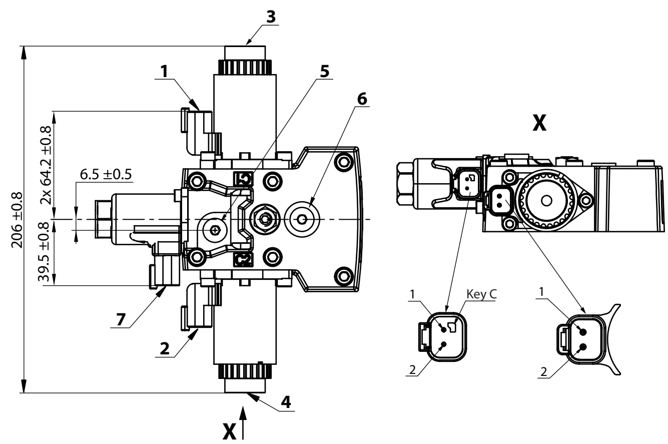


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

EDC with CCO (key C), Options E7 and E8 (12/24 V)



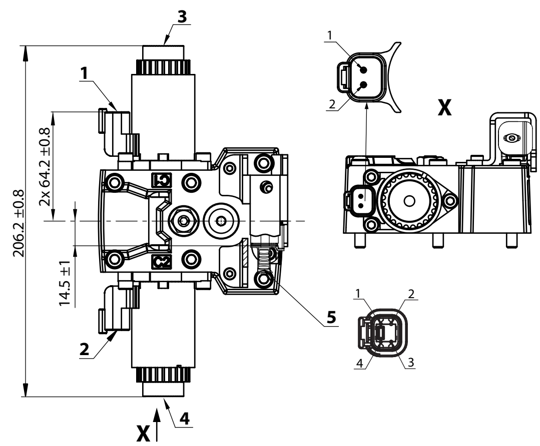
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
6. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

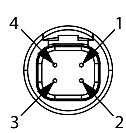
Dimensions and Data

EDC with ASNSR, Options: H2 and H3 (12/24 V)



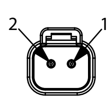
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Angle sensor connector **S2** DEUTSCH DT04-4P, paint free

Connector DEUTSCH, 4-pin



4-pin assignment:
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Connector **C1/C2**: DEUTSCH DTM04-2P*

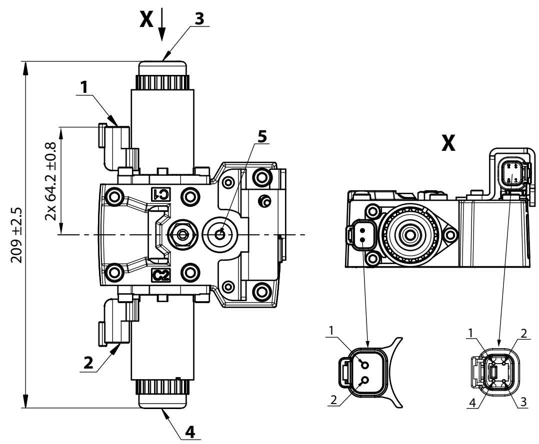


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

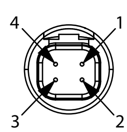
Dimensions and Data

EDC with MOR and ASNSR, Options H6 and H7 (12/24 V)



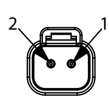
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Connector DEUTSCH, 4-pin



4-pin assignment:
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connector ***C1/C2****: DEUTSCH DTM04-2P*

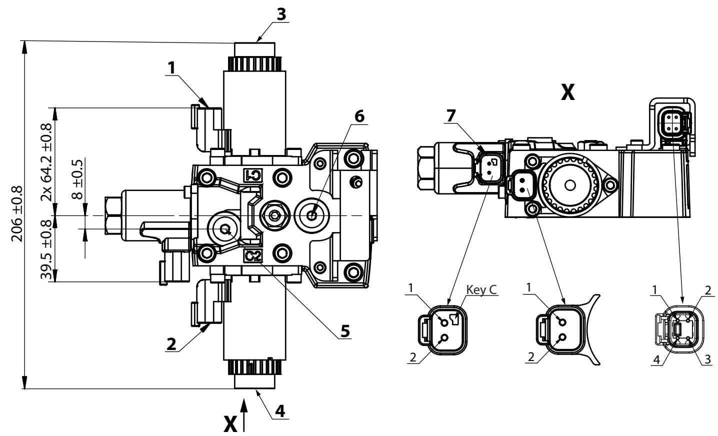


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

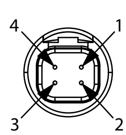
EDC with CCO and ASNSR, Options H8 and H9 (12/24 V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
6. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

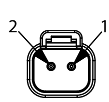
Connector DEUTSCH, 4-pin



Angle sensor connector S2: DEUTSCH DTM04-4P

1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connectors C1/C2/C4: DEUTSCH DTM04-2P

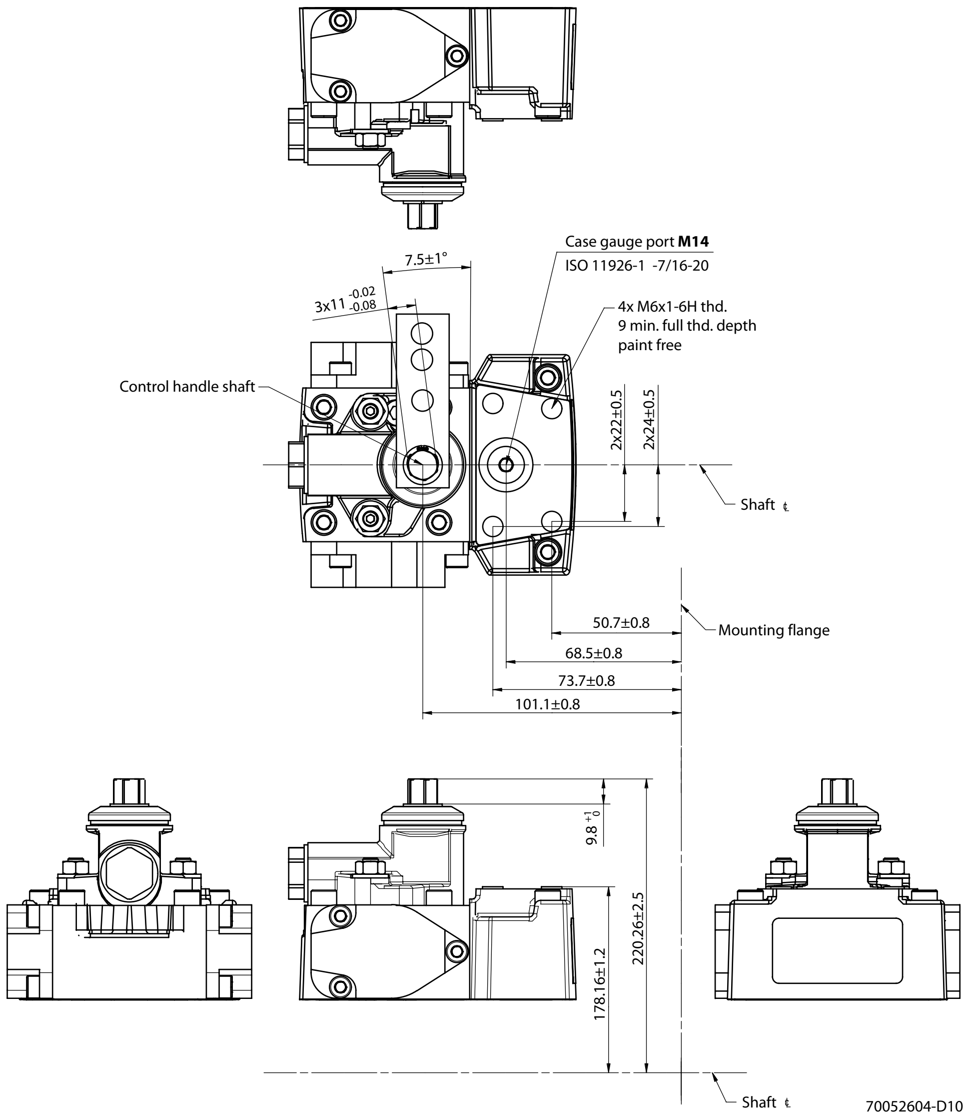


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

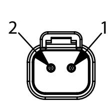
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC Option: M1



Connector DEUTSCH, 2-pin

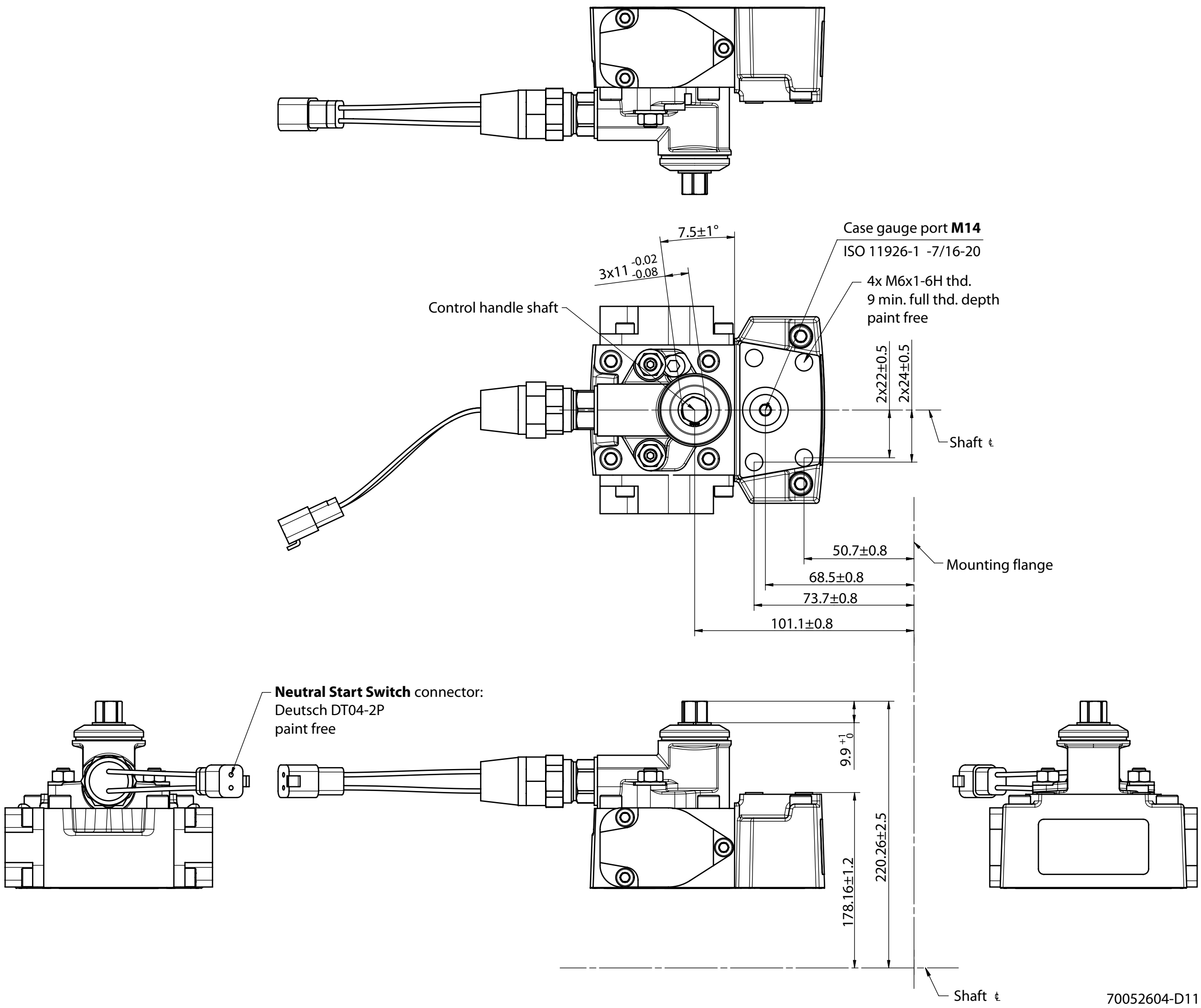


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

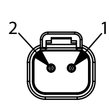
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with Neutral Start Switch Option: M2



Connector DEUTSCH, 2-pin

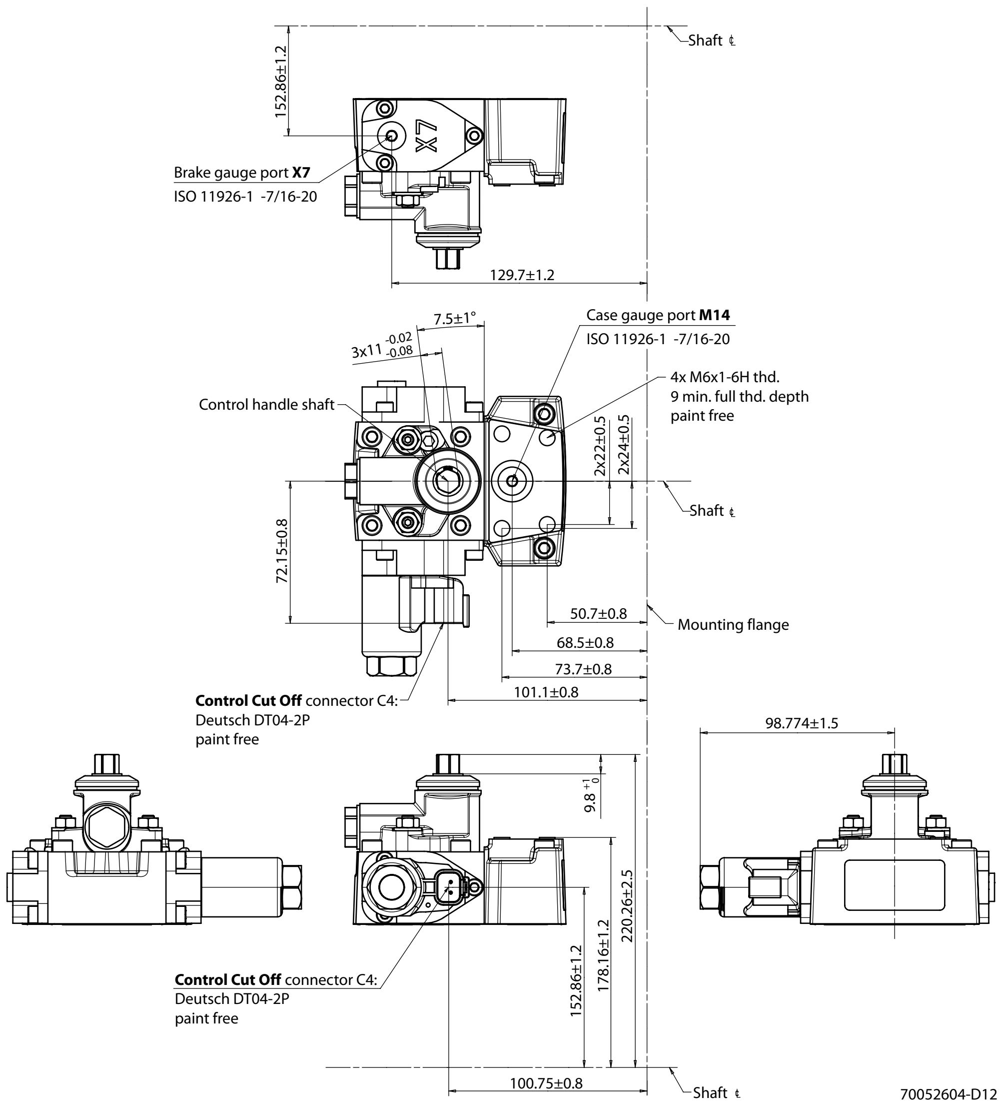


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

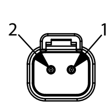
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with CCO, Options: M3, M4



Connector DEUTSCH, 2-pin

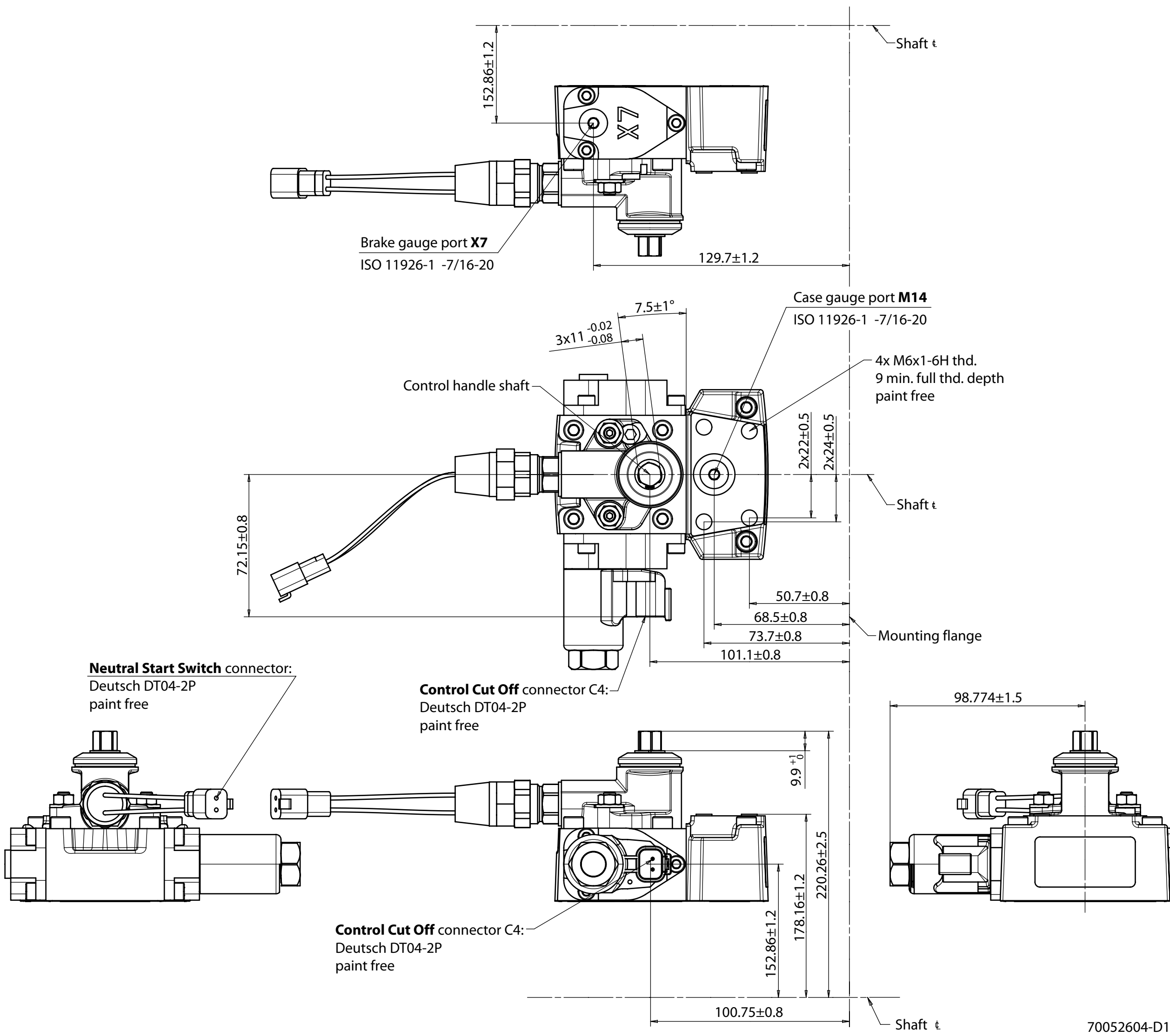


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

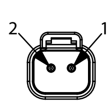
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with NSS and CCO Options: M5, M6



Connector DEUTSCH, 2-pin



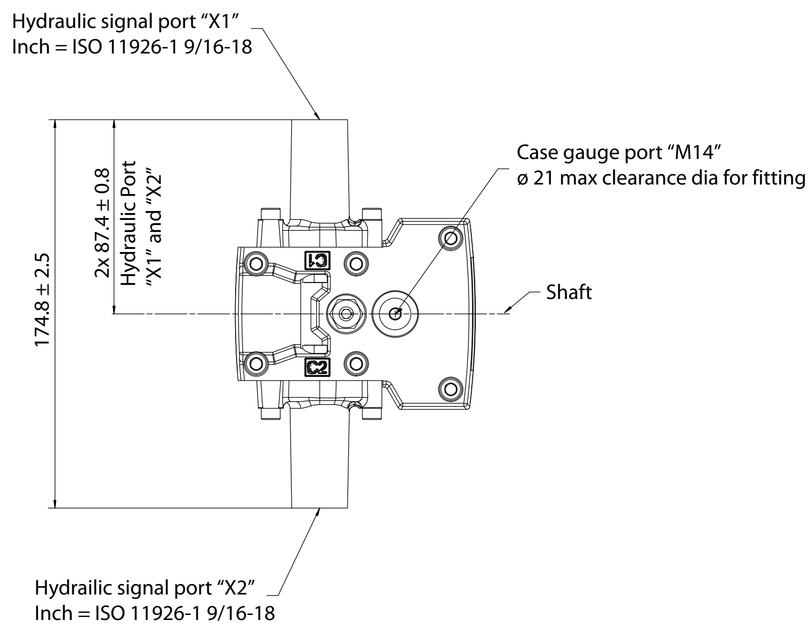
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

H1P HDC, Options: T1, T2

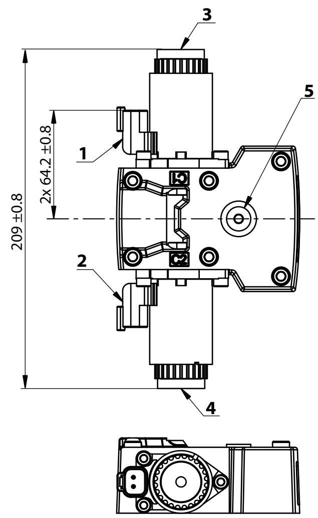
Dimensions in mm



Dimensions and Data

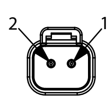
NFPE with MOR, Options: N1, N2 (12/24 V)

Non-Feedback Proportional Electric control with Manual Over Ride options N1 (12 V) and N2 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

*Control solenoid connectors **C1/C2** DEUTSCH DTM04-2P pin/assignment*



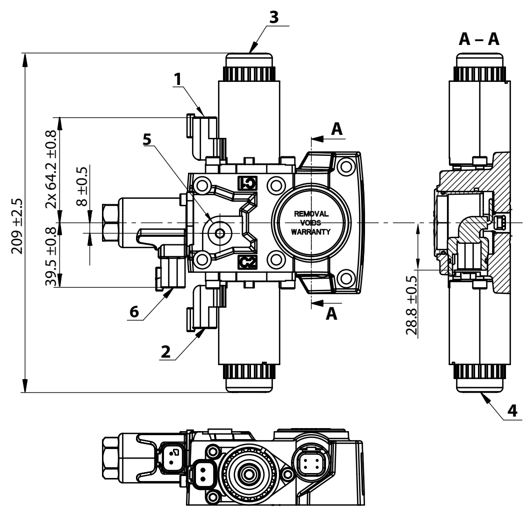
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V)

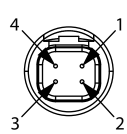
Non-Feedback Proportional Electric control with Control-Cut-Off valve with key C, Manual Over Ride and Angle Sensor, options N3 (12 V) and N4 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
6. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

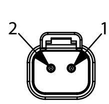
Connector DEUTSCH, 4-pin



Pin/assignment:

1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Control solenoid connectors **C1/C2/C4** DEUTSCH DTM04-2P pin/assignment*



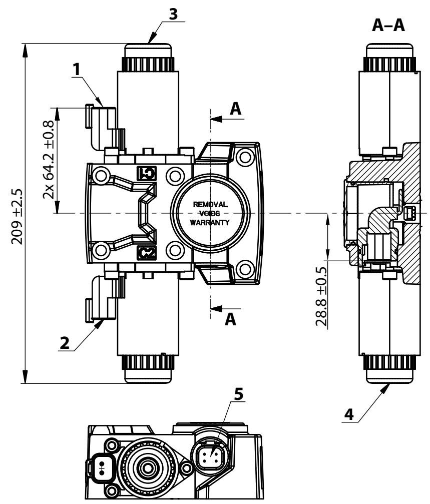
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

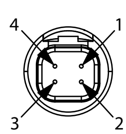
NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V)

Non-Feedback Proportional Electric control with Manual Over Ride and Angle Sensor, options N5 (12 V) and N6 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Angle sensor connector **S2** DEUTSCH DT04-4P, paint free

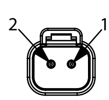
Connector DEUTSCH, 4-pin



Pin/assignment:

1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

Control solenoid connectors C1/C2 DEUTSCH 2-pin/assignment



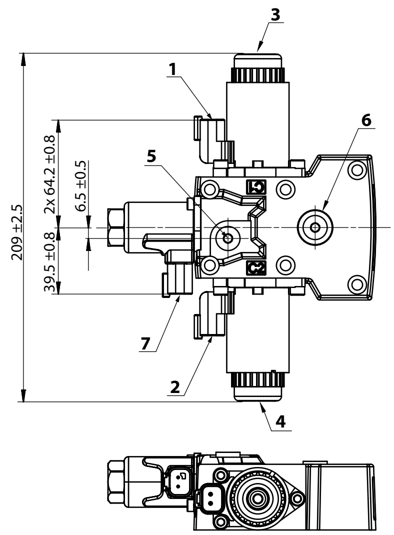
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

NFPE with MOR and CCO, Options: N7, N8 (12/24 V)

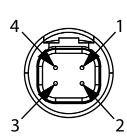
Non Feedback Proportional Electric control with Manual Over Ride and Control-Cut-Off valve key C, options N7 (12 V) and N8 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
6. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

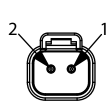
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Control solenoid connectors **C1/C2** DEUTSCH DTM04-2P pin assignment*

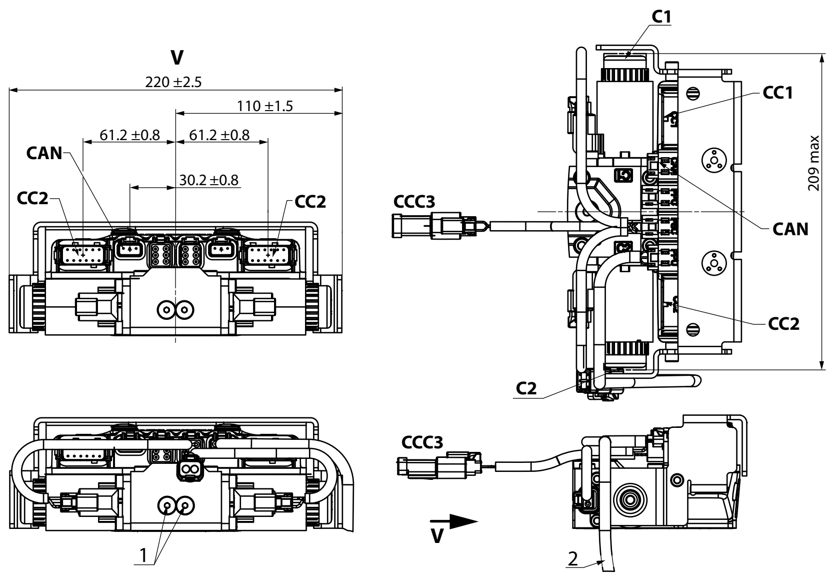


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Automotive control (AC)



1 Plug removing can cause contamination issues

2 PPU wire harness is factory installed to speed sensor

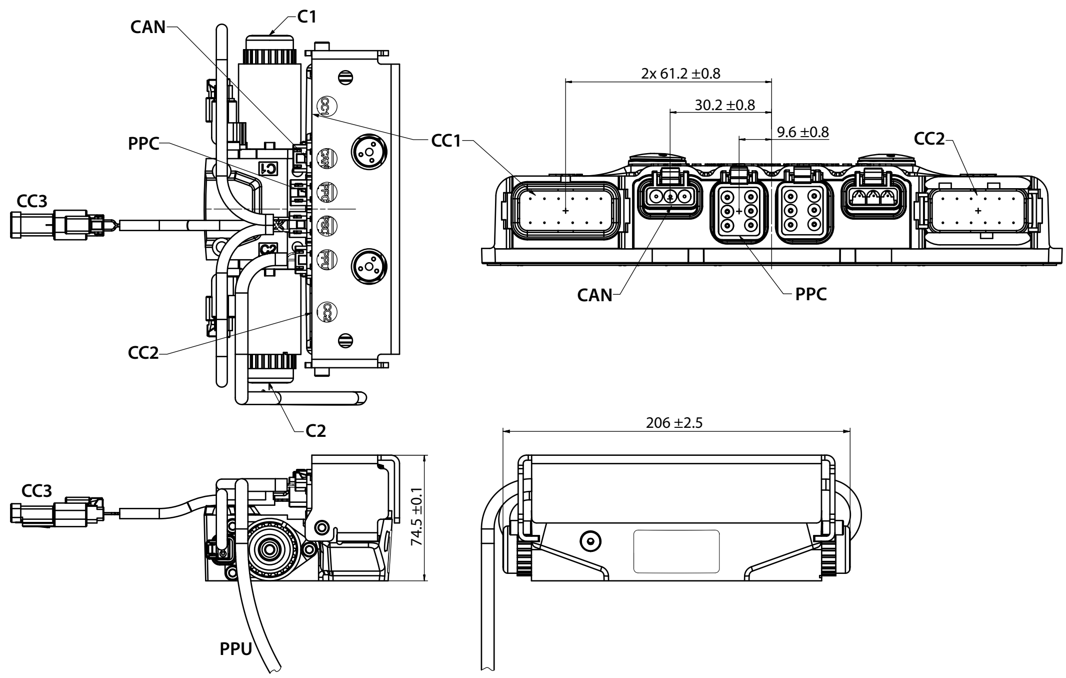
Connectors description

Port	Description
C1 and C2	**1.** Control manual override **C1** **2.** Control Manual Override **C2**
CC1	Port A control connector DEUTSCH DTM04-12P; paint free
CC2	Port B control connector DEUTSCH DTM04-12P; paint free
CC3	Control connector DEUTSCH DT06-2S; paint free; For using connector, the plug may be removed.
CAN	Control connector DEUTSCH DTM04-3P; paint free; For using connector, the plug may be removed.

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

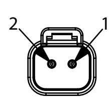
AC connectors dimensions



PPU wire harness is factory installed to speed sensor.

CC3

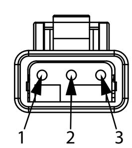
Connector DEUTSCH, 2-pin



1. Digital output A1 (+)
2. Digital output A2 (-)

CAN

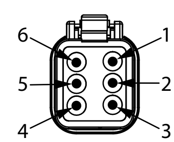
Connector DEUTSCH, 3-pin



1. CAN High
2. CAN Low
3. CAN Shield

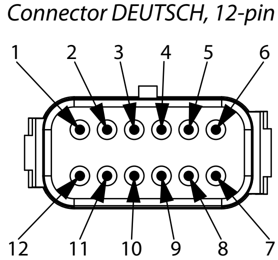
PPC

Connector DEUTSCH, 6-pin



1. Sensor A (+)
2. Analog input A
3. Sensor A (-)
4. Sensor B (-)
5. Analog input B
6. Sensor B (+)

Connector DEUTSCH, 12-pin



CC1

1. Battery (-)
2. Battery (+)
3. Sensor (+)
4. Sensor (-)
5. Motor rpm input (frequency)
6. Forward input (digital)
7. Reverse input (digital)
8. Sensor (+)
9. Sensor (-)
10. Drive pedal input (analog – nominal)
11. Drive pedal input (analog – red)
12. Neural input (digital)

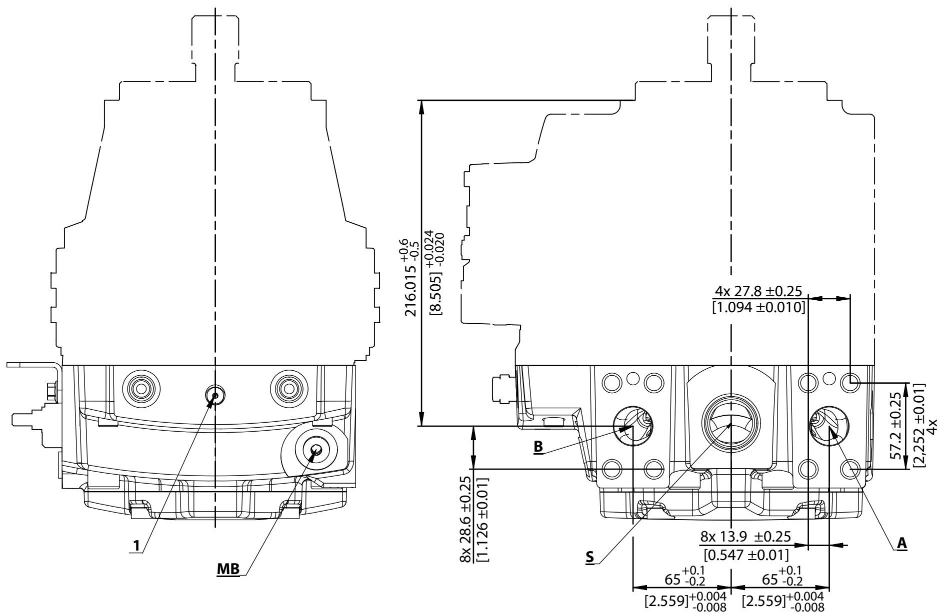
CC2

1. Inch input (analog – red)
2. Mode switch B input (digital – nominal)
3. Motor prop/PCOR driver
4. Motor direction input (analog)
5. Sensor (+)
6. Sensor (-)
7. Inch input (analog – nominal)
8. Motor BPD driver
9. Digital output B2 (-)
10. Digital output B1 (+)
11. Mode switch A input (digital)
12. Mode switch B input (digital – red)

Dimensions and Data

Filtration

H1P 69/78 Suction Filtration Option L



A System port split flange boss per ISO 6162; M12 x 1.75, 20 min full thread depth

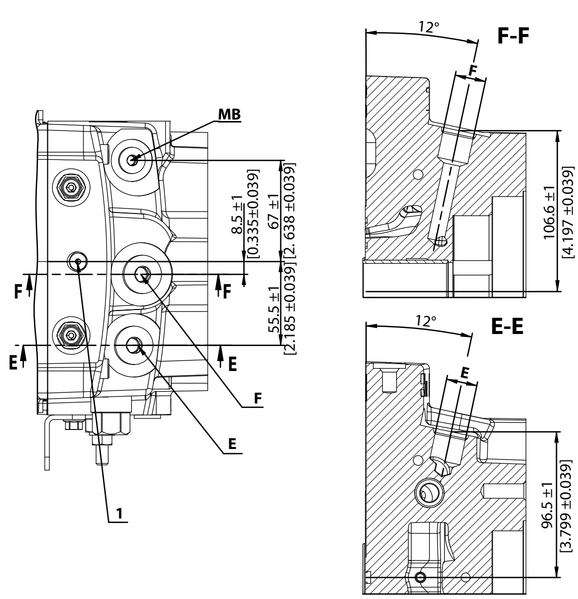
B System port split flange boss per ISO 6162; M12 x 1.75, 20 min. full thread depth

MB System B gauge port per ISO 1192601; 9/16-18

S Charge inlet port per ISO 11926-1; 1 5/16-12

H1P 69/78 Remote Full Charge Pressure Filtration Option P

Remote Filtration for end cap option F5 (SAE-C PTO)



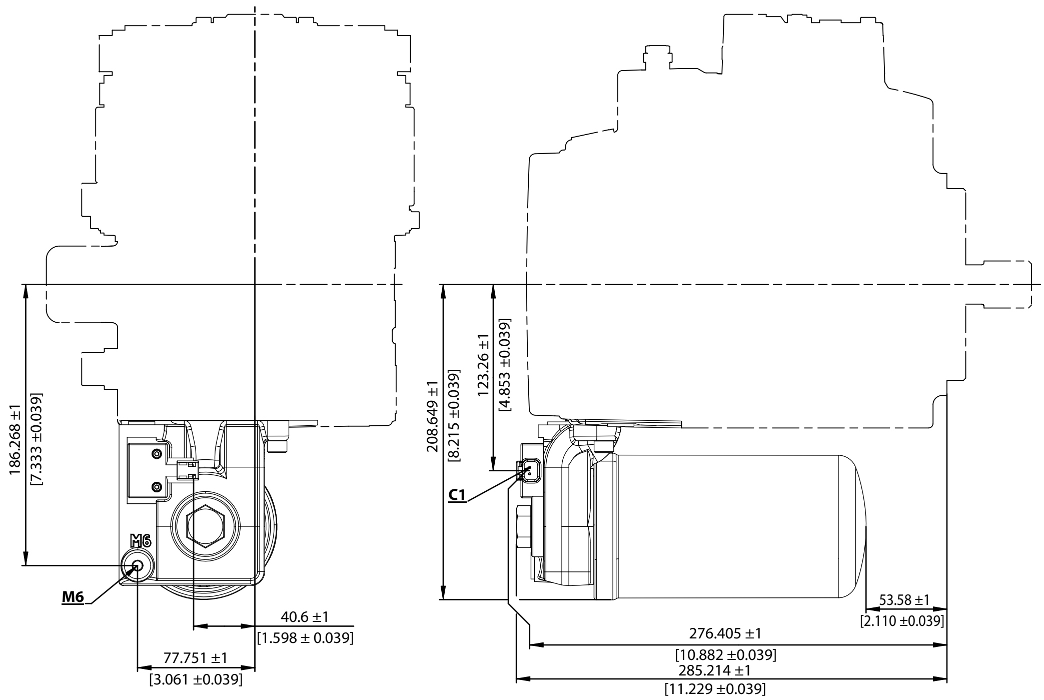
E Charge filtration port per ISO 11926-1; 7/8-14 from filter

Dimensions and Data

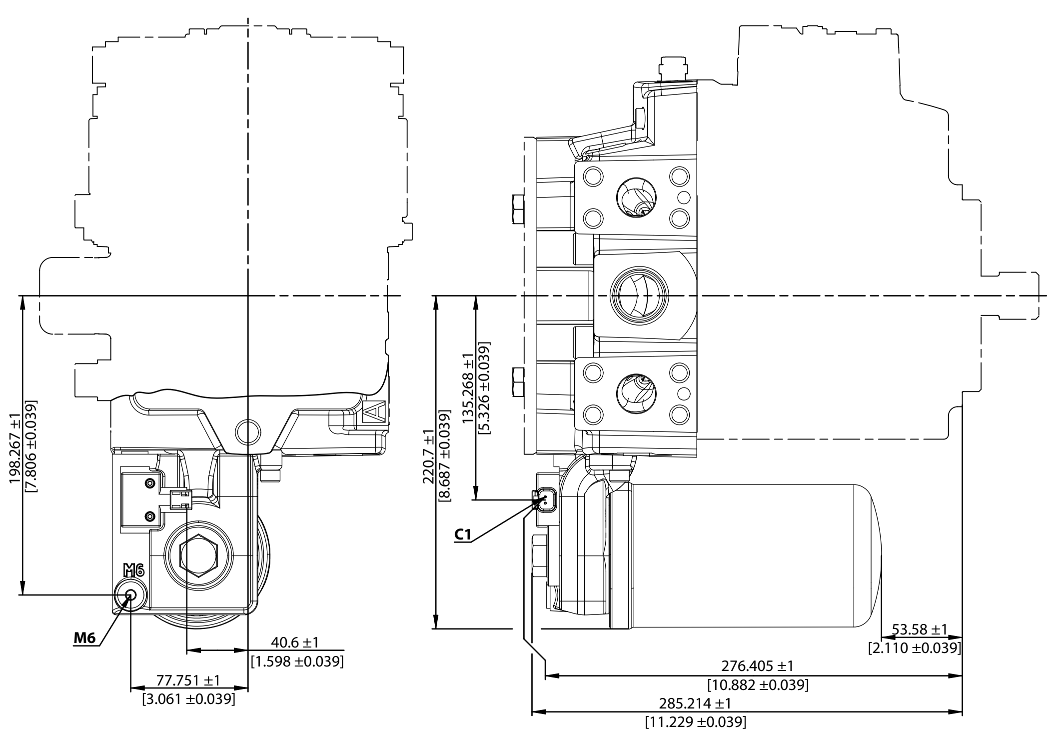
F	Charge filtration port per ISO 11926-1; 7/8-14 to filter
MB	System B gauge port per ISO 11926-1; 9/16-18

Integral Full Flow Charge Pressure Filtration, Option M

Integral filtration with filter bypass sensor, option M, for end cap option D3



Integral charge filtration with filter bypass sensor, option M, for end cap option F4 (SAE-C PTO)

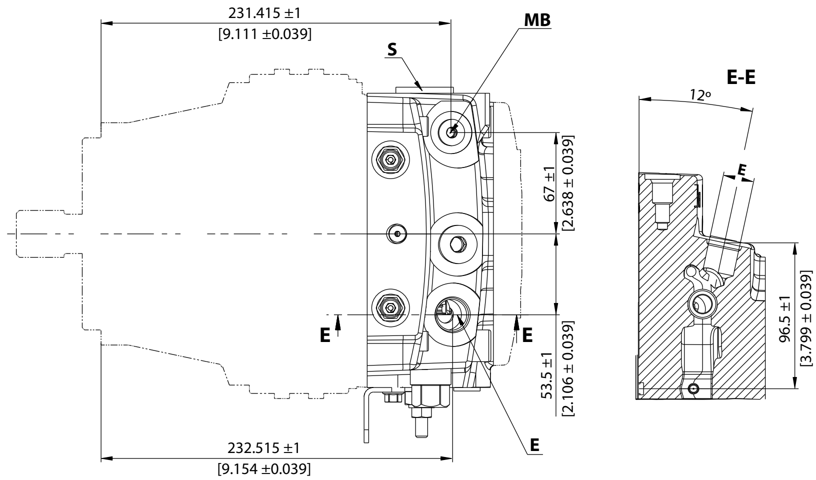


Dimensions and Data

Please contact Danfoss representative for specific installation drawings.

External Full Flow Charge Pressure Filtration, Option S

External filtration, option S for end cap options D8 or F5



E	Charge filtration ports per ISO 11926-1: $^7/_8$–14 from filter
MB	System gauge port per ISO 11926-1: $^9/_{16}$–18
S	Charge inlet port per ISO 11926-1: 1$^5/_{16}$–12

Please contact Danfoss representative for specific installation drawings.

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ENGINEERING TOMORROW

Danfoss

Technical Information

H1P 089/100
Axial Piston Single Pumps

www.danfoss.com

Revision history

Table of revisions

Date	Changed	Rev
May 2022	Corrected HDC control information	1401
December 2021	Added HDC control	1301
April 2021	Corrected interface with ECU (EDC) graphic	1208
January 2021	Corrected unit conversion errors	1207
June 2020	Corrected E/F charge filtration port size	1206
April 2020	Corrected swash plate angle sensor connector and CCO connector descriptions	1205
February 2020	Added NFPE options and changed document number from BC00000067	1204
September 2019	G3 Input shaft option added.	1102
June 2019	Major revision.	1101
May 2018	Angle sensor for EDC; FDC note added.	1001
June 2017	port size changes	0902
May 2017	NFPE gen. 3 changes.	0901
November 2015	Master Model Code changes.	0800
2010-2014	Various changes.	BA-GB
Aug 2009	First edition	AA

Contents

Technical Specifications

H1 Pumps General Specification....6
H1P 089/100 Technical Data....6
H1P 089/100 Operating Parameters....7
Fluid Specification....8
H1P 089/100 Mounting Flange Loads....8
Bearing Life and External Radial Shaft Loads....9
Charge pump....10
Charge Pump Selection....10
20/24 cm^3 Charge Pump – Flow and Power Curves....10

Master Model Code

Displacement, A—Rotation, B—Product Version, Z—Port Configuration....11
D—Controls....12
Electronic Displacement Controls....12
Fan Drive Controls....12
Forward-Neutral-Reverse (FNR) Controls....12
Non-Feedback Proportional Electric (NFPE) Controls....12
Automotive Controls....13
Manual Displacement Control....13
Hydraulic Displacement Control....13
F—Orifices, E—Displacement Limiters....14
G—Endcap....15
H—Mounting Flange, J—Input Shaft, K—Aux Pad....16
M, N—Overpressure Protection Settings....17
S—Charge Pump, T—Filtration, V—Charge Pressure Relief....18
W—Special Hardware, X—Paint, Y—Special Features....19

Control Options

Electrical Displacement Control (EDC)....20
EDC Operation....20
Control signal requirements, EDC 089/100....21
Control Solenoid Data....21
Single Pump Output Flow Direction....21
Connector....22
Control response....22
Response Time, EDC 089/100....22
Manual Displacement Control (MDC)....23
MDC operation....24
MDC shaft rotation....24
MDC Torque....25
Control response....25
Response time, MDC 089/100....25
Neutral start switch (NSS)....26
Connector....26
Case Gauge Port M14....26
Lever....26
Hydraulic Displacement Control (HDC)....27
HDC principle....27
HDC operation....27
Hydraulic signal pressure range....28
Pump output flow direction vs. control pressure....28
Control response....28
Response time, HDC 089/100....29
Forward-Neutral-Reverse Control (FNR)....30
FNR Solenoid Data....31
Single Pump Output Flow Direction....31
Connector....31
Control response....32
Response Time, FNR 089/100....32

Contents

Non feedback proportional electric control (NFPE)....33
Control Signal Requirements, NFPE 089/100....33
Control Solenoid Data....34
Single Pump Output Flow Direction....34
Connector....34
Control response....35
Response Time, NFPE 089/100....35
Automotive Control (AC)....36
Mode types....36
Basic functions....36
Performance functions....37
Protection and safety functions....37
Engine control and protection....37
Installation features....37
Fan Drive Control (FDC)....38
Control Signal Requirements, FDC 089/100....39
Control Solenoid Data....39
Single Pump Output Flow Direction....40
Connector....40
Control response....40
Response Time, FDC 089/100....40
Manual Override (MOR)....41
Swashplate angle sensor for EDC controls....42
Swash plate angle sensor parameters (EDC)....42
Swashplate Angle Sensor Connector....43
Interface with ECU (EDC)....43
Swash Plate Angle Sensor for NFPE and AC2 Controls....44
Swash Plate Angle Characteristic....44
Swash Plate Angle Sensor Parameters (NFPE/AC)....45
Swash Plate Angle Sensor Connector (NFPE)....45
Interface with ECU (NFPE)....46
Control Cut Off Valve (CCO)....46
Brake gauge port with MDC....47
CCO Connector (MDC)....48
H1P CCO Connector (EDC, NFPE)....48
CCO solenoid data....48
Displacement Limiter....49
H1P 089/100 Displacement Change (approximately)....49

Dimensions and Data

H1P 089/100 Input Shaft Option G1 (SAE C, 14 teeth)....50
H1P Input Shaft Option G3 (SAE C, 13 teeth)....51
H1P 089/100 Input Shaft Option G9 (SAE C-C, 23 teeth)....52
H1P 089/100 Input Shaft Option F1 (SAE C, 21 teeth)....53
H1P 089/100 Input Shaft Option F4, Code 38–3....54
Tapered shaft customer acknowledgement....54
H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth)....55
H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth)....56
H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth)....57
H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth)....58
H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth)....59
H1P 089/100 Auxiliary Mounting, Option S1 (SAE B-B, 14 teeth)....60
H1P Displacement Limiter, Option B....61
Single Pump Ports....62
H1P Dimensions....63
Controls....66
EDC Options A2 and A3 (12/24 V)....66
EDC with MOR, Options A4 and A5 (12/24 V)....67
EDC with CCO (key C), Options E7 and E8 (12/24 V)....68
EDC with ASNSR, Options: H2 and H3 (12/24 V)....69

Contents

EDC with MOR and ASNSR, Options H6 and H7 (12/24 V)........ 70
EDC with CCO and ASNSR, Options H8 and H9 (12/24 V)........ 71
MDC Option: M1........ 72
MDC with Neutral Start Switch Option: M2........ 73
MDC with CCO, Options: M3, M4........ 74
MDC with NSS and CCO Options: M5, M6........ 75
HDC, Options: T1, T2........ 76
NFPE with MOR, Options: N1, N2 (12/24 V)........ 77
NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V)........ 78
NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V)........ 79
NFPE with MOR and CCO, Options: N7, N8 (12/24 V)........ 80
FDC Options: F1, F2 (12/24V)........ 81
Automotive control (AC)........ 82
AC connectors dimensions........ 83
Filtration........ 84
Suction Filtration Option L........ 84
Remote Full Flow Charge Pressure Filtration Option P........ 85
Integral Full Flow Charge Pressure Filtration, Option M........ 86
External Full Flow Charge Pressure Filtration, Option S........ 87

Technical Specifications

H1 Pumps General Specification

Axial piston closed circuit variable displacement pumps of cradle swash-plate design with clockwise or counterclockwise direction of rotation.

Pipe connections

- Main pressure ports: ISO split flange boss
- Remaining ports: SAE straight thread O-ring boss

Recommended installation position

Pump installation position is discretionary, however the recommended control position is on the top or at the side with the top position preferred. If the pump is installed with the control at the bottom, flushing flow must be provided through port M14 located on the EDC, FNR and NFPE control.

Vertical input shaft installation is acceptable. If input shaft is at the top, 1 bar case pressure must be maintained during operation. The housing must always be filled with hydraulic fluid. Recommended mounting for a multiple pump stack is to arrange the highest power flow towards the input source. Consult Danfoss for nonconformance to these guidelines.

Auxiliary cavity pressure

Auxiliary cavity pressure will be inlet pressure with internal charge pump or case pressure with external charge supply. For reference see Operating Parameters. Please verify mating pump shaft seal capability.

H1P 089/100 Technical Data

Feature	Size 089	Size 100
Displacement	89.2 cm^3 [5.44 in^3]	101.7 cm^3 [6.21 in^3]
Flow at rated speed (continuous)	294 l/min [77.7 US gal/min]	335 l/min [88.5 US gal/min]
Torque at maximum displacement (theoretical)	1.42 N•m/bar [870 lbf•in/1000 psi]	1.62 N•m/bar [990 lbf•in/1000 psi]
Mass moment of inertia of rotating components	0.0116 kg•m^2 [0.0086 slug•ft^2]	0.0116 kg•m^2 [0.0086 slug•ft^2]
Mass (dry–no charge pump)	62 kg [137 lb]	62 kg [137 lb]
Oil volume	2.6 l [0.67 US gal]	2.6 l [0.67 US gal]

Shaft, flange and ports description

Input shaft per ISO 3019-1 (outer diameter)	• Outer Ø32 mm – 4 (SAE C, 14 teeth) • Outer Ø35 mm – 4 (SAE C, 21 teeth) • Outer Ø38 mm – 4 (SAE C-C, 23 teeth) • Conical keyed shaft end similar to ISO 3019-1 code 38-3, taper 1:8
Mounting flange per ISO 3019-1	Flange 127-4 (SAE C)
Auxiliary mounting flange with metric fasteners, with shaft outer diameter	• Flange 82-2 (SAE A: 9 teeth and 11 teeth) • Flange 101-2 (SAE B, 13 teeth and SAE B-B, 15 teeth) • Flange 127-4 (SAE C, 14 teeth)
Suction port per ISO 3019-1	ISO 11926-1 – 1 5⁄8 -12 (SAE O-ring boss)
Main configuration port	Ø25.4 mm; M12 x 1.75; 20 min. full thread depth
Case drain ports L2, L4 per ISO 3019-1	ISO 11926-1 – 1 $^{5}/_{16}$–12
Other ports	SAE O-ring boss
Customer interface threads	Metric fasteners

Technical Specifications

H1P 089/100 Operating Parameters

Parameter		Unit	Size 089/100
Input speed	**Min. for internal[1] and external[2] charge supply**	min^{-1} (rpm)	500
	Min. for full performance, internal charge supply		1200
	Rated		3300
	Maximum		3800
System pressure	**Maximum working**	bar [psi]	450 [6528]
	Maximum		480 [6960]
	Max./Min. low loop		45/10 [650/145]
Charge pressure	**Minimum**	bar [psi]	18 [261]
	Maximum		34 [493]
Control pressure	**Minimum (at corner power for EDC, MDC, FNR)**		17 [247]
	Minimum (at corner power for NFPE, FDC, AC)		25 [363]
	Maximum		40 [580]
Charge pump inlet pressure	**Rated**	bar (absolute) [in Hg vacuum]	0.7 [9.0]
	Minimum (cold start)		0.2 [24.0]
	Maximum	bar [psi]	4.0 [58.0]
Case pressure	**Rated**		3.0 [44.0]
	Maximum		5.0 [73.0]
Lip seal maximum pressure (external)			0.4 [5.8]

[1] Performance (displacement and pressure) may be limited due to limited control pressure.

[2] Full performance (displacement and pressure) possible at minimum charge and control pressure supply.

Filtration, cleanliness level and β_x-ratio (recommended minimum)

Cleanliness per ISO 4406	22/18/13
Efficiency β_x (charge pressure filtration)	$\beta_{15-20} = 75$ ($\beta_{10} \geq 10$)
Efficiency β_x (suction and return line filtration)	$\beta_{35-45} = 75$ ($\beta_{10} \geq 2$)
Recommended inlet screen mesh size	100 – 125 µm

Technical Specifications

Fluid Specification

Viscosity

Intermittent[1]	5 mm^2/s [42 SUS]
Minimum	7 mm^2/s [49 SUS]
Recommended range	12 – 80 mm^2/s [66 – 370 SUS]
Maximum	1600 mm^2/s [7500 SUS]

[1] Intermittent = Short term t < 1 min per incident and not exceeding 2 % of duty cycle based load-life.

Temperature

Minimum [1]	-40°C [-40°F]
Rated	104°C [220°F]
Recommended range[2]	60 – 85°C [140 – 185°F]
Maximum Intermittent	115°C [240°F]

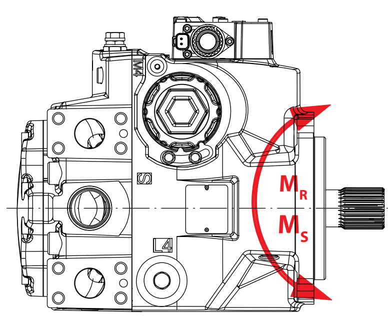
[1] Cold start = Short term t > 3 min, p ≤ 50 bar [725 psi], n ≤ 1000 min-1 (rpm).

[2] At the hottest point, normally case drain port.

H1P 089/100 Mounting Flange Loads

The Rated and Shock load moments apply for top or side orientation of control.

Mounting flange load with control on top



Rated moment	M_R = 5630 N•m [49 830 lbf•in]
Shock load moment	M_S = 12 190 N•m [107 900 lbf•in]

For more information, see *H1 Axial Piston Pumps, Basic Information,* **BC152886483968**, the section "Mounting flange loads".

Technical Specifications

Bearing Life and External Radial Shaft Loads

All external shaft loads affect bearing life. The pumps are designed with bearings that can accept some external radial loads. The external radial shaft load limits are a function of the load position and orientation, and the operating conditions of the unit.

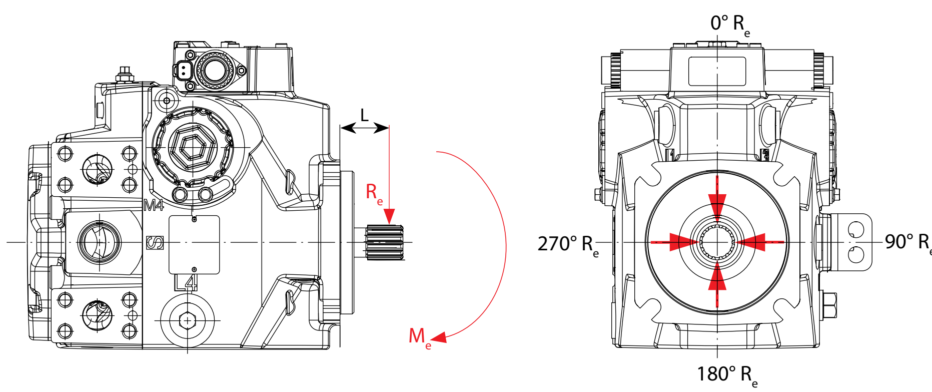
Danfoss recommends clamp-type couplings for applications with radial shaft loads. Contact your Danfoss representative for an evaluation of unit bearing life if you have continuously applied external loads exceeding 25 % of the maximum allowable radial load (R_e) or the pump swash-plate is positioned on one side of center all or most of the time.

Maximum external shaft load based on shaft deflection

External radial moment	Unit	Size 089/100
M_e	N•m [lbf•in]	118 [1044]

External radial shaft loads impact lifetime. For lifetime calculations please contact your Danfoss representative. In applications with external shaft loads, minimize the impact by positioning the load at 0° or 180° as shown below.

Radial load position



The maximum allowable radial shaft load (R_e) is based on the maximum external moment (M_e) and the distance (L) from the mounting flange to the load. It may be determined using the following formula:

$$\mathbf{R_e} = \frac{\mathbf{M_e}}{\mathbf{L}}$$

Thrust loads should be avoided. Contact your Danfoss representative in the event thrust loads are anticipated.

Technical Specifications

Charge pump

Charge Pump Selection

In most applications a general guideline is that the charge pump displacement should be at least 10% of the total displacement of all components in the system. Unusual application conditions may require a more detailed review of charge flow requirements. System features and conditions which may invalidate the 10% guideline include (but are not limited to):

- Continuous operation at low input speeds < 1500 min^{-1} (rpm)
- High shock loading and/or long loop lines
- High flushing flow requirements
- Multiple low speed high torque motors
- High input shaft speeds

Contact your Danfoss representative for application assistance if your application includes any of these conditions.

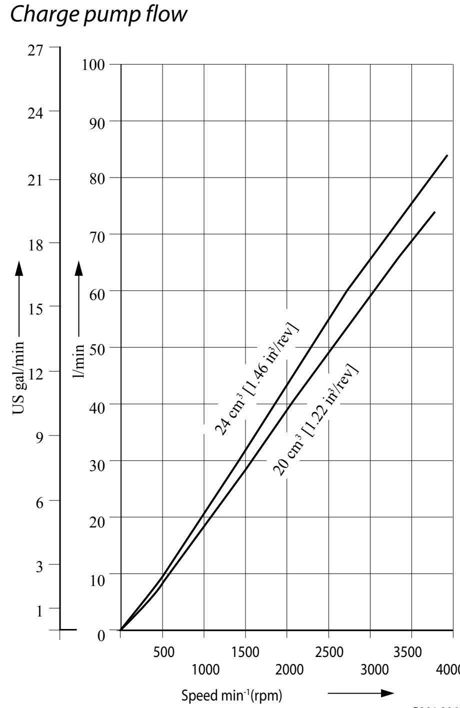
For more information, see *Selection of Drive line Components*, **BC157786484430**.

20/24 cm^3 Charge Pump – Flow and Power Curves

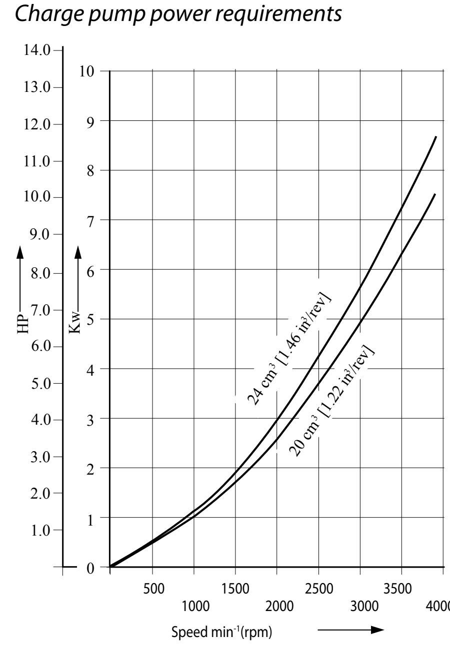
Charge pump flow and power requirements curves shown below at the following conditions:

Charge pressure = 20 bar [290 psi]
Viscosity = 11 mm^2/s [63 SUS]
Temperature = 80°C [176°F]

Charge pump flow

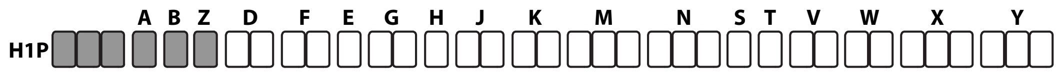


Charge pump power requirements



Master Model Code

Displacement, A—Rotation, B—Product Version, Z—Port Configuration



Displacement

089	89.2 cm^3 [5.44 in^3]
100	101.7 cm^3 [6.21 in^3]

A – Direction of Rotation

L	Left hand (counter clockwise)
R	Right hand (clockwise)

B – Product version

B	Revision code

Z – Port configuration

A	Inch, Customer O-ring port sealing according to ISO 11926-1

Master Model Code

D—Controls

A B Z D F E G H J K M N S T V W X Y

H1P

Electronic Displacement Controls

Code	Control type	Voltage	MOR	CCO with key C	Angle sensor	Connector
A2	EDC	12 V	—	—	—	DEUTSCH
A3	EDC	24 V	—	—	—	DEUTSCH
A4	EDC	12 V	●	—	—	DEUTSCH
A5	EDC	24 V	●	—	—	DEUTSCH
E7	EDC	12 V	—	●	—	DEUTSCH
E8	EDC	24 V	—	●	—	DEUTSCH
H2	EDC	12 V	—	—	●	DEUTSCH
H3	EDC	24 V	—	—	●	DEUTSCH
H6	EDC	12 V	●	—	●	DEUTSCH
H7	EDC	24 V	●	—	●	DEUTSCH
H8	EDC	12 V	—	●	●	DEUTSCH
H9	EDC	24 V	—	●	●	DEUTSCH

● – To be used for the control; — Not to be used for the control

Fan Drive Controls

F1	FDC	12 V	DEUTSCH Connector
F2	FDC	24 V	DEUTSCH Connector

Align with options: **F:** Orifices, **E:** Displacement limiters, **M, N:** Overpressure protection, and **W:** Special hardware.

Forward-Neutral-Reverse (FNR) Controls

A9	FNR	12 V	with MOR	DEUTSCH Connector
B1	FNR	24 V	with MOR	DEUTSCH Connector

Non-Feedback Proportional Electric (NFPE) Controls

Code	Control type	Voltage	MOR	CCO with key C	Angle sensor	Connector
N1	NFPE	12 V	●	—	—	DEUTSCH
N2	NFPE	24 V	●	—	—	DEUTSCH
N3	NFPE	12 V	●	●	●	DEUTSCH
N4	NFPE	24 V	●	●	●	DEUTSCH
N5	NFPE	12 V	●	—	●	DEUTSCH
N6	NFPE	24 V	●	—	●	DEUTSCH
N7	NFPE	12 V	●	●	—	DEUTSCH
N8	NFPE	24 V	●	●	—	DEUTSCH

Align with options: **E:** Displacement limiters and **W:** Special hardware.

Master Model Code

Automotive Controls

Automotive Control (AC)

Code	AC type	Voltage	MOR	Speed sensor	Wire harness	Angle sensor	Connector
P6	AC–1	12 V	●	●	●	—	DEUTSCH
P7	AC–1	24 V	●	●	●	—	DEUTSCH
P8	AC–2	12 V	●	●	●	●	DEUTSCH
P9	AC–2	24 V	●	●	●	●	DEUTSCH
P5	AC–1	12 V	●	—	—	—	DEUTSCH
R3	AC–1	24 V	●	—	—	—	DEUTSCH
R4	AC–2	12 V	●	—	—	●	DEUTSCH
R5	AC–2	24 V	●	—	—	●	DEUTSCH

● – To be used for the control; — Not to be used for the control

Manual Displacement Control

Manual Displacement Control (MDC)

Code	Control type	CCO Voltage	CCO	Neutral Start Switch	Connector
M1	MDC	—	—	—	—
M2	MDC	—	—	●	DEUTSCH
M3	MDC	12 V	●	—	DEUTSCH
M4	MDC	24 V	●	—	DEUTSCH
M5	MDC	12 V	●	●	DEUTSCH
M6	MDC	24 V	●	●	DEUTSCH

Align with options **F:** Orifices and **Y:** Settings for adjustment (if applicable).

Hydraulic Displacement Control

Hydraulic Displacement Control (HDC)

Code	Pressure range	Ports
T1	4.2 - 16.2 bar	Inch ports 9/16-18
T2	3.0 - 11.6 bar	Inch ports 9/16-18

Master Model Code

F—Orifices, E—Displacement Limiters

A B Z D F E G H J K M N S T V W X Y

H1P

F – Orifices Options

Orifices options related to control type

Code	Tank (A+B)	P orifice	A/B orifices	EDC, FNR	MDC	NFPE, AC	FDC
C3	No orifice			●	●	–	–
C1	–	–	0.8 mm	●	●	●	–
C2	–	–	1.3 mm	●	●	●	●
C4	–	–	1.8 mm	●	●	●	–
C6	1.0 mm	–	–	–	●	–	
C7	1.3 mm	–	–	–	●	–	–
D1	0.8 mm	1.0 mm	–	–	●	–	–
D2	0.8 mm	1.3 mm	–	–	●	–	–
D3	1.0 mm	1.3 mm	–	–	●	–	–
D4	1.0 mm	1.3 mm	1.3 mm	–	●	–	–
D5	0.6 mm	0.6 mm	0.8 mm	–	●	–	–
D6	1.3 mm	1.3 mm	–	–	●	–	–
D7	–	–	3.0 mm	–	–	●	–

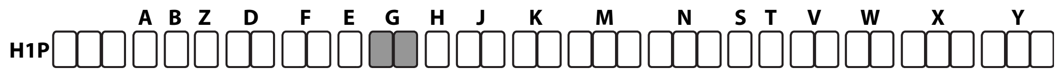
E – Displacement Limiter Options

N	None
B	Adjustable externally
C	No limiters, with nested springs, required for NFPE, AC, FDC*
D	Adjustable externally with nested springs, required for NFPE, AC, FDC*

* Align with option **Y:** Settings for adjustment (if applicable).

Master Model Code

G—Endcap



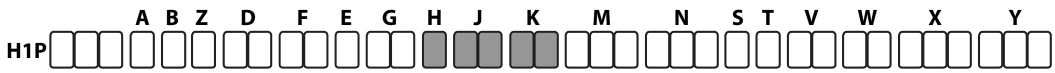
G – End-cap Options

Twin port, ISO 6162 split flange ports; Align with T: Filtration

D3	Integral pressure filtration
D6	Suction filtration
D8	Remote filtration or external charge supply

Master Model Code

H—Mounting Flange, J—Input Shaft, K—Aux Pad



H – Mounting options

Mounting to be aligned with option W: Special hardware

H	ISO 3019-1 flange 127–4 (SAE C)
K	ISO 3019-1 flange 127–4 (SAE C), 4-bolt, with speed sensor

J – Input Shaft options

G1	ISO 3019-1, outer Ø32 mm - 4 (14 teeth splined shaft 12/24 pitch)
G3	ISO 3019-1, outer Ø44 mm - 4 (13 teeth splined shaft 8/16 pitch)
G9	ISO 3019-1, outer Ø38 mm - 4 (23 teeth splined shaft 16/32 pitch
F1	ISO 3019-1, outer Ø35 mm - 4 (21 teeth splined shaft 16/32 pitch)
F4	Conical keyed shaft end, code 38-3 (similar to ISO 3019-1), taper 1:8 (key not supplied with pump)

K – Auxiliary Mounting Pad options (ISO 3019-1)

NN	None
H1	Flange 82–2 (SAE A, 11 teeth, 16/32 coupling); shipping cover
H2	Flange 82–2 (SAE A, 9 teeth, 16/32 coupling); shipping cover
H3	Flange 101–2 (SAE B, 13 teeth, 16/32 coupling); shipping cover
H5	Flange 101–2 (SAE B-B, 15 teeth, 16/32 coupling); shipping cover
H6	Flange 127–4 (SAE C, 14 teeth, 12/24 coupling); shipping cover

Master Model Code

M, N—Overpressure Protection Settings

A B Z D F E G H J K M N S T V W X Y

H1P

M and N – Overpressure protection options

L	Pressure limiter setting	HPRV with bypass setting[1]
L15	150 bar [2900 psi]	230 bar [3336 psi]
L18	180 bar [2610 psi]	230 bar [3336 psi]
L20	200 bar [2900 psi]	250 bar [3630 psi]
L23	230 bar [3336 psi]	280 bar [4061 psi]
L25	250 bar [3630 psi]	300 bar [4350 psi]
L28	280 bar [4061 psi]	330 bar [4786 psi]
L30	300 bar [4350 psi]	350 bar [5076 psi]
L33	330 bar [4786 psi]	380 bar [5510 psi]
L35	350 bar [5080 psi]	400 bar [5800 psi]
L38	380 bar [5510 psi]	420 bar [6090 psi]
L40	400 bar [5800 psi]	450 bar [6526 psi]
L42	420 bar [6090 psi]	450 bar [6526 psi]
L43	430 bar [6237 psi]	480 bar [6962 psi]
L44	440 bar [6382 psi]	480 bar [6962 psi]
L45	450 bar [6526 psi]	480 bar [6962 psi]
Overpressure protection type and setting for FDC		
F01	150 bar [2175 psi]	250 bar [3630 psi]
F02	150 bar [2175 psi]	300 bar [4350 psi]
F03	150 bar [2175 psi]	350 bar [5076 psi]

[1] Pressure limiter and HPRV with bypass, over-pressure protection type must be the same for both sides "A" and "B".

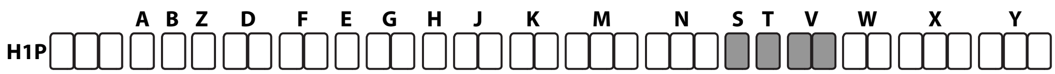
K	Pressure setting [1]
K18	180 bar [2610 psi]
K20	200 bar [2900 psi]
K23	230 bar [3336 psi]
K25	250 bar [3630 psi]
K28	280 bar [4061 psi]
K30	300 bar [4350 psi]
K33	330 bar [4786 psi]
K35	350 bar [5076 psi]
K38	380 bar [5510 psi]
K40	400 bar [5800 psi]
K42	420 bar [6090 psi]
K45	450 bar [6526 psi]

[1] Pressure limiter and HPRV with bypass, over-pressure protection type must be the same for both sides "A" and "B".

Master Model Code

Please contact Danfoss Power Solutions for pressures not shown or for applied pressure above max. working pressure.

S—Charge Pump, T—Filtration, V—Charge Pressure Relief



S – Charge pump options

D	20 cm^3/rev [1.22 in^3/rev]
M	24 cm^3/rev [1.46 in^3/rev]
N	No charge pump, external charge supply (*Align with options:* **E, T**)

T – Filtration options

Filtration to be aligned with G: End cap selection

L	Suction filtration
M	Integral full charge flow filtration with bypass sensor, medium filter length **11004918**
N	Integral full charge flow filtration with bypass sensor, without filter
P	Remote full charge flow filtration
E	External full charge flow filtration (Align with options **N, S**)

V – Charge pressure relief valve (CPRV) setting

20*	20 bar [290 psi]
22*	22 bar [319 psi]
24*	24 bar [348 psi]
26	26 bar [377 psi]
28	28 bar [406 psi]
30	30 bar [435 psi]
32	32 bar [464 psi]
34	34 bar [493 psi]

* Not to be used for **NFPE, AC** and **FDC** controls.

Master Model Code

W—Special Hardware, X—Paint, Y—Special Features

	A	B	Z	D	F	E	G	H	J	K	M	N	S	T	V	W	X	Y
H1P																		

W – Special Hardware features

Hardware features to be aligned with options D, E

P1	NFPE/FDC valve plate
P2	NFPE/FDC/AC valve plate and speed ring on the cylinder block
P4	EDC/FNR/MDC valve plate and speed ring on the cylinder block
PN	EDC/FNR/MDC valve plate
H1	MDC/EDC/FNR valve plate with MDC handle

X – Paint and Name-tag

NNN	Black paint and Danfoss name-tag
C08	Paint none and Danfoss name-tag

Y – Special settings (SIL-2 non-certifiable, without customer files)

Code	CAN J1939	ECO fuel saving mode	Functional option	Cruise control	Control	AC type
D3E	in/out	●	E	–	N1 (12 V_{DC})	AC–1
D3F	in/out	–	F	–		
D4E	in/out	●	E	–	N2 (24 V_{DC})	
D4F	in/out	–	F	–		
D5F	in/out	–	F	–	P8 (12 V_{DC})	AC–2 (with swash plate angle sensor)
D5J	in/out	●	J	●		
D6F	in/out	–	F	–	P9 (24 V_{DC})	
D6J	in/out	●	J	●		
M00	MDC handle standard position					
NNN	None					

● – To be used for the control; — Not to be used for the control

Control Options

Electrical Displacement Control (EDC)

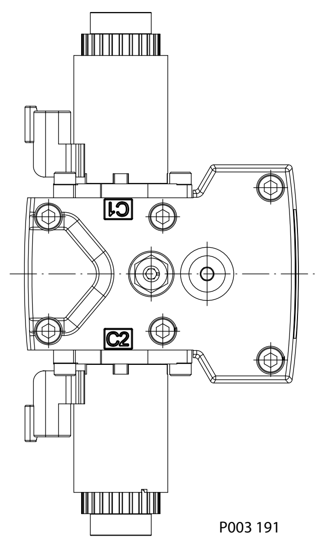
An EDC is a displacement (flow) control. Pump swash plate position is proportional to the input command and therefore vehicle or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The Electrical Displacement Control (**EDC**) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

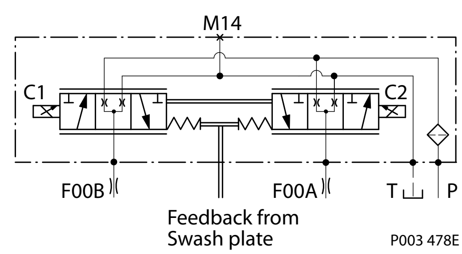
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

Electrical Displacement Control



EDC schematic, feedback from swash plate



EDC Operation

H1 EDC's are current driven controls requiring a Pulse Width Modulated (PWM) signal. Pulse width modulation allows more precise control of current to the solenoids.

The PWM signal causes the solenoid pin to push against the porting spool, which pressurizes one end of the servo piston, while draining the other. Pressure differential across the servo piston moves the swashplate.

A swashplate feedback link, opposing control links, and a linear spring provide swashplate position force feedback to the solenoid. The control system reaches equilibrium when the position of the swashplate spring feedback force exactly balances the input command solenoid force from the operator. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

The EDC incorporates a positive neutral deadband as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold current is reached, the swashplate is positioned directly proportional to the control current. To minimize the effect of the control neutral deadband, we recommend the transmission controller or operator input device incorporate a jump up current to offset a portion of the neutral deadband.

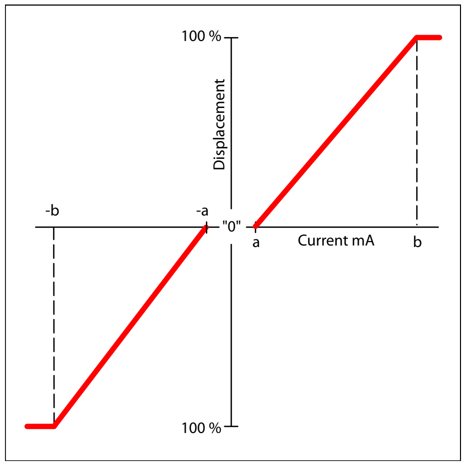
The neutral position of the control spool does provide a positive preload pressure to each end of the servo piston assembly.

When the control input signal is either lost or removed, or if there is a loss of charge pressure, the spring-loaded servo piston will automatically return the pump to the neutral position.

Control Options

Control signal requirements, EDC 089/100

Pump displacement vs. control current



EDC control current

Voltage		12 V_{DC}	24 V_{DC}
Minimum current to stroke pump	a*	640 mA	330 mA
	b	1640 mA	820 mA
Pin connections		any order	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Single Pump Output Flow Direction

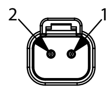
Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	out	in	in	out
Port B	in	out	out	in
Servo port pressurized	M4	M5	M4	M5

* For coil location see installation drawings.

Control Options

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, EDC 089/100

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	3.8 s	1.8 s	1.0 s
Full flow to neutral	2.2 s	1.0 s	0.6 s

Control Options

Manual Displacement Control (MDC)

A Manual proportional Displacement Control (**MDC**) consists of a handle on top of a rotary input shaft. The shaft provides an eccentric connection to a feedback link. This link is connected on its one end with a porting spool. On its other end the link is connected the pumps swashplate.

This design provides a travel feedback without spring. When turning the shaft the spool moves thus providing hydraulic pressure to either side of a double acting servo piston of the pump.

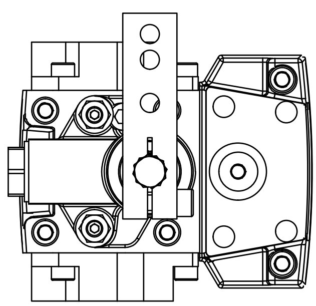
Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement. Simultaneously the swashplate movement is fed back to the control spool providing proportionality between shaft rotation on the control and swash-plate rotation. The MDC changes the pump displacement between no flow and full flow into opposite directions.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

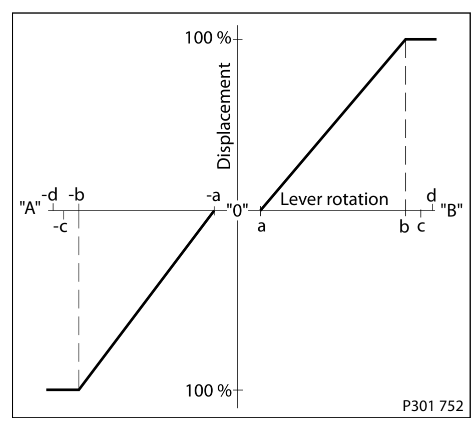
For the MDC with CCO option the brake port (X7) provides charge pressure when the coil is energized to activate static function such as a brake release. The X7 port must not be used for any continuous oil consumption.

The MDC is sealed by means of a static O-ring between the actuation system and the control block. Its shaft is sealed by means of a special O-ring which is applied for low friction. The special O-ring is protected from dust, water and aggressive liquids or gases by means of a special lip seal.

Manual Displacement Control



Pump displacement vs. control lever rotation



Deadband on **B** side: **a = 3° ±1°**
Maximum pump stroke: **b = 30° +2/-1°**
Required customer end stop: **c = 36° ±3°**
Internal end stop: **d = 40°**

Control Options

MDC operation

The MDC provides a mechanical dead-band required to overcome the tolerances in the mechanical actuation. The MDC contains an internal end stop to prevent turning the handle into any inappropriate position.

The MDC provides a permanent restoring moment appropriate for turning the MDC input shaft back to neutral position only. This is required to take the backlash out of the mechanical connections between the Bowden cable and the control.

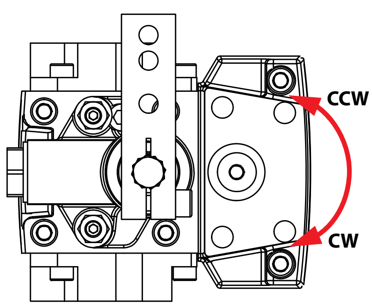
High case pressure may cause excessive wear and the NSS to indicate that the control is not in neutral position. In addition, if the case pressure exceeds 5 bar there is a risk of an insufficient restoring moment. The MDC is designed for a maximum case pressure of 5 bar and a rated case pressure of 3 bar.

- Customers must install some support to limit the setting range of their Bowden cable to avoid an overload of the MDC.
- Customers can apply their own handle design but they must care about a robust clamping connection between their handle and the control shaft and avoid overload of the shaft.
- Customers can connect two MDC's on a tandem unit in such a way that the actuation force will be transferred from the pilot control to the second control. The kinematic of the linkages must ensure that either control shaft is protected from torque overload.

Caution

Using the internal spring force on the input shaft is not an appropriate way to return the customer connection linkage to neutral, or to force a Bowden cable or a joystick back to neutral position. It is not applicable for any limitation of the Bowden cable stroke, except the applied torque to the shaft will never exceed 20 N•m.

MDC shaft rotation



Pump shaft rotation*	Clockwise (CW)		Counter-clockwise (CCW)	
MDC shaft rotation	**CW**	**CCW**	**CW**	**CCW**
Port A	in (low)	out (high)	out (high)	in (low)
Port B	out (high)	in (low)	in (low)	out (high)
Servo port high pressure	M5	M4	M5	M4

* As seen from shaft side.

Control Options

MDC Torque

Description	Value
Torque required to move handle to maximum displacement	1.4 N•m [12.39 lbf•in]
Torque required to hold handle at given displacement	0.6 N•m [5.31 lbf•in]
Maximum allowable input torque	20 N•m [177 lbf•in]

Caution

Volumetric efficiencies of the system will have impacts on the start and end input commands.

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response time, MDC 089/100

Code	Orifice description (mm)			Stroking direction	
	Tank (A+B)	P	A/B	Neutral to full flow	Full flow to neutral
C3	No orifice			0.5 s	0.6 s
C6	1	–	–	1.7 s	1.5 s
C7	1.3	–	–	1.1 s	1.0 s
D1	0.8	1	–	3.1 s	2.4 s
D2	0.8	1.3	–	2.8 s	2.2 s
D3	1	1.3	–	2.0 s	1.6 s
D4	1	1.3	1.3	2.4 s	1.9 s

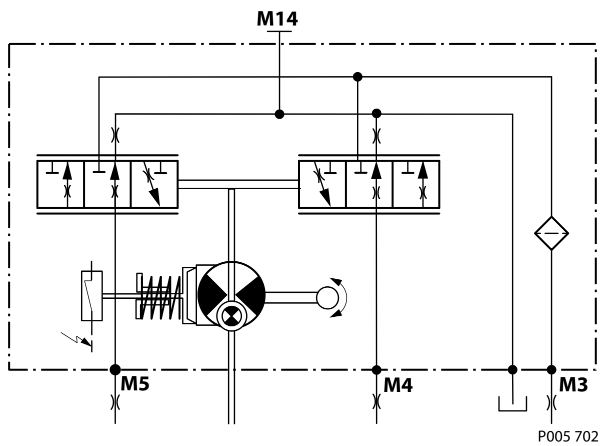
For further data please contact your Danfoss representative.

Control Options

Neutral start switch (NSS)

The Neutral Start Switch **(NSS)** contains an electrical switch that provides a signal of whether the control is in neutral. The signal in neutral is Normally Closed **(NC)**.

Neutral start switch schematic

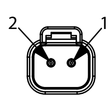


Neutral start switch data

Max. continuous current with switching	8.4 A
Max. continuous current without switching	20 A
Max. voltage	36 V_{DC}
Electrical protection class	IP67 / IP69K with mating connector

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Case Gauge Port M14

The drain port should be used when the control is mounted on the unit's bottom side to flush residual contamination out of the control.

Lever

MDC-controls are available with an integrated lever.

Control Options

Hydraulic Displacement Control (HDC)

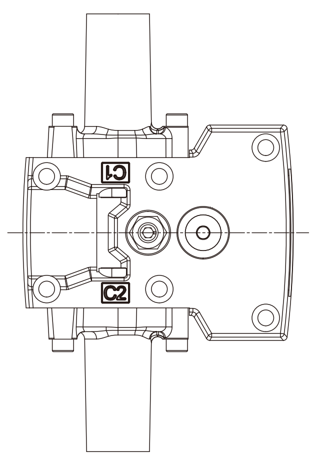
HDC principle

An HDC is a Hydraulic Displacement Control. Pump swashplate position is proportional to the input command and therefore vehicle speed or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The HDC control uses a hydraulic input signal to operate a porting spool, which ports hydraulic pressure to either side of a double acting servo piston. The hydraulic signal applies a force input to the spool which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction. Under some circumstances, such as contamination, the porting spool could stick and cause the pump to stay at some displacement.

A serviceable 175 µm screen is located in the supply line immediately before the control porting spool.

HDC control



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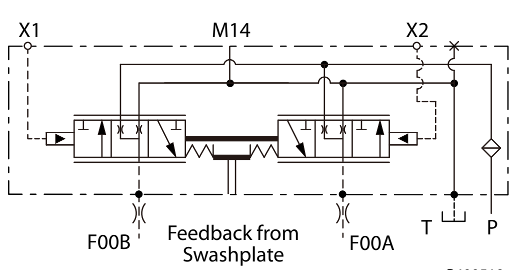
HDC schematic



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HDC operation

HDC's are hydraulically driven control which ports hydraulic pressure to either side of a porting spool, which pressurizes one end of the servo piston, while draining the other end to case. Pressure differential across the servo piston moves the swashplate.

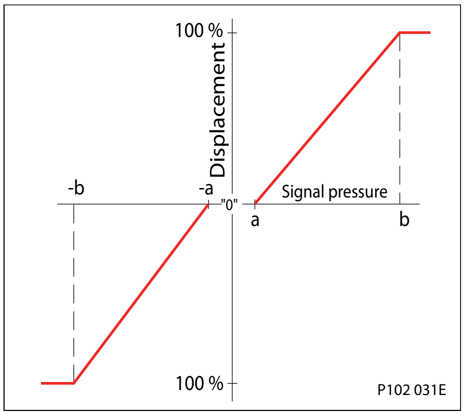
A swashplate feedback link, opposing control linkage, and a linear spring provide swashplate position force feedback to the hydraulic pressure. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

Control Options

The HDC incorporates a positive neutral dead band as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold point is reached, the swashplate is positioned directly proportional to the control pressure.

When the control input is either lost or removed, or if there is a loss of charge pressure, the spring loaded servo piston will automatically return the pump to the neutral position.

Pump displacement vs signal pressure



Hydraulic signal pressure range

Option	Type	a*	b*	Max. pressure
T1	Standard	4.2 bar	16.2 bar	30 bar
T2	Option	3 bar	11.6 bar	30 bar

* Factory test current, for vehicle movement or application actuation expect a higher or lower value.

Pump output flow direction vs. control pressure

Shaft rotation HDC	Clockwise (CW) seen from shaft		Counter Clockwise (CCW) seen from shaft	
Port energized	X1	X2	X1	X2
Port A	Out (high)	In (low)	In (low)	Out (high)
Port B	In (low)	Out (high)	Out (high)	In (low)
Servo port high pressure	M4	M5	M4	M5

For appropriate performance of HDC characteristic, keep the drain pressure of pilot valve to be equal or slightly higher than pump case pressure.

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Control Options

Response time, HDC 089/100

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	2.8s	1.3s	0.7s
Full flow to neutral	1.9s	0.9s	0.5s

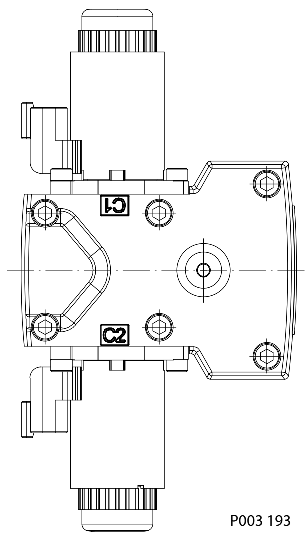
Control Options

Forward-Neutral-Reverse Control (FNR)

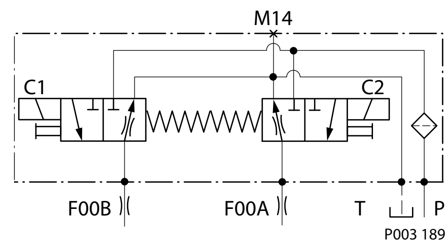
The 3-position FNR control options **A9** (12 V) and **B1** (24 V) uses an electric input signal to switch the pump to a full stroke position. A serviceable 125 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool can stick and cause the pump to stay at some displacement.

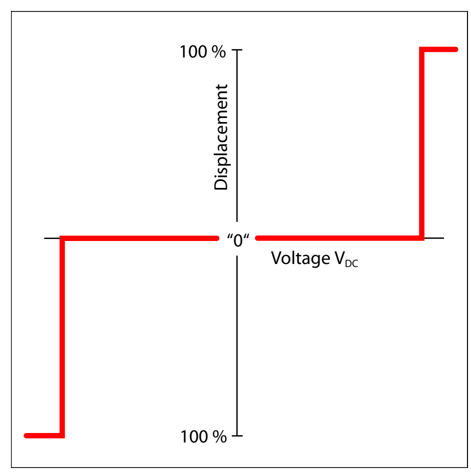
Forward-Neutral-Reverse electric control (FNR)



FNR hydraulic schematic



Pump displacement vs. electrical signal



FNR control current

Voltage	12 V_{DC}	24 V_{DC}
Minimum current to stroke pump	750 mA	380 mA
Pin connections	any order	

Control Options

FNR Solenoid Data

Solenoid data

Voltage	12 V_{DC}	24 V_{DC}
Minimum supply voltage	9.5 V_{DC}	19 V_{DC}
Maximum supply voltage (continuous)	14.6 V_{DC}	29 V_{DC}
Bi-directional diode cut off voltage	28 V_{DC}	53 V_{DC}
Maximum current	1050 mA	500 mA
Nominal coil resistance @ 20°C	8.4 Ω	34.5 Ω
PWM Range	70 – 200 Hz	
PWM Frequency (preferred)*	100 Hz	

* PWM signal required for optimum control performance.

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector

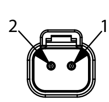
Single Pump Output Flow Direction

Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see installation drawings.

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control Options

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, FNR 089/100

Stroking direction	0.8 [0.03] orifice	1.3 [0.05] orifice	No orifice
Neutral to full flow	3.7 s	1.7 s	1.1 s
Full flow to neutral	3.0 s	1.3 s	0.6 s

Control Options

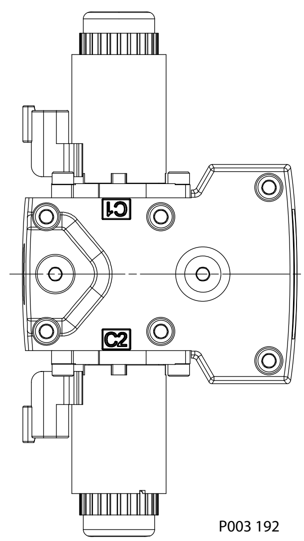
Non feedback proportional electric control (NFPE)

The Non Feedback Proportional Electric (**NFPE**) control is an electrical automotive control in which an electrical input signal activates one of two proportional solenoids that port charge pressure to either side of the pump servo cylinder. The NFPE control has no mechanical feedback mechanism.

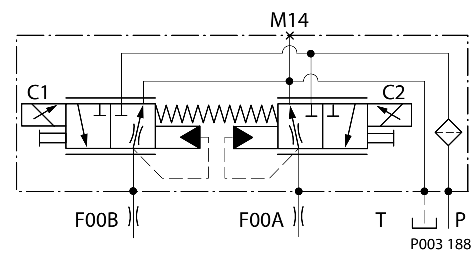
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

NFPE control



NFPE schematic

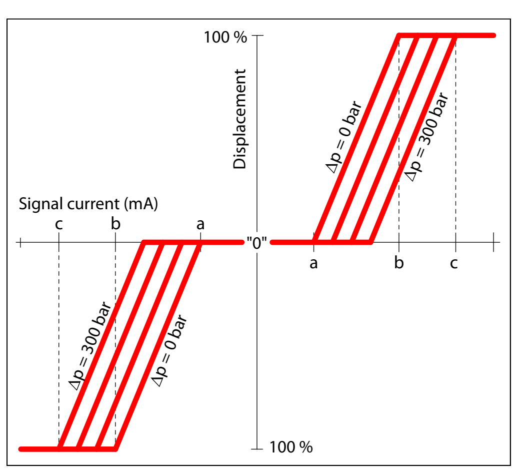


Control Signal Requirements, NFPE 089/100

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash-plate angle as system pressure increases.

A typical response characteristic is shown in the accompanying graph below:

Pump displacement vs. input signal



Control Options

Control current requirements

Voltage*	a	b	c	Pin config.
12 V_{DC}	694 mA	1168 mA	1540 mA	any order
24 V_{DC}	347 mA	600 mA	770 mA	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

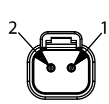
Single Pump Output Flow Direction

Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	C1	C2	C1	C2
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see installation drawings.

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control Options

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

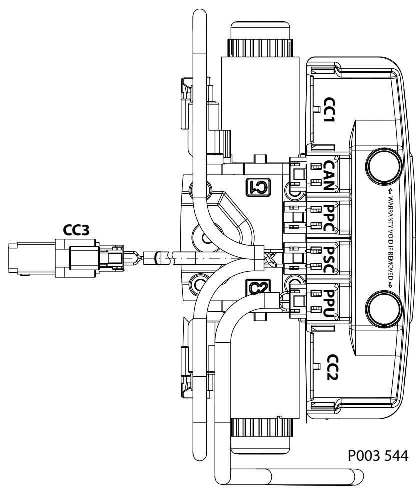
Response Time, NFPE 089/100

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	2.3 mm [0.09 in] orifice
Neutral to full flow	4.3 s	1.9 s	0.8 s
Full flow to neutral	2.6 s	1.1 s	0.5 s

Control Options

Automotive Control (AC)

The H1 **A**automotive **C**ontrol (AC) is an electric NFPE Control with an integrated micro-controller, installed on the pump. The integrated micro-controller enhanced control performance with a flexible, configurable control scheme for an entire single path propel transmission. It can be used in combination with fixed and variable displacement hydraulic-motors. With the pre-installed application software and easily changeable control parameters, it is possible to tailor the vehicle's driving behavior to the individual requirements of the customer.



The H1 Automotive Control is divided into 2 systems:

- AC-1
- AC-2

AC-2 is an extension of AC-1 that features an integrated pump swash plate angle sensor and software enabled functions such as Swash Plate Control.

Mode types

The application software provides 3 different hydrostatic propel methods, defined as mode types, which can be used individually.

- **Automotive Load dependent** (torque controlled) driving behavior. Setpoint for the drive curve is the engine rpm.
- **Non-Automotive Load independent** (speed controlled) driving mode. Setpoint for the drive curve is a Joystick or drive pedal signal, independent of the engine rpm. The best performance will achieved with an AC-2 Swash Plate Angle Sensor.
- **Creep-Automotive Load dependent** (torque controlled) driving behavior (like Automotive). Setpoint for the drive curve is the engine rpm. The setpoint can be reduced by the creep potentiometer if a high engine rpm in combination with low vehicle speed is needed.

Basic functions

- Four selectable system modes, selectable via switch.
- Individual settings for forward and reverse driving direction (4 x 2 curves).
- Independent pump and hydraulic-motor profiling and ramping for each mode.
- Electric drive pedal connection
- Electronic inching function without separate control valve
- Electric creep mode potentiometer

Control Options

- Configurable System Mode & Direction change
- Load independent pump displacement control with integrated Swash Plate Angle Sensor (AC-2)
- Hydraulic-motor displacement control including brake pressure defeat function

Performance functions

- ECO fuel saving mode with automatic reduction of the engine speed during transport (Cruise control)
- Vehicle constant speed drive control
- Vehicle speed limitation
- Dynamic brake light, automatic park brake, reverse buzzer and status LED outputs
- Vehicle speed controlled output function.
- Temperature compensation for predictable performance
- Advanced CAN J1939 interface for the information exchange with the vehicle control system

Protection and safety functions

- Safety controlled vehicle start protection with engine speed check, battery check and FNR must be in neutral, etc..
- Operator presence detection
- Hydraulic system overheat and low-temperature protection
- Hydraulic motor over speed protection
- Park brake test mode for roller applications to fulfill SAE J1472 / EN500-4.
- SIL2 compliant

Engine control and protection

- CAN J1939 engine interface
- Engine speed control via drive pedal with safety controlled monitoring function
- Engine antistall protection
- Engine over speed protection during inching
- Engine speed dependent Retarder control
- Engine cold start protection

Installation features

- Factory calibration for hysteresis compensation.
- Starting current adjustment in the factory
- Pre-installed application software and parameter files

For more information, see *Automotive Control for H1 Single Pumps Technical Information*, **BC152986482596**.

Control Options

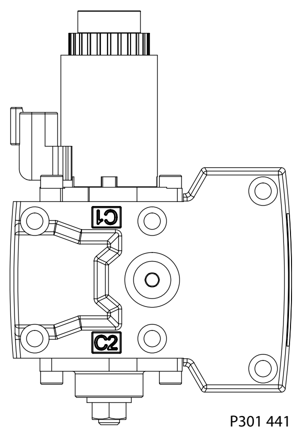
Fan Drive Control (FDC)

The Fan Drive Control (**FDC**) is a non-feedback control in which an electrical input signal activates the proportional solenoid that ports charge pressure to either side of the pump servo cylinder. The single proportional solenoid is used to control pump displacement in the forward or reverse direction.

The control spool is spring biased to produce maximum forward pump displacement in the absence of an electrical input signal. Based on the spring bias spool default forward flow for a CW rotation pump is out of port B while default forward flow for a CCW rotation pump is out of port A.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

FDC control



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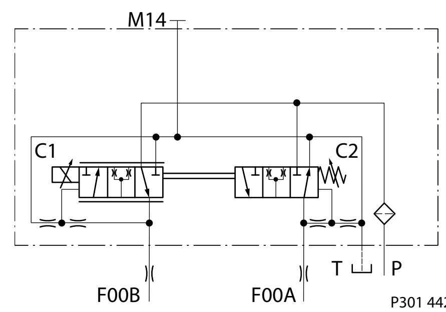
FDC schematic



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The pump should be configured with 0.8 mm control orifices to provide slowest response and maximize system stability. Additionally, pressure limiter (PL) valves are used to limit maximum fan trim speed in both (forward and reverse) directions.

H1 pumps with FDC will be delivered from factory with nominal pressure limiter setting of 150 bar [2175 psi]. The PL must be re-adjusted to ensure that the fan reaches the desired fan speed to satisfy the cooling needs of the system. HPRV setting must be always at least 30 bar [435 psi] higher than PL setting.

For more information necessary to properly size and configure a hydraulic fan drive system, see *Hydraulic Fan Drive Design Guidelines* **AB152886482265**.

Warning

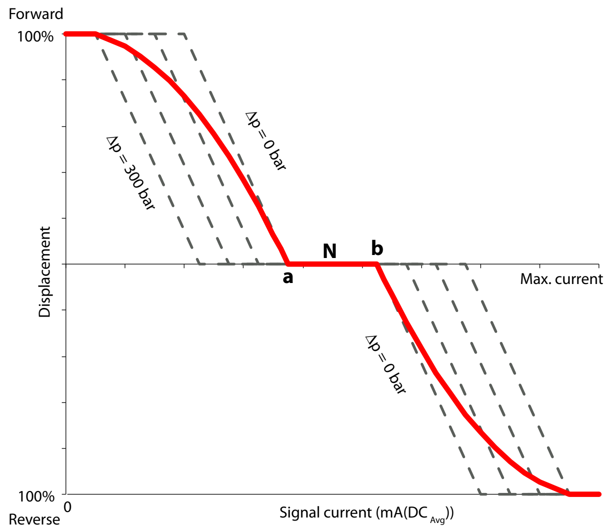
Use in other systems could result in unintended movement of the machine or it's elements. Loss of the input signal to this control will cause the pump to produce maximum flow.
The FDC is for Fan Drive systems only!

Due to the fail-safe functionality of the FDC control the pump will stroke to max. displacement in case the input signal to the pump control and the Diesel engine will be switched off at the same time. In this situation a low loop event can occur which may damage the pump. Therefore, it's strictly recommended to keep the input signal to the pump control alive while switching off the engine.
For further information please contact your Danfoss representative.

Control Options

Control Signal Requirements, FDC 089/100

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash plate angle as system pressure increases. A typical response characteristic is shown in the accompanying graph below:



a – Forward threshold

b – Reverse threshold

N – Neutral override current

Control current requirements

Voltage*	a	N	b	Pin config.
12 V_{DC}	780 mA	1100 mA	1300 mA	any order
24 V_{DC}	400 mA	550 mA	680 mA	

* Factory test current, for fan movement expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Control Options

Single Pump Output Flow Direction

Pump output flow direction vs. control signal

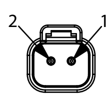
Shaft rotation		ClockWise			CounterClockWise		
Control Logic	**12 V**	**0-780 mA**	**1100 mA**	**1300-1800 mA**	**0-780 mA**	**1100 mA**	**1300-1800 mA**
	24 V	**0-400 mA**	**550 mA**	**680-920 mA**	**0-400 mA**	**550 mA**	**680-920 mA**
Port A		in	no flow	out	out	no flow	in
Port B		out	no flow	in	in	no flow	out
Servo port pressurized		M5	n/a	M4	M5	n/a	M4

Warning

Loss of input signal to the control will cause the pump to produce maximum flow.

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, FDC 089/100

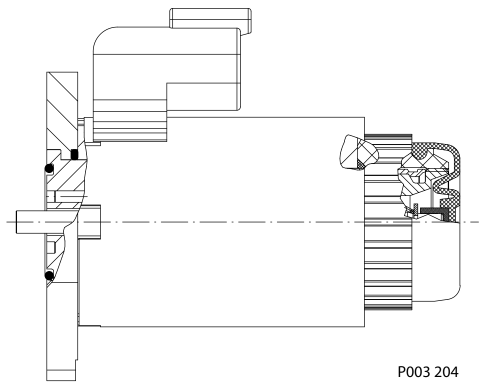
Stroking direction	0.8 mm [0.03 in] orifice
Full flow to neutral	3.9 s
Full forward flow to full reverse flow	5.6 s

Control Options

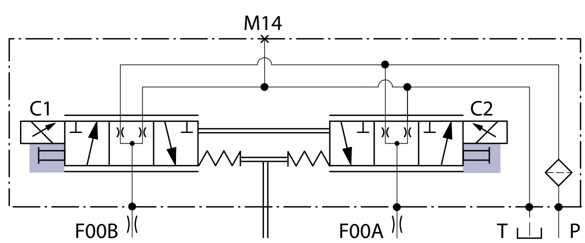
Manual Override (MOR)

All controls are available with a manual override functionality, either as a standard or as an option for temporary actuation of the control to aid in diagnostics.

Control with manual override



MOR schematic (EDC control shown)



Feedback from swash plate.

The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke. The MOR should be engaged anticipating a full stroke response from the pump.

An o-ring seal is used to seal the MOR plunger where initial actuation of the function will require a force of 45 N to engage the plunger. Additional actuation typically require less force to engage the MOR plunger.

Proportional control of the pump using the MOR should not be expected.

Warning

Unintended MOR operation will cause the pump to go into stroke; *example:* vehicle lifted off the ground. The vehicle or device must always be in a safe condition when using the MOR function.

Refer to control flow table for the relationship of solenoid to direction of flow.

Control Options

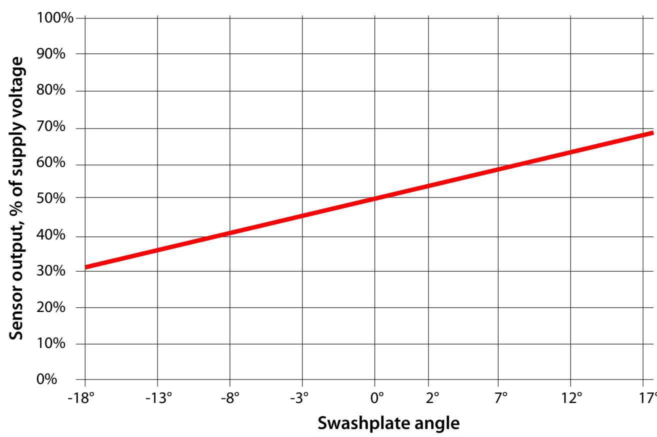
Swashplate angle sensor for EDC controls

The angle sensor detects the swash plate position with an accuracy dependent upon the calibration effort done for the application and direction of rotation from the neutral position. At minimum the sensor can be used for forward, neutral and reverse (FNR) detection.

The sensor works on the hall-effect technology. The implemented technology is based on a measurement of the magnetic field direction in parallel to the chip surface. This field direction is converted to a voltage signal at the output.

Enhanced calibration of the non-linear behavior leads to more exact calculation of the pump swashplate angle. The 4-pin DEUTSCH connector is part of the sensor housing. The swashplate angle sensor is available for all EDC controls for 12 V and 24 V.

Swashplate angle vs. output of supply voltage



Warning

Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

Contact your Danfoss representative in case the angle sensor will be used for safety functions.

Swash plate angle sensor parameters (EDC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.5 V_{DC}	5 V_{DC}	5.5 V_{DC}
Supply protection	–	–	18 V_{DC}
Pump neutral output (% of supply voltage)	–	50%	–
Working range (swash plate angle)	−18°	–	18°
Required supply current	–	–	30 mA
Output current signal	–	9 mA	11 mA
Working temperature	−40 °C	80 °C	115 °C

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector
EMC Immunity	ISO 11452-2	100 V/m

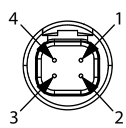
Control Options

Calibration of the sensor output within the software is mandatory. Vehicle neutral thresholds in the software (±0.5°) are vehicle dependent and must consider different conditions, example: system temperature, system pressure and/or shaft speed.

For safety function: If the sensor fails (invalid signal <10% or >90% of supply voltage), it must be sure that the ECU will go into a diagnostic mode and shift into limited mode in order for the driver to take the full control or the mechanical breaks should be activated. Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

H1P Swash Plate Angle Sensor Connector

Connector DEUTSCH, 4-pin

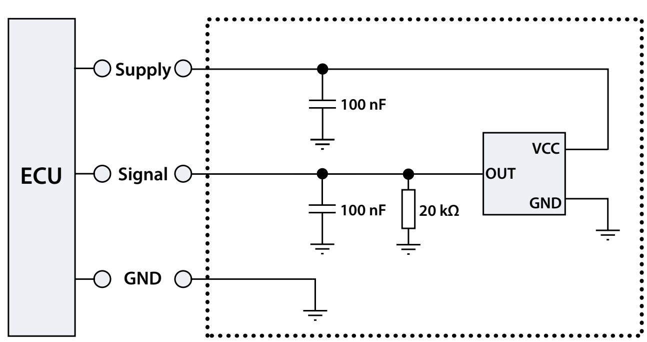


1	Ground (GND)
2	Not connected
3	Output signal 1 (SIG 1)
4	Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Interface with ECU (EDC)

Interface with ECU diagram

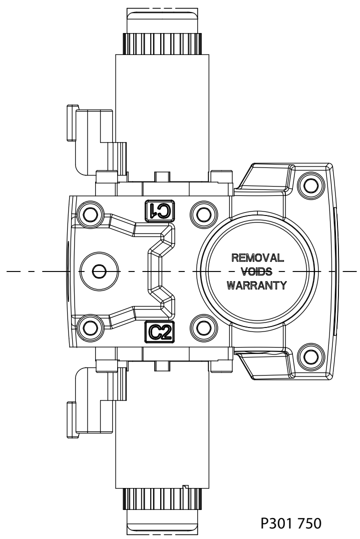


Control Options

Swash Plate Angle Sensor for NFPE and AC2 Controls

The angle sensor detects the swash plate angle position and direction of rotation from the zero position. The swash angle sensor works on the AMR sensing technology. Under the saturated magnetic field, the resistance of the element varies with the magnetic field direction.

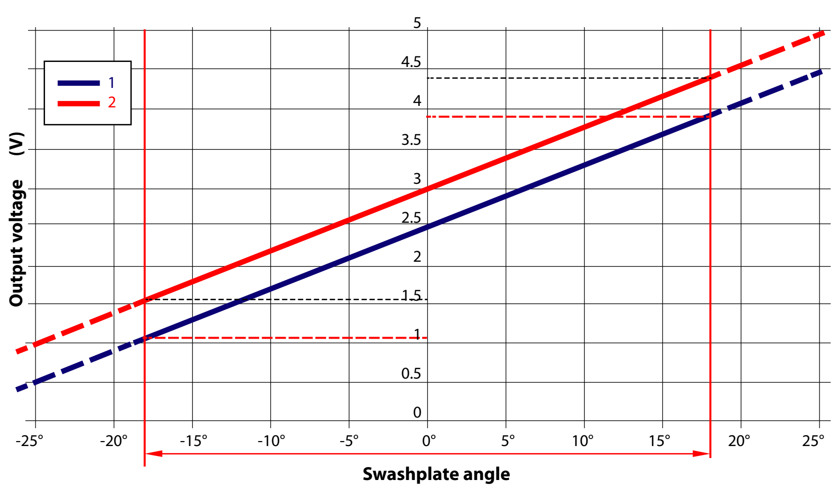
The output signal give a linear output voltage for the various magnet positions in the sensing range.



Swash Plate Angle Characteristic

The volumetric losses depend on pump max. displacement, actual displacement, speed, delta pressure, viscosity and temperature.

Swashplate angle vs. output voltage (calibrated at 50 °C)



1. Signal 1 (nominal)
2. Signal 2 (redundant)

The displacement can be calculated by:

$$V = \frac{\tan \alpha \cdot V}{\tan 18°} \ (cm^3)$$

The corresponding flow is:

$$Q = \frac{V \cdot n \cdot \eta_{vol}}{1000} \ (l/min)$$

Control Options

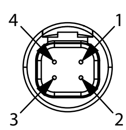
Swash Plate Angle Sensor Parameters (NFPE/AC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.75 V	5 V	5.25 V
Supply protection	–	–	28 V
Supply current	–	22 mA	25 mA
Output current (Signal 1, 2)	–	0.1 mA	–
Short circuit output current to supply or GND[1)]	–	–	7.5 mA
Sensitivity	70.0 mV/deg	78.0 mV/deg	85.8 mV/deg
Working range (swash plate angle)	−18°	0°	18°
Correlation between signals 1 and 2[2)]	475 mV	500 mV	525 mV

1) Up to duration of 2.5 seconds at 25°C

2) Signal 1 (nominal) is lower than signal 2 (redundant)

H1P Swash Plate Angle Sensor Connector (NFPE)



1 Ground (GND)

2 Output Signal 2 (SIG 2) – Secondary (redundant)

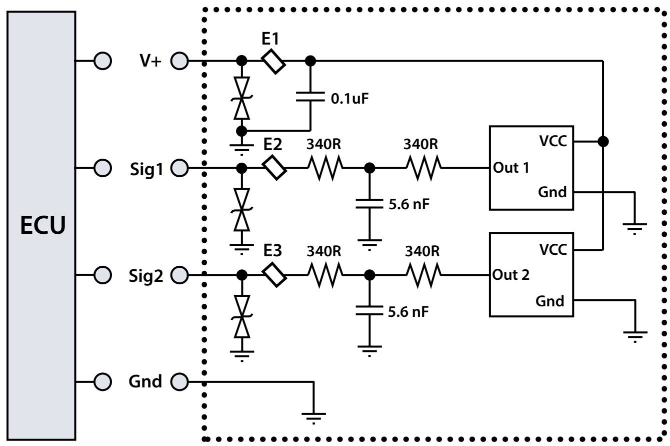
3 Output signal 1 (SIG 1)

4 Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Control Options

Interface with ECU (NFPE)



Minimum recommended load resistance is 100 kΩ.

Control Cut Off Valve (CCO)

The H1 pump offers an optional control cut off valve integrated into the control. All EDC, NFPE and MDC controls are available with a CCO valve. This valve will block charge pressure to the control, allowing the servo springs to de-stroke both pumps regardless of the pump´s primary control input.

There is also a hydraulic logic port, X7, which can be used to control other machine functions, such as spring applied pressure release brakes. The pressure at X7 is controlled by the control cut off solenoid. The X7 port would remain plugged if not needed.

In the normal (de-energized) state of the solenoid charge flow is prevented from reaching the controls. At the same time the control passages and the X7 logic port are connected and drained to the pump case. The pump will remain in neutral, or return to neutral, independent of the control input signal. Return to neutral time will be dependent on oil viscosity, pump speed, swashplate angle, and system pressure.

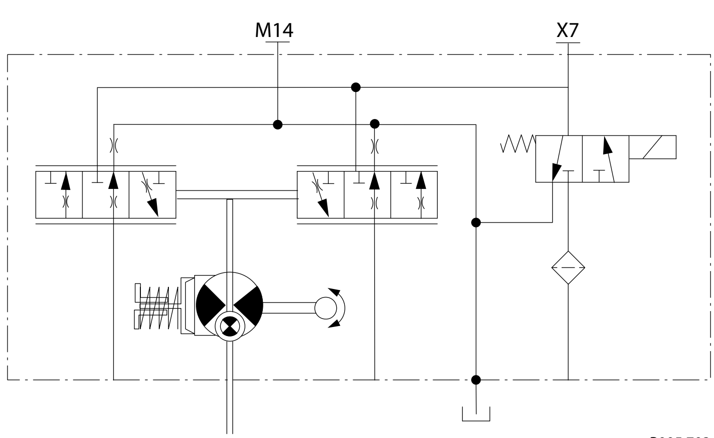
When the solenoid is energized, charge flow and pressure is allowed to reach the pump control. The X7 logic port will also be connected to charge pressure and flow.

The solenoid control is intended to be independent of the primary pump control making the control cut off an override control feature. It is however recommended that the control logic of the CCO valve be maintained such that the primary pump control signal is also disabled whenever the CCO valve is de-energized. Other control logic conditions may also be considered.

The CCO valve is available with 12 V or 24 V solenoid.

The response time of the unit depends on the control type and the used control orifices.

CCO schematic (MDC shown)



P005 703

Control Options

Brake gauge port with MDC

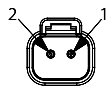
Caution

It is not recommended to use brake port for any external flow consumption to avoid malfunction of CCO function.

Control Options

CCO Connector (MDC)

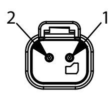
Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

H1P CCO Connector (EDC, NFPE)

Connector CCO DEUTSCH, 2-pin with key C



Description	Quantity	Order number
Mating connector	1	DEUTSCH DT06-2S-C015
Wedge lock	1	DEUTSCH W2SC-P012
Socket contact	4	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	11212714

CCO solenoid data

Nominal supply voltage		**12 V**	**24 V**
Supply voltage	**Maximum**	14.6 V	29 V
	Minimum	9.5 V	19 V
Bi-directional diode cut off voltage		28 V	53 V
Nominal coil resistance at 20 °C		10.7 Ω	41.7 Ω
Supply current	**Maximum**	850 mA	430 mA
	Minimum	580 mA	300 mA
PWM frequency	**Range**	50 – 200 Hz	
	Preferred	100 Hz	
Electrical protection class		IP67 / IP69K with mating connector	

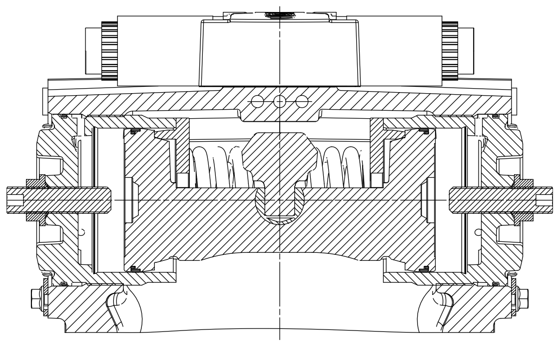
CCO solenoids are design for battery voltage application within the voltage range in the table above, in consideration of a wide range of environmental temperature common for known hydraulic applications. Closed loop PWM current supply can be also applied and is helpful in case that the voltage range is exceeded, or ambient temperature could rise in an unusual manner.

Control Options

Displacement Limiter

H1 pumps are designed with optional mechanical displacement (stroke) limiters factory set to max. displacement. The maximum displacement of the pump can be set independently for forward and reverse using the two adjustment screws to mechanically limit the travel of the servo piston down to 50% displacement.

Adjustments under operating conditions may cause leakage. The adjustment screw can be completely removed from the threaded bore if backed out to far.



P003 266

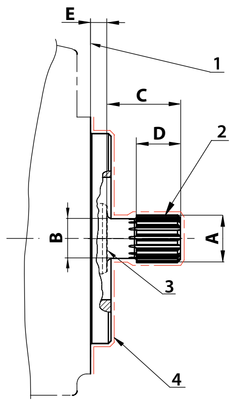
H1P 089/100 Displacement Change (approximately)

Parameter	Size 089	Size 100
1 turn of displacement limiter screw	9.3 cm^3 [0.57 in^3]	10.7 cm^3 [0.65 in^3]
Internal wrench size	5 mm	
External wrench size	17 mm	
Torque for external hex seal lock nut	48 N•m [424 lbf•in]	

For more information, see *H1 Axial Piston Pumps, Service Manual,* **AX152886482551**, the section "Displacement Limiter Adjustment".

Dimensions and Data

H1P 089/100 Input Shaft Option G1 (SAE C, 14 teeth)



1. Mounting flange 127 – 4 per ISO 3019-1; surface to be paint free
2. **Spline Data:** 14 teeth, Pressure angle: 30°, Pitch: 12/24, Ø29.633 [1.167]; Fillet root side fit per ANSI B92.1-1996, Class 6H
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø31.14 ±0.08 [1.226 ±0.003]	Ø26 ±0.13 [1.024 ±0.005]	48.1 ±1.0 [1.894 ±0.039]	28.8 ±1.0 [1.134 ±0.039]	7.94 ±0.8 [0.313 ±0.03]

[1)] Minimum active spline length for the specified torque ratings.

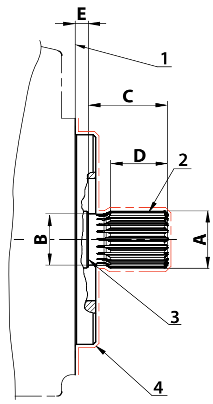
Torque rating

Rated torque	Maximum torque
534 N•m [4720 lb•in]	816 N•m [7220 lb•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P Input Shaft Option G3 (SAE C, 13 teeth)



1. Mounting flange 127 – 4 per ISO 3019-1; surface to be paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 8/16, Ø41.275 [1.625]; Fillet root side fit per ANSI B92.1-1996, Class 5
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø44.4 ±0.09 [1.746 ±0.004]	Ø36.4 ±0.25 [1.433 ±0.01]	67.0 ±1.0 [2.638 ±0.039]	39.5 ±1.0 [1.555 ±0.039]	8.05 ±0.8 [0.317 ±0.03]

[1)] Minimum active spline length for the specified torque ratings.

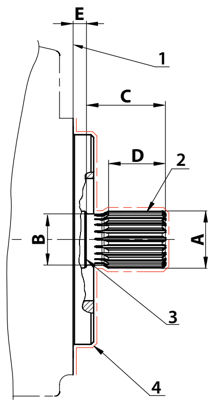
Torque rating

Rated torque	Maximum torque
1442 N•m [12 800 lbf•in]	2206 N•m [19 500 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P 089/100 Input Shaft Option G9 (SAE C-C, 23 teeth)



1. Surface of mounting flange 127 – 4 per ISO 3019-1 (SAE C); to be paint free
2. **Spline Data:** 23 teeth, Pressure angle: 30°, Pitch: 16/32, Ø36.513 [1.438]; Fillet root side fit per ANSI B92.1-1996, Class 6H
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø37.59 ±0.08 [1.480 ±0.003]	Ø33.6 ±0.13 [1.323 ±0.005]	54.0 ±1.0 [2.126 ±0.039]	38.2 ±1.0 [1.504 ±0.039]	7.94 ±0.8 [0.313 ±0.03]

1) Minimum active spline length for the specified torque ratings.

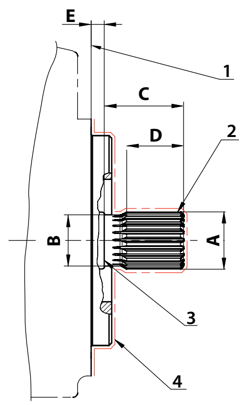
Torque rating

Rated torque	Maximum torque
999 N•m [8840 lb•in]	1818 N•m [16 090 lb•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P 089/100 Input Shaft Option F1 (SAE C, 21 teeth)



1. Mounting flange 127 – 4 per ISO 3019-1; surface to be paint free
2. **Spline Data:** 21 teeth, Pressure angle: 30°, Pitch: 16/32, Ø33.338 [1.313]; Fillet root side fit per ANSI B92.1-1996, Class 6H
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø34.42 ±0.08 [1.355 ±0.003]	Ø30.4 ±0.13 [1.197 ±0.005]	48.0 ±1 [1.894 ±0.039]	30.7 ±1 [1.209 ±0.0039]	7.94 ±0.8 [0.313 ±0.031]

[1)] Minimum active spline length for the specified torque ratings.

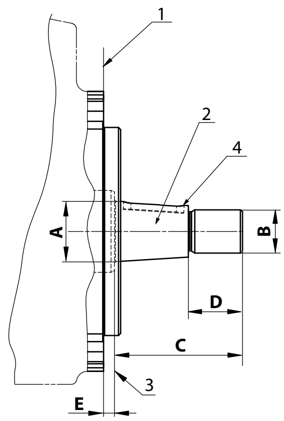
Torque rating

Rated torque	Maximum torque
760 N•m [6730 lbf•in]	1297 N•m [11 479 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P 089/100 Input Shaft Option F4, Code 38–3



1. Mounting flange 127 – 4 per ISO 3019-1; surface to be paint free
2. **Tapered shaft:** Conical keyed shaft end similar to ISO3019-1 code 38–3; Suitable key $^3/_8$ x $^3/_8$ x 1 $^1/_2$ per ANSI B17.1
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D	E
Ø38.1 ±0.09 [1.5 ±0.004]	1$^1/_8$ –12	81.9 ±1.0 [3.224 ±0.039]	34.9 ±1.0 [1.374 ±0.039]	8.025 ±0.8 [0.36 ±0.03]

Torque rating

Rated torque1)	Maximum torque2)
1116 N•m [9880 lbf•in]	1488 N•m [13 170 lbf•in]

1) Rated torque includes just the capability of the press-fit in accordance with an assumed fastener grade 5.

2) Mating part must maintain a minimum gap width of 1.0 mm with the shaft shoulder after installation of the part. Transmittable torque will be reduced if the minimum gap requirement is not met.

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section "Shaft Torque Ratings and Spline Lubrication".

Tapered shaft customer acknowledgement

The Danfoss H1 tapered shaft has been designed using the industry standard ISO 3019-1, minus the through-hole in the end of the shaft. Danfoss guarantees the design and manufactured quality of the tapered shaft.

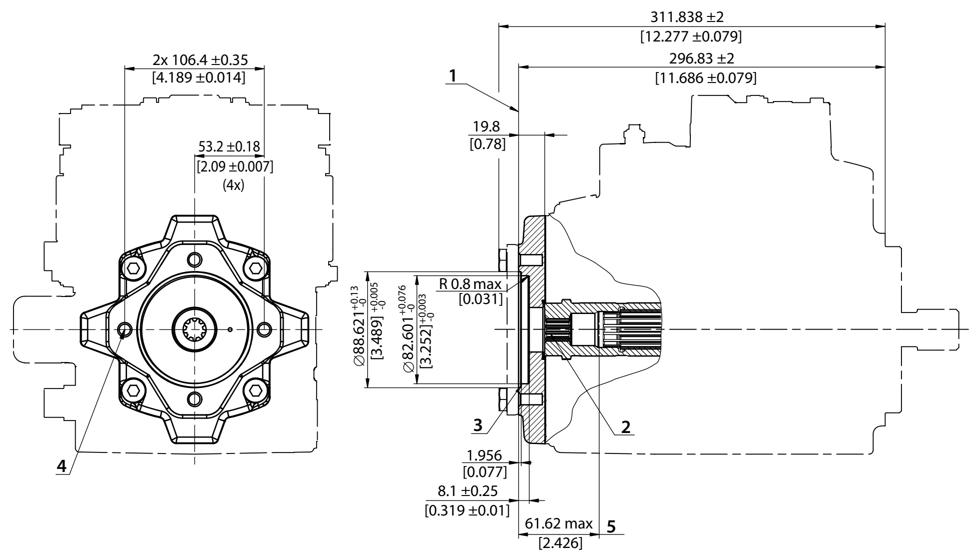
Danfoss recommends a self-locking nut instead of a castle nut and pin. The nut and mating square-cut key are customer supplied. The specified torque rating of the tapered shaft is based on the cross-sectional diameter of the shaft, through the keyway, and assumes the proper clamp and fit between shaft and coupling. The customer is responsible for the design and manufactured quality of the mating female coupling and key and applied torque on the nut. Danfoss has made provisions for the key in accordance to the ISO specification with the understanding that the key is solely to assist in the installation of the mating coupling.

Caution

Possible hazard because torque or loading inadvertently transmitted by the customer supplied key may lead to premature shaft failure. Torque must be transmitted by the taper fit between the shaft and it's mating coupling, not the key.

Dimensions and Data

H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth)



1. Auxiliary mounting pad for mating flange 82-2 per ISO 3019-1 (SAE A); Paint free
2. **Spline Data:** 11 teeth, Pressure angle: 30°, Pitch: 16/32, Ø17.463 [0.6875]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 10.5 mm
3. O-ring seal required; Ref. Ø82.22 [3.237] ID x 2.62, cross section
4. Thread: M10x1.5-6H; 15 [0.59] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	296 N•m [2620 lbf•in]

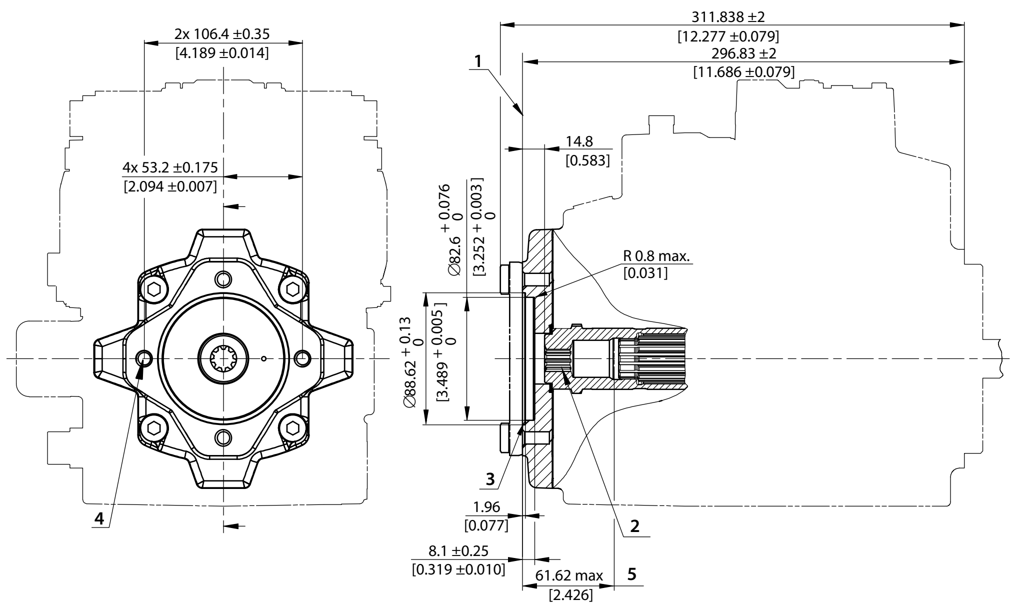
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth)



1. Auxiliary mounting pad for mating flange 82-2 per ISO 3019-1 (SAE A); Paint free
2. **Spline Data:** 9 teeth, Pressure angle: 30°, Pitch: 16/32, Ø14.288 [0.5625]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 8.6 mm
3. O-ring seal required; Ref. Ø82.22 [3.237] ID x 2.62, cross section
4. Thread: M10x1.5-6H; 15 [0.59] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	162 N•m [1430 lbf•in]

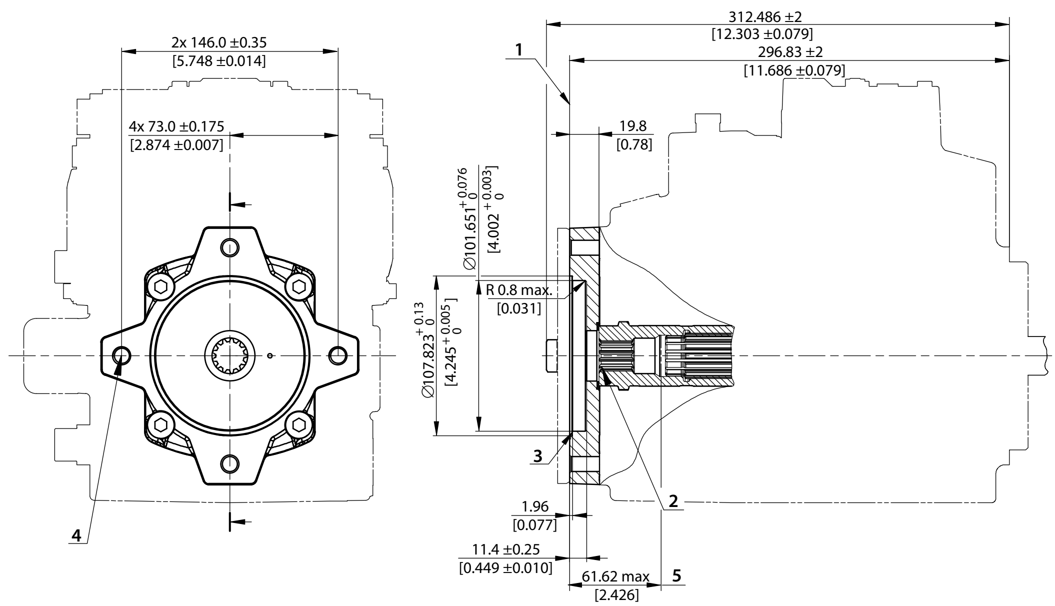
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 16/32, Ø20.638 [0.813]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 12.4 mm
3. O-ring seal required; Ref. Ø94.92 [3.737] ID x 2.62, cross section
4. Thread: M12x1.75-6H; 20 [0.787] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	395 N•m [3500 lbf•in]

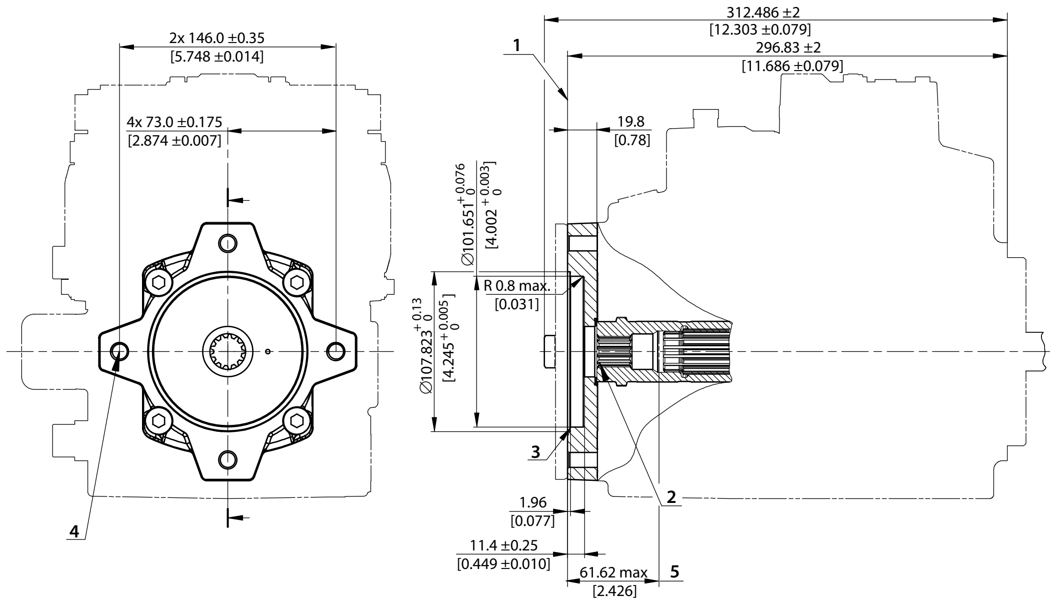
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section "Shaft Torque Ratings and Spline Lubrication".

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 15 teeth, Pressure angle: 30°, Pitch: 16/32, Ø23.813 [0.938]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 14.3 mm
3. O-ring seal required; Ref. Ø94.92 [3.737] ID x 2.62, cross section
4. Thread: M12x1.75-6H; 20 [0.787] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	693 N•m [6130 lbf•in]

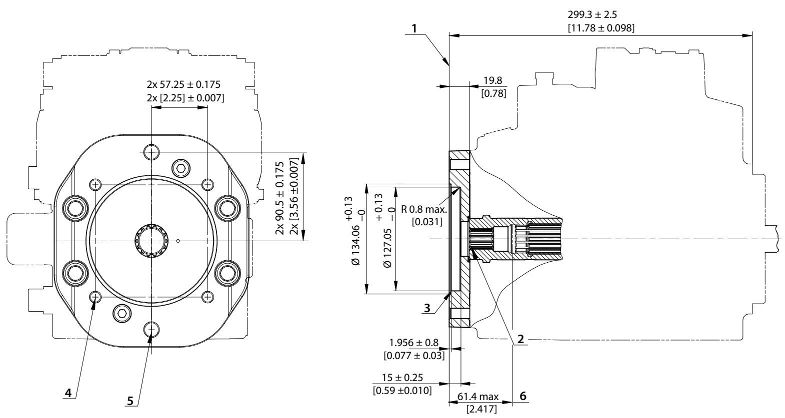
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth)



1. Auxiliary mounting pad for mating flange 127-4 per ISO 3019-1 (SAE C); Paint free
2. **Spline Data:** 14 teeth, Pressure angle: 30°, Pitch: 12/24, Ø29.633 [1.667]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 17.8 mm
3. O-ring seal required; Ref. Ø120.32 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 22.25 [0.876] min. depth (4x)
5. Thread: M16x2-6H; 22.25 [0.876] min. depth (2x)
6. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum torque	816 N•m [7220 lbf•in]

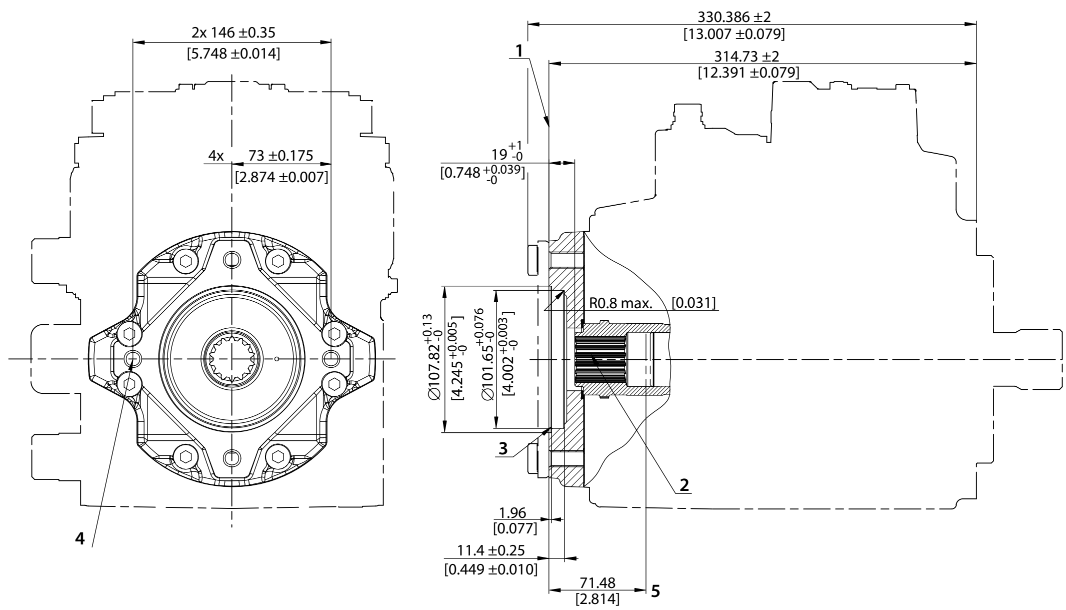
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P 089/100 Auxiliary Mounting, Option S1 (SAE B-B, 14 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 14 teeth, Pressure angle: 30°, Pitch: 12/24, Ø29.633 [1.667]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 17.8 mm
3. O-ring seal required; Ref. Ø101.32 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 20 [0.787] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum torque	816 N•m [7220 lbf•in]

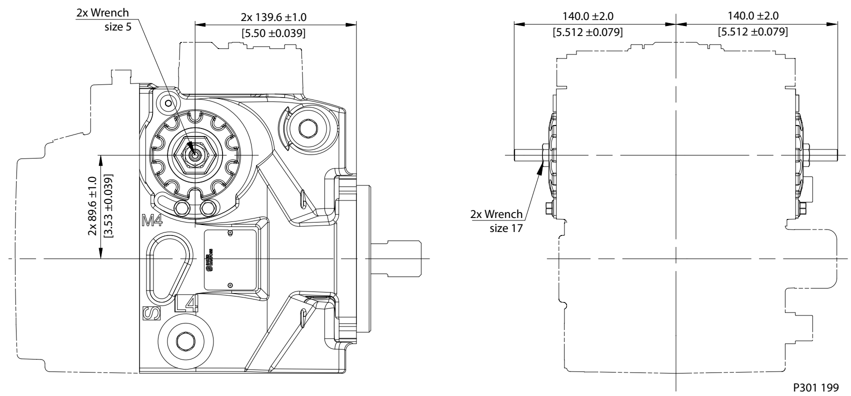
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Displacement Limiter, Option B



1. Displacement limiter screw (2x)
2. Displacement limiter seal nut (2x)

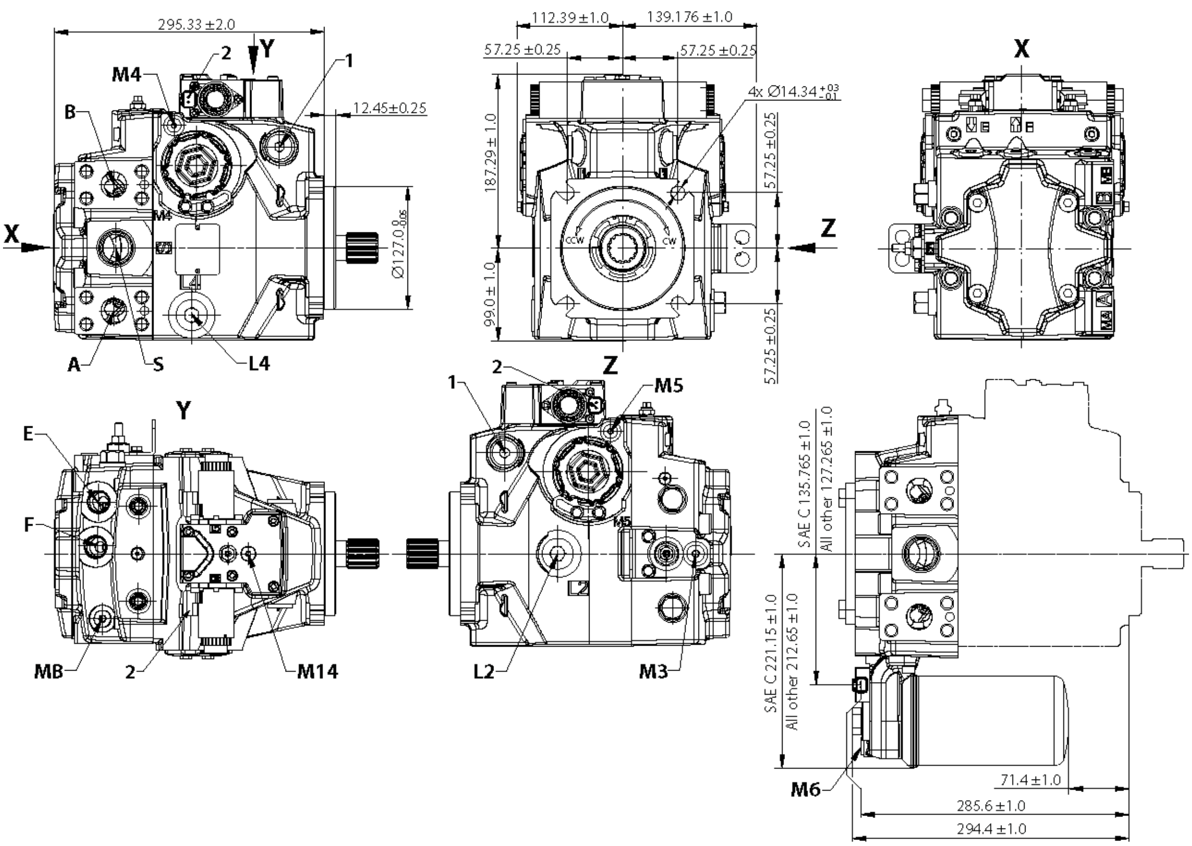
Wrench size, torque

Wrench size for DL screw	Wrench size for DL seal nut	Torque
5 internal hex	17 external hex	48 N•m [35 lb•ft]

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Single Pump Ports



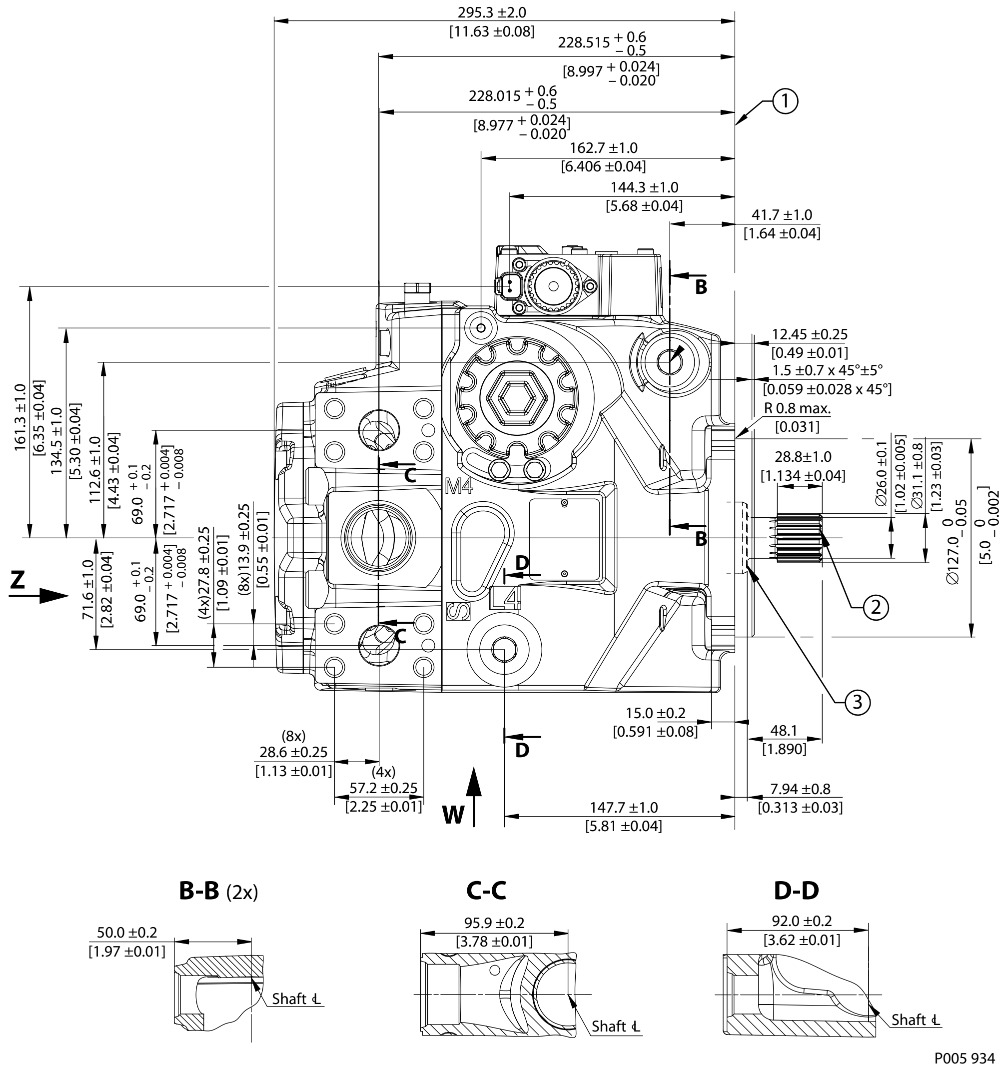
Ports per ISO 11 926-1

Port	Description	Size
A, B	System ports	Ø25.4 mm; M12 x 1.75; 20 min. full thread depth Recommended screw in depth 1.5 x thread dia
L2, L4	Case drain ports	$1\frac{1}{16}$–12
MA, MB	System **A/B** gauge ports	$\frac{9}{16}$–18
E/F	Charge filtration ports	$\frac{7}{8}$–14
M3	Charge pressure gauge port	$\frac{9}{16}$–18
M4, M5	Servo gauge port	$\frac{7}{16}$–20
M14	Case gauge port (EDC, FNR, NFPE)	$\frac{7}{16}$–20
S	Charge inlet port	$1\frac{5}{8}$–12 Recommended screw in depth 1.5 x thread dia
1	Case pressure port	$1\frac{1}{16}$–12
2	Connector DEUTSCH DT04-2P, to be paint free	

Please contact Danfoss representative for specific installation drawings.

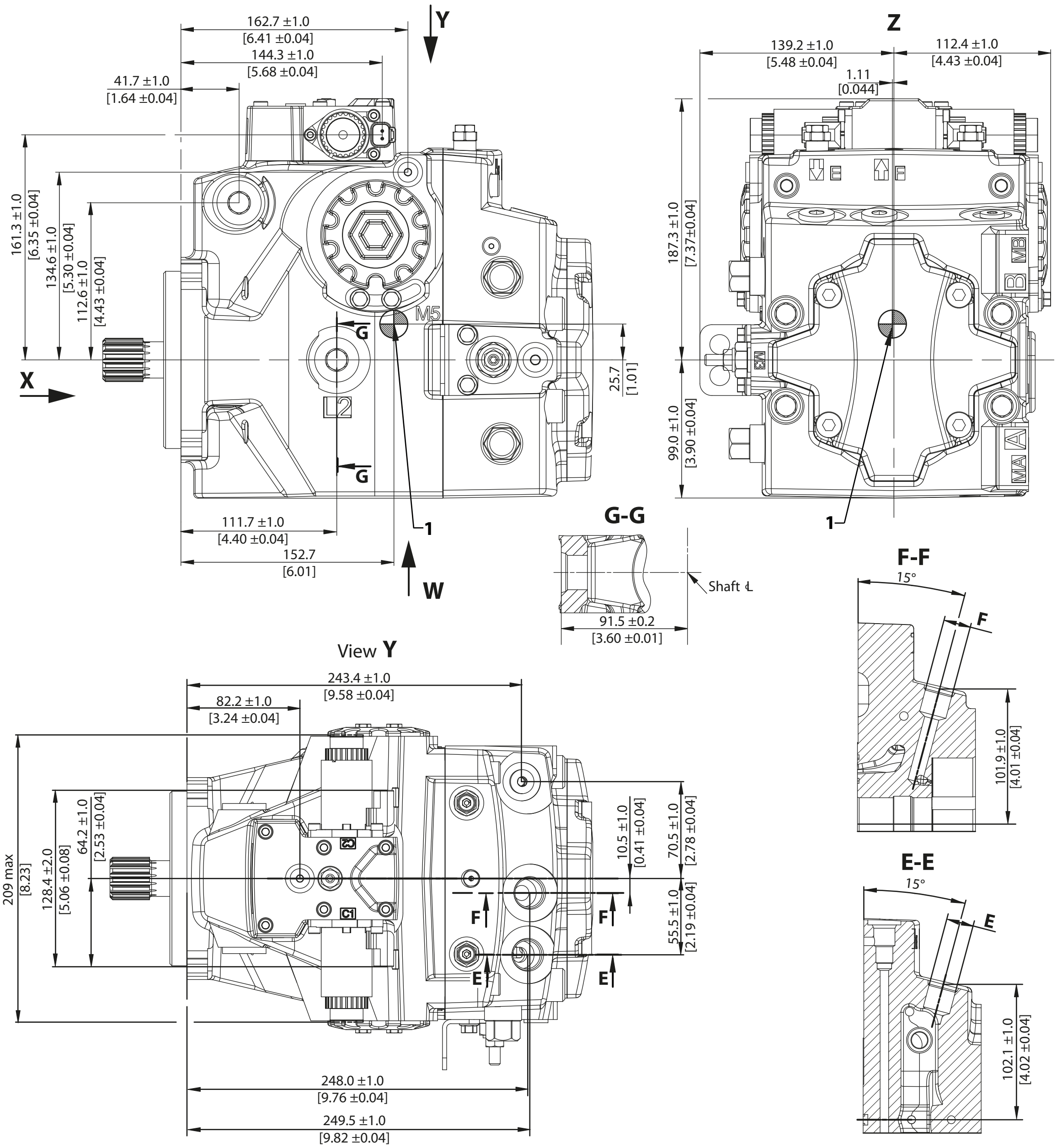
Dimensions and Data

H1P Dimensions



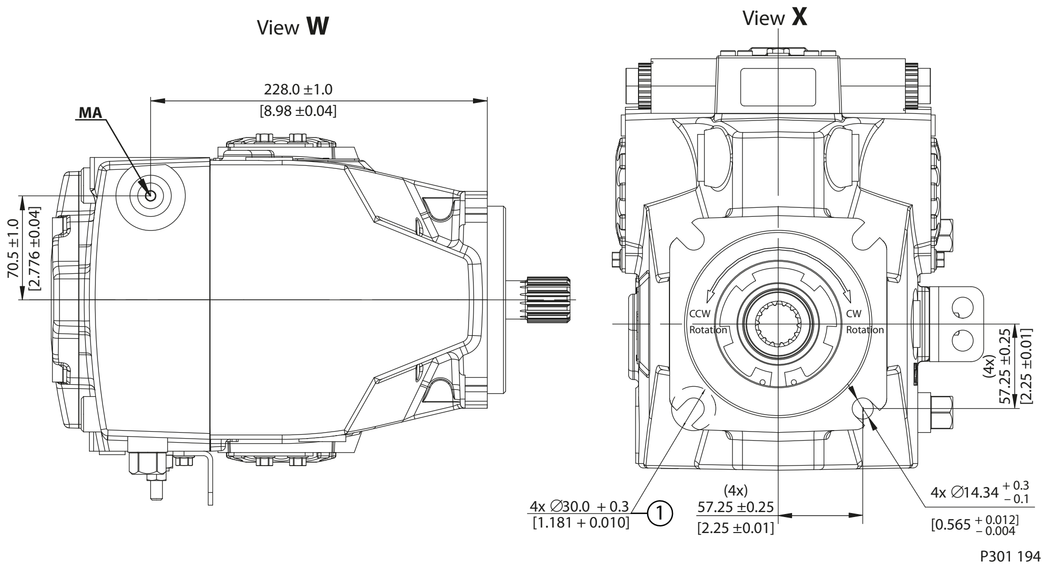
1. Mounting flange 127 – 4 per ISO 3019-1; surface to be paint free
2. Shaft to be paint free
3. Coupling must not protrude beyond this point

Dimensions and Data



1 — Approximate center of gravity

Dimensions and Data

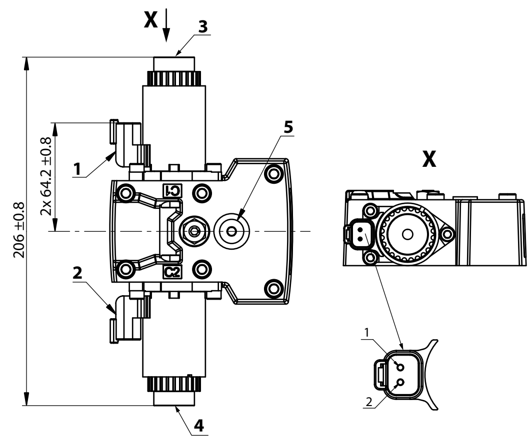


1 — Other side screw head space

Dimensions and Data

Controls

EDC Options A2 and A3 (12/24 V)



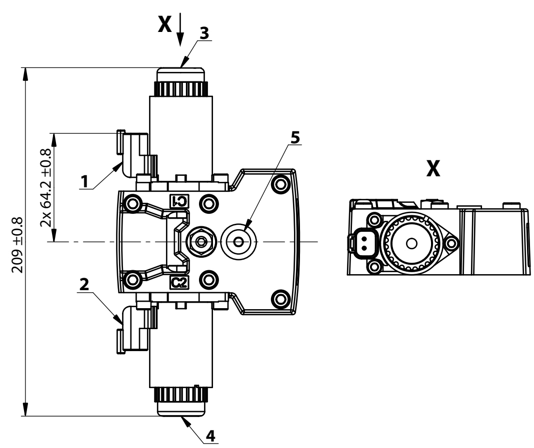
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

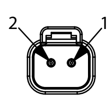
EDC with MOR, Options A4 and A5 (12/24 V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector C1/C2: DEUTSCH DTM04-2P

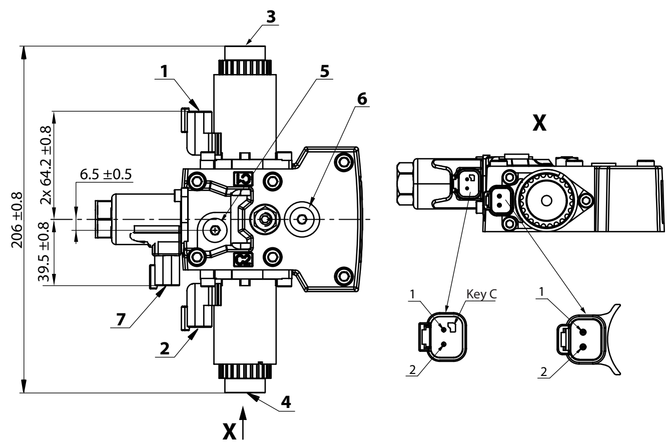


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

EDC with CCO (key C), Options E7 and E8 (12/24 V)



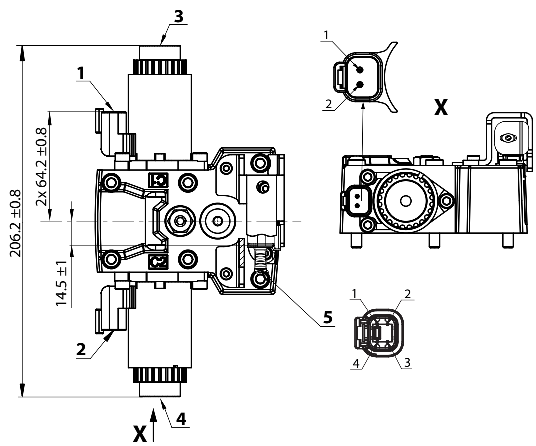
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
6. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

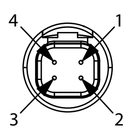
Dimensions and Data

EDC with ASNSR, Options: H2 and H3 (12/24 V)



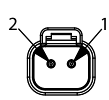
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Angle sensor connector **S2** DEUTSCH DT04-4P, paint free

Connector DEUTSCH, 4-pin



4-pin assignment:
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Connector **C1/C2**: DEUTSCH DTM04-2P*

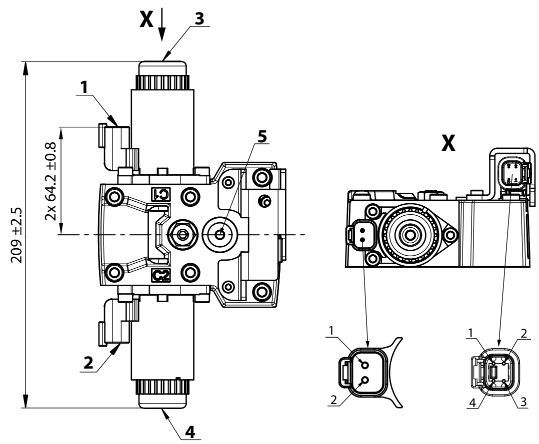


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

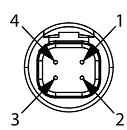
Dimensions and Data

EDC with MOR and ASNSR, Options H6 and H7 (12/24 V)



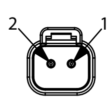
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Connector DEUTSCH, 4-pin



4-pin assignment:
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Connector **C1/C2**: DEUTSCH DTM04-2P*

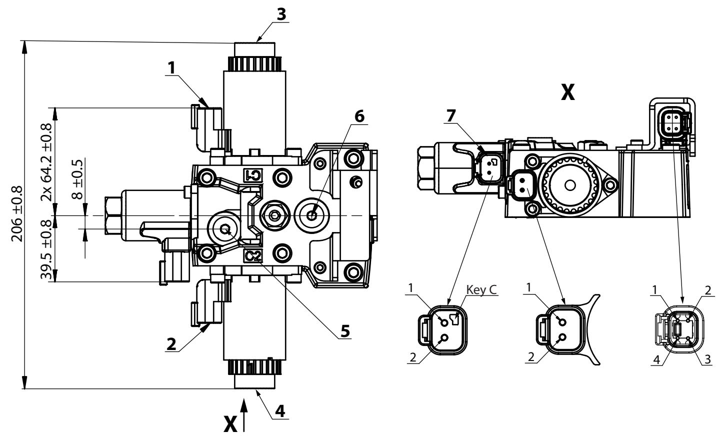


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

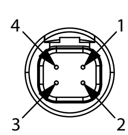
EDC with CCO and ASNSR, Options H8 and H9 (12/24 V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
6. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

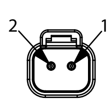
Connector DEUTSCH, 4-pin



Angle sensor connector S2: DEUTSCH DTM04-4P

1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connectors C1/C2/C4: DEUTSCH DTM04-2P

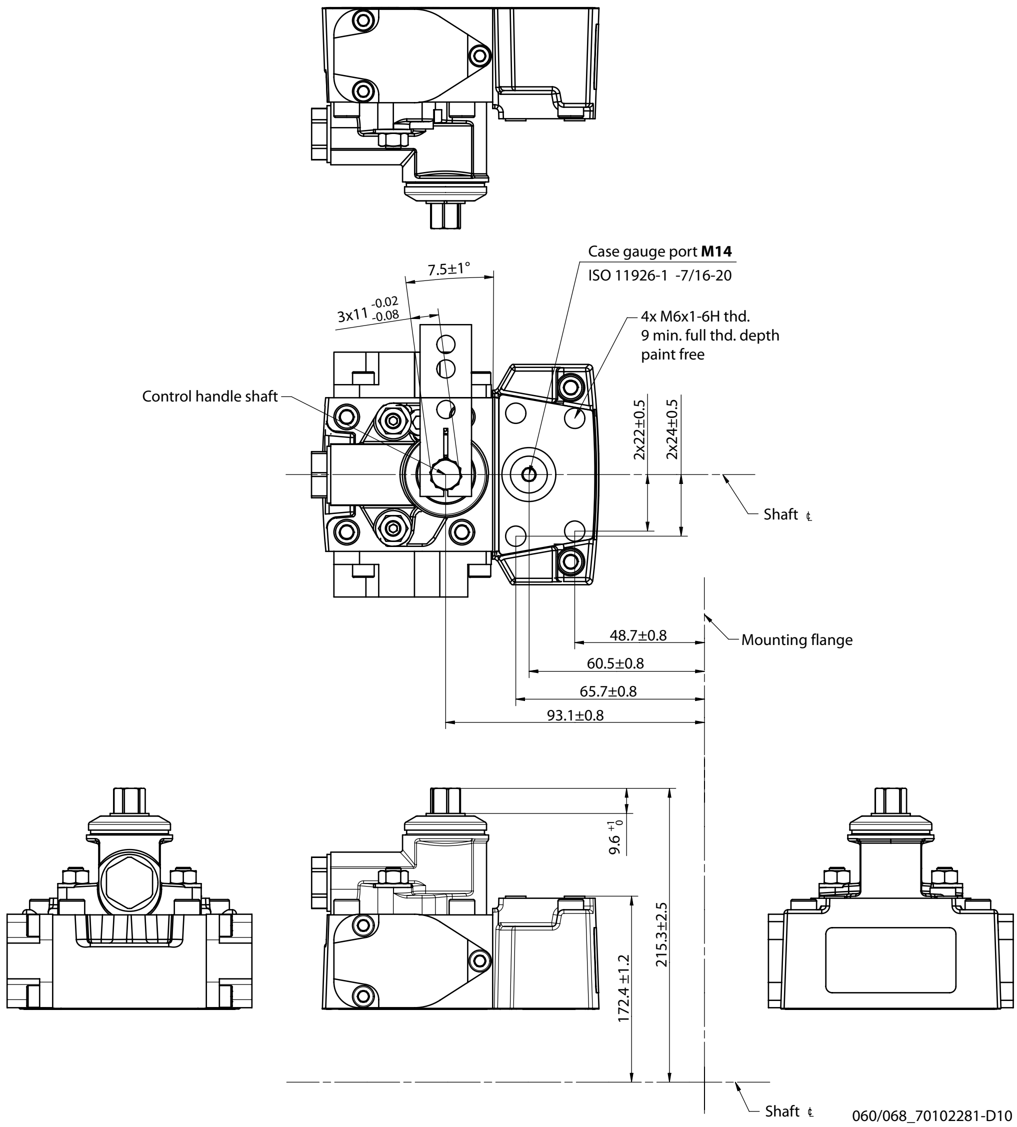


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

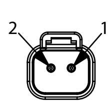
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC Option: M1



Connector DEUTSCH, 2-pin

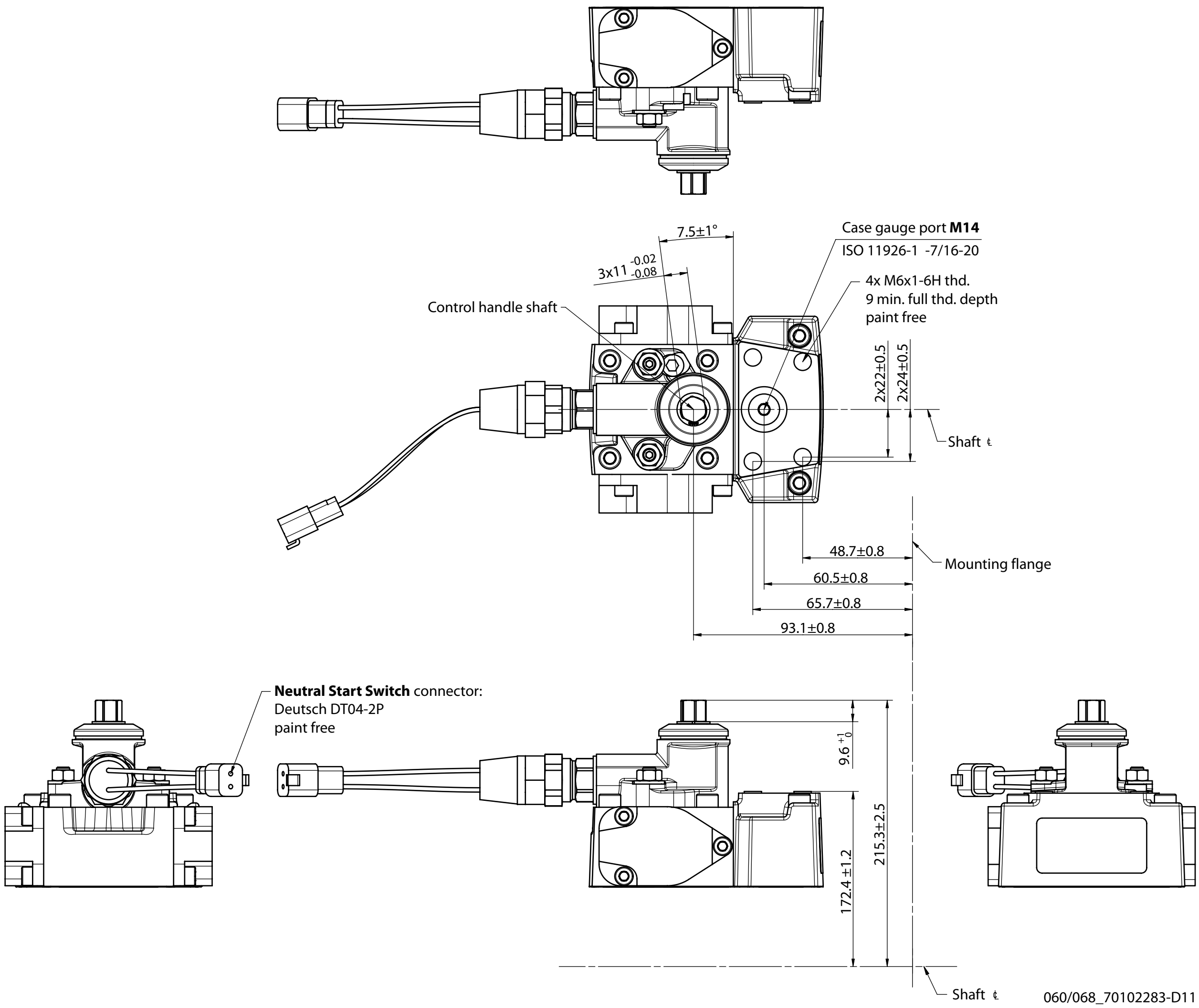


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

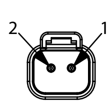
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with Neutral Start Switch Option: M2



Connector DEUTSCH, 2-pin

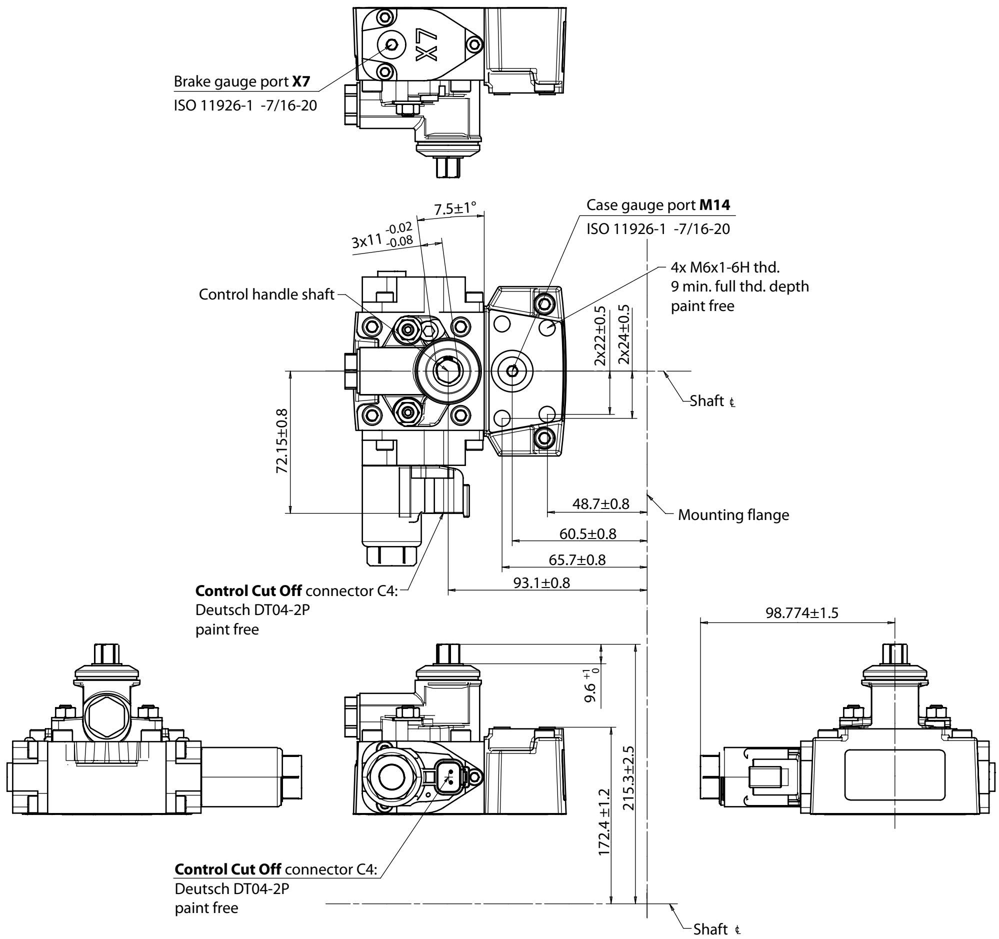


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

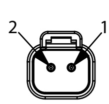
Dimensions and Data

MDC with CCO, Options: M3, M4



060/068_70102283-D12

Connector DEUTSCH, 2-pin

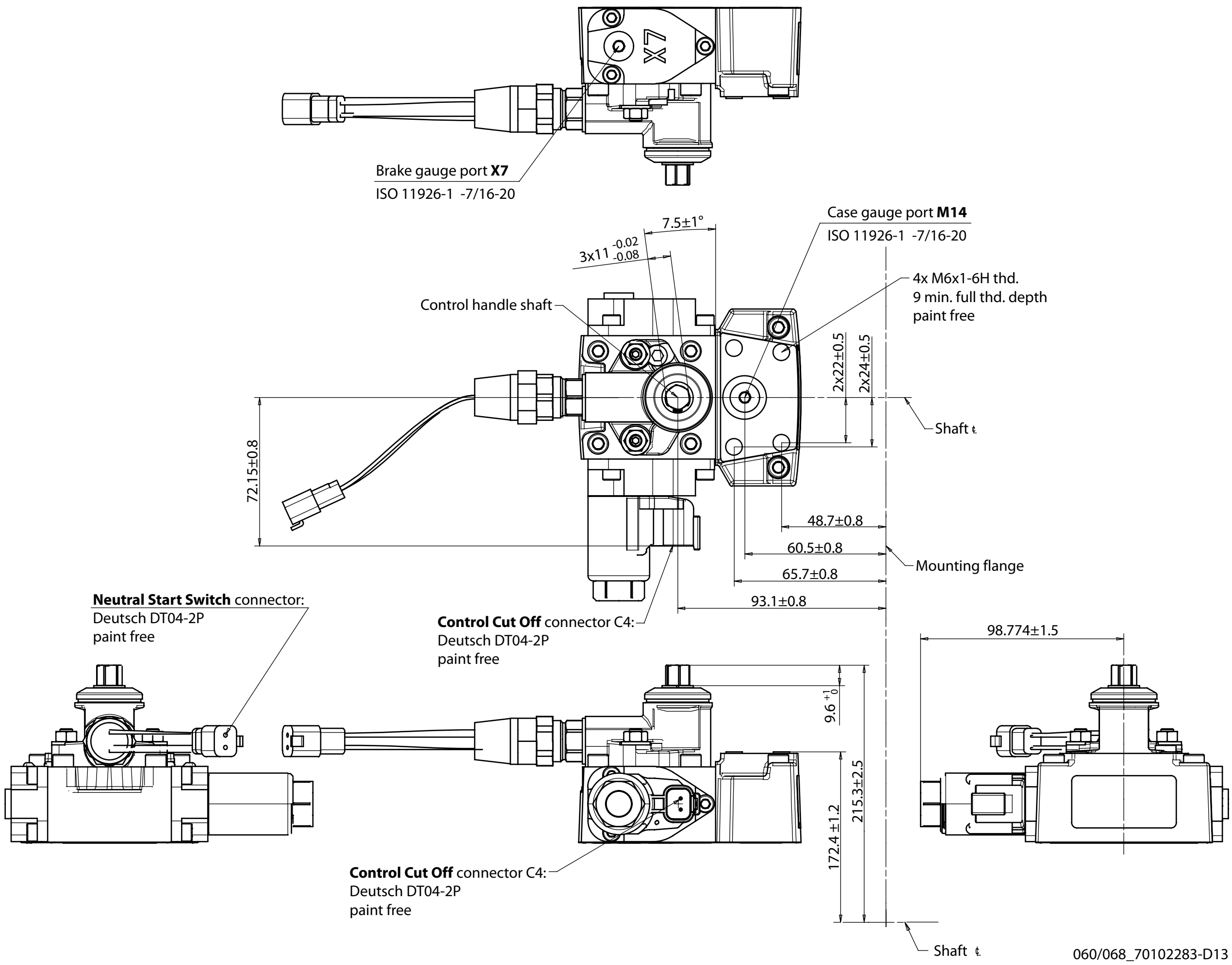


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

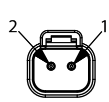
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with NSS and CCO Options: M5, M6



Connector DEUTSCH, 2-pin



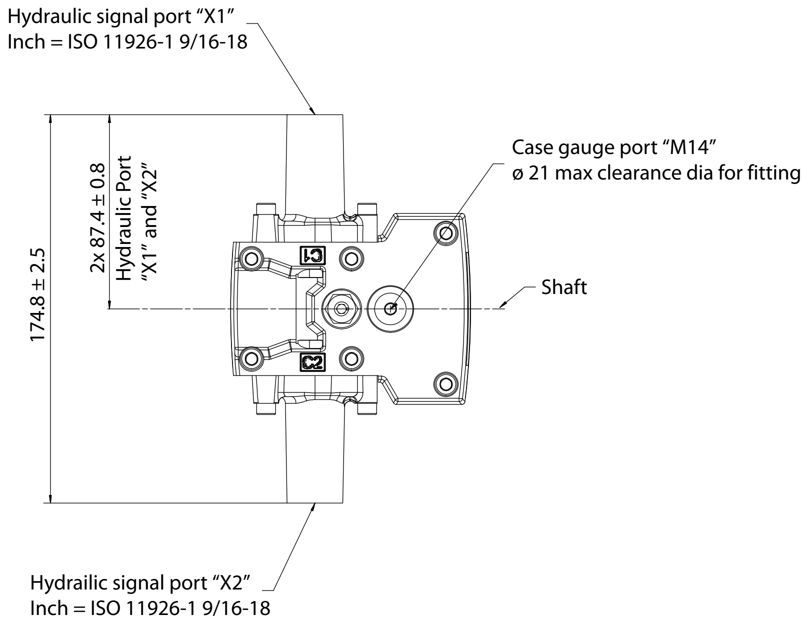
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

H1P HDC, Options: T1, T2

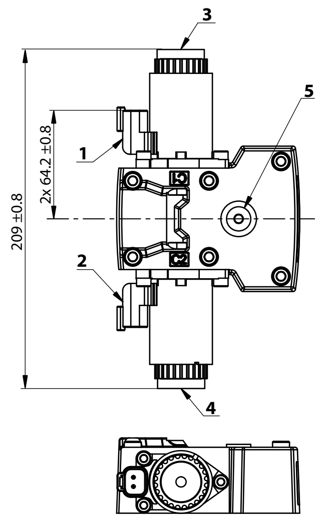
Dimensions in mm



Dimensions and Data

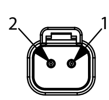
NFPE with MOR, Options: N1, N2 (12/24 V)

Non-Feedback Proportional Electric control with Manual Over Ride options N1 (12 V) and N2 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

*Control solenoid connectors **C1/C2** DEUTSCH DTM04-2P pin/assignment*



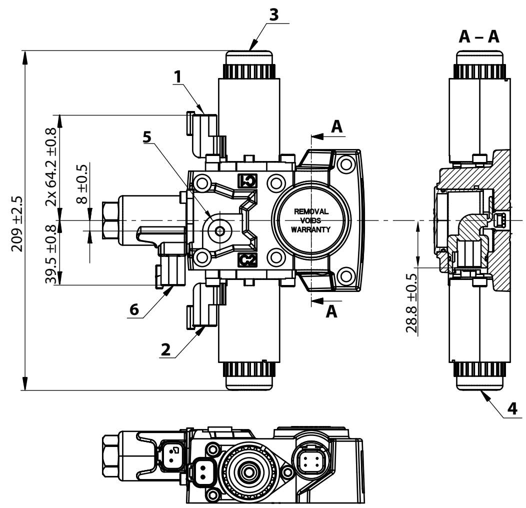
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V)

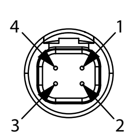
Non-Feedback Proportional Electric control with Control-Cut-Off valve with key C, Manual Over Ride and Angle Sensor, options N3 (12 V) and N4 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
6. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

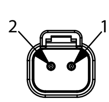
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Control solenoid connectors **C1/C2/C4** DEUTSCH DTM04-2P pin/assignment*



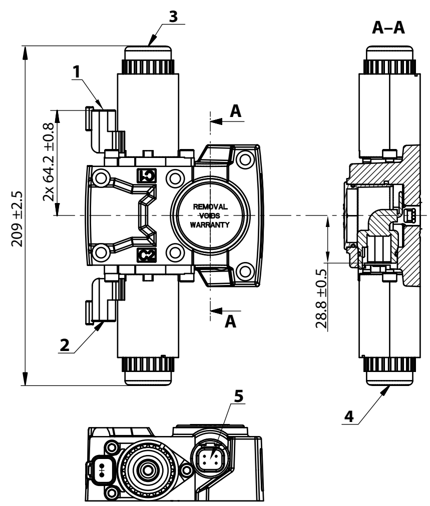
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

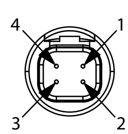
NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V)

Non-Feedback Proportional Electric control with Manual Over Ride and Angle Sensor, options N5 (12 V) and N6 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Angle sensor connector **S2** DEUTSCH DT04-4P, paint free

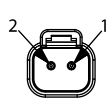
Connector DEUTSCH, 4-pin



Pin/assignment:

1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

Control solenoid connectors C1/C2 DEUTSCH 2-pin/assignment



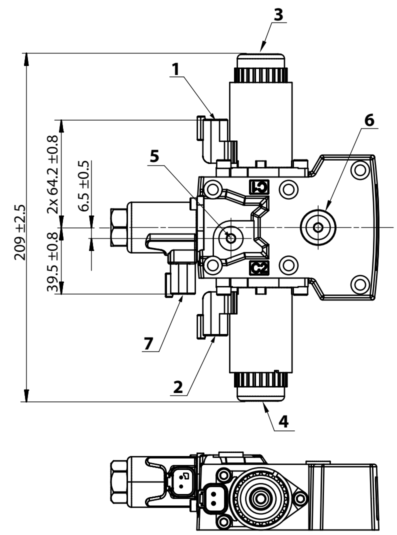
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

NFPE with MOR and CCO, Options: N7, N8 (12/24 V)

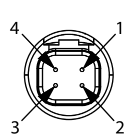
Non Feedback Proportional Electric control with Manual Over Ride and Control-Cut-Off valve key C, options N7 (12 V) and N8 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
6. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

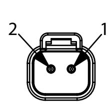
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Control solenoid connectors **C1/C2** DEUTSCH DTM04-2P pin assignment*

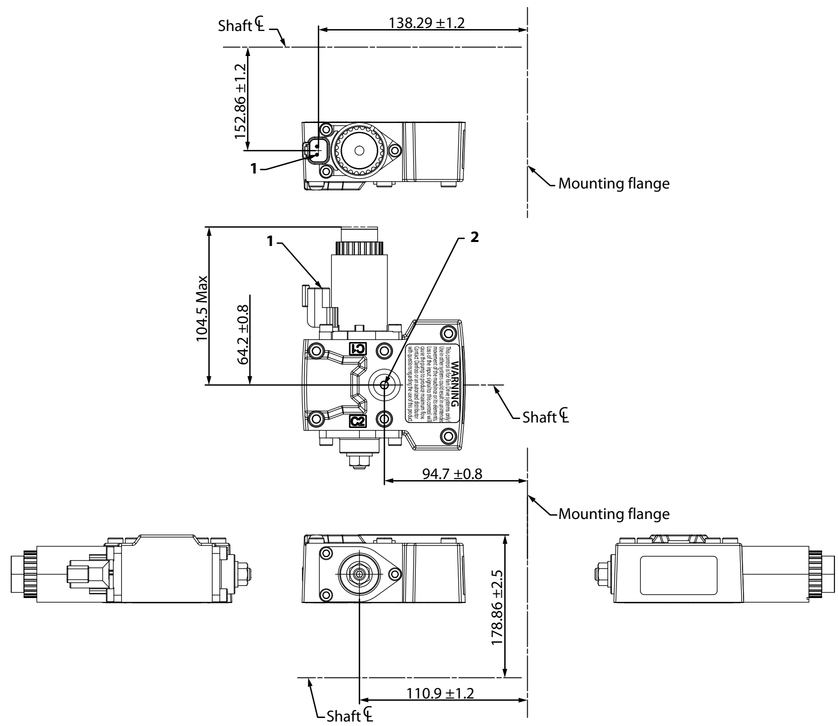


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

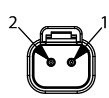
Dimensions and Data

FDC Options: F1, F2 (12/24V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Control solenoid connectors DEUTSCH, 2-pin assignment

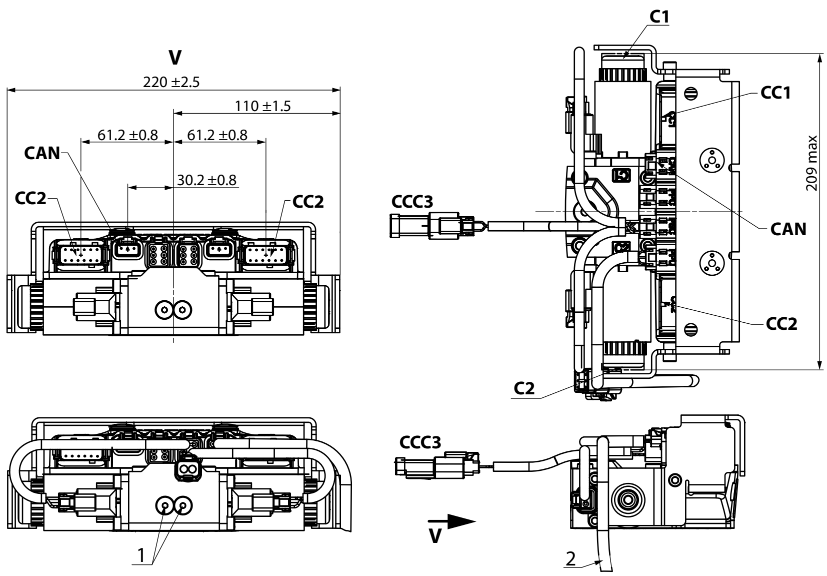


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Automotive control (AC)



1 Plug removing can cause contamination issues

2 PPU wire harness is factory installed to speed sensor

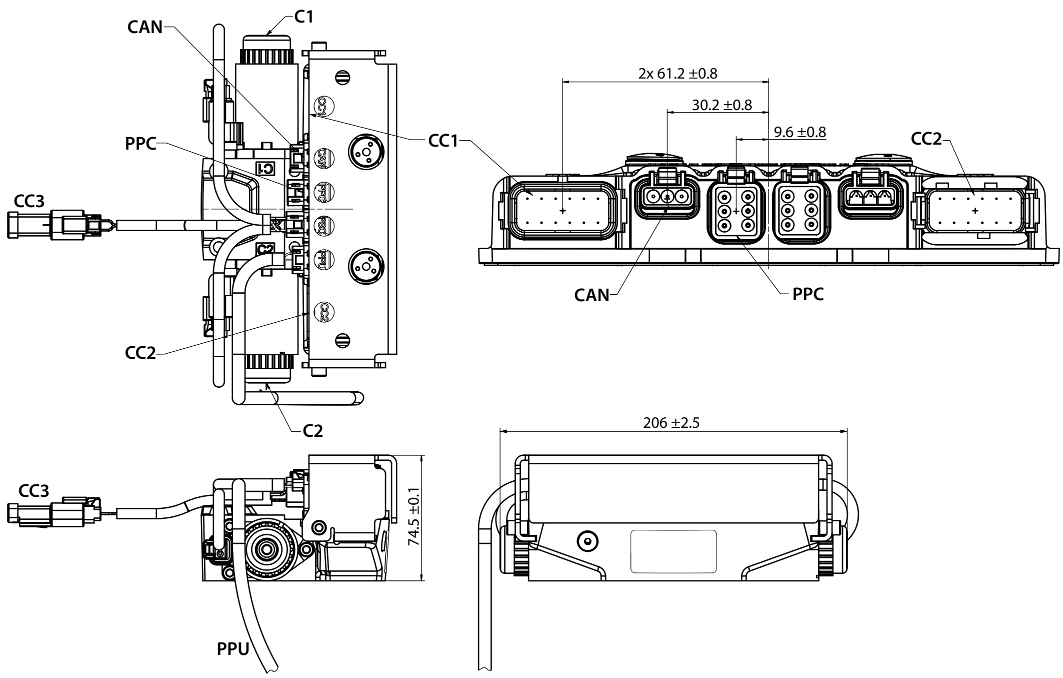
Connectors description

Port	Description
C1 and C2	**1.** Control manual override **C1** **2.** Control Manual Override **C2**
CC1	Port A control connector DEUTSCH DTM04-12P; paint free
CC2	Port B control connector DEUTSCH DTM04-12P; paint free
CC3	Control connector DEUTSCH DT06-2S; paint free; For using connector, the plug may be removed.
CAN	Control connector DEUTSCH DTM04-3P; paint free; For using connector, the plug may be removed.

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

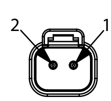
AC connectors dimensions



PPU wire harness is factory installed to speed sensor.

CC3

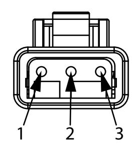
Connector DEUTSCH, 2-pin



1. Digital output A1 (+)
2. Digital output A2 (-)

CAN

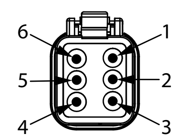
Connector DEUTSCH, 3-pin



1. CAN High
2. CAN Low
3. CAN Shield

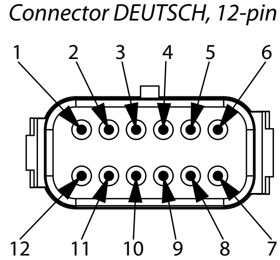
PPC

Connector DEUTSCH, 6-pin



1. Sensor A (+)
2. Analog input A
3. Sensor A (-)
4. Sensor B (-)
5. Analog input B
6. Sensor B (+)

Connector DEUTSCH, 12-pin



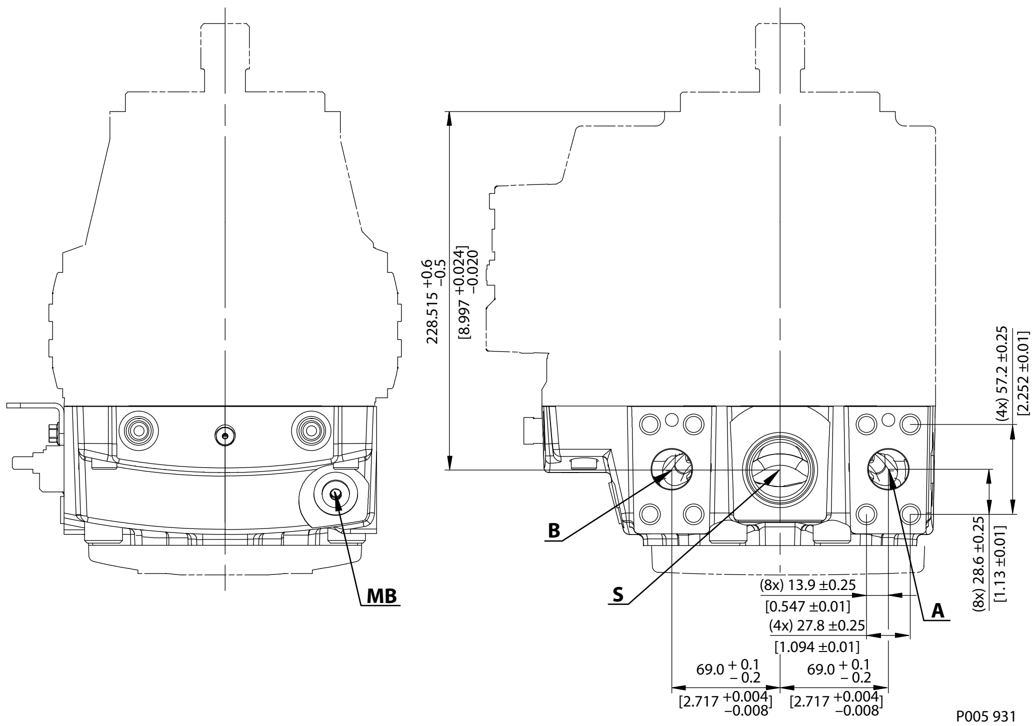
CC1
1. Battery (-)
2. Battery (+)
3. Sensor (+)
4. Sensor (-)
5. Motor rpm input (frequency)
6. Forward input (digital)
7. Reverse input (digital)
8. Sensor (+)
9. Sensor (-)
10. Drive pedal input (analog – nominal)
11. Drive pedal input (analog – red)
12. Neural input (digital)

CC2
1. Inch input (analog – red)
2. Mode switch B input (digital – nominal)
3. Motor prop/PCOR driver
4. Motor direction input (analog)
5. Sensor (+)
6. Sensor (-)
7. Inch input (analog – nominal)
8. Motor BPD driver
9. Digital output B2 (-)
10. Digital output B1 (+)
11. Mode switch A input (digital)
12. Mode switch B input (digital – red)

Dimensions and Data

Filtration

H1P 89/100 Suction Filtration Option L



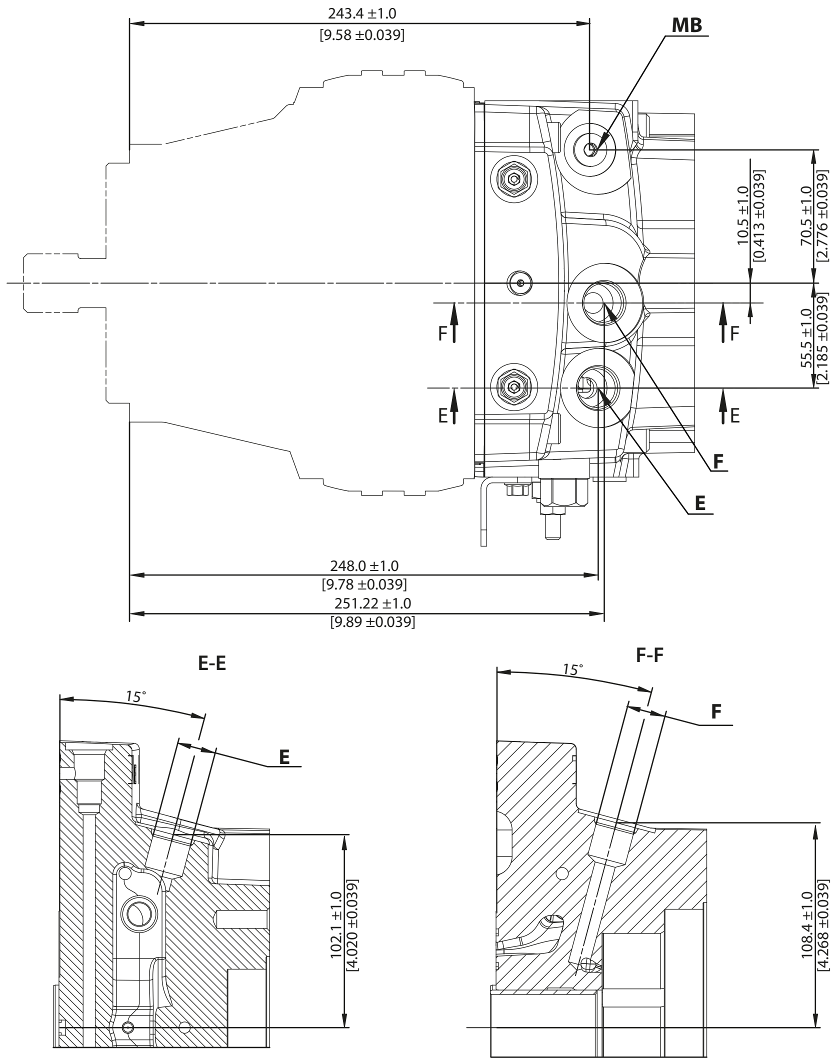
A, B	System ports; 450 bar, split flange boss per ISO 6162
MB	System B gauge port
S	Charge inlet port per ISO 11926-1: 1⁵⁄₈–12

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

H1P 89/100 Remote Full Flow Charge Pressure Filtration Option P

Remote Filtration for end cap option F5 (SAE-C PTO)



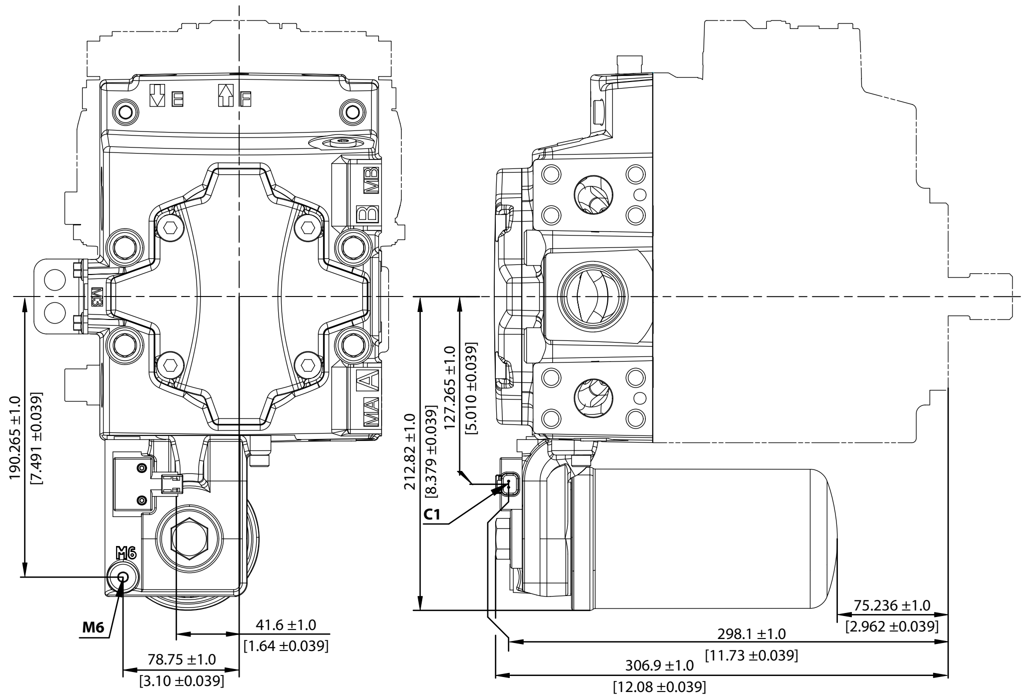
MB	System B gauge port per ISO 11926-1
F	Charge filtration port to filter
E	Charge filtration port from filter

Please contact Danfoss representative for specific installation drawings.

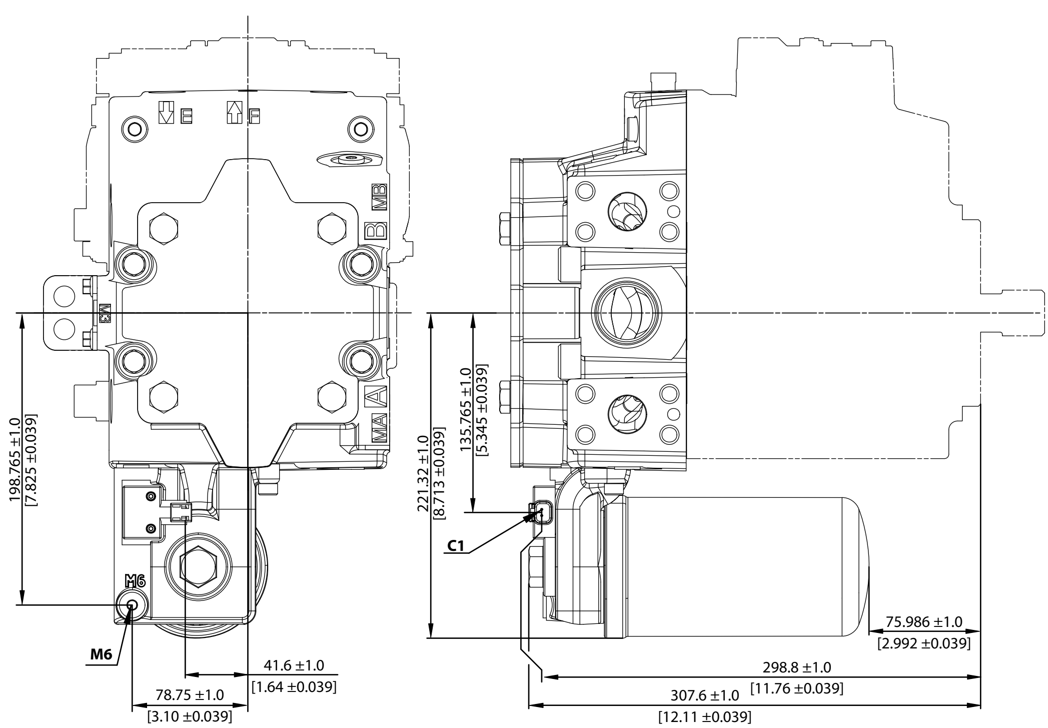
Dimensions and Data

Integral Full Flow Charge Pressure Filtration, Option M

Integral full flow charge pressure filtration with filter bypass sensor, option M, for end cap option D3



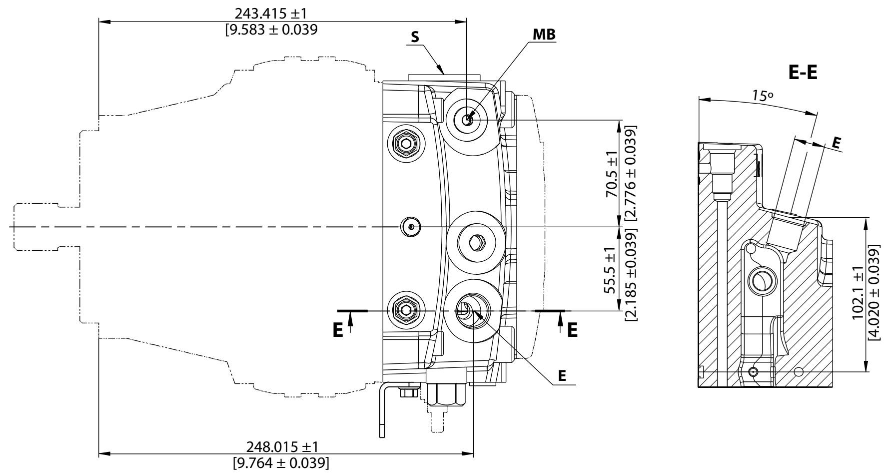
Integral charge filtration with filter bypass sensor, option M, for end cap option F4 (SAE-C PTO)



Dimensions and Data

External Full Flow Charge Pressure Filtration, Option S

External filtration, option S for end cap options D8 or F5



E	Charge filtration ports per ISO 11926-1: 7⁄8–14 from filter
MB	System gauge port per ISO 11926-1: 9⁄16–18
S	Charge inlet port per ISO 11926-1: 1 5⁄8–12

Please contact Danfoss representative for specific installation drawings.

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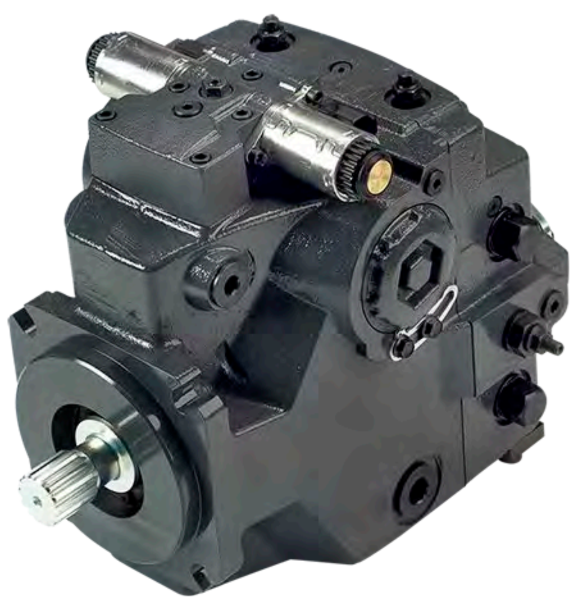
ENGINEERING
TOMORROW

Danfoss

Technical Information

H1P 115/130
Axial Piston Single Pumps



Revision history

Table of revisions

Date	Changed	Rev
May 2022	Corrected HDC control information	1301
December 2021	Added HDC control	1201
April 2021	Corrected interface with ECU (EDC) graphic	1105
April 2020	Corrected swash plate angle sensor connector and CCO connector descriptions	1104
February 2020	Added NFPE control options and changed the document number from BC00000198	1103
June 2019	Major revision.	1001
May 2018	Angle sensor for EDC, FDC note added.	0901
May 2017	NFPE gen. 3 changes.	0801
March 2016	Minor edit	0701
November 2015	Master Model Code changes.	0700
2010-2014	Various changes.	BA-GB
Jul 2009	First edition	AA

Contents

Technical Specifications

H1 Pumps General Specification....6
H1P 115/130 Technical Data.... 6
H1P 115/130 Operating Parameters 7
Fluid Specification....8
H1P 115/130 Mounting Flange Loads 8
Bearing Life and External Radial Shaft Loads.... 9
Charge pump....10
Charge Pump Selection....10
26/34 cm^3 Charge Pump – Flow and Power Curves....10

Master Model Code

Displacement, A—Rotation, B—Product Version, Z—Port Configuration....11
D—Controls.... 12
Electronic Displacement Controls.... 12
Fan Drive Controls....12
Forward-Neutral-Reverse (FNR) Controls....12
Non-Feedback Proportional Electric (NFPE) Controls.... 12
Automotive Controls....13
Manual Displacement Control....13
Manual Displacement Control....13
Hydraulic Displacement Control....14
F—Orifices, E—Displacement Limiters....15
G—Endcap.... 16
H—Mounting Flange, J—Input Shaft, K—Aux Pad....17
M, N—Overpressure Protection Settings....18
S—Charge Pump, T—Filtration, V—Charge Pressure Relief....19
W—Special Hardware, X—Paint, Y—Special Features.... 20

Control Options

Electrical Displacement Control (EDC)....21
EDC Operation....21
Control signal requirements, EDC 115/130....22
Control Solenoid Data....22
Single Pump Output Flow Direction....22
Connector....23
Control response....23
Response Time, EDC 115/130....23
Manual Displacement Control (MDC) 24
MDC operation.... 24
MDC shaft rotation....25
MDC Torque....25
Control response....25
Response time, MDC 115/130....26
Neutral start switch (NSS).... 26
Connector....26
Case Gauge Port M14....27
Lever....27
Hydraulic Displacement Control (HDC).... 28
HDC principle....28
HDC operation....28
Hydraulic signal pressure range....29
Pump output flow direction vs. control pressure.... 29
Control response....29
Response time, HDC 115/130....30
Forward-Neutral-Reverse Control (FNR)....31
FNR Solenoid Data....32
Single Pump Output Flow Direction....32
Connector....32
Control response....32

Contents

Response Time, FNR 115/130 ... 33
Non feedback proportional electric control (NFPE) ... 34
Control Signal Requirements, NFPE 115/130 ... 34
Control Solenoid Data ... 35
Single Pump Output Flow Direction ... 35
Connector ... 35
Control response ... 36
Response Time, NFPE 115/130 ... 36
Automotive Control (AC) ... 37
Mode types ... 37
Basic functions ... 37
Performance functions ... 38
Protection and safety functions ... 38
Engine control and protection ... 38
Installation features ... 38
Fan Drive Control (FDC) ... 39
Control Signal Requirements, FDC 115/130 ... 40
Control Solenoid Data ... 40
Single Pump Output Flow Direction ... 41
Connector ... 41
Control response ... 41
Manual Override (MOR) ... 42
Swashplate angle sensor for EDC controls ... 43
Swash plate angle sensor parameters (EDC) ... 43
Swashplate Angle Sensor Connector ... 44
Interface with ECU (EDC) ... 44
Swash Plate Angle Sensor for NFPE and AC2 Controls ... 45
Swash Plate Angle Characteristic ... 45
Swash Plate Angle Sensor Parameters (NFPE/AC) ... 46
Swash Plate Angle Sensor Connector (NFPE) ... 46
Interface with ECU (NFPE) ... 46
Control Cut Off Valve (CCO) ... 47
CCO Connector (MDC) ... 47
H1P CCO Connector (EDC, NFPE) ... 48
CCO solenoid data ... 48
Displacement Limiter ... 49
H1P 115/130 Displacement Change (approximately) ... 49

Dimensions and Data

H1P Input Shaft Option G2 (SAE D, 27 teeth) ... 50
H1P Input Shaft Option G3 (SAE D, 13 teeth) ... 51
H1P 115/130 Input Shaft Option F3, Code 44–3 ... 52
Tapered shaft customer acknowledgement ... 52
H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth) ... 53
H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth) ... 54
H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth) ... 55
H1P Auxiliary Mounting, Option H4 (SAE D, 13 teeth) ... 56
H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth) ... 57
H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth) ... 58
H1P 115/130 Auxiliary Mounting, Option S1 (SAE B-B, 14 teeth) ... 59
H1P Displacement Limiter, Option B and D ... 60
Single Pump Ports ... 61
H1P Dimensions ... 62
Controls ... 65
EDC Options A2 and A3 (12/24 V) ... 65
EDC with MOR, Options A4 and A5 (12/24 V) ... 66
EDC with CCO (key C), Options E7 and E8 (12/24 V) ... 67
EDC with ASNSR, Options: H2 and H3 (12/24 V) ... 68
EDC with MOR and ASNSR, Options H6 and H7 (12/24 V) ... 69
EDC with CCO and ASNSR, Options H8 and H9 (12/24 V) ... 70

Contents

MDC Option: M1 ... 71
MDC with Neutral Start Switch Option: M2 ... 72
MDC with CCO, Options: M3, M4 ... 73
MDC with NSS and CCO Options: M5, M6 ... 74
HDC, Options: T1, T2 ... 75
NFPE with MOR, Options: N1, N2 (12/24 V) ... 76
NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V) ... 77
NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V) ... 78
NFPE with MOR and CCO, Options: N7, N8 (12/24 V) ... 79
FDC Options: F1, F2 (12/24V) ... 80
Automotive control (AC) ... 81
AC connectors dimensions ... 82
Filtration ... 83
Suction Filtration Option L ... 83
Integral Full Flow Charge Pressure Filtration, Option M ... 84

Technical Specifications

H1 Pumps General Specification

Axial piston closed circuit variable displacement pumps of cradle swash-plate design with clockwise or counterclockwise direction of rotation.

Pipe connections

- Main pressure ports: ISO split flange boss
- Remaining ports: SAE straight thread O-ring boss

Recommended installation position

Pump installation position is discretionary, however the recommended control position is on the top or at the side with the top position preferred. If the pump is installed with the control at the bottom, flushing flow must be provided through port M14 located on the EDC, FNR and NFPE control.

Vertical input shaft installation is acceptable. If input shaft is at the top, 1 bar case pressure must be maintained during operation. The housing must always be filled with hydraulic fluid. Recommended mounting for a multiple pump stack is to arrange the highest power flow towards the input source. Consult Danfoss for nonconformance to these guidelines.

Auxiliary cavity pressure

Auxiliary cavity pressure will be inlet pressure with internal charge pump or case pressure with external charge supply. For reference see Operating Parameters. Please verify mating pump shaft seal capability.

H1P 115/130 Technical Data

Feature	Size 115	Size 130
Displacement	115.2 cm^3 [7.03 in^3]	130.0 cm^3 [7.93 in^3]
Flow at rated speed (continuous)	371 l/min [98 US gal/min]	419 l/min [111 US gal/min]
Torque at maximum displacement (theoretical)	1.83 N•m/bar [1120 lbf•in/1000 psi]	2.07 N•m/bar [1260 lbf•in/1000 psi]
Mass moment of inertia of rotating components	0.021 kg•m^2 [0.0155 slug•ft^2]	0.021 kg•m^2 [0.0155 slug•ft^2]
Mass (dry–no charge pump)	83 kg [187 lb]	83 kg [187 lb]
Oil volume	2.0 l [0.5 US gal]	2.0 l [0.5 US gal]

Shaft, flange and ports description

Input shaft per ISO 3019-1 (outer diameter)	• Outer Ø44 mm – 4 (SAE D, 13 teeth) • Outer Ø44 mm – 4 (SAE D, 27 teeth) • Conical keyed shaft end similar to ISO 3019-1 code 44-3, taper 1:8
Mounting flange per ISO 3019-1	Flange 152-4 (SAE D)
Auxiliary mounting flange with metric fasteners, with shaft outer diameter	• Flange 82-2 (SAE A, 9 teeth and 11 teeth) • Flange 101-2 (SAE B, 13 teeth and SAE B-B, 15 teeth) • Flange 127-4 (SAE C, 14 teeth) • Flange 152-4 (SAE D, 13 teeth)
Suction port per ISO 3019-1	ISO 11926-1 – 1⅝–12 (SAE O-ring boss)
Main configuration port	Ø31.5 mm; M12 x 1.75; 20 min. full thread depth
Case drain ports L2, L4 per ISO 3019-1	ISO 11926-1 – 1 5/16–12 (SAE O-ring boss)
Other ports	SAE O-ring boss
Customer interface threads	Metric fasteners

Technical Specifications

H1P 115/130 Operating Parameters

Parameter		Unit	Size 115/130
Input speed	**Min. for internal[1] and external[2] charge supply**	min^{-1} (rpm)	500
	Min. for full performance, internal charge supply		1200
	Rated		3200
	Maximum		3400
System pressure	**Maximum working**	bar [psi]	450 [6528]
	Maximum		480 [6960]
	Max./Min. low loop		45/10 [650/145]
Charge pressure	**Minimum**	bar [psi]	16 [232]
	Maximum		34 [493]
Control pressure	**Minimum (at corner power for EDC, MDC, FNR)**		17 [247]
	Minimum (at corner power for NFPE, FDC, AC)		25 [363]
	Maximum		40 [580]
Charge pump inlet pressure	**Rated**	bar (absolute) [in Hg vacuum]	0.7 [9.0]
	Minimum (cold start)		0.2 [24.0]
	Maximum	bar [psi]	4.0 [58.0]
Case pressure	**Rated**		3.0 [44.0]
	Maximum		5.0 [73.0]
Lip seal maximum pressure (external)			0.4 [5.8]

[1] Performance (displacement and pressure) may be limited due to limited control pressure.

[2] Full performance (displacement and pressure) possible at minimum charge and control pressure supply.

Filtration, cleanliness level and β_x-ratio (recommended minimum)

Cleanliness per ISO 4406	22/18/13
Efficiency β_x (charge pressure filtration)	$\beta_{15-20} = 75$ ($\beta_{10} \geq 10$)
Efficiency β_x (suction and return line filtration)	$\beta_{35-45} = 75$ ($\beta_{10} \geq 2$)
Recommended inlet screen mesh size	100 – 125 µm

Technical Specifications

Fluid Specification

Viscosity

Intermittent[1]	5 mm^2/s [42 SUS]
Minimum	7 mm^2/s [49 SUS]
Recommended range	12 – 80 mm^2/s [66 – 370 SUS]
Maximum	1600 mm^2/s [7500 SUS]

[1] Intermittent = Short term t < 1 min per incident and not exceeding 2 % of duty cycle based load-life.

Temperature

Minimum [1]	-40°C [-40°F]
Rated	104°C [220°F]
Recommended range[2]	60 – 85°C [140 – 185°F]
Maximum Intermittent	115°C [240°F]

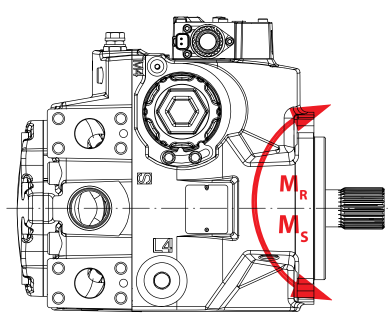
[1] Cold start = Short term t > 3 min, p ≤ 50 bar [725 psi], n ≤ 1000 min-1 (rpm).

[2] At the hottest point, normally case drain port.

H1P 115/130 Mounting Flange Loads

The Rated and Shock load moments apply for top or side orientation of control.

Mounting flange load with control on top



Rated moment	M_R = 5933 N•m [52 510 lbf•in]
Shock load moment	M_S = 12 640 N•m [111 870 lbf•in]

For more information, see *H1 Axial Piston Pumps, Basic Information*, **BC152886483968**, the section “Mounting flange loads”.

Technical Specifications

Bearing Life and External Radial Shaft Loads

All external shaft loads affect bearing life. The pumps are designed with bearings that can accept some external radial loads. The external radial shaft load limits are a function of the load position and orientation, and the operating conditions of the unit.

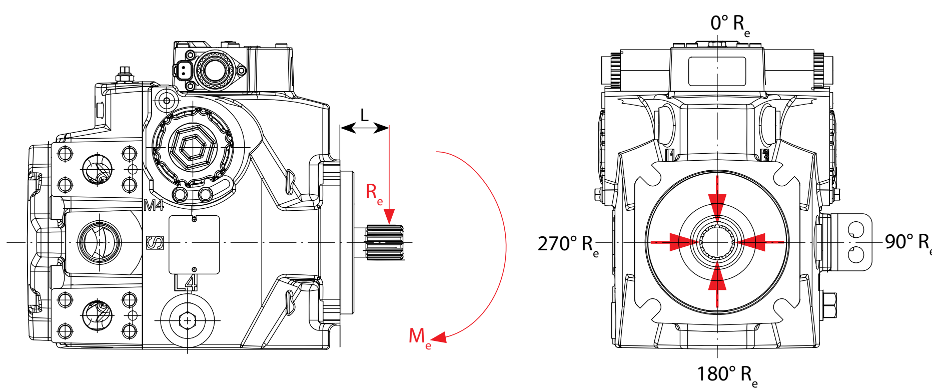
Danfoss recommends clamp-type couplings for applications with radial shaft loads. Contact your Danfoss representative for an evaluation of unit bearing life if you have continuously applied external loads exceeding 25 % of the maximum allowable radial load (R_e) or the pump swash-plate is positioned on one side of center all or most of the time.

Maximum external shaft load based on shaft deflection

External radial moment	Unit	Size 115/130
M_e	N•m [lbf•in]	129 [1140]

External radial shaft loads impact lifetime. For lifetime calculations please contact your Danfoss representative. In applications with external shaft loads, minimize the impact by positioning the load at 0° or 180° as shown below.

Radial load position



The maximum allowable radial shaft load (R_e) is based on the maximum external moment (M_e) and the distance (L) from the mounting flange to the load. It may be determined using the following formula:

$$\mathbf{R_e} = \frac{\mathbf{M_e}}{\mathbf{L}}$$

Thrust loads should be avoided. Contact your Danfoss representative in the event thrust loads are anticipated.

Technical Specifications

Charge pump

Charge Pump Selection

In most applications a general guideline is that the charge pump displacement should be at least 10% of the total displacement of all components in the system. Unusual application conditions may require a more detailed review of charge flow requirements. System features and conditions which may invalidate the 10% guideline include (but are not limited to):

- Continuous operation at low input speeds < 1500 min^{-1} (rpm)
- High shock loading and/or long loop lines
- High flushing flow requirements
- Multiple low speed high torque motors
- High input shaft speeds

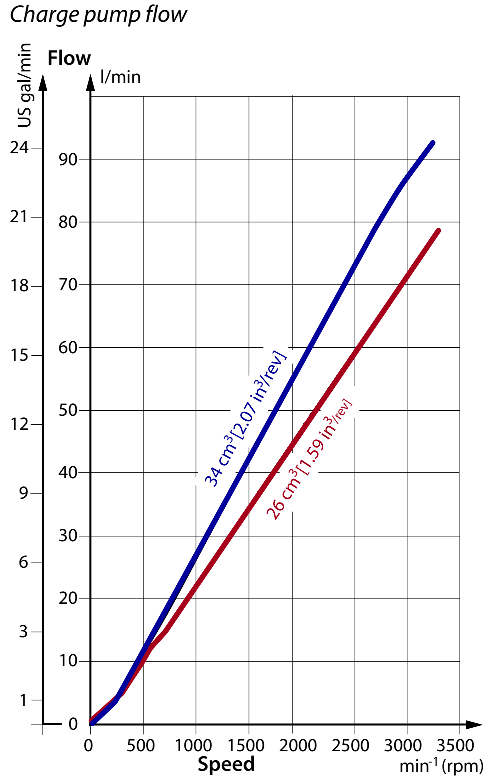
Contact your Danfoss representative for application assistance if your application includes any of these conditions.

26/34 cm³ Charge Pump – Flow and Power Curves

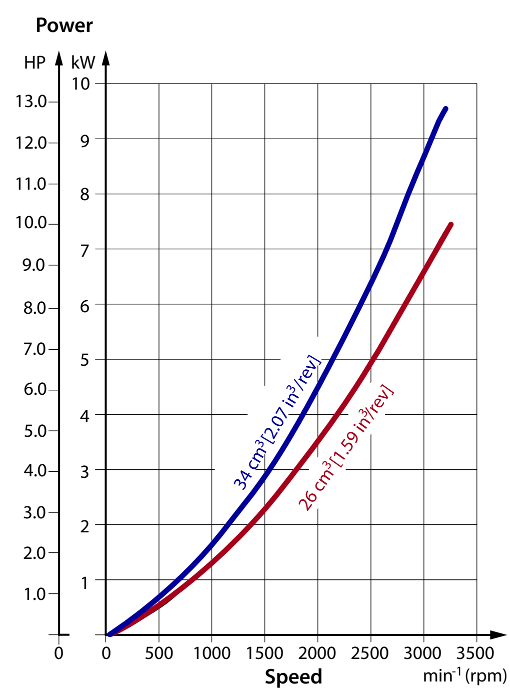
Charge pump flow and power requirements curves shown below at the following conditions:

Charge pressure = 20 bar [290 psi]
Viscosity = 11 mm²/s [63 SUS]
Temperature = 80°C [176°F]

Charge pump flow

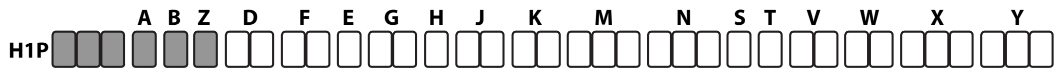


Charge pump power requirements



Master Model Code

Displacement, A—Rotation, B—Product Version, Z—Port Configuration



Displacement

115	115.2 cm³ [7.03 in³]
130	130.0 cm³ [7.93 in³]

A – Direction of Rotation

L	Left hand (counter clockwise)
R	Right hand (clockwise)

B – Product version

B	Revision code

Z – Port configuration

A	Inch, Customer O-ring port sealing according to ISO 11926-1

Master Model Code

D—Controls

A B Z D F E G H J K M N S T V W X Y
H1P

Electronic Displacement Controls

Code	Control type	Voltage	MOR	CCO with key C	Angle sensor	Connector
A2	EDC	12 V	—	—	—	DEUTSCH
A3	EDC	24 V	—	—	—	DEUTSCH
A4	EDC	12 V	●	—	—	DEUTSCH
A5	EDC	24 V	●	—	—	DEUTSCH
E7	EDC	12 V	—	●	—	DEUTSCH
E8	EDC	24 V	—	●	—	DEUTSCH
H2	EDC	12 V	—	—	●	DEUTSCH
H3	EDC	24 V	—	—	●	DEUTSCH
H6	EDC	12 V	●	—	●	DEUTSCH
H7	EDC	24 V	●	—	●	DEUTSCH
H8	EDC	12 V	—	●	●	DEUTSCH
H9	EDC	24 V	—	●	●	DEUTSCH

● – To be used for the control; — Not to be used for the control

Fan Drive Controls

F1	FDC	12 V	DEUTSCH Connector
F2	FDC	24 V	DEUTSCH Connector

Align with options: **F:** Orifices, **E:** Displacement limiters, **M, N:** Overpressure protection, and **W:** Special hardware.

Forward-Neutral-Reverse (FNR) Controls

A9	FNR	12 V	with MOR	DEUTSCH Connector
B1	FNR	24 V	with MOR	DEUTSCH Connector

Non-Feedback Proportional Electric (NFPE) Controls

Code	Control type	Voltage	MOR	CCO with key C	Angle sensor	Connector
N1	NFPE	12 V	●	—	—	DEUTSCH
N2	NFPE	24 V	●	—	—	DEUTSCH
N3	NFPE	12 V	●	●	●	DEUTSCH
N4	NFPE	24 V	●	●	●	DEUTSCH
N5	NFPE	12 V	●	—	●	DEUTSCH
N6	NFPE	24 V	●	—	●	DEUTSCH
N7	NFPE	12 V	●	●	—	DEUTSCH
N8	NFPE	24 V	●	●	—	DEUTSCH

Align with options: **E:** Displacement limiters and **W:** Special hardware.

Master Model Code

Automotive Controls

Automotive Control (AC)

Code	AC type	Voltage	MOR	Speed sensor	Wire harness	Angle sensor	Connector
P6	AC–1	12 V	●	●	●	—	DEUTSCH
P7	AC–1	24 V	●	●	●	—	DEUTSCH
P8	AC–2	12 V	●	●	●	●	DEUTSCH
P9	AC–2	24 V	●	●	●	●	DEUTSCH
P5	AC–1	12 V	●	—	—	—	DEUTSCH
R3	AC–1	24 V	●	—	—	—	DEUTSCH
R4	AC–2	12 V	●	—	—	●	DEUTSCH
R5	AC–2	24 V	●	—	—	●	DEUTSCH

● – To be used for the control; — Not to be used for the control

Manual Displacement Control

Manual Displacement Control (MDC)

Code	Control type	CCO Voltage	CCO	Neutral Start Switch	Connector
M1	MDC	—	—	—	—
M2	MDC	—	—	●	DEUTSCH
M3	MDC	12 V	●	—	DEUTSCH
M4	MDC	24 V	●	—	DEUTSCH
M5	MDC	12 V	●	●	DEUTSCH
M6	MDC	24 V	●	●	DEUTSCH

Align with options **F:** Orifices and **Y:** Settings for adjustment (if applicable).

Manual Displacement Control

Manual Displacement Control (MDC)

Code	Control type	CCO Voltage	CCO	Neutral Start Switch	Connector
M1	MDC	—	—	—	—
M2	MDC	—	—	●	DEUTSCH
M3	MDC	12 V	●	—	DEUTSCH
M4	MDC	24 V	●	—	DEUTSCH
M5	MDC	12 V	●	●	DEUTSCH
M6	MDC	24 V	●	●	DEUTSCH

Align with options **F:** Orifices and **Y:** Settings for adjustment (if applicable).

Master Model Code

Hydraulic Displacement Control

Hydraulic Displacement Control (HDC)

Code	Pressure range	Ports
T1	4.2 - 16.2 bar	Inch ports 9/16-18
T2	3.0 - 11.6 bar	Inch ports 9/16-18

Master Model Code

F—Orifices, E—Displacement Limiters

A B Z D F E G H J K M N S T V W X Y

H1P

F – Orifices Options

Orifices options related to control type

Code	Tank (A+B)	P orifice	A/B orifices	EDC, FNR	MDC	NFPE, AC	FDC
C3	No orifice			●	●	–	–
C1	–	–	0.8 mm	●	●	●	–
C2	–	–	1.3 mm	●	●	●	●
C4	–	–	1.8 mm	●	●	●	–
C6	1.0 mm	–	–	–	●	–	
C7	1.3 mm	–	–	–	●	–	–
D1	0.8 mm	1.0 mm	–	–	●	–	–
D2	0.8 mm	1.3 mm	–	–	●	–	–
D3	1.0 mm	1.3 mm	–	–	●	–	–
D4	1.0 mm	1.3 mm	1.3 mm	–	●	–	–
D5	0.6 mm	0.6 mm	0.8 mm	–	●	–	–
D6	1.3 mm	1.3 mm	–	–	●	–	–
D7	–	–	3.0 mm	–	–	●	–

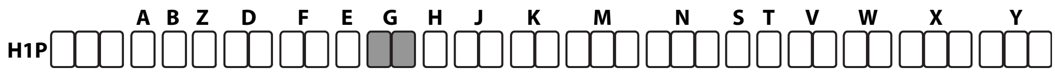
E – Displacement Limiter Options

N	None
B	Adjustable externally
C	No limiters, with nested springs, required for NFPE, AC, FDC*
D	Adjustable externally with nested springs, required for NFPE, AC, FDC*

* Align with option **Y:** Settings for adjustment (if applicable).

Master Model Code

G—Endcap



G – End-cap Options

Twin port, ISO 6162 split flange ports; Align with T: Filtration

D3	Integral pressure filtration
D6	Suction filtration
D8	Remote filtration or external charge supply

Master Model Code

H—Mounting Flange, J—Input Shaft, K—Aux Pad

A B Z D F E G H J K M N S T V W X Y

H1P

H – Mounting options

Mounting to be aligned with option W: Special hardware

G	ISO 3019-1 flange 152–4 (SAE D)
L	ISO 3019-1 flange 152–4 (SAE D), 4-bolt, with speed sensor

J – Input Shaft options

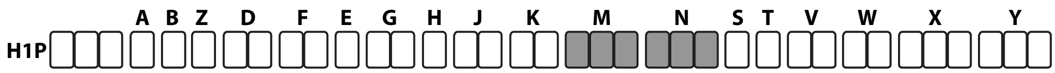
G2	ISO 3019-1, outer Ø44 mm - 4 (27 teeth splined shaft 16/32 pitch)
G3	ISO 3019-1, outer Ø44 mm - 4 (13 teeth splined shaft 8/16 pitch)
F3	Conical keyed shaft end, code 44-3 (similar to ISO 3019-1), taper 1:8 (key not supplied with pump)

K – Auxiliary Mounting Pad options (ISO 3019-1)

NN	None
H1	Flange 82–2 (SAE A, 11 teeth, 16/32 coupling); shipping cover
H2	Flange 82–2 (SAE A, 9 teeth, 16/32 coupling); shipping cover
H3	Flange 101–2 (SAE B, 13 teeth, 16/32 coupling); shipping cover
S1	Flange 101–2 (SAE B, 14 teeth, 12/24 coupling); shipping cover
H5	Flange 101–2 (SAE B-B, 15 teeth, 16/32 coupling); shipping cover
H6	Flange 127–4 (SAE C, 14 teeth, 12/24 coupling); shipping cover
E5	Flange 127–4 (SAE C, 13 teeth, 8/16 coupling); shipping cover
H4	Flange 152–4 (SAE D, 13 teeth, 8/16 coupling); shipping cover

Master Model Code

M, N—Overpressure Protection Settings



M and N – Overpressure protection options

L	Pressure limiter setting	HPRV with bypass setting[1]
L20	200 bar [2900 psi]	250 bar [3630 psi]
L23	230 bar [3336 psi]	280 bar [4061 psi]
L25	250 bar [3630 psi]	300 bar [4350 psi]
L28	280 bar [4061 psi]	330 bar [4786 psi]
L30	300 bar [4350 psi]	350 bar [5076 psi]
L33	330 bar [4786 psi]	380 bar [5510 psi]
L35	350 bar [5080 psi]	400 bar [5800 psi]
L38	380 bar [5510 psi]	420 bar [6090 psi]
L40	400 bar [5800 psi]	450 bar [6526 psi]
L42	420 bar [6090 psi]	450 bar [6526 psi]
L43	430 bar [6237 psi]	480 bar [6962 psi]
L44	440 bar [6382 psi]	480 bar [6962 psi]
L45	450 bar [6526 psi]	480 bar [6962 psi]
Overpressure protection type and setting for FDC		
F01	150 bar [2175 psi]	250 bar [3630 psi]
F02	150 bar [2175 psi]	300 bar [4350 psi]
F03	150 bar [2175 psi]	350 bar [5076 psi]
F04	150 bar [2175 psi]	400 bar [5800 psi]

[1] Pressure limiter and HPRV with bypass, over-pressure protection type must be the same for both sides “A” and “B”.

K	Pressure setting [1]
K18	180 bar [2610 psi]
K20	200 bar [2900 psi]
K23	230 bar [3336 psi]
K25	250 bar [3630 psi]
K28	280 bar [4061 psi]
K30	300 bar [4350 psi]
K33	330 bar [4786 psi]
K35	350 bar [5076 psi]
K38	380 bar [5510 psi]
K40	400 bar [5800 psi]
K42	420 bar [6090 psi]
K45	450 bar [6526 psi]

[1] Pressure limiter and HPRV with bypass, over-pressure protection type must be the same for both sides “A” and “B”.

Please contact Danfoss Power Solutions for pressures not shown or for applied pressure above max. working pressure.

Master Model Code

S—Charge Pump, T—Filtration, V—Charge Pressure Relief

A B Z D F E G H J K M N S T V W X Y

H1P

S – Charge pump options

A	26 cm^3/rev [1.69 in^3/rev]
L	34 cm^3/rev [2.07 in^3/rev]
N	No charge pump, external charge supply (*Align with options:* **E, T**)

T – Filtration options

Filtration to be aligned with G: End cap selection

L	Suction filtration
M	Integral full charge flow filtration with bypass sensor, long filter length **11004919**
N	Integral full charge flow filtration with bypass sensor, without filter
P	Remote full charge flow filtration
E	External full charge flow filtration (Align with options **N, S**)

V – Charge pressure relief valve (CPRV) setting

20*	20 bar [290 psi]
22*	22 bar [319 psi]
24*	24 bar [348 psi]
26	26 bar [377 psi]
28	28 bar [406 psi]
30	30 bar [435 psi]
32	32 bar [464 psi]
34	34 bar [493 psi]

* Not to be used for **NFPE, AC** and **FDC** controls.

Master Model Code

W—Special Hardware, X—Paint, Y—Special Features

A B Z D F E G H J K M N S T V W X Y

H1P

W – Special Hardware features

Hardware features to be aligned with options D, E

P1	NFPE/FDC valve plate
P2	NFPE/FDC/AC valve plate and speed ring on the cylinder block
P4	EDC/FNR/MDC valve plate and speed ring on the cylinder block
PN	EDC/FNR/MDC valve plate
H1	MDC/EDC/FNR valve plate with MDC handle

X – Paint and Name-tag

NNN	Black paint and Danfoss name-tag
C08	Paint none and Danfoss name-tag

Y – Special settings (SIL-2 non-certifiable, without customer files)

Code	CAN J1939	ECO fuel saving mode	Functional option	Cruise control	Control	AC type
D3E	in/out	●	E	–	N1 ($12\ V_{DC}$)	AC–1
D3F	in/out	–	F	–		
D4E	in/out	●	E	–	N2 ($24\ V_{DC}$)	
D4F	in/out	–	F	–		
D5F	in/out	–	F	–	P8 ($12\ V_{DC}$)	AC–2 (with swash plate angle sensor)
D5J	in/out	●	J	●		
D6F	in/out	–	F	–	P9 ($24\ V_{DC}$)	
D6J	in/out	●	J	●		
M00	MDC handle standard position					
NNN	None					

● – To be used for the control; — Not to be used for the control

Control Options

Electrical Displacement Control (EDC)

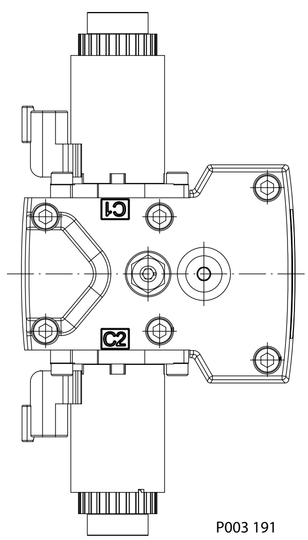
An EDC is a displacement (flow) control. Pump swash plate position is proportional to the input command and therefore vehicle or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The Electrical Displacement Control (**EDC**) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

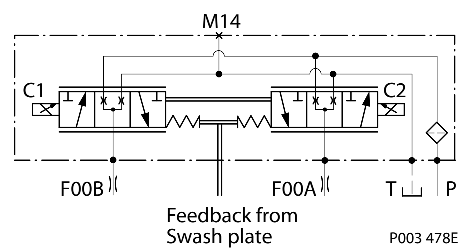
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

Electrical Displacement Control



EDC schematic, feedback from swash plate



EDC Operation

H1 EDC's are current driven controls requiring a Pulse Width Modulated (PWM) signal. Pulse width modulation allows more precise control of current to the solenoids.

The PWM signal causes the solenoid pin to push against the porting spool, which pressurizes one end of the servo piston, while draining the other. Pressure differential across the servo piston moves the swashplate.

A swashplate feedback link, opposing control links, and a linear spring provide swashplate position force feedback to the solenoid. The control system reaches equilibrium when the position of the swashplate spring feedback force exactly balances the input command solenoid force from the operator. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

The EDC incorporates a positive neutral deadband as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold current is reached, the swashplate is positioned directly proportional to the control current. To minimize the effect of the control neutral deadband, we recommend the transmission controller or operator input device incorporate a jump up current to offset a portion of the neutral deadband.

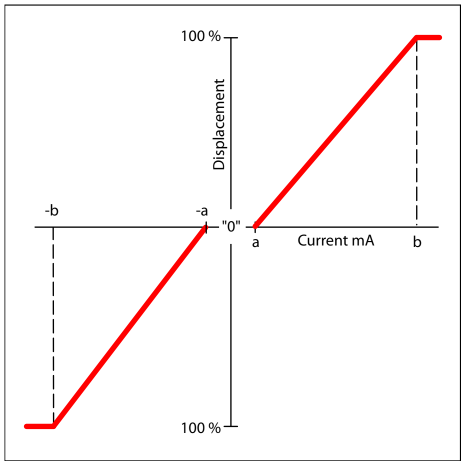
The neutral position of the control spool does provide a positive preload pressure to each end of the servo piston assembly.

When the control input signal is either lost or removed, or if there is a loss of charge pressure, the spring-loaded servo piston will automatically return the pump to the neutral position.

Control Options

Control signal requirements, EDC 115/130

Pump displacement vs. control current



EDC control current

Voltage		$12\ V_{DC}$	$24\ V_{DC}$
Minimum current to stroke pump	**a***	640 mA	330 mA
	b	1640 mA	820 mA
Pin connections		any order	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Single Pump Output Flow Direction

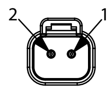
Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	out	in	in	out
Port B	in	out	out	in
Servo port pressurized	M4	M5	M4	M5

* For coil location see installation drawings.

Control Options

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, EDC 115/130

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	4.4 s	2.0 s	1.0 s
Full flow to neutral	2.9 s	1.3 s	0.8 s

Control Options

Manual Displacement Control (MDC)

A Manual proportional Displacement Control (**MDC**) consists of a handle on top of a rotary input shaft. The shaft provides an eccentric connection to a feedback link. This link is connected on its one end with a porting spool. On its other end the link is connected the pumps swashplate.

This design provides a travel feedback without spring. When turning the shaft the spool moves thus providing hydraulic pressure to either side of a double acting servo piston of the pump.

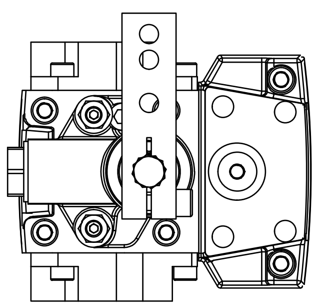
Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement. Simultaneously the swashplate movement is fed back to the control spool providing proportionality between shaft rotation on the control and swash-plate rotation. The MDC changes the pump displacement between no flow and full flow into opposite directions.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

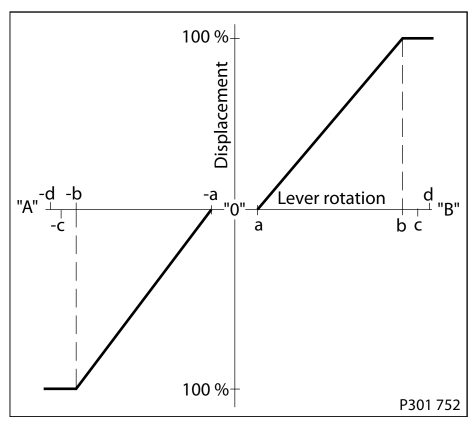
For the MDC with CCO option the brake port (X7) provides charge pressure when the coil is energized to activate static function such as a brake release. The X7 port must not be used for any continuous oil consumption.

The MDC is sealed by means of a static O-ring between the actuation system and the control block. Its shaft is sealed by means of a special O-ring which is applied for low friction. The special O-ring is protected from dust, water and aggressive liquids or gases by means of a special lip seal.

Manual Displacement Control



Pump displacement vs. control lever rotation



Deadband on **B** side: **a = 3° ±1°**
Maximum pump stroke: **b = 30° +2/-1°**
Required customer end stop: **c = 36° ±3°**
Internal end stop: **d = 40°**

MDC operation

The MDC provides a mechanical dead-band required to overcome the tolerances in the mechanical actuation. The MDC contains an internal end stop to prevent turning the handle into any inappropriate position.

The MDC provides a permanent restoring moment appropriate for turning the MDC input shaft back to neutral position only. This is required to take the backlash out of the mechanical connections between the Bowden cable and the control.

High case pressure may cause excessive wear and the NSS to indicate that the control is not in neutral position. In addition, if the case pressure exceeds 5 bar there is a risk of an insufficient restoring moment. The MDC is designed for a maximum case pressure of 5 bar and a rated case pressure of 3 bar.

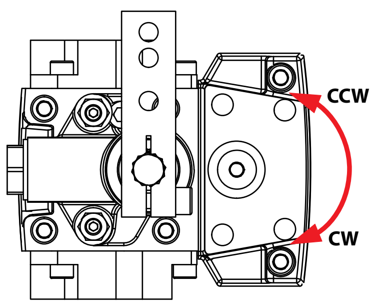
Control Options

- Customers must install some support to limit the setting range of their Bowden cable to avoid an overload of the MDC.
- Customers can apply their own handle design but they must care about a robust clamping connection between their handle and the control shaft and avoid overload of the shaft.
- Customers can connect two MDC's on a tandem unit in such a way that the actuation force will be transferred from the pilot control to the second control. The kinematic of the linkages must ensure that either control shaft is protected from torque overload.

Caution

Using the internal spring force on the input shaft is not an appropriate way to return the customer connection linkage to neutral, or to force a Bowden cable or a joystick back to neutral position. It is not applicable for any limitation of the Bowden cable stroke, except the applied torque to the shaft will never exceed 20 N•m.

MDC shaft rotation



Pump shaft rotation*	Clockwise (CW)		Counter-clockwise (CCW)	
MDC shaft rotation	**CW**	**CCW**	**CW**	**CCW**
Port A	in (low)	out (high)	out (high)	in (low)
Port B	out (high)	in (low)	in (low)	out (high)
Servo port high pressure	M5	M4	M5	M4

* As seen from shaft side.

MDC Torque

Description	Value
Torque required to move handle to maximum displacement	1.4 N•m [12.39 lbf•in]
Torque required to hold handle at given displacement	0.6 N•m [5.31 lbf•in]
Maximum allowable input torque	20 N•m [177 lbf•in]

Caution

Volumetric efficiencies of the system will have impacts on the start and end input commands.

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]

Control Options

Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm²/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response time, MDC 115/130

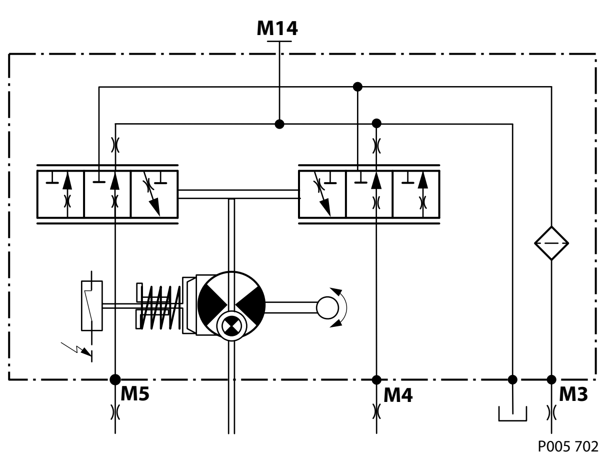
Code	Orifice description (mm)			Stroking direction	
	Tank (A+B)	P	A/B	Neutral to full flow	Full flow to neutral
C3	No orifice			0.4 s	0.4 s
C6	1	–	–	1.1 s	1.0 s
C7	1.3	–	–	0.7 s	0.7 s
D1	0.8	1	–	2.1 s	1.5 s
D2	0.8	1.3	–	1.8 s	1.4 s
D3	1	1.3	–	1.3 s	1.0 s
D4	1	1.3	1.3	1.6 s	1.2 s

For further data please contact your Danfoss representative.

Neutral start switch (NSS)

The Neutral Start Switch **(NSS)** contains an electrical switch that provides a signal of whether the control is in neutral. The signal in neutral is Normally Closed **(NC)**.

Neutral start switch schematic

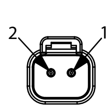


Neutral start switch data

Max. continuous current with switching	8.4 A
Max. continuous current without switching	20 A
Max. voltage	36 V_{DC}
Electrical protection class	IP67 / IP69K with mating connector

Connector

Connector DEUTSCH, 2-pin



Control Options

Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Case Gauge Port M14

The drain port should be used when the control is mounted on the unit's bottom side to flush residual contamination out of the control.

Lever

MDC-controls are available with an integrated lever.

Control Options

Hydraulic Displacement Control (HDC)

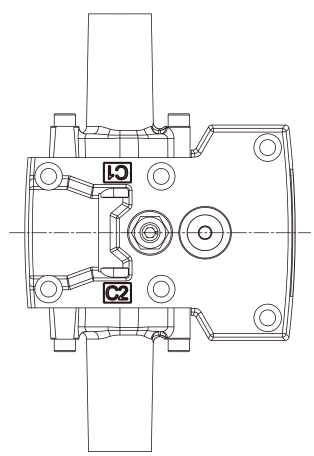
HDC principle

An HDC is a Hydraulic Displacement Control. Pump swashplate position is proportional to the input command and therefore vehicle speed or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The HDC control uses a hydraulic input signal to operate a porting spool, which ports hydraulic pressure to either side of a double acting servo piston. The hydraulic signal applies a force input to the spool which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction. Under some circumstances, such as contamination, the porting spool could stick and cause the pump to stay at some displacement.

A serviceable 175 µm screen is located in the supply line immediately before the control porting spool.

HDC control



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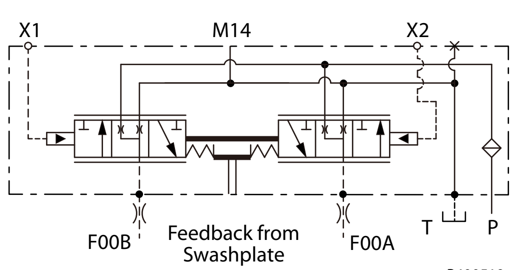
HDC schematic



P400519

HDC operation

HDC's are hydraulically driven control which ports hydraulic pressure to either side of a porting spool, which pressurizes one end of the servo piston, while draining the other end to case. Pressure differential across the servo piston moves the swashplate.

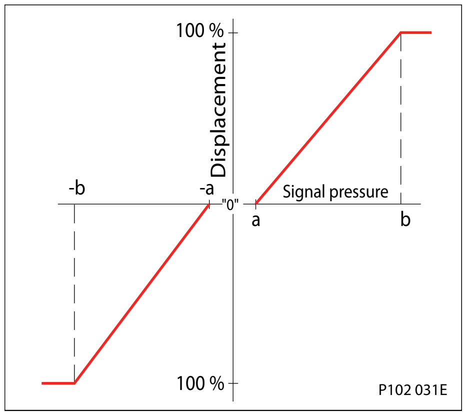
A swashplate feedback link, opposing control linkage, and a linear spring provide swashplate position force feedback to the hydraulic pressure. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

Control Options

The HDC incorporates a positive neutral dead band as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold point is reached, the swashplate is positioned directly proportional to the control pressure.

When the control input is either lost or removed, or if there is a loss of charge pressure, the spring loaded servo piston will automatically return the pump to the neutral position.

Pump displacement vs signal pressure



Hydraulic signal pressure range

Option	Type	a*	b*	Max. pressure
T1	Standard	4.2 bar	16.2 bar	30 bar
T2	Option	3 bar	11.6 bar	30 bar

* Factory test current, for vehicle movement or application actuation expect a higher or lower value.

Pump output flow direction vs. control pressure

Shaft rotation HDC	Clockwise (CW) seen from shaft		Counter Clockwise (CCW) seen from shaft	
Port energized	X1	X2	X1	X2
Port A	Out (high)	In (low)	In (low)	Out (high)
Port B	In (low)	Out (high)	Out (high)	In (low)
Servo port high pressure	M4	M5	M4	M5

For appropriate performance of HDC characteristic, keep the drain pressure of pilot valve to be equal or slightly higher than pump case pressure.

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm²/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min⁻¹ (rpm)

Control Options

Response time, HDC 115/130

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	3.7s	1.7s	1s
Full flow to neutral	2.4s	1.1s	0.6s

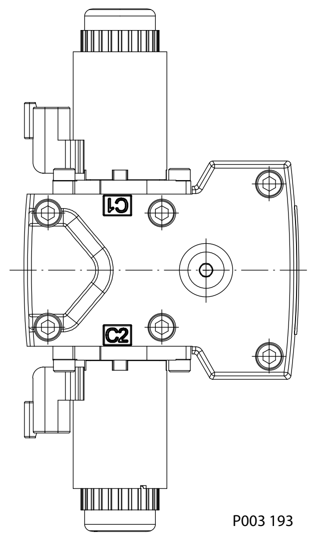
Control Options

Forward-Neutral-Reverse Control (FNR)

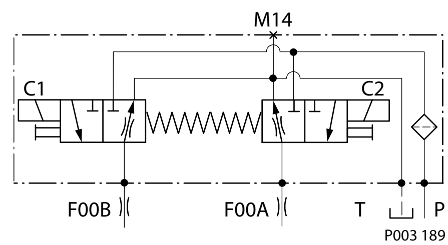
The 3-position FNR control options **A9** (12 V) and **B1** (24 V) uses an electric input signal to switch the pump to a full stroke position. A serviceable 125 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool can stick and cause the pump to stay at some displacement.

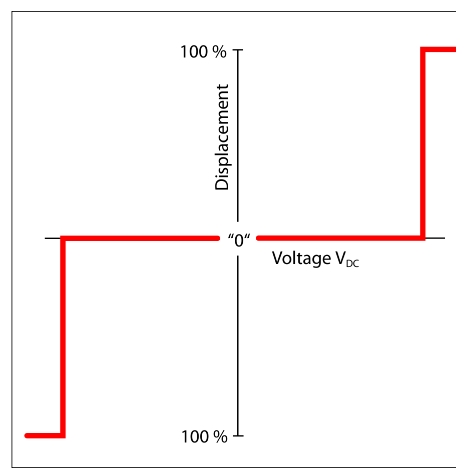
Forward-Neutral-Reverse electric control (FNR)



FNR hydraulic schematic



Pump displacement vs. electrical signal



FNR control current

Voltage	$12\ V_{DC}$	$24\ V_{DC}$
Minimum current to stroke pump	750 mA	380 mA
Pin connections	any order	

Control Options

FNR Solenoid Data

Solenoid data

Voltage	12 V_{DC}	24 V_{DC}
Minimum supply voltage	9.5 V_{DC}	19 V_{DC}
Maximum supply voltage (continuous)	14.6 V_{DC}	29 V_{DC}
Bi-directional diode cut off voltage	28 V_{DC}	53 V_{DC}
Maximum current	1050 mA	500 mA
Nominal coil resistance @ 20°C	8.4 Ω	34.5 Ω
PWM Range	70 – 200 Hz	
PWM Frequency (preferred)*	100 Hz	

* PWM signal required for optimum control performance.

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector

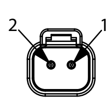
Single Pump Output Flow Direction

Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see installation drawings.

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]

Control Options

Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, FNR 115/130

Stroking direction	0.8 [0.03] orifice	1.3 [0.05] orifice	No orifice
Neutral to full flow	4.2 s	1.9 s	1.2 s
Full flow to neutral	5.2 s	2.2 s	1.1 s

Control Options

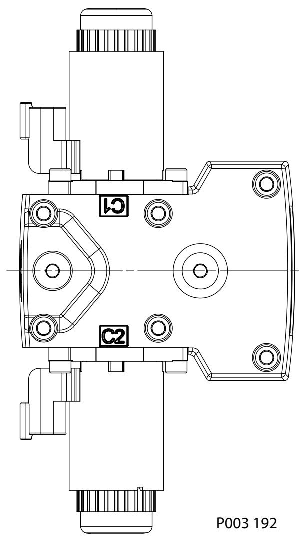
Non feedback proportional electric control (NFPE)

The Non Feedback Proportional Electric (**NFPE**) control is an electrical automotive control in which an electrical input signal activates one of two proportional solenoids that port charge pressure to either side of the pump servo cylinder. The NFPE control has no mechanical feedback mechanism.

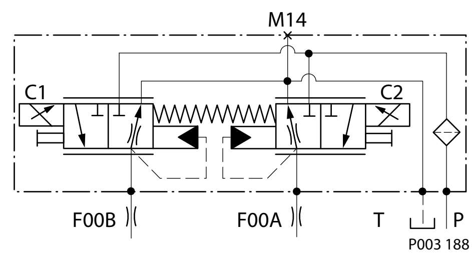
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

NFPE control



NFPE schematic

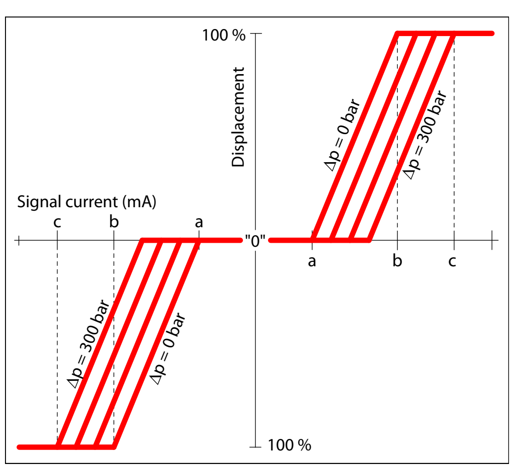


Control Signal Requirements, NFPE 115/130

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash-plate angle as system pressure increases.

A typical response characteristic is shown in the accompanying graph below:

Pump displacement vs. input signal



Control Options

Control current requirements

Voltage*	a	b	c	Pin config.
12 V_{DC}	870 mA	1290 mA	1540 mA	any order
24 V_{DC}	440 mA	670 mA	770 mA	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

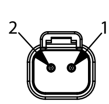
Single Pump Output Flow Direction

Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	C1	C2	C1	C2
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see installation drawings.

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control Options

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

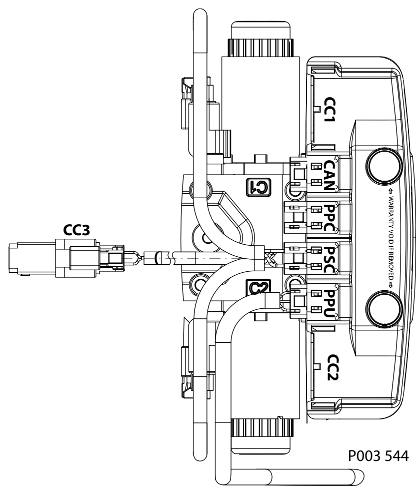
Response Time, NFPE 115/130

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	3.0 mm [0.12 in] orifice
Neutral to full flow	5.0 s	2.3 s	0.9 s
Full flow to neutral	2.5 s	1.1 s	0.4 s

Control Options

Automotive Control (AC)

The H1 **A**automotive **C**ontrol (AC) is an electric NFPE Control with an integrated micro-controller, installed on the pump. The integrated micro-controller enhanced control performance with a flexible, configurable control scheme for an entire single path propel transmission. It can be used in combination with fixed and variable displacement hydraulic-motors. With the pre-installed application software and easily changeable control parameters, it is possible to tailor the vehicle's driving behavior to the individual requirements of the customer.



The H1 Automotive Control is divided into 2 systems:
- AC-1
- AC-2

AC-2 is an extension of AC-1 that features an integrated pump swash plate angle sensor and software enabled functions such as Swash Plate Control.

Mode types

The application software provides 3 different hydrostatic propel methods, defined as mode types, which can be used individually.
- **Automotive Load dependent** (torque controlled) driving behavior. Setpoint for the drive curve is the engine rpm.
- **Non-Automotive Load independent** (speed controlled) driving mode. Setpoint for the drive curve is a Joystick or drive pedal signal, independent of the engine rpm. The best performance will achieved with an AC-2 Swash Plate Angle Sensor.
- **Creep-Automotive Load dependent** (torque controlled) driving behavior (like Automotive). Setpoint for the drive curve is the engine rpm. The setpoint can be reduced by the creep potentiometer if a high engine rpm in combination with low vehicle speed is needed.

Basic functions

- Four selectable system modes, selectable via switch.
- Individual settings for forward and reverse driving direction (4 x 2 curves).
- Independent pump and hydraulic-motor profiling and ramping for each mode.
- Electric drive pedal connection
- Electronic inching function without separate control valve
- Electric creep mode potentiometer

Control Options

- Configurable System Mode & Direction change
- Load independent pump displacement control with integrated Swash Plate Angle Sensor (AC-2)
- Hydraulic-motor displacement control including brake pressure defeat function

Performance functions

- ECO fuel saving mode with automatic reduction of the engine speed during transport (Cruise control)
- Vehicle constant speed drive control
- Vehicle speed limitation
- Dynamic brake light, automatic park brake, reverse buzzer and status LED outputs
- Vehicle speed controlled output function.
- Temperature compensation for predictable performance
- Advanced CAN J1939 interface for the information exchange with the vehicle control system

Protection and safety functions

- Safety controlled vehicle start protection with engine speed check, battery check and FNR must be in neutral, etc..
- Operator presence detection
- Hydraulic system overheat and low-temperature protection
- Hydraulic motor over speed protection
- Park brake test mode for roller applications to fulfill SAE J1472 / EN500-4.
- SIL2 compliant

Engine control and protection

- CAN J1939 engine interface
- Engine speed control via drive pedal with safety controlled monitoring function
- Engine antistall protection
- Engine over speed protection during inching
- Engine speed dependent Retarder control
- Engine cold start protection

Installation features

- Factory calibration for hysteresis compensation.
- Starting current adjustment in the factory
- Pre-installed application software and parameter files

For more information, see *Automotive Control for H1 Single Pumps Technical Information*, **BC152986482596**.

Control Options

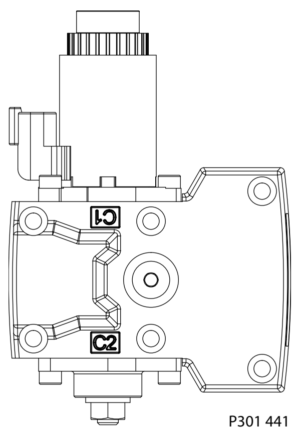
Fan Drive Control (FDC)

The Fan Drive Control (**FDC**) is a non-feedback control in which an electrical input signal activates the proportional solenoid that ports charge pressure to either side of the pump servo cylinder. The single proportional solenoid is used to control pump displacement in the forward or reverse direction.

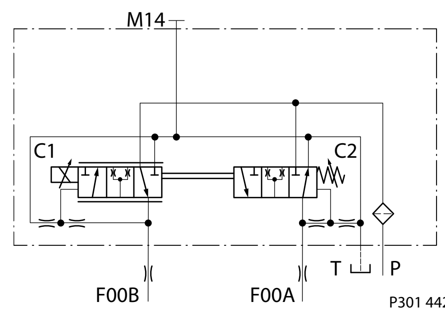
The control spool is spring biased to produce maximum forward pump displacement in the absence of an electrical input signal. Based on the spring bias spool default forward flow for a CW rotation pump is out of port B while default forward flow for a CCW rotation pump is out of port A.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

FDC control



FDC schematic



The pump should be configured with 0.8 mm control orifices to provide slowest response and maximize system stability. Additionally, pressure limiter (PL) valves are used to limit maximum fan trim speed in both (forward and reverse) directions.

H1 pumps with FDC will be delivered from factory with nominal pressure limiter setting of 150 bar [2175 psi]. The PL must be re-adjusted to ensure that the fan reaches the desired fan speed to satisfy the cooling needs of the system. HPRV setting must be always at least 30 bar [435 psi] higher than PL setting.

For more information necessary to properly size and configure a hydraulic fan drive system, see *Hydraulic Fan Drive Design Guidelines* **AB152886482265**.

Warning

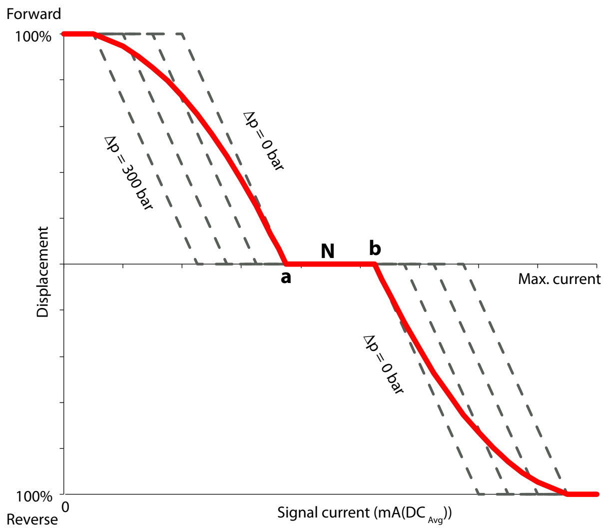
Use in other systems could result in unintended movement of the machine or it's elements. Loss of the input signal to this control will cause the pump to produce maximum flow.
The FDC is for Fan Drive systems only!

Due to the fail-safe functionality of the FDC control the pump will stroke to max. displacement in case the input signal to the pump control and the Diesel engine will be switched off at the same time. In this situation a low loop event can occur which may damage the pump. Therefore, it's strictly recommended to keep the input signal to the pump control alive while switching off the engine.
For further information please contact your Danfoss representative.

Control Options

Control Signal Requirements, FDC 115/130

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash plate angle as system pressure increases. A typical response characteristic is shown in the accompanying graph below:



a – Forward threshold

b – Reverse threshold

N – Neutral override current

Control current requirements

Voltage*	a	N	b	Pin config.
12 V_{DC}	780 mA	1100 mA	1300 mA	any order
24 V_{DC}	400 mA	550 mA	680 mA	

* Factory test current, for fan movement expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Control Options

Single Pump Output Flow Direction

Pump output flow direction vs. control signal

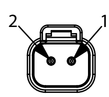
Shaft rotation		**ClockWise**			**CounterClockWise**		
Control Logic	**12 V**	**0-780 mA**	**1100 mA**	**1300-1800 mA**	**0-780 mA**	**1100 mA**	**1300-1800 mA**
	24 V	**0-400 mA**	**550 mA**	**680-920 mA**	**0-400 mA**	**550 mA**	**680-920 mA**
Port A		in	no flow	out	out	no flow	in
Port B		out	no flow	in	in	no flow	out
Servo port pressurized		M5	n/a	M4	M5	n/a	M4

Warning

Loss of input signal to the control will cause the pump to produce maximum flow.

Connector

Connector DEUTSCH, 2-pin



Description	**Quantity**	**Order data**
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

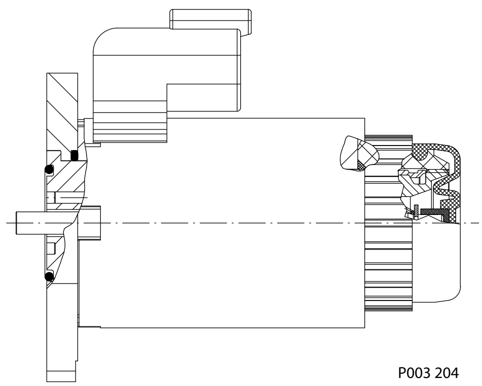
Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Control Options

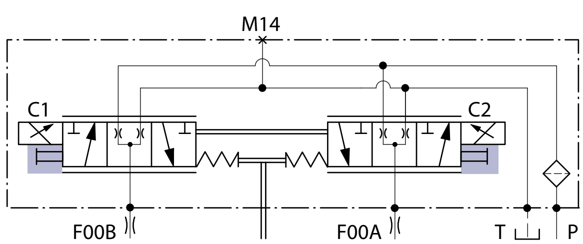
Manual Override (MOR)

All controls are available with a manual override functionality, either as a standard or as an option for temporary actuation of the control to aid in diagnostics.

Control with manual override



MOR schematic (EDC control shown)



Feedback from swash plate.

The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke. The MOR should be engaged anticipating a full stroke response from the pump.

An o-ring seal is used to seal the MOR plunger where initial actuation of the function will require a force of 45 N to engage the plunger. Additional actuation typically require less force to engage the MOR plunger.

Proportional control of the pump using the MOR should not be expected.

Warning

Unintended MOR operation will cause the pump to go into stroke; *example:* vehicle lifted off the ground. The vehicle or device must always be in a safe condition when using the MOR function.

Refer to control flow table for the relationship of solenoid to direction of flow.

Control Options

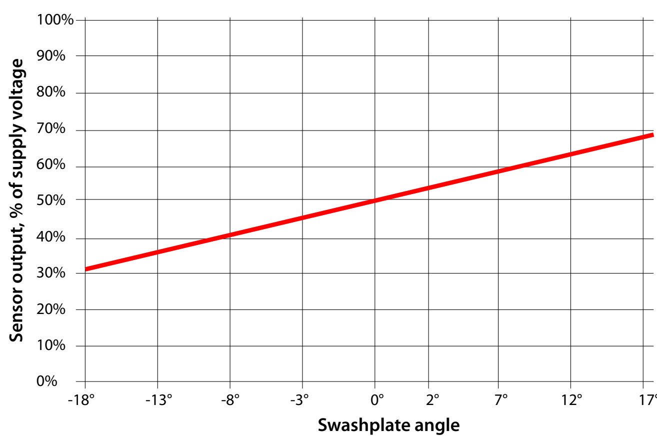
Swashplate angle sensor for EDC controls

The angle sensor detects the swash plate position with an accuracy dependent upon the calibration effort done for the application and direction of rotation from the neutral position. At minimum the sensor can be used for forward, neutral and reverse (FNR) detection.

The sensor works on the hall-effect technology. The implemented technology is based on a measurement of the magnetic field direction in parallel to the chip surface. This field direction is converted to a voltage signal at the output.

Enhanced calibration of the non-linear behavior leads to more exact calculation of the pump swashplate angle. The 4-pin DEUTSCH connector is part of the sensor housing. The swashplate angle sensor is available for all EDC controls for 12 V and 24 V.

Swashplate angle vs. output of supply voltage



Warning

Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

Contact your Danfoss representative in case the angle sensor will be used for safety functions.

Swash plate angle sensor parameters (EDC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.5 V_{DC}	5 V_{DC}	5.5 V_{DC}
Supply protection	–	–	18 V_{DC}
Pump neutral output (% of supply voltage)	–	50%	–
Working range (swash plate angle)	–18°	–	18°
Required supply current	–	–	30 mA
Output current signal	–	9 mA	11 mA
Working temperature	–40 °C	80 °C	115 °C

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector
EMC Immunity	ISO 11452-2	100 V/m

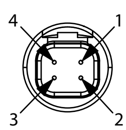
Control Options

Calibration of the sensor output within the software is mandatory. Vehicle neutral thresholds in the software (±0.5°) are vehicle dependent and must consider different conditions, example: system temperature, system pressure and/or shaft speed.

For safety function: If the sensor fails (invalid signal <10% or >90% of supply voltage), it must be sure that the ECU will go into a diagnostic mode and shift into limited mode in order for the driver to take the full control or the mechanical breaks should be activated. Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

H1P Swash Plate Angle Sensor Connector

Connector DEUTSCH, 4-pin

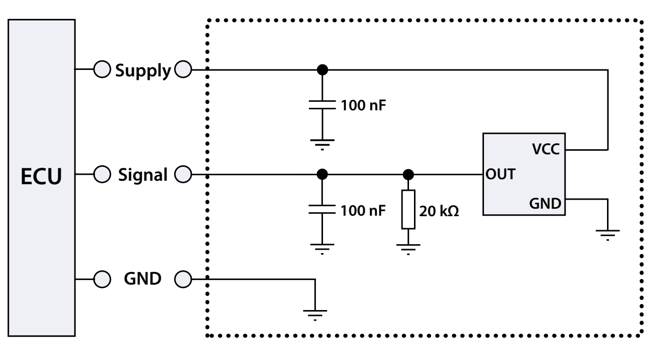


1	Ground (GND)
2	Not connected
3	Output signal 1 (SIG 1)
4	Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Interface with ECU (EDC)

Interface with ECU diagram

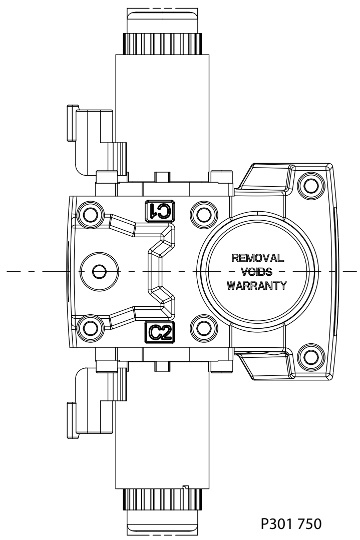


Control Options

Swash Plate Angle Sensor for NFPE and AC2 Controls

The angle sensor detects the swash plate angle position and direction of rotation from the zero position. The swash angle sensor works on the AMR sensing technology. Under the saturated magnetic field, the resistance of the element varies with the magnetic field direction.

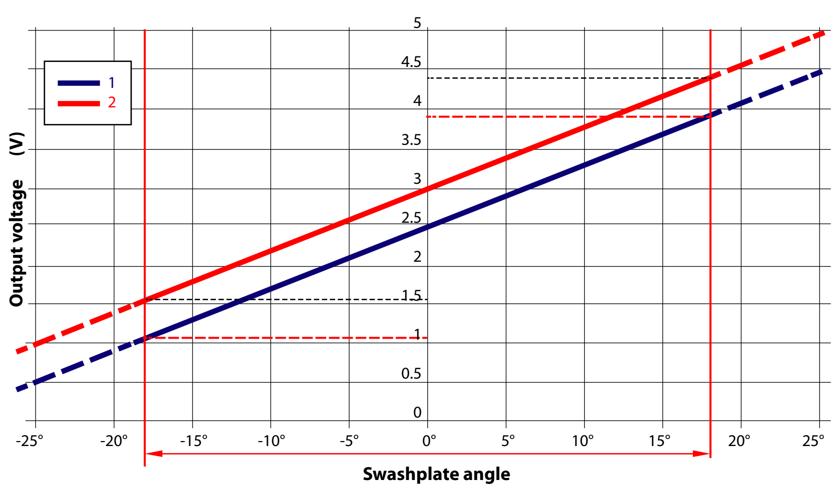
The output signal give a linear output voltage for the various magnet positions in the sensing range.



Swash Plate Angle Characteristic

The volumetric losses depend on pump max. displacement, actual displacement, speed, delta pressure, viscosity and temperature.

Swashplate angle vs. output voltage (calibrated at 50 °C)



1. Signal 1 (nominal)
2. Signal 2 (redundant)

The displacement can be calculated by:

$$V = \frac{\tan\alpha \cdot V}{\tan 18°} \quad (cm^3)$$

The corresponding flow is:

$$Q = \frac{V \cdot n \cdot \eta_{vol}}{1000} \quad (l/min)$$

Control Options

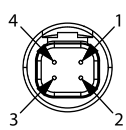
Swash Plate Angle Sensor Parameters (NFPE/AC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.75 V	5 V	5.25 V
Supply protection	–	–	28 V
Supply current	–	22 mA	25 mA
Output current (Signal 1, 2)	–	0.1 mA	–
Short circuit output current to supply or GND[1)]	–	–	7.5 mA
Sensitivity	70.0 mV/deg	78.0 mV/deg	85.8 mV/deg
Working range (swash plate angle)	−18°	0°	18°
Correlation between signals 1 and 2[2)]	475 mV	500 mV	525 mV

[1)] Up to duration of 2.5 seconds at 25°C

[2)] Signal 1 (nominal) is lower than signal 2 (redundant)

H1P Swash Plate Angle Sensor Connector (NFPE)



1 Ground (GND)

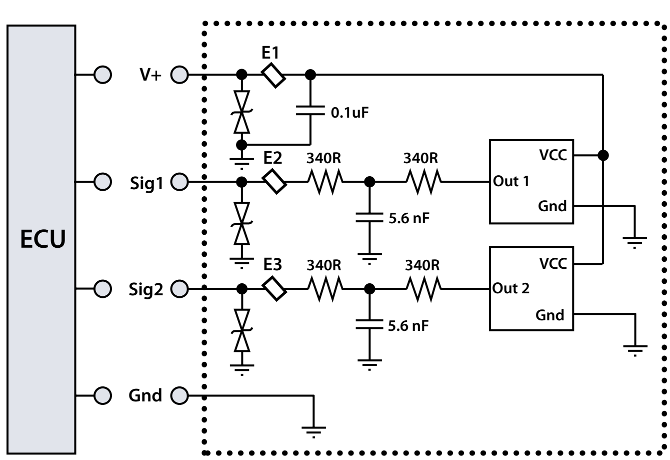
2 Output Signal 2 (SIG 2) – Secondary (redundant)

3 Output signal 1 (SIG 1)

4 Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Interface with ECU (NFPE)



Minimum recommended load resistance is 100 kΩ.

Control Options

Control Cut Off Valve (CCO)

The H1 pump offers an optional control cut off valve integrated into the control. All EDC, NFPE and MDC controls are available with a CCO valve. This valve will block charge pressure to the control, allowing the servo springs to de-stroke both pumps regardless of the pump´s primary control input.

There is also a hydraulic logic port, X7, which can be used to control other machine functions, such as spring applied pressure release brakes. The pressure at X7 is controlled by the control cut off solenoid. The X7 port would remain plugged if not needed.

In the normal (de-energized) state of the solenoid charge flow is prevented from reaching the controls. At the same time the control passages and the X7 logic port are connected and drained to the pump case. The pump will remain in neutral, or return to neutral, independent of the control input signal. Return to neutral time will be dependent on oil viscosity, pump speed, swashplate angle, and system pressure.

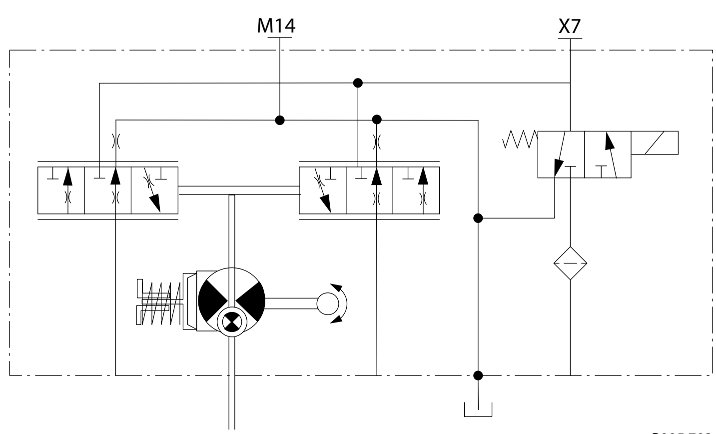
When the solenoid is energized, charge flow and pressure is allowed to reach the pump control. The X7 logic port will also be connected to charge pressure and flow.

The solenoid control is intended to be independent of the primary pump control making the control cut off an override control feature. It is however recommended that the control logic of the CCO valve be maintained such that the primary pump control signal is also disabled whenever the CCO valve is de-energized. Other control logic conditions may also be considered.

The CCO valve is available with 12 V or 24 V solenoid.

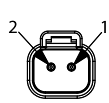
The response time of the unit depends on the control type and the used control orifices.

CCO schematic (MDC shown)



CCO Connector (MDC)

Connector DEUTSCH, 2-pin

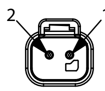


Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control Options

H1P CCO Connector (EDC, NFPE)

Connector CCO DEUTSCH, 2-pin with key C



Description	Quantity	Order number
Mating connector	1	DEUTSCH DT06-2S-C015
Wedge lock	1	DEUTSCH W2SC-P012
Socket contact	4	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	11212714

CCO solenoid data

Nominal supply voltage		12 V	24 V
Supply voltage	Maximum	14.6 V	29 V
	Minimum	9.5 V	19 V
Bi-directional diode cut off voltage		28 V	53 V
Nominal coil resistance at 20 °C		10.7 Ω	41.7 Ω
Supply current	Maximum	850 mA	430 mA
	Minimum	580 mA	300 mA
PWM frequency	Range	50 – 200 Hz	
	Preferred	100 Hz	
Electrical protection class		IP67 / IP69K with mating connector	

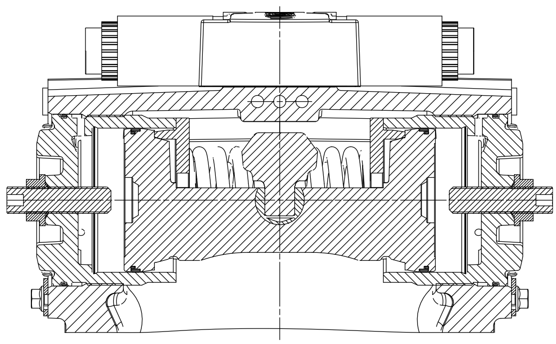
CCO solenoids are design for battery voltage application within the voltage range in the table above, in consideration of a wide range of environmental temperature common for known hydraulic applications. Closed loop PWM current supply can be also applied and is helpful in case that the voltage range is exceeded, or ambient temperature could rise in an unusual manner.

Control Options

Displacement Limiter

H1 pumps are designed with optional mechanical displacement (stroke) limiters factory set to max. displacement. The maximum displacement of the pump can be set independently for forward and reverse using the two adjustment screws to mechanically limit the travel of the servo piston down to 50% displacement.

Adjustments under operating conditions may cause leakage. The adjustment screw can be completely removed from the threaded bore if backed out to far.



P003 266

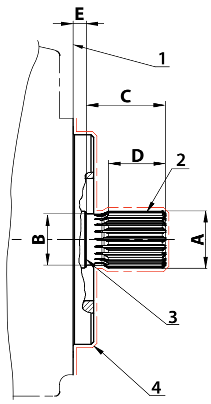
H1P 115/130 Displacement Change (approximately)

Parameter	Size 115	Size 130
1 turn of displacement limiter screw	10.8 cm^3 [0.66 in^3]	12.2 cm^3 [0.74 in^3]
Internal wrench size	6 mm	
External wrench size	22 mm	
Torque for external hex seal lock nut	80 N•m [708 lbf•in]	

For more information, see *H1 Axial Piston Pumps, Service Manual,* **AX152886482551**, the section "Displacement Limiter Adjustment".

Dimensions and Data

H1P Input Shaft Option G2 (SAE D, 27 teeth)



1. Mounting flange 152–4 per ISO 3019-1; surface to be paint free
2. **Spline Data:** 27 teeth, Pressure angle: 30°, Pitch: 16/32, Ø42.863 [1.688]; Fillet root side fit, per ANSI B92.1-1996, Class 5;
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø44.36 ±0.09 [1.746 ±0.004]	Ø39.5 ±0.13 [1.555 ±0.05]	67.0 ±1.0 [2.638 ±0.039]	42.0 ±1.0 [1.654 ±0.039]	8.05 ±0.8 [0.317 ± 0.03]

[1)] Minimum active spline length for the specified torque ratings.

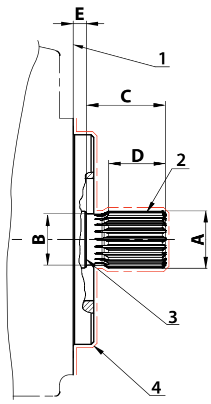
Torque rating

Rated torque	Maximum torque
1615 N•m [14 300 lbf•in]	3000 N•m [26 550 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P Input Shaft Option G3 (SAE D, 13 teeth)



1. Mounting flange 152–4 per ISO 3019-1; surface to be paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 8/16, Ø41.275 [1.625]; Fillet root side fit, per ANSI B92.1-1996, Class 5
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø44.4 ±0.09 [1.746 ±0.004]	Ø36.4 ±0.25 [1.433 ±0.01]	67.0 ±1.0 [2.638 ±0.039]	39.5 ±1.0 [1.555 ±0.039]	8.05 ±0.8 [0.317 ±0.03]

[1)] Minimum active spline length for the specified torque ratings.

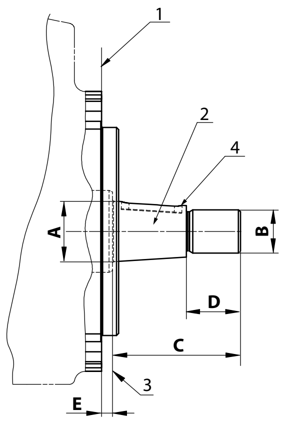
Torque rating

Rated torque	Maximum torque
1442 N•m [12 800 lbf•in]	2206 N•m [19 500 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P 115/130 Input Shaft Option F3, Code 44–3



1. Mounting flange 152–4 per ISO 3019-1; surface to be paint free
2. **Tapered shaft:** Conical keyed shaft end, code 44–3 (similar to ISO 3019-1 code 38–3); Suitable key $^{7}/_{16}$ x $^{7}/_{16}$ x 1 ¾ per ANSI B17.1; to be paint free
3. Coupling must not protrude beyond this point
4. Cone 125 ±0.5:1000

Dimensions

A	B	C	D	E
Ø44.45 ±0.09 [1.746 ±0.004]	1¼ –12	93.7 ±1.0 [3.69 ±0.039]	39.7 ±1.0 [1.563 ±0.039]	8.025 ±0.8 [0.361 ±0.031]

Torque rating

Rated torque[1)]	Maximum torque[2)]
1766 N•m [15 630 lbf•in]	2354 N•m [20 830 lbf•in]

[1)] Rated torque includes just the capability of the press-fit in accordance with an assumed fastener grade 5

[2)] Mating part must maintain a minimum gap width of 1.0 mm with the shaft shoulder after installation of the part. Transmittable torque will be reduced if the minimum gap requirement is not met.

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section "Shaft Torque Ratings and Spline Lubrication".

Tapered shaft customer acknowledgement

The Danfoss H1 tapered shaft has been designed using the industry standard ISO 3019-1, minus the through-hole in the end of the shaft. Danfoss guarantees the design and manufactured quality of the tapered shaft.

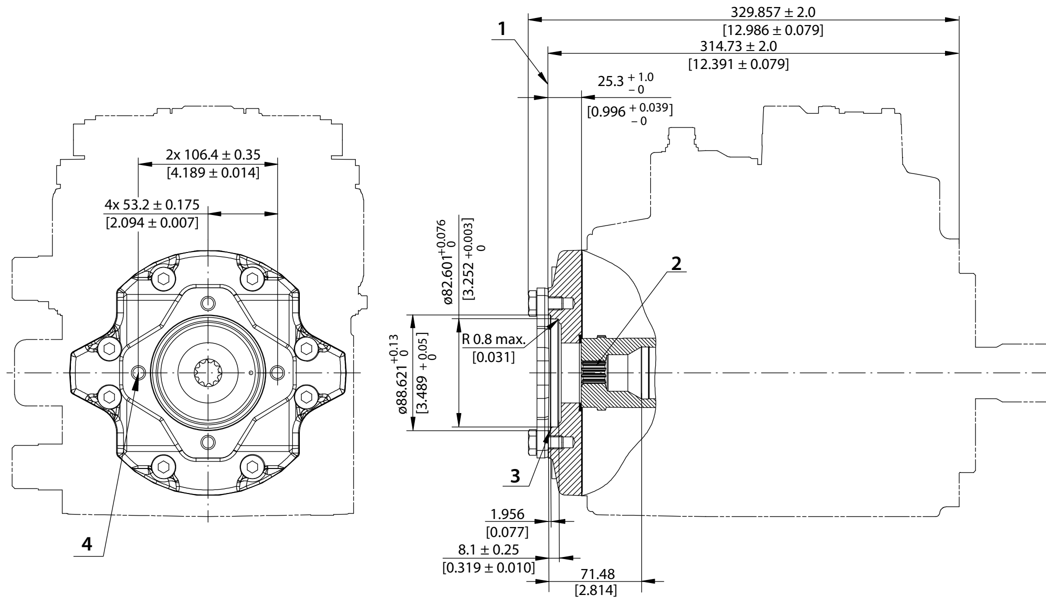
Danfoss recommends a self-locking nut instead of a castle nut and pin. The nut and mating square-cut key are customer supplied. The specified torque rating of the tapered shaft is based on the cross-sectional diameter of the shaft, through the keyway, and assumes the proper clamp and fit between shaft and coupling. The customer is responsible for the design and manufactured quality of the mating female coupling and key and applied torque on the nut. Danfoss has made provisions for the key in accordance to the ISO specification with the understanding that the key is solely to assist in the installation of the mating coupling.

Caution

Possible hazard because torque or loading inadvertently transmitted by the customer supplied key may lead to premature shaft failure. Torque must be transmitted by the taper fit between the shaft and it's mating coupling, not the key.

Dimensions and Data

H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth)



1. Auxiliary mounting pad for mating flange 82-2 per ISO 3019-1 (SAE A); Paint free
2. **Spline Data:** 11 teeth, Pressure angle: 30°, Pitch: 16/32, Ø17.463 [0.688]; Fillet root side fit; per ANSI B92.1-1996, Class 6; Minimum active spline length 10.5 mm
3. O-ring seal required; Ref. Ø82.22 ID x 2.62, cross section
4. Thread: M10x1.5-6H; 16 mm [0.63 in] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	296 N•m [2620 lbf•in]

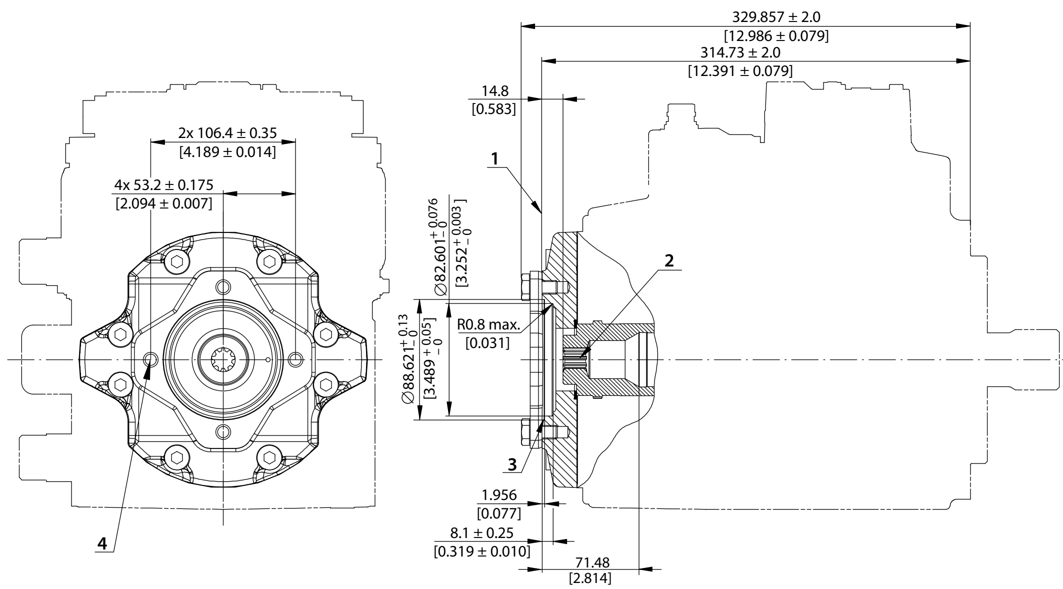
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth)



1. Auxiliary mounting pad for mating flange 82-2 per ISO 3019-1 (SAE A); Paint free
2. **Spline Data:** 9 teeth, Pressure angle: 30°, Pitch: 16/32, Ø14.288 [0.563]; Fillet root side fit; per ANSI B92.1-1996, Class 6; Minimum active spline length 8.6 mm
3. O-ring seal required; Ref. Ø82.22 ID x 2.62, cross section
4. Thread: M10x1.5-6H; 16 mm [0.63 in] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	162 N•m [1430 lbf•in]

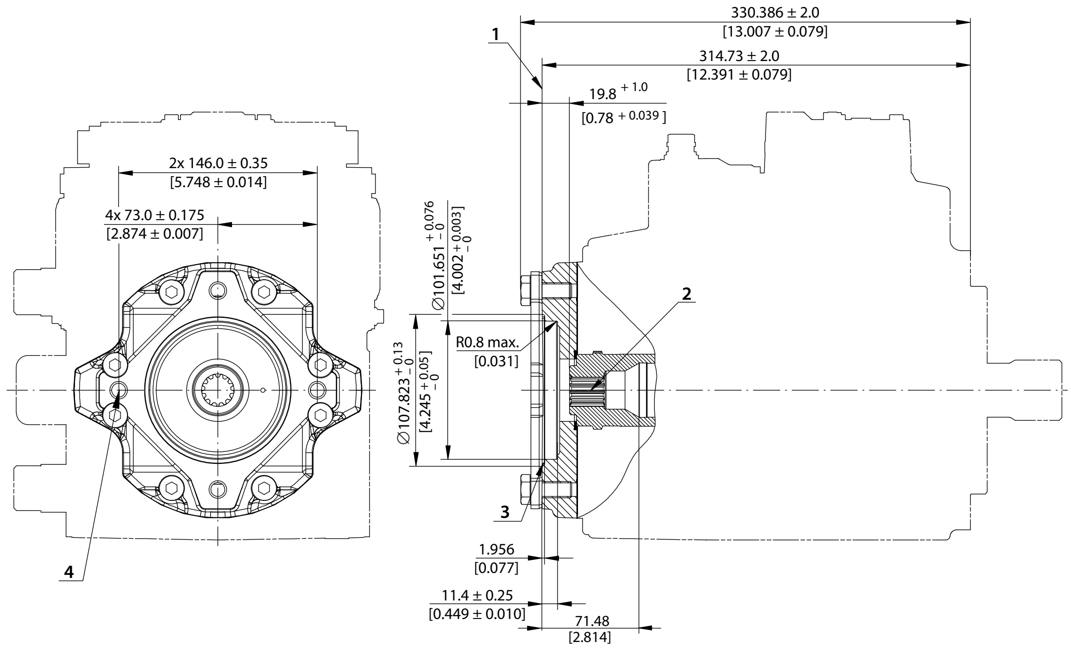
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 16/32, Ø20.638 [0.813]; Fillet root side fit; per ANSI B92.1-1996, Class 6; Minimum active spline length 12.4 mm
3. O-ring seal required; Ref. Ø101.32 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 25 mm [0.984 in] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	395 N•m [3500 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

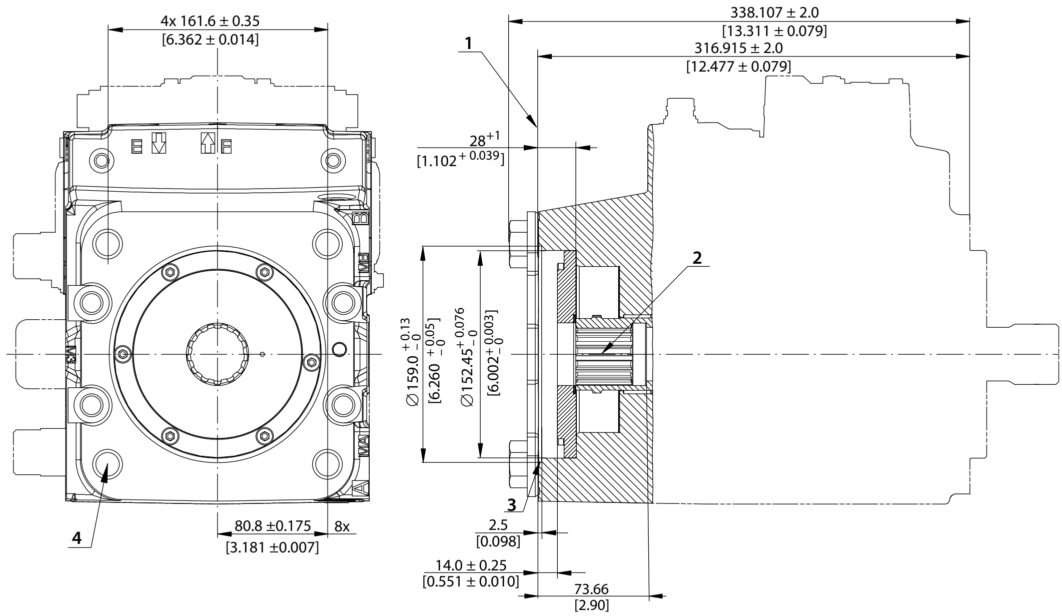
Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H4 (SAE D, 13 teeth)

Option H4, ISO 3019-1, flange 152-4 (SAE D, 13 teeth)



1. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 8/16, Ø41.275 [1.625]; Fillet root side fit; per ANSI B92.1-1996, Class 6; Minimum active spline length 24.8 mm
2. O-ring seal required; Ref. Ø150.0 ID x 3.0, cross section
3. Thread: M20x2.5-6H; 30 mm [1.181 in] min. depth (4x)
4. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	2206 N•m [19 525 lbf•in]

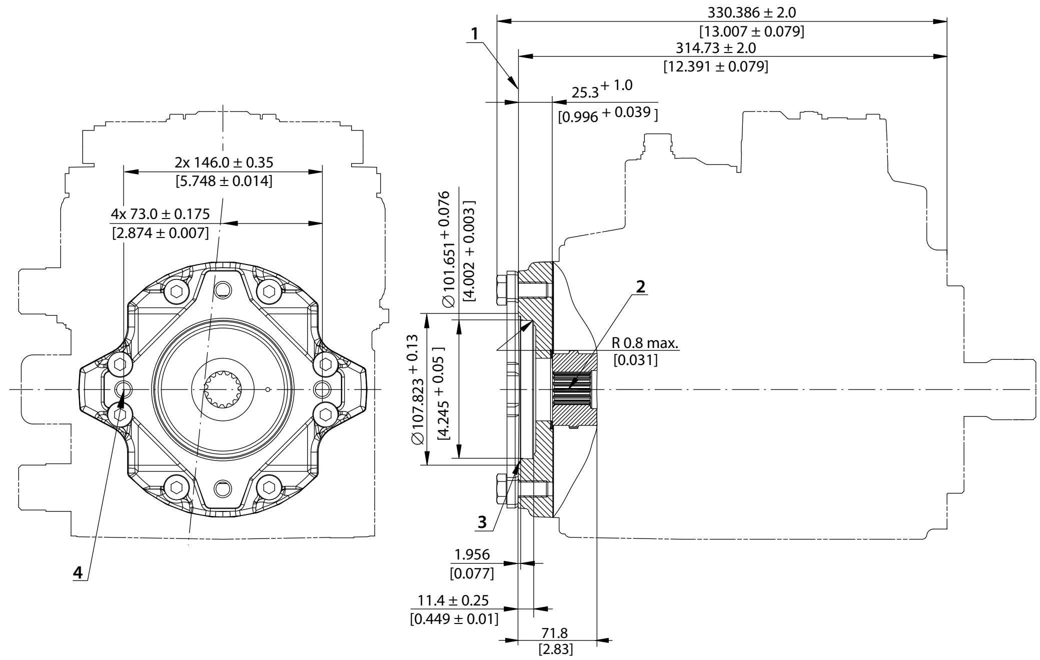
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section "Shaft Torque Ratings and Spline Lubrication".

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 15 teeth, Pressure angle: 30°, Pitch: 16/32, Ø23.813 [0.938]; Fillet root side fit; per ANSI B92.1-1996, Class 6; Minimum active spline length 14.3 mm
3. O-ring seal required; Ref. Ø101.32 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 25 mm [0.984 in] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	693 N•m [6130 lbf•in]

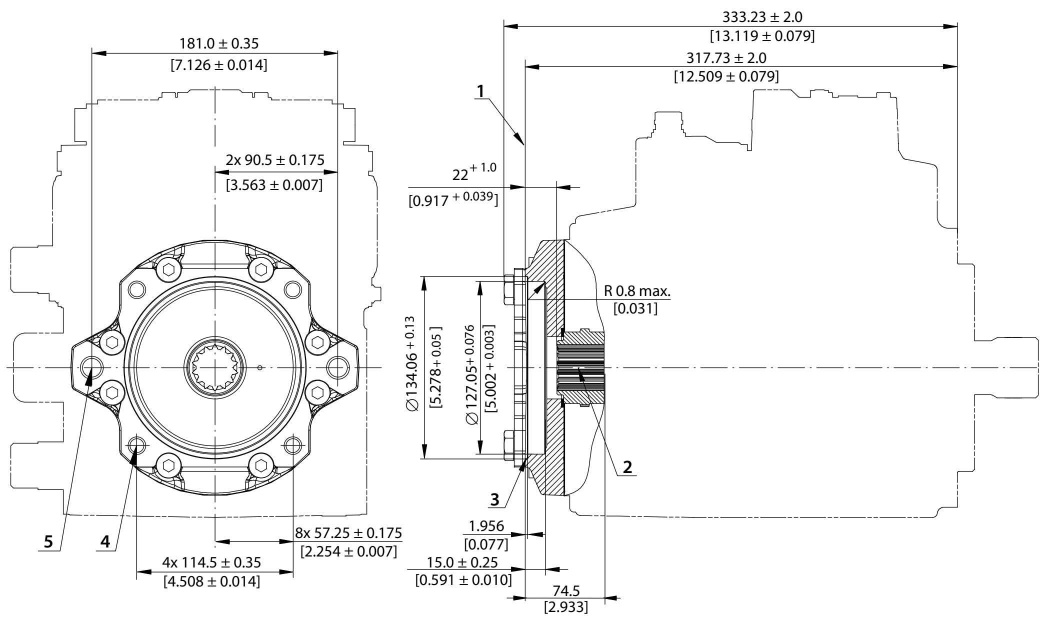
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth)



1. Auxiliary mounting pad for mating flanges: 127-2, 127-4 per ISO 3019-1 (SAE C); Paint free
2. **Spline Data:** 14 teeth, Pressure angle: 30°, Pitch: 12/24, Ø29.633 [1.167]; Fillet root side fit; per ANSI B92.1-1996, Class 6; Minimum active spline length 17.8 mm
3. O-ring seal required; Ref. Ø120.32 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 21 mm [0.827 in] min. depth (4x)
5. Thread: M16x2-6H; 28.5 mm [1.122 in] min. depth (2x)
6. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum torque	816 N•m [7220 lbf•in]

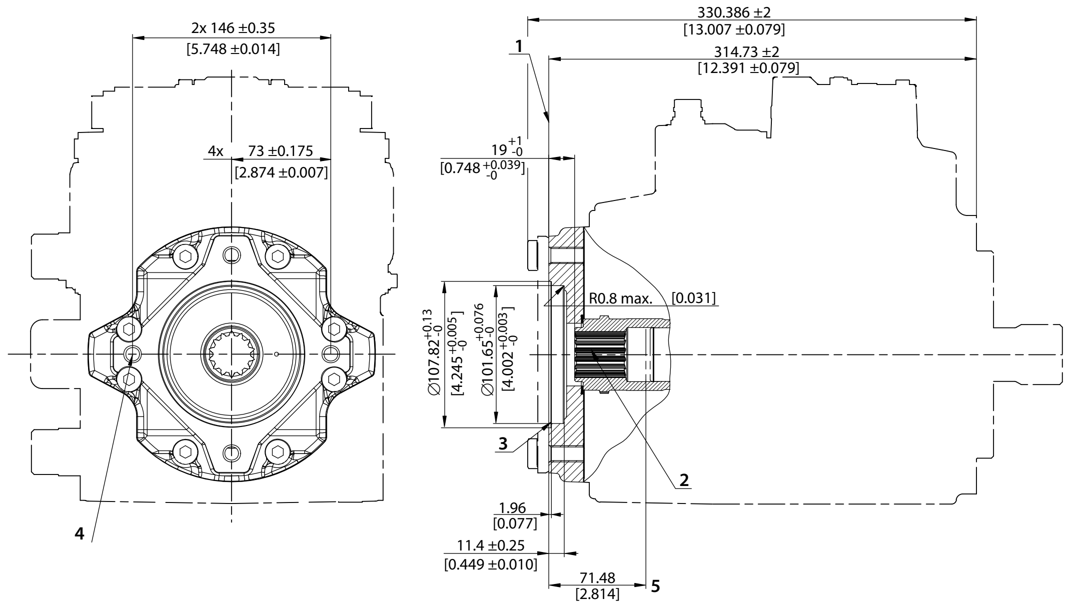
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P 115/130 Auxiliary Mounting, Option S1 (SAE B-B, 14 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 14 teeth, Pressure angle: 30°, Pitch: 12/24, Ø29.633 [1.167]; Fillet root side fit; per ANSI B92.1-1996, Class 6; Minimum active spline length 17.8 mm
3. O-ring seal required; Ref. Ø101.32 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 25 mm [0.984 in] min. depth (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum torque	816 N•m [7220 lbf•in]

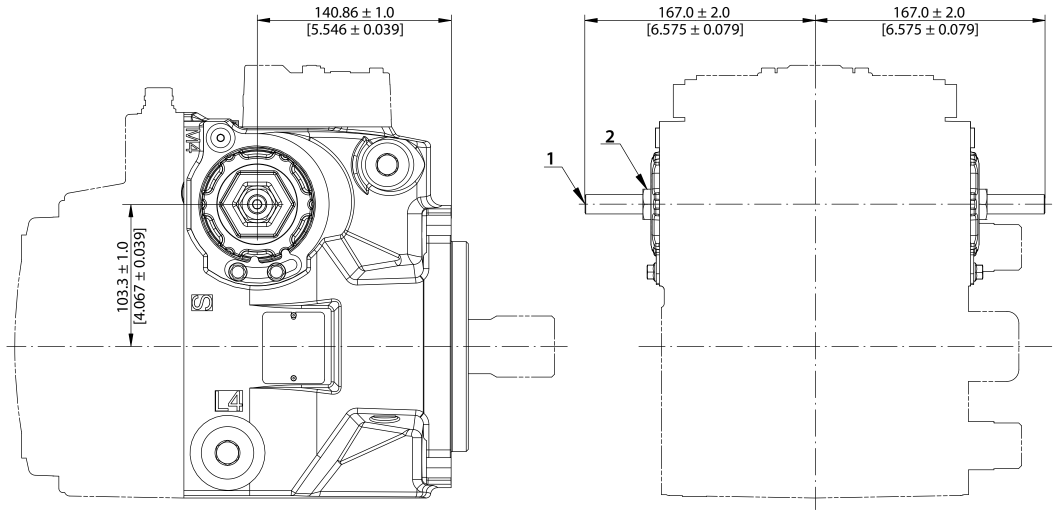
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Displacement Limiter, Option B and D



1. Displacement limiter screw (2x)
2. Displacement limiter seal nut (2x)

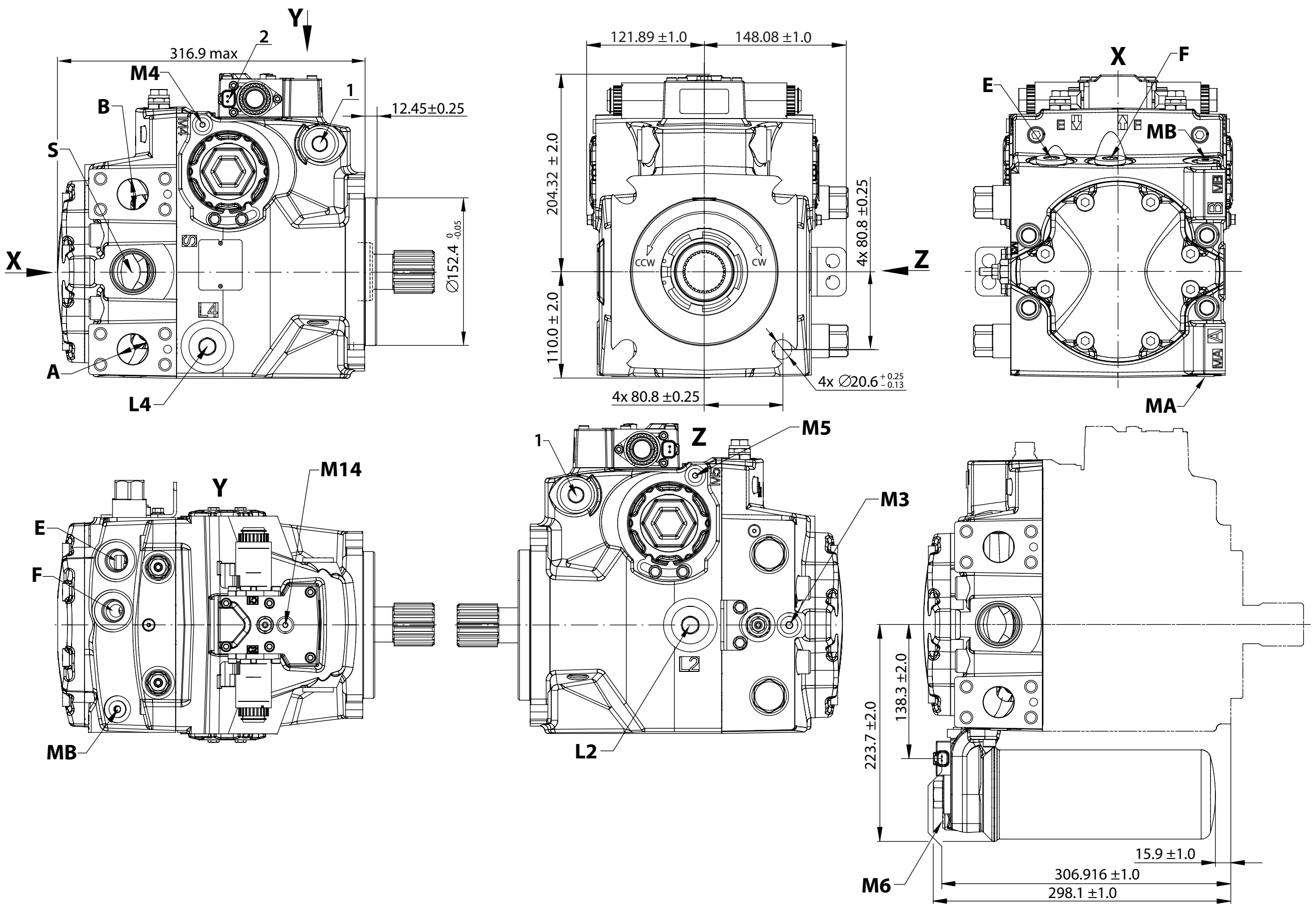
Wrench size, torque

Wrench size for DL screw	Wrench size for DL seal nut	Torque
6 internal hex	22 external hex	80 N•m [708 lbf•in]

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Single Pump Ports



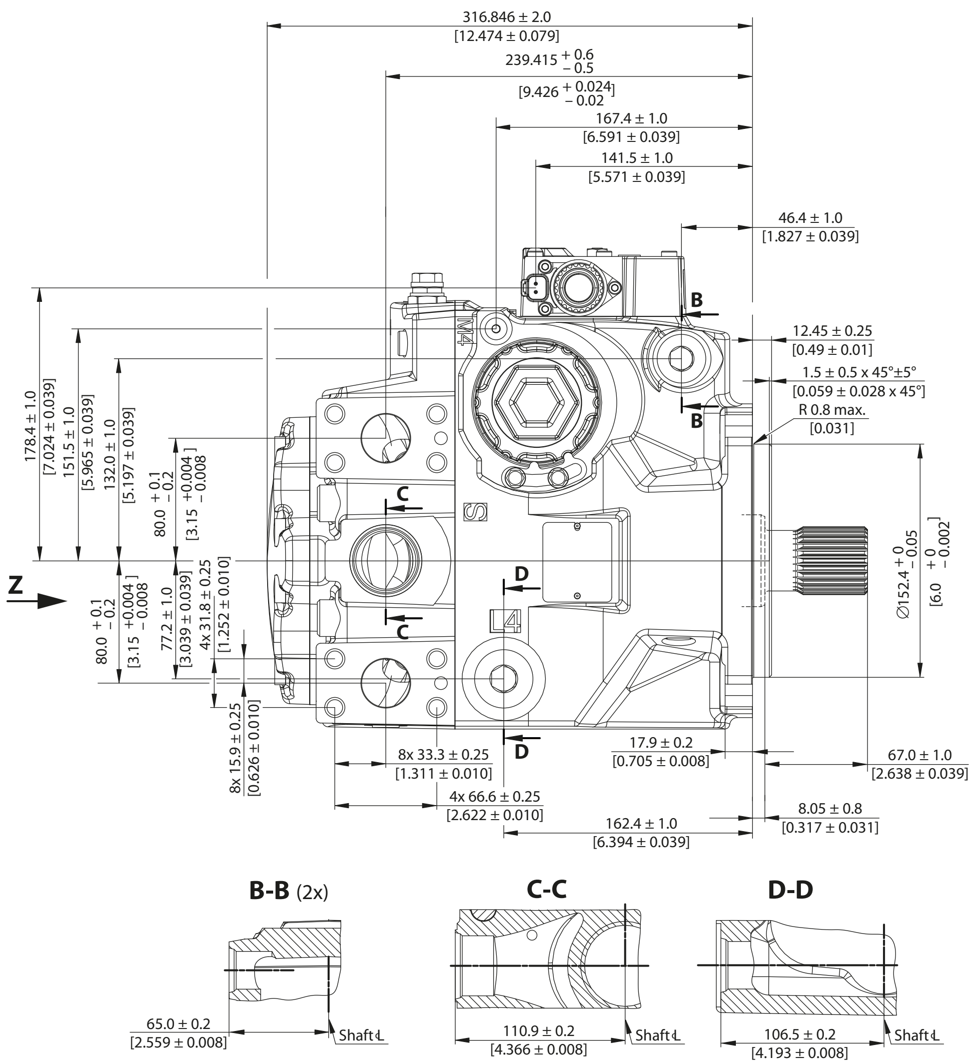
Ports per ISO 11 926-1

Port	Description	Size
A, B	System ports	Ø31.5 mm; M12 x 1.75; 20 min. full thread depth Recommended screw in depth 1.5 x thread dia
L2, L4	Case drain ports	$1\frac{5}{16}$–12
MA, MB	System **A/B** gauge ports	$\frac{9}{16}$–18
E/F	Charge filtration ports	$1\frac{1}{16}$–12
M3	Charge pressure gauge port	$\frac{9}{16}$–18
M4, M5	Servo gauge port	$\frac{7}{16}$–20
M14	Case gauge port (EDC, FNR, NFPE)	$\frac{7}{16}$–20
S	Charge inlet port	$1\frac{5}{8}$–12 (SAE O-ring boss) Recommended screw in depth 1.5 x thread dia
1	Case pressure port	$1\frac{1}{16}$–2
2	Connector DEUTSCH DT04-2P, to be paint free	

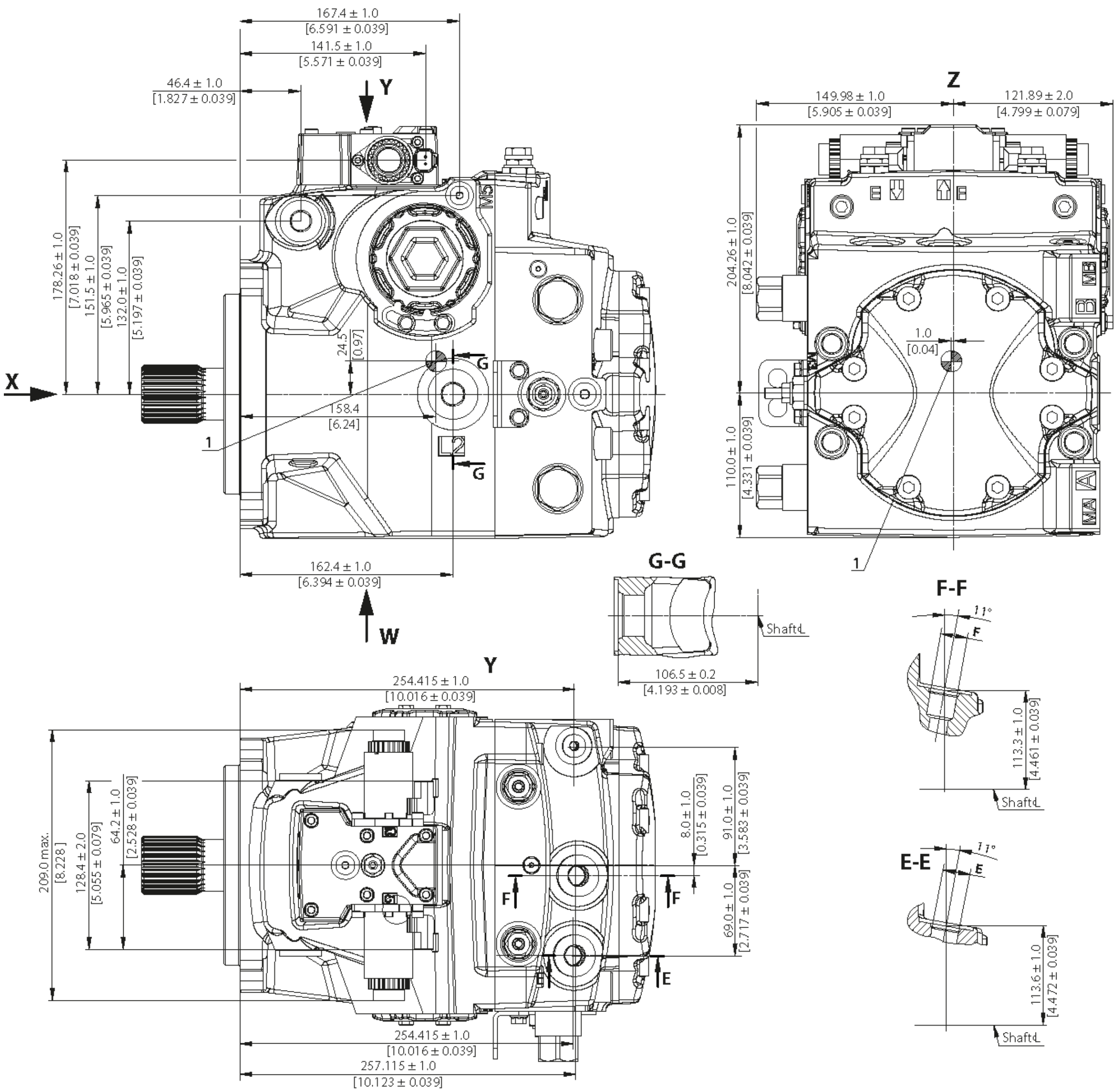
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

H1P Dimensions

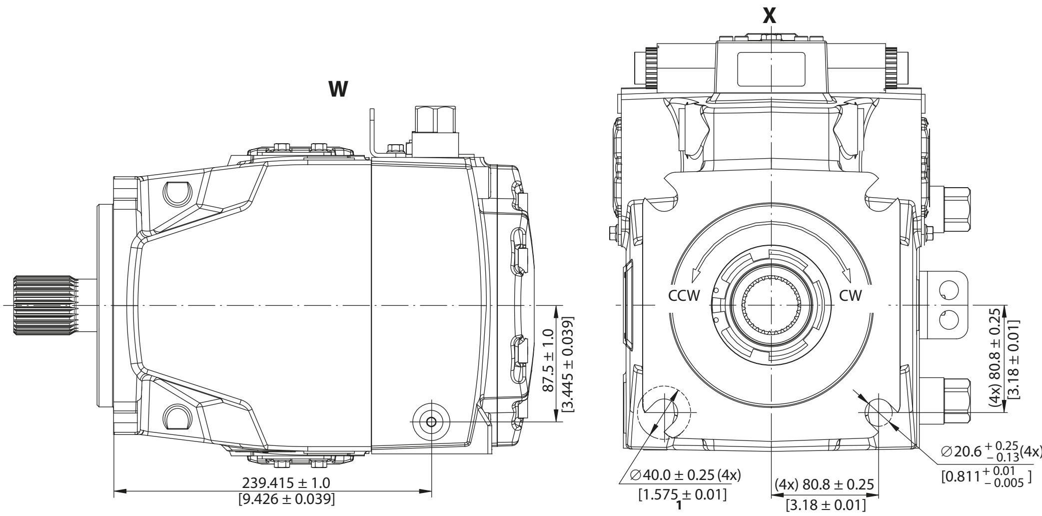


Dimensions and Data



1 — Approximate center of gravity

Dimensions and Data

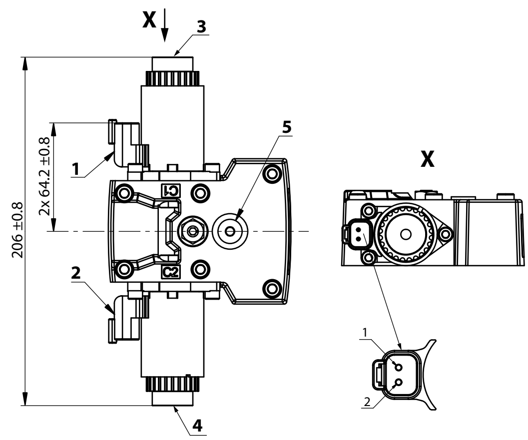


1 — Other side screw head space

Dimensions and Data

Controls

EDC Options A2 and A3 (12/24 V)



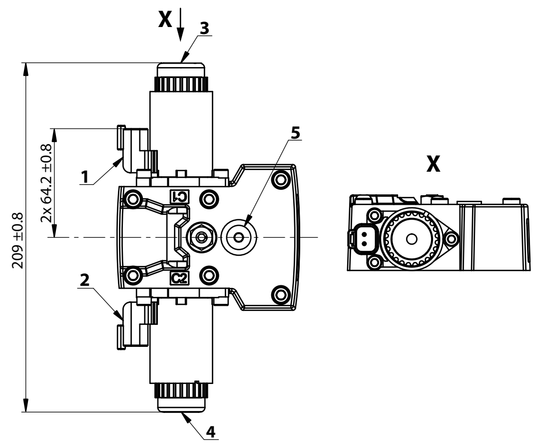
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

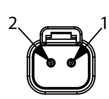
EDC with MOR, Options A4 and A5 (12/24 V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

*Connector **C1/C2**: DEUTSCH DTM04-2P*

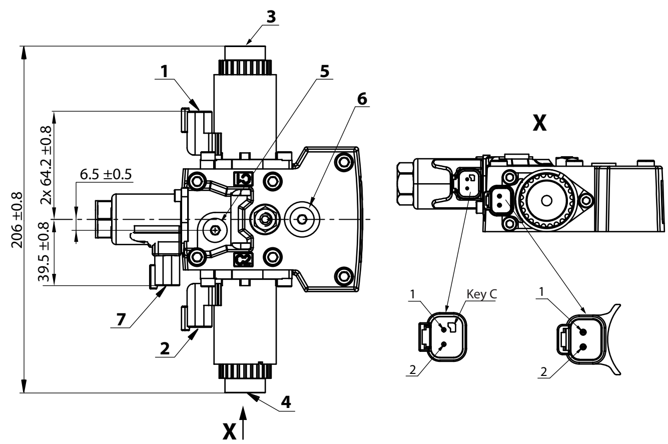


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

EDC with CCO (key C), Options E7 and E8 (12/24 V)



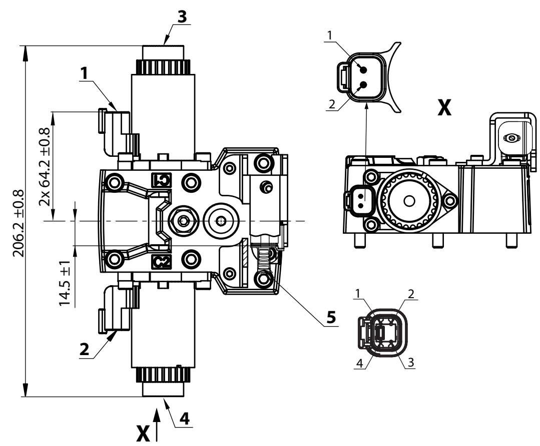
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
6. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

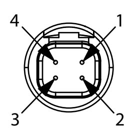
Dimensions and Data

EDC with ASNSR, Options: H2 and H3 (12/24 V)



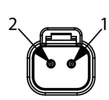
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Angle sensor connector **S2** DEUTSCH DT04-4P, paint free

Connector DEUTSCH, 4-pin



4-pin assignment:
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connector C1/C2: DEUTSCH DTM04-2P

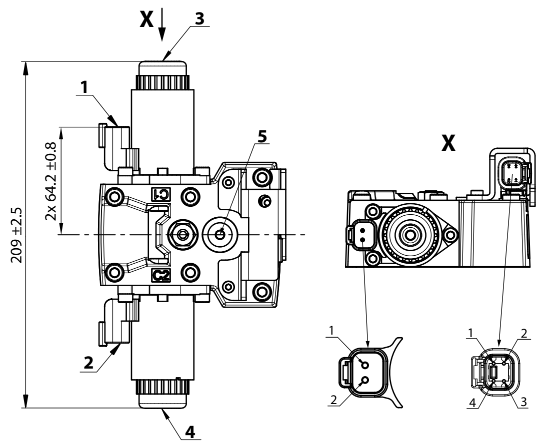


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

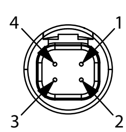
Dimensions and Data

EDC with MOR and ASNSR, Options H6 and H7 (12/24 V)



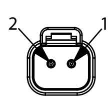
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Connector DEUTSCH, 4-pin



4-pin assignment:
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connector C1/C2: DEUTSCH DTM04-2P

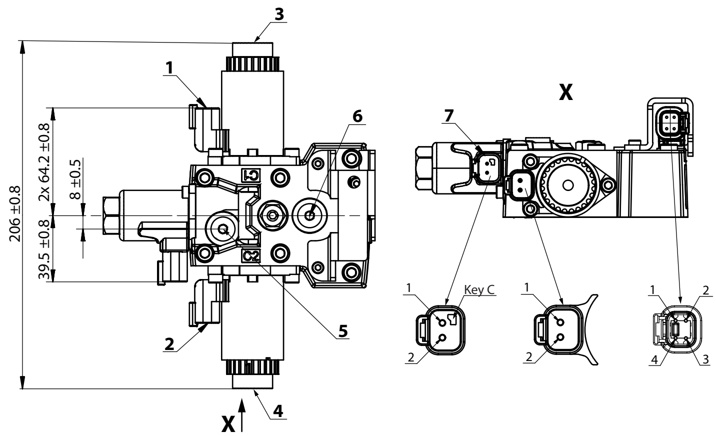


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

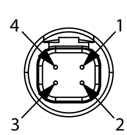
EDC with CCO and ASNSR, Options H8 and H9 (12/24 V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
6. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

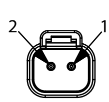
Connector DEUTSCH, 4-pin



Angle sensor connector S2: DEUTSCH DTM04-4P

1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connectors C1/C2/C4: DEUTSCH DTM04-2P

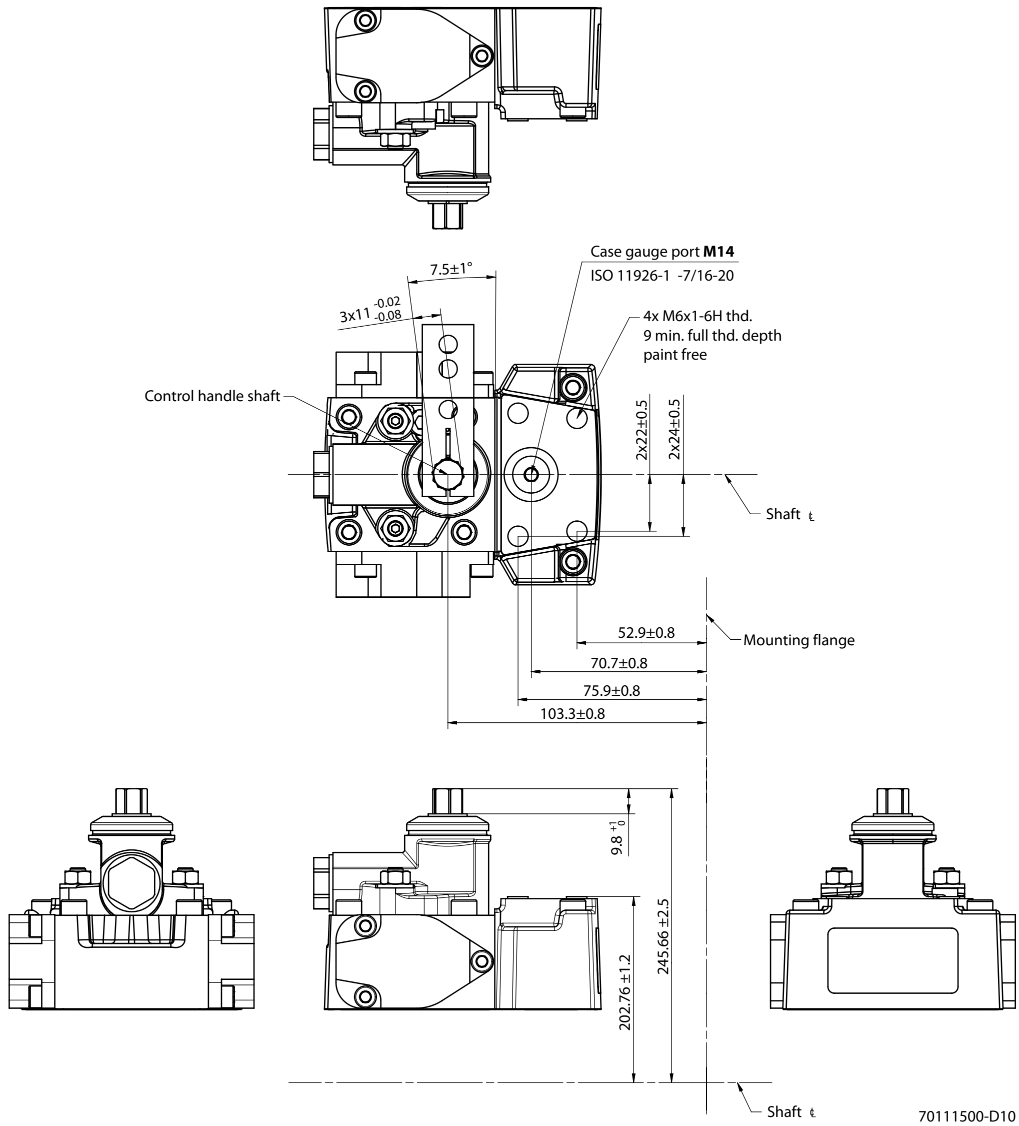


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

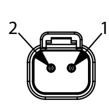
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC Option: M1



Connector DEUTSCH, 2-pin

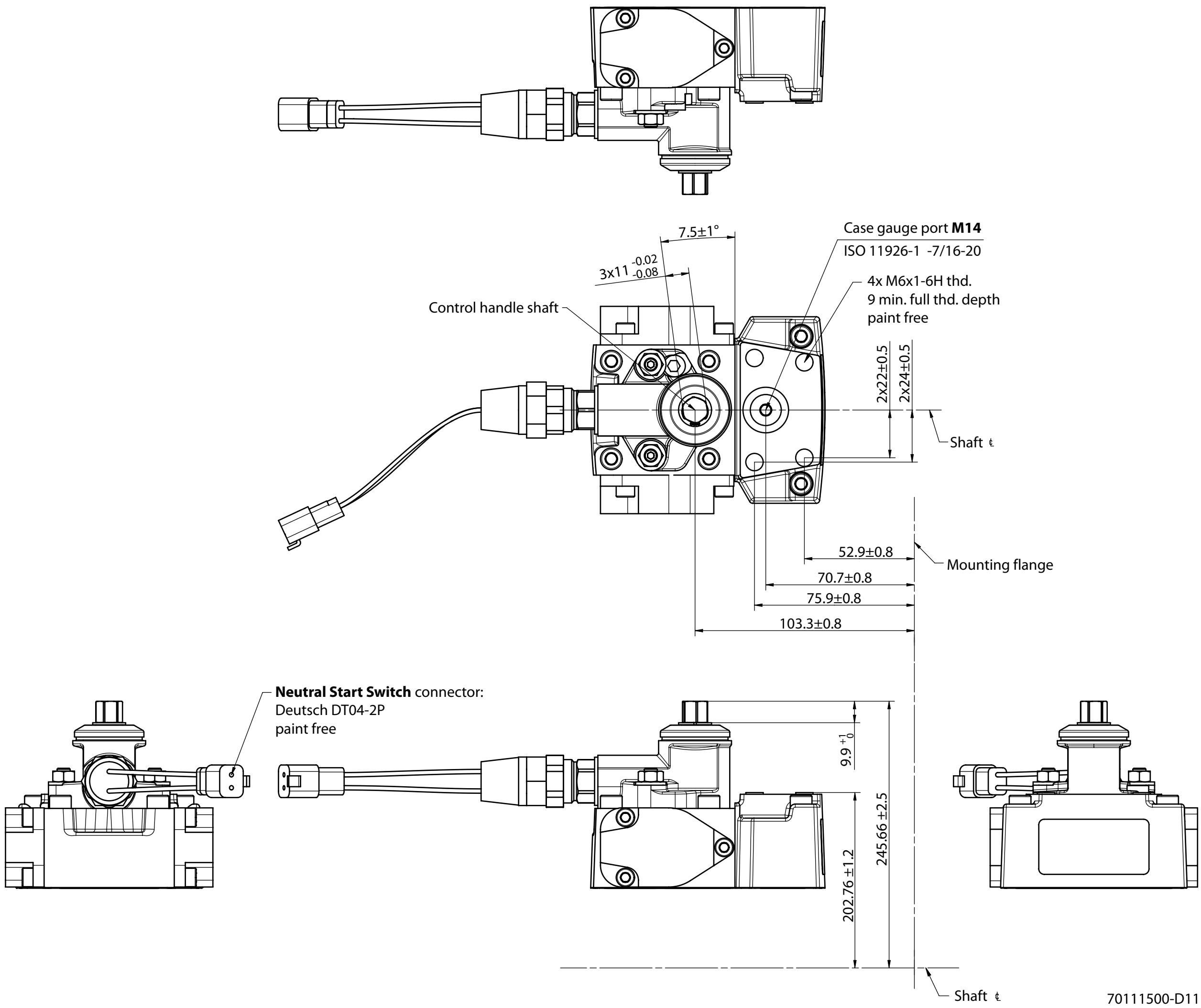


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

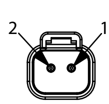
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with Neutral Start Switch Option: M2



Connector DEUTSCH, 2-pin

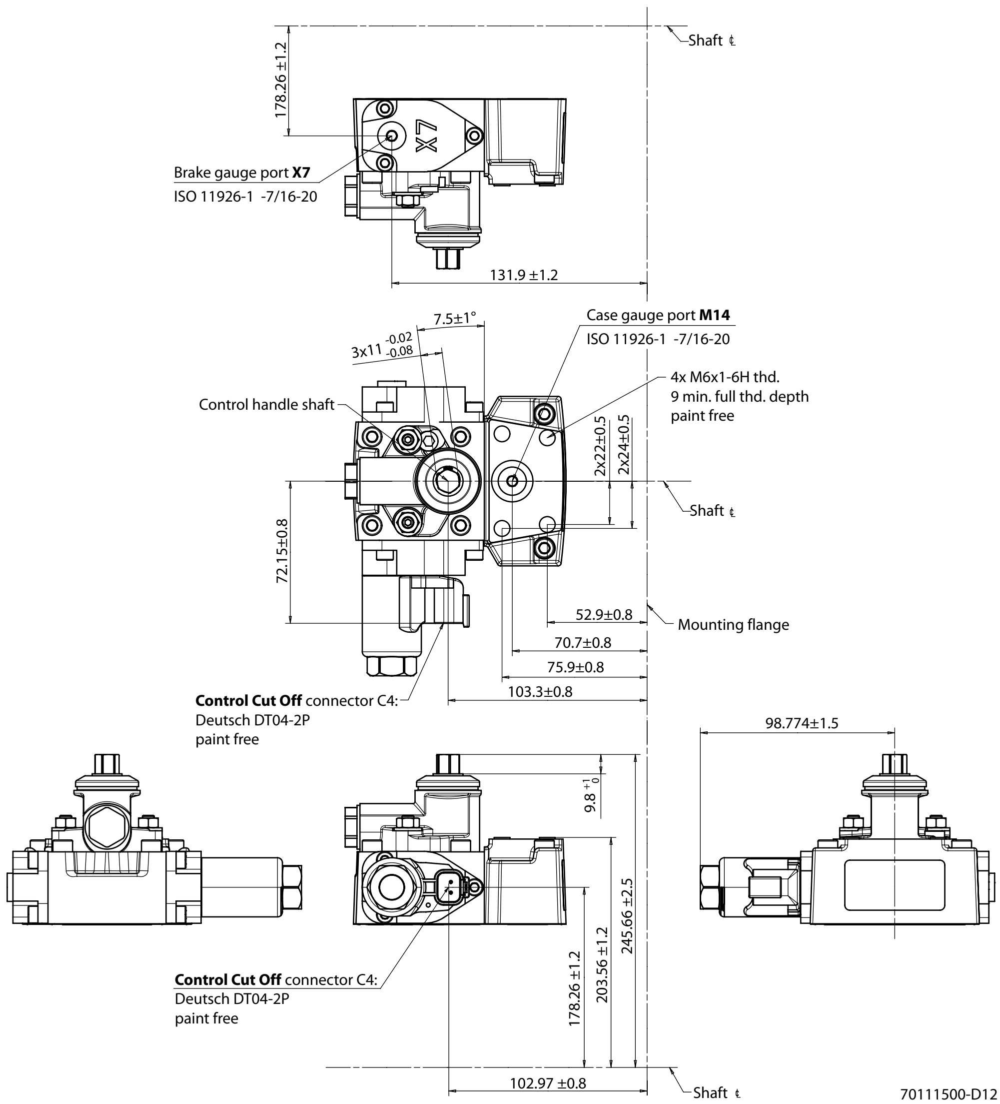


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

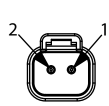
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with CCO, Options: M3, M4



Connector DEUTSCH, 2-pin

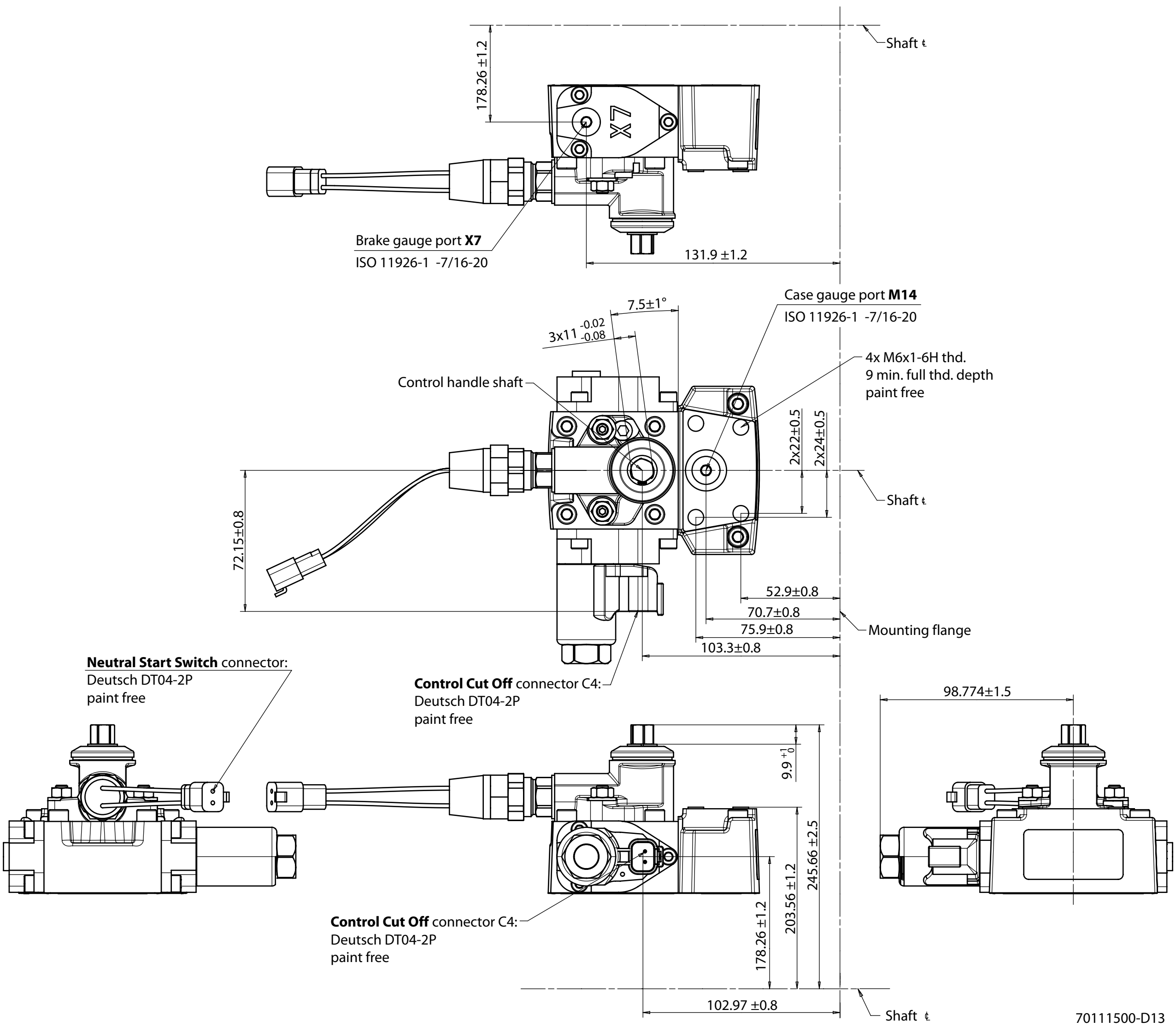


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

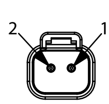
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with NSS and CCO Options: M5, M6



Connector DEUTSCH, 2-pin



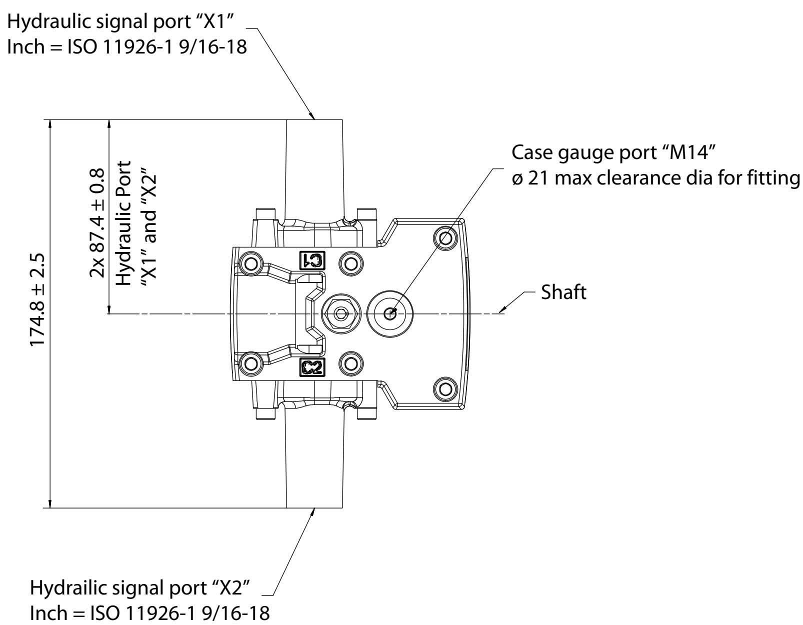
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

H1P HDC, Options: T1, T2

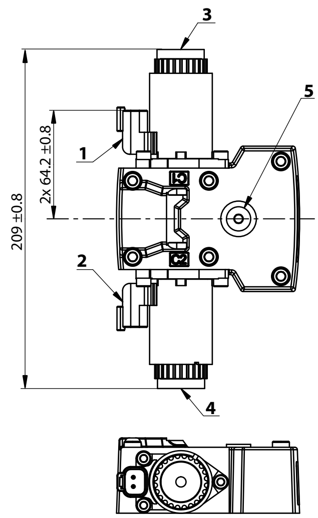
Dimensions in mm



Dimensions and Data

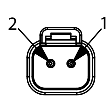
NFPE with MOR, Options: N1, N2 (12/24 V)

Non-Feedback Proportional Electric control with Manual Over Ride options N1 (12 V) and N2 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Control solenoid connectors C1/C2 DEUTSCH DTM04-2P pin/assignment



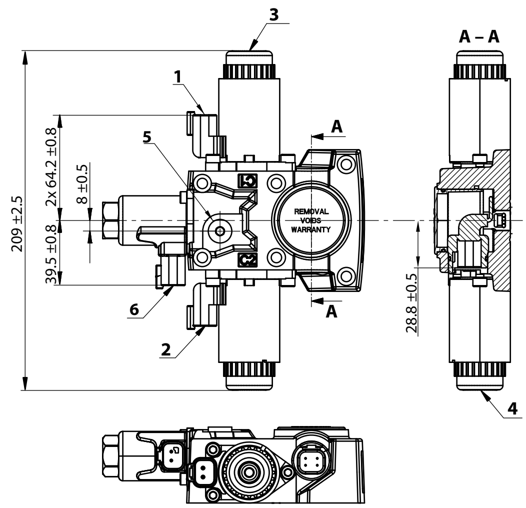
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V)

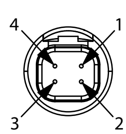
Non-Feedback Proportional Electric control with Control-Cut-Off valve with key C, Manual Over Ride and Angle Sensor, options N3 (12 V) and N4 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
6. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

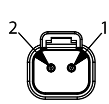
Connector DEUTSCH, 4-pin



Pin/assignment:

1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Control solenoid connectors **C1/C2/C4** DEUTSCH DTM04-2P pin/assignment*



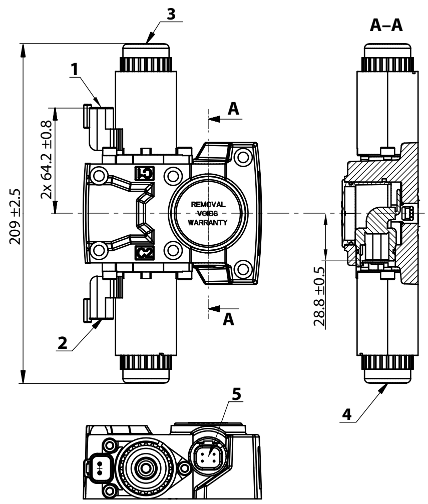
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

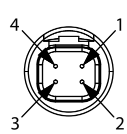
NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V)

Non-Feedback Proportional Electric control with Manual Over Ride and Angle Sensor, options N5 (12 V) and N6 (24 V).



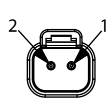
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Angle sensor connector **S2** DEUTSCH DT04-4P, paint free

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

Control solenoid connectors C1/C2 DEUTSCH 2-pin/assignment



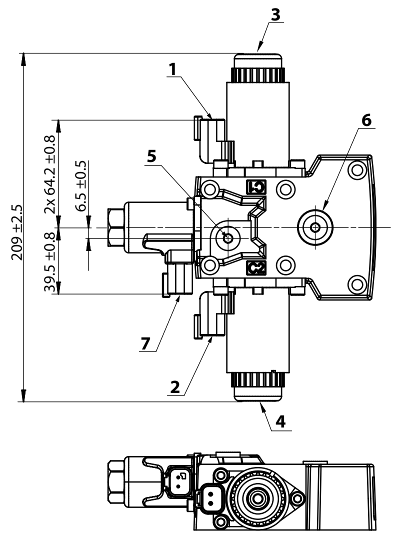
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

NFPE with MOR and CCO, Options: N7, N8 (12/24 V)

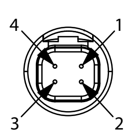
Non Feedback Proportional Electric control with Manual Over Ride and Control-Cut-Off valve key C, options N7 (12 V) and N8 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
6. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

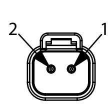
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Control solenoid connectors **C1/C2** DEUTSCH DTM04-2P pin assignment*

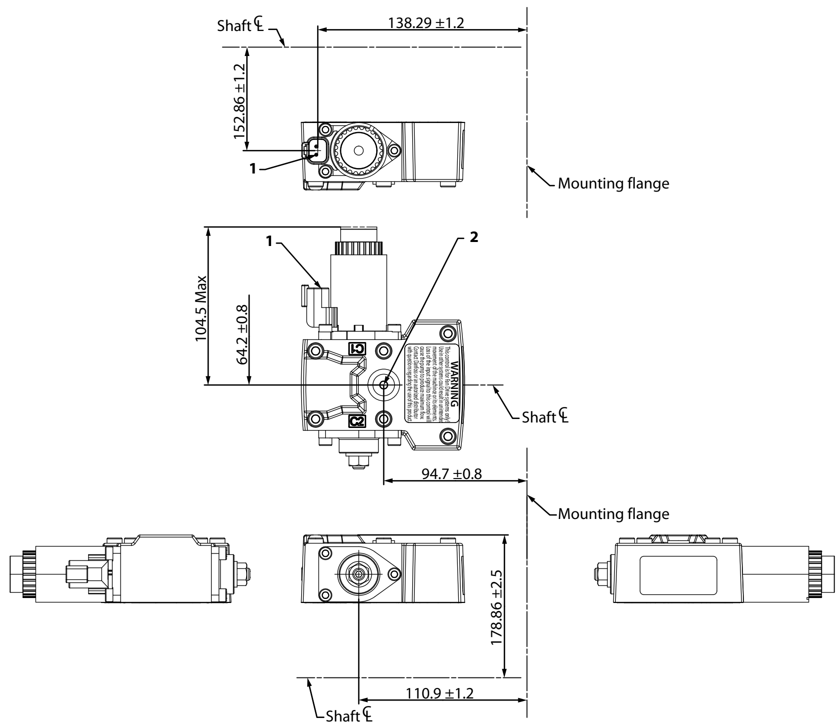


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

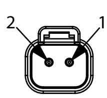
Dimensions and Data

FDC Options: F1, F2 (12/24V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Control solenoid connectors DEUTSCH, 2-pin assignment

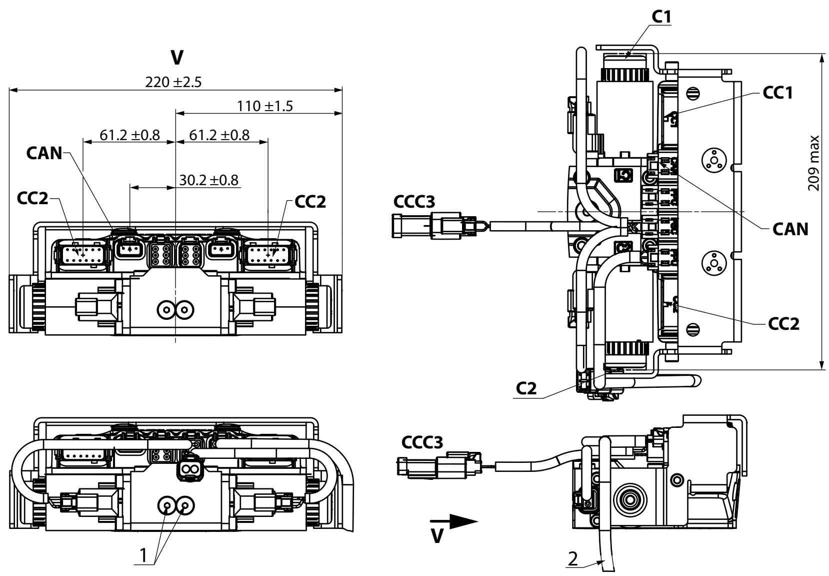


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Automotive control (AC)



1 Plug removing can cause contamination issues

2 PPU wire harness is factory installed to speed sensor

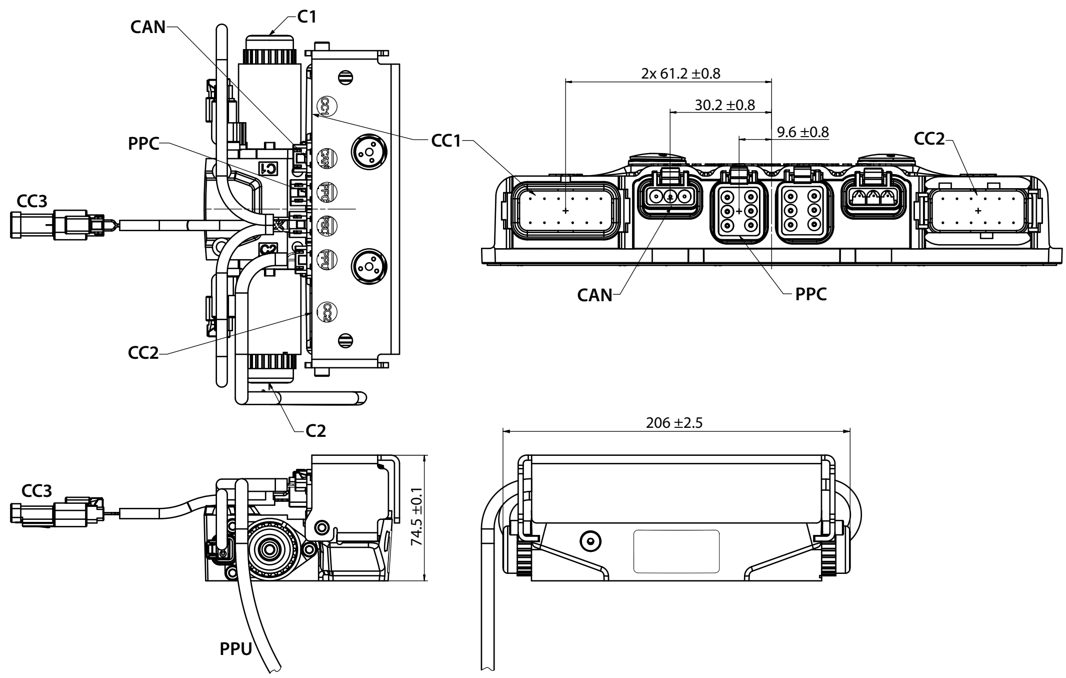
Connectors description

Port	Description
C1 and C2	**1.** Control manual override **C1** **2.** Control Manual Override **C2**
CC1	Port A control connector DEUTSCH DTM04-12P; paint free
CC2	Port B control connector DEUTSCH DTM04-12P; paint free
CC3	Control connector DEUTSCH DT06-2S; paint free; For using connector, the plug may be removed.
CAN	Control connector DEUTSCH DTM04-3P; paint free; For using connector, the plug may be removed.

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

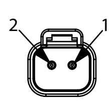
AC connectors dimensions



PPU wire harness is factory installed to speed sensor.

CC3

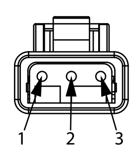
Connector DEUTSCH, 2-pin



1. Digital output A1 (+)
2. Digital output A2 (-)

CAN

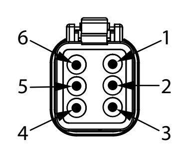
Connector DEUTSCH, 3-pin



1. CAN High
2. CAN Low
3. CAN Shield

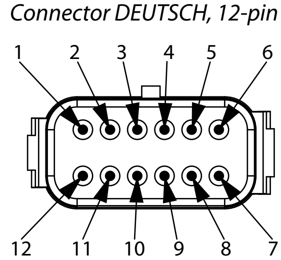
PPC

Connector DEUTSCH, 6-pin



1. Sensor A (+)
2. Analog input A
3. Sensor A (-)
4. Sensor B (-)
5. Analog input B
6. Sensor B (+)

Connector DEUTSCH, 12-pin



CC1

1. Battery (-)
2. Battery (+)
3. Sensor (+)
4. Sensor (-)
5. Motor rpm input (frequency)
6. Forward input (digital)
7. Reverse input (digital)
8. Sensor (+)
9. Sensor (-)
10. Drive pedal input (analog – nominal)
11. Drive pedal input (analog – red)
12. Neural input (digital)

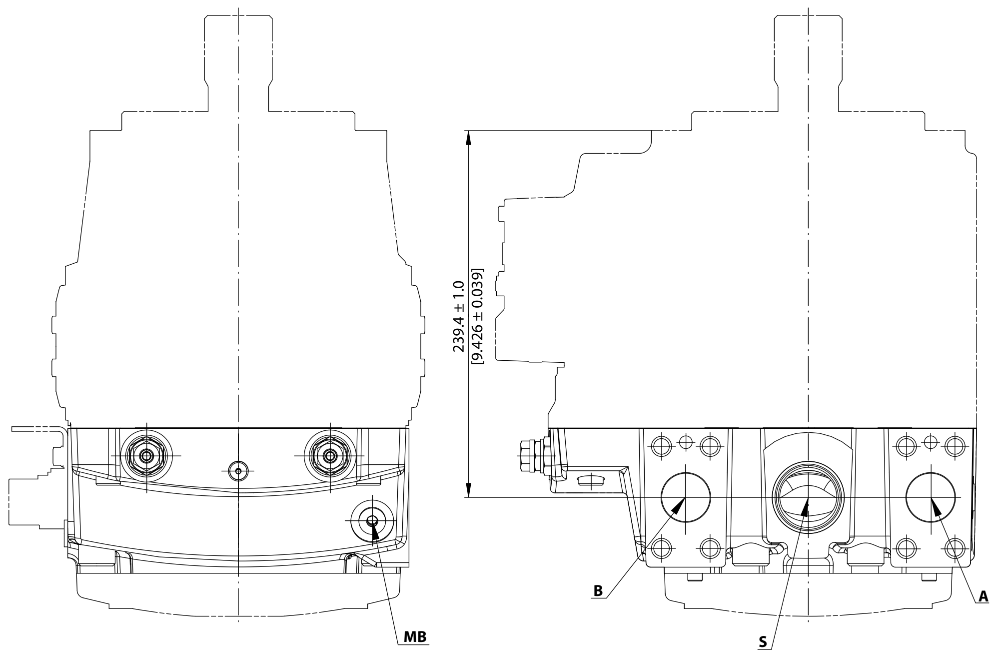
CC2

1. Inch input (analog – red)
2. Mode switch B input (digital – nominal)
3. Motor prop/PCOR driver
4. Motor direction input (analog)
5. Sensor (+)
6. Sensor (-)
7. Inch input (analog – nominal)
8. Motor BPD driver
9. Digital output B2 (-)
10. Digital output B1 (+)
11. Mode switch A input (digital)
12. Mode switch B input (digital – red)

Dimensions and Data

Filtration

H1P 115/130 Suction Filtration Option L

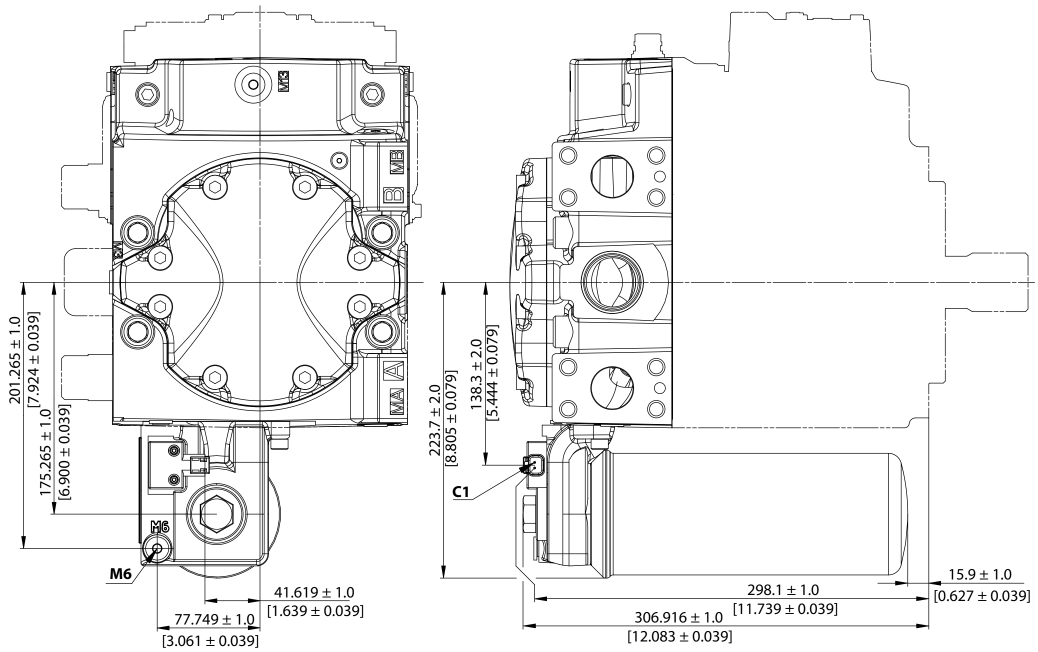


A	System port split flange boss per ISO 6162; M12 x 1.75; 20 min full thread depth
B	System port split flange boss per ISO 6162; M12 x 1.75; 20 min full thread depth
MB	System B gage port per ISO 11926-1; 9/16-18
S	Charge inlet port per ISO 11926-1; 1 5/8-12

Dimensions and Data

Integral Full Flow Charge Pressure Filtration, Option M

Integral full flow charge pressure filtration with filter bypass sensor, option M



Please contact Danfoss representative for specific installation drawings.

ENGINEERING TOMORROW

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ENGINEERING TOMORROW

Technical Information

H1P 147/165
Axial Piston Single Pumps

Revision history

Table of revisions

Date	Changed	Rev
May 2022	Corrected HDC control information	1201
December 2021	Added HDC control	1101
April 2021	Corrected interface with ECU (EDC) graphic	1006
September 2020	Corrected input shaft option F3 key dimensions	1005
April 2020	Corrected swash plate angle sensor connector and CCO connector descriptions	1004
February 2020	Added NFPE control options and changed document number from BC00000061	1003
May 2019	Major update.	0901
May 2018	Angle sensor for EDC; FDC note added.	0801
May 2017	NFPE gen. 3 changes.	0701
2009-2016	First edition-Varios updates.	AA to FA

Contents

Technical Specifications

H1 Pumps General Specification....6
H1P 147/165 Technical Data.... 6
H1P 147/165 Operating Parameters 7
Fluid Specification....8
H1P 147/165 Mounting Flange Loads 8
Bearing Life and External Radial Shaft Loads.... 9
Charge pump....10
  Charge Pump Selection....10
  26/34 cm^3 Charge Pump – Flow and Power Curves....10

Master Model Code

Displacement, A—Rotation, B—Product Version, Z—Port Configuration....11
D—Controls.... 12
  Electronic Displacement Controls.... 12
  Fan Drive Controls....12
  Non-Feedback Proportional Electric (NFPE) Controls.... 12
  Automotive Controls....13
  Manual Displacement Control....13
  Hydraulic Displacement Control....13
F—Orifices, E—Displacement Limiters....14
G—Endcap.... 15
H—Mounting Flange, J—Input Shaft, K—Aux Pad....16
M, N—Overpressure Protection Settings.... 17
S—Charge Pump, T—Filtration, V—Charge Pressure Relief....18
W—Special Hardware, X—Paint, Y—Special Features.... 19

Control Options

Electrical Displacement Control (EDC).... 20
  EDC Operation....20
  Control signal requirements, EDC 147/165....21
  Control Solenoid Data....21
  Single Pump Output Flow Direction....21
  Connector....22
  Control response....22
  Response Time, EDC 147/165....22
Manual Displacement Control (MDC) 23
  MDC operation.... 23
  MDC shaft rotation....24
  MDC Torque....24
  Control response....25
  Response time, MDC 147/165....25
  Neutral start switch (NSS).... 25
    Connector.... 26
  Case Gauge Port M14.... 26
  Lever....26
Hydraulic Displacement Control (HDC).... 27
  HDC principle.... 27
  HDC operation....27
  Hydraulic signal pressure range....28
  Pump output flow direction vs. control pressure.... 28
  Control response....28
  Response time, HDC 147/165....29
Forward-Neutral-Reverse Control (FNR)....30
  FNR Solenoid Data....31
  Single Pump Output Flow Direction....31
  Connector....31
  Control response....32
  Response Time, FNR 147/165....32
Non feedback proportional electric control (NFPE).... 33

Contents

Control Signal Requirements, NFPE 147/165 ... 33
Control Solenoid Data ... 34
Single Pump Output Flow Direction ... 34
Connector ... 34
Control response ... 35
Response Time, NFPE 147/165 ... 35
Automotive Control (AC) ... 36
Mode types ... 36
Basic functions ... 36
Performance functions ... 37
Protection and safety functions ... 37
Engine control and protection ... 37
Installation features ... 37
Fan Drive Control (FDC) ... 38
Control Signal Requirements, FDC 147/165 ... 39
Control Solenoid Data ... 39
Single Pump Output Flow Direction ... 40
Connector ... 40
Control response ... 40
Response Time, FDC 147/165 ... 40
Manual Override (MOR) ... 41
Swashplate angle sensor for EDC controls ... 42
Swash plate angle sensor parameters (EDC) ... 42
Swashplate Angle Sensor Connector ... 43
Interface with ECU (EDC) ... 43
Swash Plate Angle Sensor for NFPE and AC2 Controls ... 44
Swash Plate Angle Characteristic ... 44
Swash Plate Angle Sensor Parameters (NFPE/AC) ... 45
Swash Plate Angle Sensor Connector (NFPE) ... 45
Interface with ECU (NFPE) ... 45
Control Cut Off Valve (CCO) ... 46
Brake gauge port with MDC ... 46
CCO Connector (MDC) ... 47
H1P CCO Connector (EDC, NFPE) ... 47
CCO solenoid data ... 47
Displacement Limiter ... 48
H1P 147/165 Displacement Change (approximately) ... 48

Dimensions and Data

H1P Input Shaft Option G2 (SAE D, 27 teeth) ... 49
H1P Input Shaft Option G3 (SAE D, 13 teeth) ... 50
H1P 147/165 Input Shaft Option F3, Code 44–3 ... 51
Tapered shaft customer acknowledgement ... 51
H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth) ... 52
H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth) ... 53
H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth) ... 54
H1P Auxiliary Mounting, Option H4 (SAE D, 13 teeth) ... 55
H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth) ... 56
H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth) ... 57
H1P Displacement Limiter, Option B ... 58
Single Pump Ports ... 59
H1P Dimensions ... 60
Controls ... 63
EDC Options A2 and A3 (12/24 V) ... 63
EDC with MOR, Options A4 and A5 (12/24 V) ... 64
EDC with CCO (key C), Options E7 and E8 (12/24 V) ... 65
EDC with ASNSR, Options: H2 and H3 (12/24 V) ... 66
EDC with MOR and ASNSR, Options H6 and H7 (12/24 V) ... 67
EDC with CCO and ASNSR, Options H8 and H9 (12/24 V) ... 68
MDC Option: M1 ... 69

Contents

MDC with Neutral Start Switch Option: M2....70
MDC with CCO, Options: M3, M4....71
MDC with NSS and CCO Options: M5, M6....72
HDC, Options: T1, T2....73
NFPE with MOR, Options: N1, N2 (12/24 V)....74
NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V)....75
NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V)....76
NFPE with MOR and CCO, Options: N7, N8 (12/24 V)....77
Automotive control (AC)....78
AC connectors dimensions....79
Filtration....80
Suction Filtration Option L....80
Integral Full Flow Charge Pressure Filtration, Option M....80

Technical Specifications

H1 Pumps General Specification

Axial piston closed circuit variable displacement pumps of cradle swash-plate design with clockwise or counterclockwise direction of rotation.

Pipe connections

- Main pressure ports: ISO split flange boss
- Remaining ports: SAE straight thread O-ring boss

Recommended installation position

Pump installation position is discretionary, however the recommended control position is on the top or at the side with the top position preferred. If the pump is installed with the control at the bottom, flushing flow must be provided through port M14 located on the EDC, FNR and NFPE control.

Vertical input shaft installation is acceptable. If input shaft is at the top, 1 bar case pressure must be maintained during operation. The housing must always be filled with hydraulic fluid. Recommended mounting for a multiple pump stack is to arrange the highest power flow towards the input source. Consult Danfoss for nonconformance to these guidelines.

Auxiliary cavity pressure

Auxiliary cavity pressure will be inlet pressure with internal charge pump or case pressure with external charge supply. For reference see Operating Parameters. Please verify mating pump shaft seal capability.

H1P 147/165 Technical Data

Feature	Size 147	Size 165
Displacement	147.2 cm^3 [8.98 in^3]	165.1 cm^3 [10.08 in^3]
Flow at rated speed (continuous)	441 l/min [117 US gal/min]	495 l/min [131 US gal/min]
Torque at maximum displacement (theoretical)	2.34 N•m/bar [1430 lbf•in/1000 psi]	2.63 N•m/bar [1605 lbf•in/1000 psi]
Mass moment of inertia of rotating components	0.027 kg•m^2 [0.0199 slug•ft^2]	0.027 kg•m^2 [0.0199 slug•ft^2]
Mass (dry–no charge pump)	96 kg [211 lb]	96 kg [211 lb]
Oil volume	3.0 l [0.8 US gal]	3.0 l [0.8 US gal]

Shaft, flange and ports description

Input shaft per ISO 3019-1 (outer diameter)	• Outer Ø44 mm – 4 (SAE D, 13 teeth) • Outer Ø44 mm – 4 (SAE D, 27 teeth) • Conical keyed shaft end similar to ISO 3019-1 code 44-3, taper 1:8
Mounting flange per ISO 3019-1	Flange 152-4 (SAE D)
Auxiliary mounting flange with metric fasteners, with shaft outer diameter	• Flange 82-2 Outer Ø16 mm – 4 (SAE A, 9 teeth) • Flange 82-2 Outer Ø19 mm – 4 (SAE A, 11 teeth) • Flange 101-2 Outer Ø22 mm – 4 (SAE B, 13 teeth) • Flange 101-2 Outer Ø25 mm – 4 (SAE B-B, 15 teeth) • Flange 127-4 Outer Ø32 mm – 4 (SAE C, 14 teeth) • Flange 152-4 Outer Ø44 mm – 4 (SAE D, 13 teeth)
Suction port per ISO 3019-1	1 $^5/_8$ -12 (SAE O-ring boss)
Main configuration port	Ø31.5 mm - 450 bar split flange boss per ISO 6162, M12x1.75
Case drain ports L2, L4 per ISO 3019-1	ISO 11926-1 – 1$^5/_{16}$–12

Technical Specifications

Shaft, flange and ports description (continued)

Other ports	SAE O-ring boss
Customer interface threads	Metric fasteners

H1P 147/165 Operating Parameters

Parameter		Unit	Size 147/165
Input speed	**Min. for internal[1] and external[2] charge supply**	min^{-1} (rpm)	500
	Min. for full performance, internal charge supply		1200
	Rated		3000
	Maximum		3100
System pressure	**Maximum working**	bar [psi]	450 [6527]
	Maximum		480 [6962]
	Max./Min. low loop		45/10 [650/145]
Charge pressure	**Minimum**	bar [psi]	16 [232]
	Maximum		34 [493]
Control pressure	**Minimum (at corner power for EDC, MDC, FNR)**		17 [247]
	Minimum (at corner power for NFPE, FDC, AC)		26 [377]
	Maximum		40 [580]
Charge pump inlet pressure	**Rated**	bar (absolute) [in Hg vacuum]	0.7 [9.0]
	Minimum (cold start)		0.2 [24.0]
	Maximum	bar [psi]	4.0 [58.0]
Case pressure	**Rated**		3.0 [44.0]
	Maximum		5.0 [73.0]
Lip seal maximum pressure (external)			0.4 [5.8]

[1] Performance (displacement and pressure) may be limited due to limited control pressure.

[2] Full performance (displacement and pressure) possible at minimum charge and control pressure supply.

Filtration, cleanliness level and β_x-ratio (recommended minimum)

Cleanliness per ISO 4406	22/18/13
Efficiency β_x (charge pressure filtration)	$\beta_{15-20} = 75$ ($\beta_{10} \geq 10$)
Efficiency β_x (suction and return line filtration)	$\beta_{35-45} = 75$ ($\beta_{10} \geq 2$)
Recommended inlet screen mesh size	100 – 125 µm

Technical Specifications

Fluid Specification

Viscosity

Intermittent[1]	5 mm^2/s [42 SUS]
Minimum	7 mm^2/s [49 SUS]
Recommended range	12 – 80 mm^2/s [66 – 370 SUS]
Maximum	1600 mm^2/s [7500 SUS]

[1] Intermittent = Short term t < 1 min per incident and not exceeding 2 % of duty cycle based load-life.

Temperature

Minimum [1]	-40°C [-40°F]
Rated	104°C [220°F]
Recommended range[2]	60 – 85°C [140 – 185°F]
Maximum Intermittent	115°C [240°F]

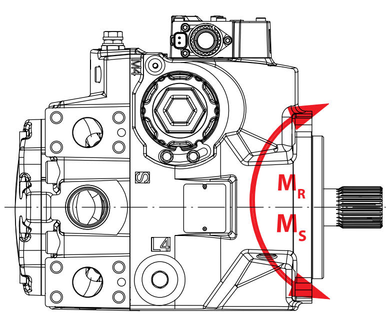
[1] Cold start = Short term t > 3 min, p ≤ 50 bar [725 psi], n ≤ 1000 min-1 (rpm).

[2] At the hottest point, normally case drain port.

H1P 147/165 Mounting Flange Loads

The Rated and Shock load moments apply for top or side orientation of control.

Mounting flange load with control on top



Rated moment	M_R = 6500 N•m [57 500 lbf•in]
Shock load moment	M_S = 16 300 N•m [144 000 lbf•in]

For more information, see *H1 Axial Piston Pumps, Basic Information,* **BC152886483968**, the section “Mounting flange loads”.

Technical Specifications

Bearing Life and External Radial Shaft Loads

All external shaft loads affect bearing life. The pumps are designed with bearings that can accept some external radial loads. The external radial shaft load limits are a function of the load position and orientation, and the operating conditions of the unit.

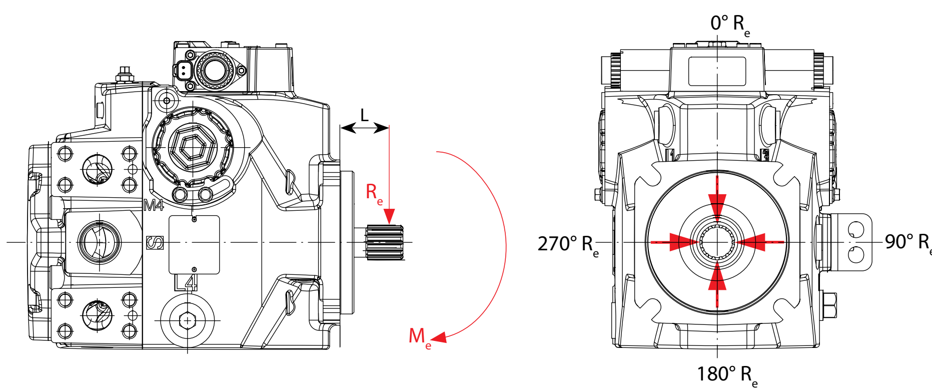
Danfoss recommends clamp-type couplings for applications with radial shaft loads. Contact your Danfoss representative for an evaluation of unit bearing life if you have continuously applied external loads exceeding 25 % of the maximum allowable radial load (R_e) or the pump swash-plate is positioned on one side of center all or most of the time.

Maximum external shaft load based on shaft deflection

External radial moment	Unit	Size 147/165
M_e	N•m [lbf•in]	140 [1240]

External radial shaft loads impact lifetime. For lifetime calculations please contact your Danfoss representative. In applications with external shaft loads, minimize the impact by positioning the load at 0° or 180° as shown below.

Radial load position



The maximum allowable radial shaft load (R_e) is based on the maximum external moment (M_e) and the distance (L) from the mounting flange to the load. It may be determined using the following formula:

$$\mathbf{R_e} = \frac{\mathbf{M_e}}{\mathbf{L}}$$

Thrust loads should be avoided. Contact your Danfoss representative in the event thrust loads are anticipated.

Technical Specifications

Charge pump

Charge Pump Selection

In most applications a general guideline is that the charge pump displacement should be at least 10% of the total displacement of all components in the system. Unusual application conditions may require a more detailed review of charge flow requirements. System features and conditions which may invalidate the 10% guideline include (but are not limited to):

- Continuous operation at low input speeds < 1500 min^{-1} (rpm)
- High shock loading and/or long loop lines
- High flushing flow requirements
- Multiple low speed high torque motors
- High input shaft speeds

Contact your Danfoss representative for application assistance if your application includes any of these conditions.

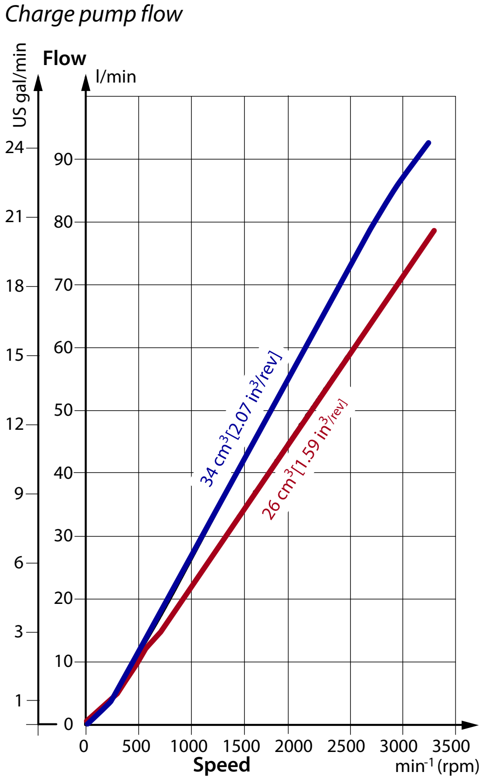
For more information, see *Selection of Drive line Components*, **BC157786484430**.

26/34 cm^3 Charge Pump – Flow and Power Curves

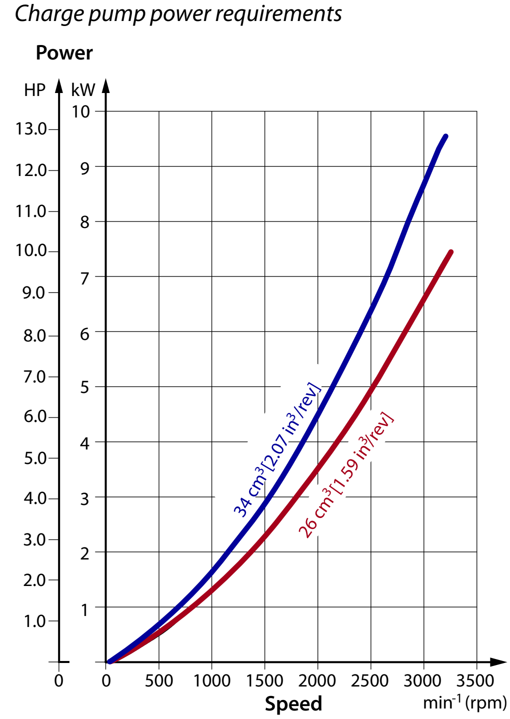
Charge pump flow and power requirements curves shown below at the following conditions:

Charge pressure = 20 bar [290 psi]
Viscosity = 11 mm^2/s [63 SUS]
Temperature = 80°C [176°F]

Charge pump flow



Charge pump power requirements



Master Model Code

Displacement, A—Rotation, B—Product Version, Z—Port Configuration

H1P A B Z D F E G H J K M N S T V W X Y

Displacement

147	147.2 cm^3 [8.98 in^3]
165	165.1 cm^3 [10.08 in^3]

A – Direction of Rotation

L	Left hand (counter clockwise)
R	Right hand (clockwise)

B – Product version

D	Revision code

Z – Port configuration

A	Inch, Customer O-ring port sealing according to ISO 11926-1

Master Model Code

D—Controls

A B Z D F E G H J K M N S T V W X Y

H1P

Electronic Displacement Controls

Code	Control type	Voltage	MOR	CCO with key C	Angle sensor	Connector
A2	EDC	12 V	—	—	—	DEUTSCH
A3	EDC	24 V	—	—	—	DEUTSCH
A4	EDC	12 V	●	—	—	DEUTSCH
A5	EDC	24 V	●	—	—	DEUTSCH
E7	EDC	12 V	—	●	—	DEUTSCH
E8	EDC	24 V	—	●	—	DEUTSCH
H2	EDC	12 V	—	—	●	DEUTSCH
H3	EDC	24 V	—	—	●	DEUTSCH
H6	EDC	12 V	●	—	●	DEUTSCH
H7	EDC	24 V	●	—	●	DEUTSCH
H8	EDC	12 V	—	●	●	DEUTSCH
H9	EDC	24 V	—	●	●	DEUTSCH

● – To be used for the control; — Not to be used for the control

Fan Drive Controls

F1	FDC	12 V	DEUTSCH Connector
F2	FDC	24 V	DEUTSCH Connector

Align with options: **F:** Orifices, **E:** Displacement limiters, **M, N:** Overpressure protection, and **W:** Special hardware.

Non-Feedback Proportional Electric (NFPE) Controls

Code	Control type	Voltage	MOR	CCO with key C	Angle sensor	Connector
N1	NFPE	12 V	●	—	—	DEUTSCH
N2	NFPE	24 V	●	—	—	DEUTSCH
N3	NFPE	12 V	●	●	●	DEUTSCH
N4	NFPE	24 V	●	●	●	DEUTSCH
N5	NFPE	12 V	●	—	●	DEUTSCH
N6	NFPE	24 V	●	—	●	DEUTSCH
N7	NFPE	12 V	●	●	—	DEUTSCH
N8	NFPE	24 V	●	●	—	DEUTSCH

Align with options: **E:** Displacement limiters and **W:** Special hardware.

Master Model Code

Automotive Controls

Automotive Control (AC)

Code	AC type	Voltage	MOR	Speed sensor	Wire harness	Angle sensor	Connector
P6	AC–1	12 V	●	●	●	—	DEUTSCH
P7	AC–1	24 V	●	●	●	—	DEUTSCH
P8	AC–2	12 V	●	●	●	●	DEUTSCH
P9	AC–2	24 V	●	●	●	●	DEUTSCH
P5	AC–1	12 V	●	—	—	—	DEUTSCH
R3	AC–1	24 V	●	—	—	—	DEUTSCH
R4	AC–2	12 V	●	—	—	●	DEUTSCH
R5	AC–2	24 V	●	—	—	●	DEUTSCH

● – To be used for the control; — Not to be used for the control

Manual Displacement Control

Manual Displacement Control (MDC)

Code	Control type	CCO Voltage	CCO	Neutral Start Switch	Connector
M1	MDC	—	—	—	—
M2	MDC	—	—	●	DEUTSCH
M3	MDC	12 V	●	—	DEUTSCH
M4	MDC	24 V	●	—	DEUTSCH
M5	MDC	12 V	●	●	DEUTSCH
M6	MDC	24 V	●	●	DEUTSCH

Align with options **F:** Orifices and **Y:** Settings for adjustment (if applicable).

Hydraulic Displacement Control

Hydraulic Displacement Control (HDC)

Code	Pressure range	Ports
T1	4.2 - 16.2 bar	Inch ports 9/16-18
T2	3.0 - 11.6 bar	Inch ports 9/16-18

Master Model Code

F—Orifices, E—Displacement Limiters

A B Z D F E G H J K M N S T V W X Y

H1P

F – Orifices Options

Orifices options related to control type

Code	Tank (A+B)	P orifice	A/B orifices	EDC, FNR	MDC	NFPE, AC	FDC
C3	No orifice			●	●	–	–
C1	–	–	0.8 mm	●	●	●	–
C2	–	–	1.3 mm	●	●	●	●
C4	–	–	1.8 mm	●	●	●	–
C5	–	–	2.5 mm	–	–	–	–
C6	1.0 mm	–	–	–	●	–	
C7	1.3 mm	–	–	–	●	–	–
D1	0.8 mm	1.0 mm	–	–	●	–	–
D2	0.8 mm	1.3 mm	–	–	●	–	–
D3	1.0 mm	1.3 mm	–	–	●	–	–
D4	1.0 mm	1.3 mm	1.3 mm	–	●	–	–
D5	0.6 mm	0.6 mm	0.8 mm	–	●	–	–
D6	1.3 mm	1.3 mm	–	–	●	–	–

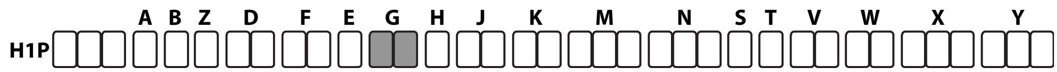
E – Displacement Limiter Options

N	None
B	Adjustable externally
C	No limiters, with nested springs, required for NFPE, AC, FDC*
D	Adjustable externally with nested springs, required for NFPE, AC, FDC*

* Align with option **Y:** Settings for adjustment (if applicable).

Master Model Code

G—Endcap



G – End-cap Options

Twin port, ISO 6162 split flange ports; Align with T: Filtration

D3	Integral pressure filtration
D6	Suction filtration
D8	Remote filtration or external charge supply

Master Model Code

H—Mounting Flange, J—Input Shaft, K—Aux Pad

A B Z D F E G H J K M N S T V W X Y

H1P

H – Mounting options

Mounting to be aligned with option W: Special hardware

G	ISO 3019-1 flange 152–4 (SAE D)
L	ISO 3019-1 flange 152–4 (SAE D), 4-bolt, with speed sensor

J – Input Shaft options

G2	ISO 3019-1, outer Ø44 mm - 4 (27 teeth splined shaft 16/32 pitch)
G3	ISO 3019-1, outer Ø44 mm - 4 (13 teeth splined shaft 8/16 pitch)
F3	Conical keyed shaft end, code 44-3 (similar to ISO 3019-1), taper 1:8 (key not supplied with pump)

K – Auxiliary Mounting Pad options (ISO 3019-1)

NN	None
H1	Flange 82–2 (SAE A, 11 teeth, 16/32 coupling); shipping cover
H2	Flange 82–2 (SAE A, 9 teeth, 16/32 coupling); shipping cover
H3	Flange 101–2 (SAE B, 13 teeth, 16/32 coupling); shipping cover
S1	Flange 101–2 (SAE B, 14 teeth, 12/24 coupling); shipping cover
H5	Flange 101–2 (SAE B-B, 15 teeth, 16/32 coupling); shipping cover
H6	Flange 127–4 (SAE C, 14 teeth, 12/24 coupling); shipping cover
E5	Flange 127–4 (SAE C, 13 teeth, 8/16 coupling); shipping cover
H4	Flange 152–4 (SAE D, 13 teeth, 8/16 coupling); shipping cover

Master Model Code

M, N—Overpressure Protection Settings

A B Z D F E G H J K M N S T V W X Y

H1P

M and N – Overpressure protection options

L	Pressure limiter setting	HPRV with bypass setting[1)]
L20	200 bar [2900 psi]	250 bar [3630 psi]
L23	230 bar [3336 psi]	280 bar [4061 psi]
L25	250 bar [3630 psi]	300 bar [4350 psi]
L28	280 bar [4061 psi]	330 bar [4786 psi]
L30	300 bar [4350 psi]	350 bar [5076 psi]
L33	330 bar [4786 psi]	380 bar [5510 psi]
L35	350 bar [5080 psi]	400 bar [5800 psi]
L37	370 bar [5366 psi]	420 bar [6090 psi]
L38	380 bar [5510 psi]	420 bar [6090 psi]
L40	400 bar [5800 psi]	450 bar [6526 psi]
L42	420 bar [6090 psi]	450 bar [6526 psi]
L43	430 bar [6237 psi]	480 bar [6962 psi]
L44	440 bar [6382 psi]	480 bar [6962 psi]
L45	450 bar [6526 psi]	480 bar [6962 psi]
Overpressure protection type and setting for FDC		
F01	150 bar [2175 psi]	250 bar [3630 psi]
F02	150 bar [2175 psi]	300 bar [4350 psi]
F03	150 bar [2175 psi]	350 bar [5076 psi]
F04	150 bar [2175 psi]	400 bar [5800 psi]

[1)] Pressure limiter and HPRV with bypass, over-pressure protection type must be the same for both sides "A" and "B".

K	Pressure setting [1)]
K20	200 bar [2900 psi]
K23	230 bar [3336 psi]
K25	250 bar [3630 psi]
K28	280 bar [4061 psi]
K30	300 bar [4350 psi]
K33	330 bar [4786 psi]
K35	350 bar [5076 psi]
K38	380 bar [5510 psi]
K40	400 bar [5800 psi]
K42	420 bar [6090 psi]
K45	450 bar [6526 psi]

[1)] Pressure limiter and HPRV with bypass, over-pressure protection type must be the same for both sides "A" and "B".

Please contact Danfoss Power Solutions for pressures not shown or for applied pressure above max. working pressure.

Master Model Code

S—Charge Pump, T—Filtration, V—Charge Pressure Relief

A B Z D F E G H J K M N S T V W X Y

H1P

S – Charge pump options

A	26 cm^3/rev [1.69 in^3/rev]
L	34 cm^3/rev [2.07 in^3/rev]
N	No charge pump, external charge supply (*Align with options:* **E, T**)

T – Filtration options

Filtration to be aligned with G: End cap selection

L	Suction filtration
M	Integral full charge flow filtration with bypass sensor, long filter length **11004919**
N	Integral full charge flow filtration with bypass sensor, without filter
P	Remote full charge flow filtration
E	External full charge flow filtration (Align with options **N, S**)

V – Charge pressure relief valve (CPRV) setting

20*	20 bar [290 psi]
22*	22 bar [319 psi]
24*	24 bar [348 psi]
26	26 bar [377 psi]
28	28 bar [406 psi]
30	30 bar [435 psi]
32	32 bar [464 psi]
34	34 bar [493 psi]

* Not to be used for **NFPE, AC** and **FDC** controls.

Master Model Code

W—Special Hardware, X—Paint, Y—Special Features

A B Z D F E G H J K M N S T V W X Y
H1P

W – Special Hardware features

Hardware features to be aligned with options D, E

P1	NFPE/FDC valve plate
P2	NFPE/FDC/AC valve plate and speed ring on the cylinder block
P4	EDC/FNR/MDC valve plate and speed ring on the cylinder block
PN	EDC/FNR/MDC valve plate
H1	MDC/EDC/FNR valve plate with MDC handle

X – Paint and Name-tag

NNN	Black paint and Danfoss name-tag
C08	Paint none and Danfoss name-tag

Y – Special settings (SIL-2 non-certifiable, without customer files)

Code	CAN J1939	ECO fuel saving mode	Functional option	Cruise control	Control	AC type
D3E	in/out	●	E	–	N1 (12 V_{DC})	AC–1
D3F	in/out	–	F	–		
D4E	in/out	●	E	–	N2 (24 V_{DC})	
D4F	in/out	–	F	–		
D5F	in/out	–	F	–	P8 (12 V_{DC})	AC–2 (with swash plate angle sensor)
D5J	in/out	●	J	●		
D6F	in/out	–	F	–	P9 (24 V_{DC})	
D6J	in/out	●	J	●		
M00	MDC handle standard position					
NNN	None					

● – To be used for the control; — Not to be used for the control

Control Options

Electrical Displacement Control (EDC)

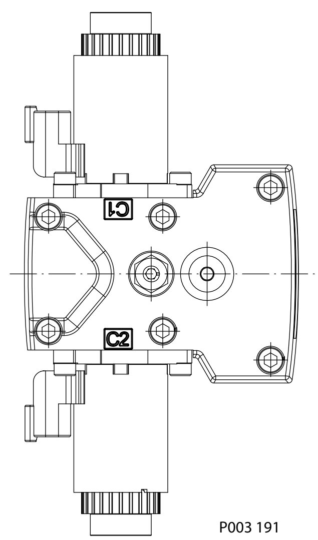
An EDC is a displacement (flow) control. Pump swash plate position is proportional to the input command and therefore vehicle or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The Electrical Displacement Control (**EDC**) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

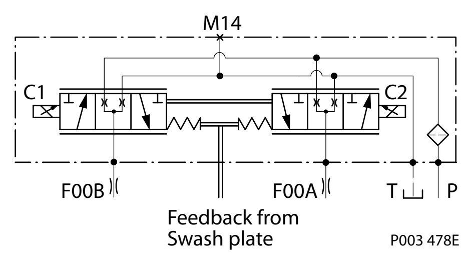
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

Electrical Displacement Control



EDC schematic, feedback from swash plate



EDC Operation

H1 EDC's are current driven controls requiring a Pulse Width Modulated (PWM) signal. Pulse width modulation allows more precise control of current to the solenoids.

The PWM signal causes the solenoid pin to push against the porting spool, which pressurizes one end of the servo piston, while draining the other. Pressure differential across the servo piston moves the swashplate.

A swashplate feedback link, opposing control links, and a linear spring provide swashplate position force feedback to the solenoid. The control system reaches equilibrium when the position of the swashplate spring feedback force exactly balances the input command solenoid force from the operator. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

The EDC incorporates a positive neutral deadband as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold current is reached, the swashplate is positioned directly proportional to the control current. To minimize the effect of the control neutral deadband, we recommend the transmission controller or operator input device incorporate a jump up current to offset a portion of the neutral deadband.

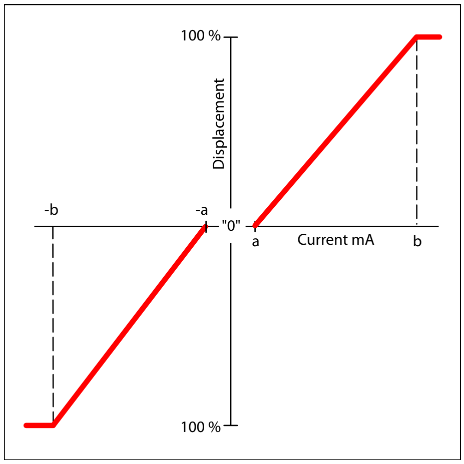
The neutral position of the control spool does provide a positive preload pressure to each end of the servo piston assembly.

When the control input signal is either lost or removed, or if there is a loss of charge pressure, the spring-loaded servo piston will automatically return the pump to the neutral position.

Control Options

Control signal requirements, EDC 147/165

Pump displacement vs. control current



EDC control current

Voltage		$12\ V_{DC}$	$24\ V_{DC}$
Minimum current to stroke pump	**a***	640 mA	330 mA
	b	1640 mA	820 mA
Pin connections		any order	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Single Pump Output Flow Direction

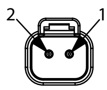
Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	out	in	in	out
Port B	in	out	out	in
Servo port pressurized	M4	M5	M4	M5

* For coil location see installation drawings.

Control Options

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, EDC 147/165

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	5.8 s	2.1 s	1.3 s
Full flow to neutral	2.4 s	1.6 s	1.2 s

Control Options

Manual Displacement Control (MDC)

A Manual proportional Displacement Control (**MDC**) consists of a handle on top of a rotary input shaft. The shaft provides an eccentric connection to a feedback link. This link is connected on its one end with a porting spool. On its other end the link is connected the pumps swashplate.

This design provides a travel feedback without spring. When turning the shaft the spool moves thus providing hydraulic pressure to either side of a double acting servo piston of the pump.

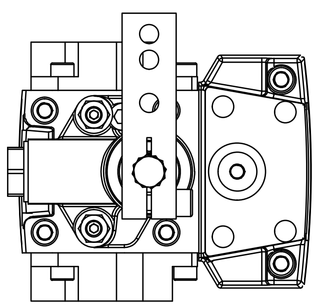
Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement. Simultaneously the swashplate movement is fed back to the control spool providing proportionality between shaft rotation on the control and swash-plate rotation. The MDC changes the pump displacement between no flow and full flow into opposite directions.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

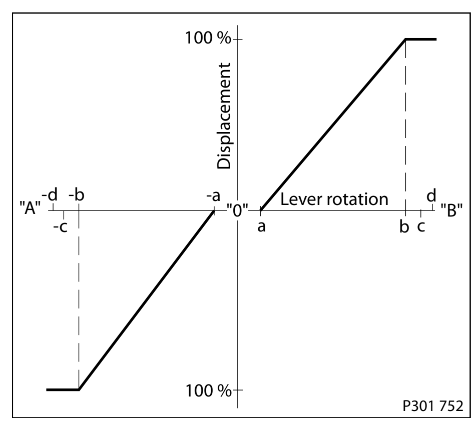
For the MDC with CCO option the brake port (X7) provides charge pressure when the coil is energized to activate static function such as a brake release. The X7 port must not be used for any continuous oil consumption.

The MDC is sealed by means of a static O-ring between the actuation system and the control block. Its shaft is sealed by means of a special O-ring which is applied for low friction. The special O-ring is protected from dust, water and aggressive liquids or gases by means of a special lip seal.

Manual Displacement Control



Pump displacement vs. control lever rotation



Deadband on **B** side: **a = 3° ±1°**
Maximum pump stroke: **b = 30° +2/-1°**
Required customer end stop: **c = 36° ±3°**
Internal end stop: **d = 40°**

MDC operation

The MDC provides a mechanical dead-band required to overcome the tolerances in the mechanical actuation. The MDC contains an internal end stop to prevent turning the handle into any inappropriate position.

The MDC provides a permanent restoring moment appropriate for turning the MDC input shaft back to neutral position only. This is required to take the backlash out of the mechanical connections between the Bowden cable and the control.

High case pressure may cause excessive wear and the NSS to indicate that the control is not in neutral position. In addition, if the case pressure exceeds 5 bar there is a risk of an insufficient restoring moment. The MDC is designed for a maximum case pressure of 5 bar and a rated case pressure of 3 bar.

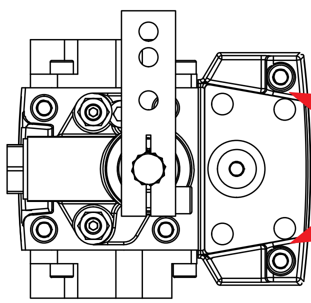
Control Options

- Customers must install some support to limit the setting range of their Bowden cable to avoid an overload of the MDC.
- Customers can apply their own handle design but they must care about a robust clamping connection between their handle and the control shaft and avoid overload of the shaft.
- Customers can connect two MDC's on a tandem unit in such a way that the actuation force will be transferred from the pilot control to the second control. The kinematic of the linkages must ensure that either control shaft is protected from torque overload.

Caution

Using the internal spring force on the input shaft is not an appropriate way to return the customer connection linkage to neutral, or to force a Bowden cable or a joystick back to neutral position. It is not applicable for any limitation of the Bowden cable stroke, except the applied torque to the shaft will never exceed 20 N•m.

MDC shaft rotation



Pump shaft rotation*	Clockwise (CW)		Counter-clockwise (CCW)	
MDC shaft rotation	**CW**	**CCW**	**CW**	**CCW**
Port A	in (low)	out (high)	out (high)	in (low)
Port B	out (high)	in (low)	in (low)	out (high)
Servo port high pressure	M5	M4	M5	M4

* As seen from shaft side.

MDC Torque

Description	Value
Torque required to move handle to maximum displacement	1.4 N•m [12.39 lbf•in]
Torque required to hold handle at given displacement	0.6 N•m [5.31 lbf•in]
Maximum allowable input torque	20 N•m [177 lbf•in]

Caution

Volumetric efficiencies of the system will have impacts on the start and end input commands.

Control Options

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response time, MDC 147/165

Code	Orifice description (mm)			Stroking direction	
	Tank (A+B)	P	A/B	Neutral to full flow	Full flow to neutral
C3	No orifice			0.9 s	1.0 s
C5	–	–	2.5	0.9 s	1.0 s
C6	1	–	–	3.3 s	2.9 s
C7	1.3	–	–	2.1 s	1.9 s
D1	0.8	1	–	5.0 s	3.9 s
D2	0.8	1.3	–	4.4 s	4.4 s
D3	1	1.3	–	3.8 s	3.2 s
D4	1	1.3	1.3	4.6 s	3.8 s

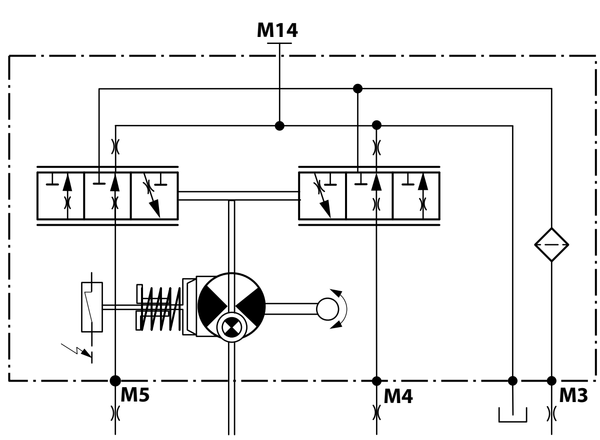
D1, D2 – for H1P 147 cc pump only.

For further data please contact your Danfoss representative.

Neutral start switch (NSS)

The Neutral Start Switch **(NSS)** contains an electrical switch that provides a signal of whether the control is in neutral. The signal in neutral is Normally Closed **(NC)**.

Neutral start switch schematic



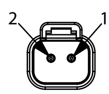
Control Options

Neutral start switch data

Max. continuous current with switching	8.4 A
Max. continuous current without switching	20 A
Max. voltage	36 V_{DC}
Electrical protection class	IP67 / IP69K with mating connector

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Case Gauge Port M14

The drain port should be used when the control is mounted on the unit's bottom side to flush residual contamination out of the control.

Lever

MDC-controls are available with an integrated lever.

Control Options

Hydraulic Displacement Control (HDC)

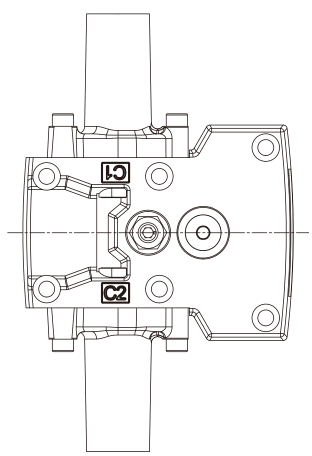
HDC principle

An HDC is a Hydraulic Displacement Control. Pump swashplate position is proportional to the input command and therefore vehicle speed or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The HDC control uses a hydraulic input signal to operate a porting spool, which ports hydraulic pressure to either side of a double acting servo piston. The hydraulic signal applies a force input to the spool which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction. Under some circumstances, such as contamination, the porting spool could stick and cause the pump to stay at some displacement.

A serviceable 175 µm screen is located in the supply line immediately before the control porting spool.

HDC control



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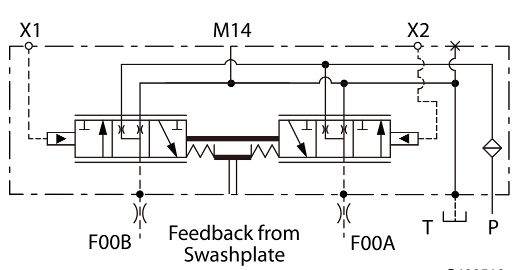
HDC schematic



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HDC operation

HDC's are hydraulically driven control which ports hydraulic pressure to either side of a porting spool, which pressurizes one end of the servo piston, while draining the other end to case. Pressure differential across the servo piston moves the swashplate.

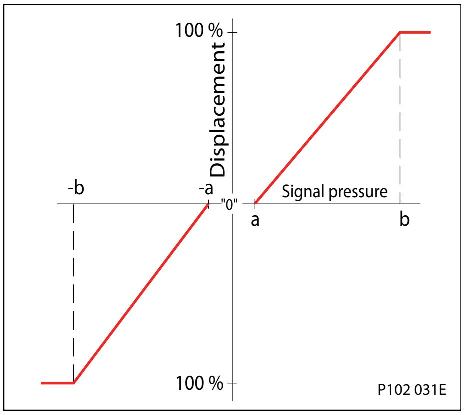
A swashplate feedback link, opposing control linkage, and a linear spring provide swashplate position force feedback to the hydraulic pressure. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

Control Options

The HDC incorporates a positive neutral dead band as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold point is reached, the swashplate is positioned directly proportional to the control pressure.

When the control input is either lost or removed, or if there is a loss of charge pressure, the spring loaded servo piston will automatically return the pump to the neutral position.

Pump displacement vs signal pressure



Hydraulic signal pressure range

Option	Type	a*	b*	Max. pressure
T1	Standard	4.2 bar	16.2 bar	30 bar
T2	Option	3 bar	11.6 bar	30 bar

* Factory test current, for vehicle movement or application actuation expect a higher or lower value.

Pump output flow direction vs. control pressure

Shaft rotation HDC	Clockwise (CW) seen from shaft		Counter Clockwise (CCW) seen from shaft	
Port energized	X1	X2	X1	X2
Port A	Out (high)	In (low)	In (low)	Out (high)
Port B	In (low)	Out (high)	Out (high)	In (low)
Servo port high pressure	M4	M5	M4	M5

For appropriate performance of HDC characteristic, keep the drain pressure of pilot valve to be equal or slightly higher than pump case pressure.

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Control Options

Response time, HDC 147/165

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	4.8s	2.2s	1.3s
Full flow to neutral	3s	1.4s	0.8s

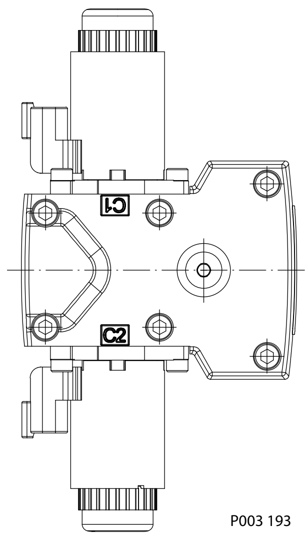
Control Options

Forward-Neutral-Reverse Control (FNR)

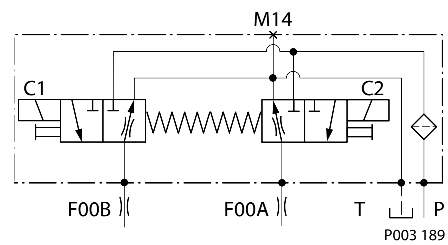
The 3-position FNR control options **A9** (12 V) and **B1** (24 V) uses an electric input signal to switch the pump to a full stroke position. A serviceable 125 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool can stick and cause the pump to stay at some displacement.

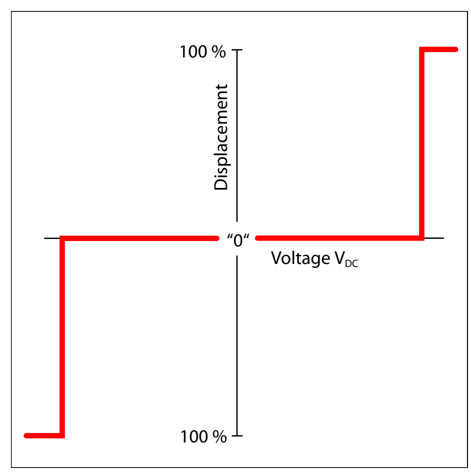
Forward-Neutral-Reverse electric control (FNR)



FNR hydraulic schematic



Pump displacement vs. electrical signal



FNR control current

Voltage	**12 V_{DC}**	**24 V_{DC}**
Minimum current to stroke pump	750 mA	380 mA
Pin connections	any order	

Control Options

FNR Solenoid Data

Solenoid data

Voltage	**12 V_{DC}**	**24 V_{DC}**
Minimum supply voltage	9.5 V_{DC}	19 V_{DC}
Maximum supply voltage (continuous)	14.6 V_{DC}	29 V_{DC}
Bi-directional diode cut off voltage	28 V_{DC}	53 V_{DC}
Maximum current	1050 mA	500 mA
Nominal coil resistance @ 20°C	8.4 Ω	34.5 Ω
PWM Range	70 – 200 Hz	
PWM Frequency (preferred)*	100 Hz	

* PWM signal required for optimum control performance.

Electrical Protection	**Standard**	**Class**
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector

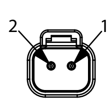
Single Pump Output Flow Direction

Shaft rotation	**Clock-Wise (CW)**		**Counter-Clock-Wise (CCW)**	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see installation drawings.

Connector

Connector DEUTSCH, 2-pin



Description	**Quantity**	**Order data**
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control Options

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, FNR 147/165

Stroking direction	0.8 [0.03] orifice	1.3 [0.05] orifice	No orifice
Neutral to full flow	3.7 s	2.7 s	1.6 s
Full flow to neutral	5.7 s	2.4 s	1.1 s

Control Options

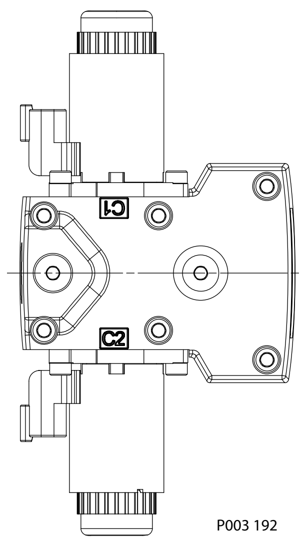
Non feedback proportional electric control (NFPE)

The Non Feedback Proportional Electric (**NFPE**) control is an electrical automotive control in which an electrical input signal activates one of two proportional solenoids that port charge pressure to either side of the pump servo cylinder. The NFPE control has no mechanical feedback mechanism.

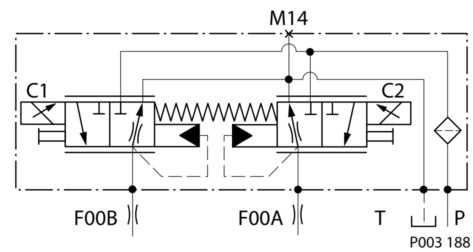
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

NFPE control



NFPE schematic

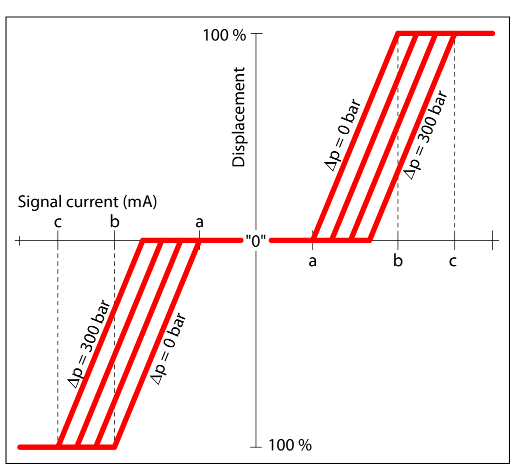


Control Signal Requirements, NFPE 147/165

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash-plate angle as system pressure increases.

A typical response characteristic is shown in the accompanying graph below:

Pump displacement vs. input signal



Control Options

Control current requirements

Voltage*	a	b	c	Pin config.
12 V_{DC}	666 mA	1168 mA	1540 mA	any order
24 V_{DC}	320 mA	600 mA	770 mA	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

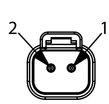
Single Pump Output Flow Direction

Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see installation drawings.

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control Options

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

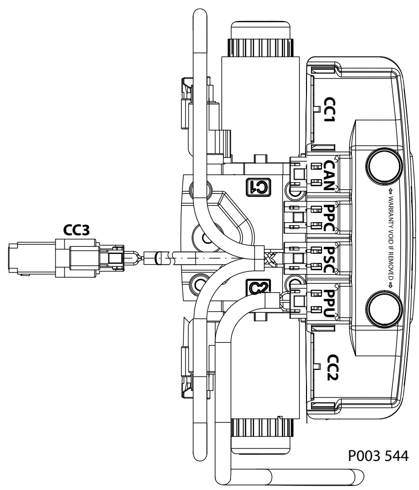
Response Time, NFPE 147/165

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	2.3 mm [0.09 in] orifice
Neutral to full flow	6.7 s	2.7 s	0.9 s
Full flow to neutral	3.4 s	1.5 s	0.4 s

Control Options

Automotive Control (AC)

The H1 **A**automotive **C**ontrol (AC) is an electric NFPE Control with an integrated micro-controller, installed on the pump. The integrated micro-controller enhanced control performance with a flexible, configurable control scheme for an entire single path propel transmission. It can be used in combination with fixed and variable displacement hydraulic-motors. With the pre-installed application software and easily changeable control parameters, it is possible to tailor the vehicle's driving behavior to the individual requirements of the customer.



The H1 Automotive Control is divided into 2 systems:

- AC-1
- AC-2

AC-2 is an extension of AC-1 that features an integrated pump swash plate angle sensor and software enabled functions such as Swash Plate Control.

Mode types

The application software provides 3 different hydrostatic propel methods, defined as mode types, which can be used individually.

- **Automotive Load dependent** (torque controlled) driving behavior. Setpoint for the drive curve is the engine rpm.
- **Non-Automotive Load independent** (speed controlled) driving mode. Setpoint for the drive curve is a Joystick or drive pedal signal, independent of the engine rpm. The best performance will achieved with an AC-2 Swash Plate Angle Sensor.
- **Creep-Automotive Load dependent** (torque controlled) driving behavior (like Automotive). Setpoint for the drive curve is the engine rpm. The setpoint can be reduced by the creep potentiometer if a high engine rpm in combination with low vehicle speed is needed.

Basic functions

- Four selectable system modes, selectable via switch.
- Individual settings for forward and reverse driving direction (4 x 2 curves).
- Independent pump and hydraulic-motor profiling and ramping for each mode.
- Electric drive pedal connection
- Electronic inching function without separate control valve
- Electric creep mode potentiometer

Control Options

- Configurable System Mode & Direction change
- Load independent pump displacement control with integrated Swash Plate Angle Sensor (AC-2)
- Hydraulic-motor displacement control including brake pressure defeat function

Performance functions

- ECO fuel saving mode with automatic reduction of the engine speed during transport (Cruise control)
- Vehicle constant speed drive control
- Vehicle speed limitation
- Dynamic brake light, automatic park brake, reverse buzzer and status LED outputs
- Vehicle speed controlled output function.
- Temperature compensation for predictable performance
- Advanced CAN J1939 interface for the information exchange with the vehicle control system

Protection and safety functions

- Safety controlled vehicle start protection with engine speed check, battery check and FNR must be in neutral, etc..
- Operator presence detection
- Hydraulic system overheat and low-temperature protection
- Hydraulic motor over speed protection
- Park brake test mode for roller applications to fulfill SAE J1472 / EN500-4.
- SIL2 compliant

Engine control and protection

- CAN J1939 engine interface
- Engine speed control via drive pedal with safety controlled monitoring function
- Engine antistall protection
- Engine over speed protection during inching
- Engine speed dependent Retarder control
- Engine cold start protection

Installation features

- Factory calibration for hysteresis compensation.
- Starting current adjustment in the factory
- Pre-installed application software and parameter files

For more information, see *Automotive Control for H1 Single Pumps Technical Information*, **BC152986482596**.

Control Options

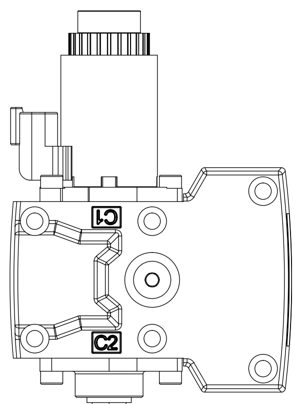
Fan Drive Control (FDC)

The Fan Drive Control (**FDC**) is a non-feedback control in which an electrical input signal activates the proportional solenoid that ports charge pressure to either side of the pump servo cylinder. The single proportional solenoid is used to control pump displacement in the forward or reverse direction.

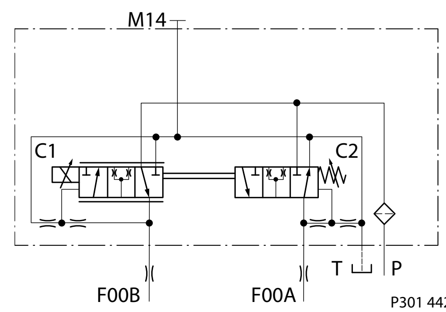
The control spool is spring biased to produce maximum forward pump displacement in the absence of an electrical input signal. Based on the spring bias spool default forward flow for a CW rotation pump is out of port B while default forward flow for a CCW rotation pump is out of port A.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

FDC control



FDC schematic



The pump should be configured with 0.8 mm control orifices to provide slowest response and maximize system stability. Additionally, pressure limiter (PL) valves are used to limit maximum fan trim speed in both (forward and reverse) directions.

H1 pumps with FDC will be delivered from factory with nominal pressure limiter setting of 150 bar [2175 psi]. The PL must be re-adjusted to ensure that the fan reaches the desired fan speed to satisfy the cooling needs of the system. HPRV setting must be always at least 30 bar [435 psi] higher than PL setting.

For more information necessary to properly size and configure a hydraulic fan drive system, see *Hydraulic Fan Drive Design Guidelines* **AB152886482265**.

Warning

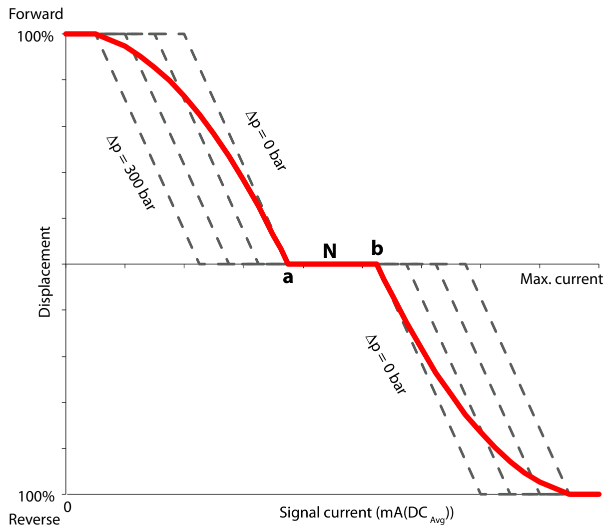
Use in other systems could result in unintended movement of the machine or it's elements. Loss of the input signal to this control will cause the pump to produce maximum flow.
The FDC is for Fan Drive systems only!

Due to the fail-safe functionality of the FDC control the pump will stroke to max. displacement in case the input signal to the pump control and the Diesel engine will be switched off at the same time. In this situation a low loop event can occur which may damage the pump. Therefore, it's strictly recommended to keep the input signal to the pump control alive while switching off the engine.
For further information please contact your Danfoss representative.

Control Options

Control Signal Requirements, FDC 147/165

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash plate angle as system pressure increases. A typical response characteristic is shown in the accompanying graph below:



a – Forward threshold

b – Reverse threshold

N – Neutral override current

Control current requirements

Voltage*	a	N	b	Pin config.
12 V_{DC}	780 mA	1100 mA	1300 mA	any order
24 V_{DC}	400 mA	550 mA	680 mA	

* Factory test current, for fan movement expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Control Options

Single Pump Output Flow Direction

Pump output flow direction vs. control signal

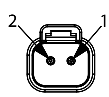
Shaft rotation		**ClockWise**			**CounterClockWise**		
Control Logic	**12 V**	**0-780 mA**	**1100 mA**	**1300-1800 mA**	**0-780 mA**	**1100 mA**	**1300-1800 mA**
	24 V	**0-400 mA**	**550 mA**	**680-920 mA**	**0-400 mA**	**550 mA**	**680-920 mA**
Port A		in	no flow	out	out	no flow	in
Port B		out	no flow	in	in	no flow	out
Servo port pressurized		M5	n/a	M4	M5	n/a	M4

Warning

Loss of input signal to the control will cause the pump to produce maximum flow.

Connector

Connector DEUTSCH, 2-pin



Description	**Quantity**	**Order data**
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, FDC 147/165

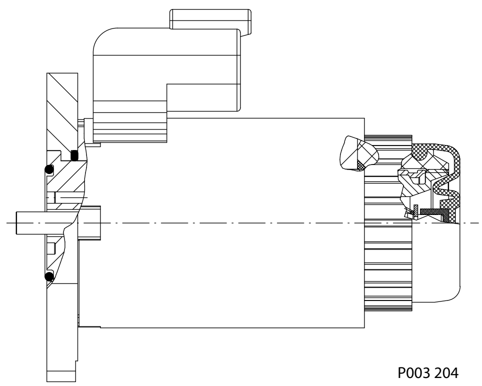
Stroking direction	**0.8 mm [0.03 in] orifice**
Full flow to neutral	3.9 s
Full forward flow to full reverse flow	5.6 s

Control Options

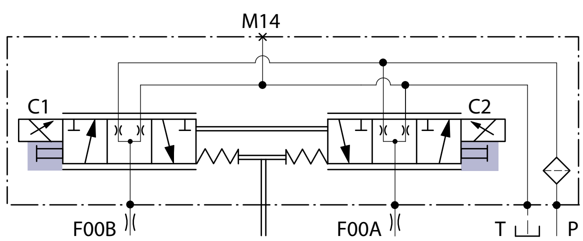
Manual Override (MOR)

All controls are available with a manual override functionality, either as a standard or as an option for temporary actuation of the control to aid in diagnostics.

Control with manual override



MOR schematic (EDC control shown)



Feedback from swash plate.

The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke. The MOR should be engaged anticipating a full stroke response from the pump.

An o-ring seal is used to seal the MOR plunger where initial actuation of the function will require a force of 45 N to engage the plunger. Additional actuation typically require less force to engage the MOR plunger.

Proportional control of the pump using the MOR should not be expected.

Warning

Unintended MOR operation will cause the pump to go into stroke; *example:* vehicle lifted off the ground. The vehicle or device must always be in a safe condition when using the MOR function.

Refer to control flow table for the relationship of solenoid to direction of flow.

Control Options

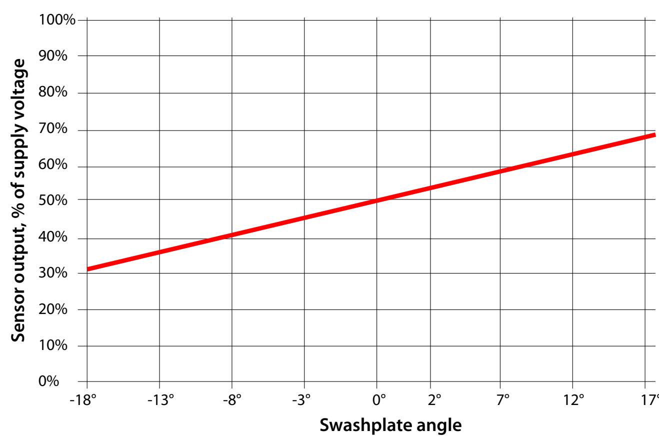
Swashplate angle sensor for EDC controls

The angle sensor detects the swash plate position with an accuracy dependent upon the calibration effort done for the application and direction of rotation from the neutral position. At minimum the sensor can be used for forward, neutral and reverse (FNR) detection.

The sensor works on the hall-effect technology. The implemented technology is based on a measurement of the magnetic field direction in parallel to the chip surface. This field direction is converted to a voltage signal at the output.

Enhanced calibration of the non-linear behavior leads to more exact calculation of the pump swashplate angle. The 4-pin DEUTSCH connector is part of the sensor housing. The swashplate angle sensor is available for all EDC controls for 12 V and 24 V.

Swashplate angle vs. output of supply voltage



Warning

Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

Contact your Danfoss representative in case the angle sensor will be used for safety functions.

Swash plate angle sensor parameters (EDC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.5 V_{DC}	5 V_{DC}	5.5 V_{DC}
Supply protection	–	–	18 V_{DC}
Pump neutral output (% of supply voltage)	–	50%	–
Working range (swash plate angle)	–18°	–	18°
Required supply current	–	–	30 mA
Output current signal	–	9 mA	11 mA
Working temperature	–40 °C	80 °C	115 °C

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector
EMC Immunity	ISO 11452-2	100 V/m

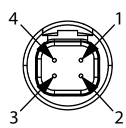
Control Options

Calibration of the sensor output within the software is mandatory. Vehicle neutral thresholds in the software (±0.5°) are vehicle dependent and must consider different conditions, example: system temperature, system pressure and/or shaft speed.

For safety function: If the sensor fails (invalid signal <10% or >90% of supply voltage), it must be sure that the ECU will go into a diagnostic mode and shift into limited mode in order for the driver to take the full control or the mechanical breaks should be activated. Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

H1P Swash Plate Angle Sensor Connector

Connector DEUTSCH, 4-pin

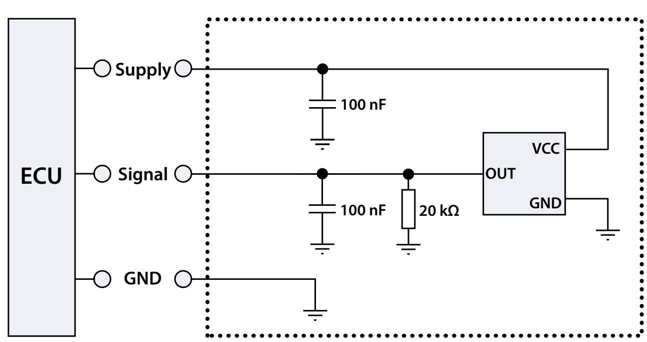


1	Ground (GND)
2	Not connected
3	Output signal 1 (SIG 1)
4	Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Interface with ECU (EDC)

Interface with ECU diagram

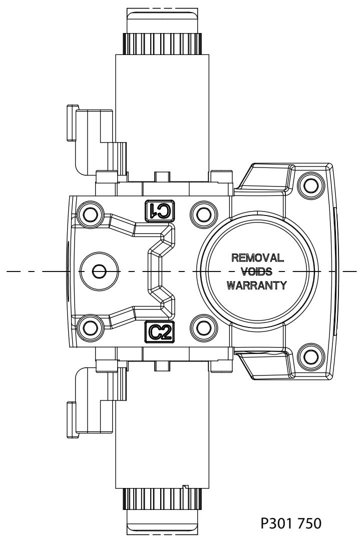


Control Options

Swash Plate Angle Sensor for NFPE and AC2 Controls

The angle sensor detects the swash plate angle position and direction of rotation from the zero position. The swash angle sensor works on the AMR sensing technology. Under the saturated magnetic field, the resistance of the element varies with the magnetic field direction.

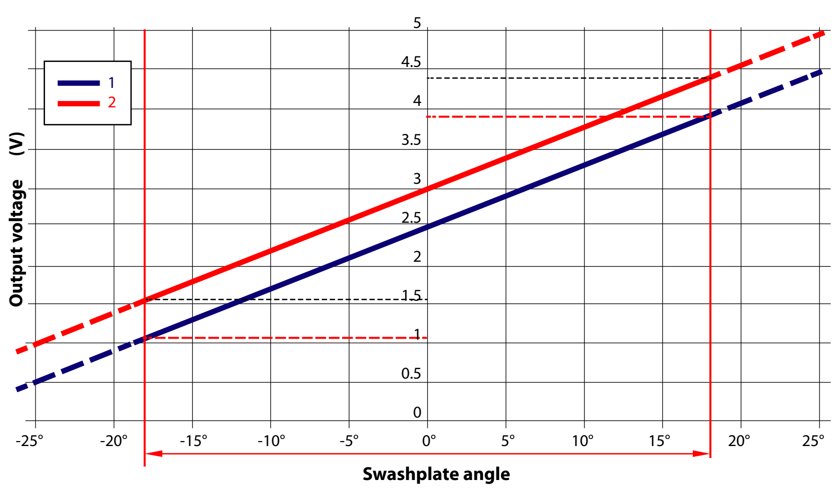
The output signal give a linear output voltage for the various magnet positions in the sensing range.



Swash Plate Angle Characteristic

The volumetric losses depend on pump max. displacement, actual displacement, speed, delta pressure, viscosity and temperature.

Swashplate angle vs. output voltage (calibrated at 50 °C)



1. Signal 1 (nominal)
2. Signal 2 (redundant)

The displacement can be calculated by:

$$V = \frac{\tan\alpha \cdot V}{\tan 18°} \ (cm^3)$$

The corresponding flow is:

$$Q = \frac{V \cdot n \cdot \eta_{vol}}{1000} \ (l/min)$$

Control Options

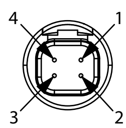
Swash Plate Angle Sensor Parameters (NFPE/AC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.75 V	5 V	5.25 V
Supply protection	–	–	28 V
Supply current	–	22 mA	25 mA
Output current (Signal 1, 2)	–	0.1 mA	–
Short circuit output current to supply or GND[1)]	–	–	7.5 mA
Sensitivity	70.0 mV/deg	78.0 mV/deg	85.8 mV/deg
Working range (swash plate angle)	–18°	0°	18°
Correlation between signals 1 and 2[2)]	475 mV	500 mV	525 mV

[1)] Up to duration of 2.5 seconds at 25°C

[2)] Signal 1 (nominal) is lower than signal 2 (redundant)

H1P Swash Plate Angle Sensor Connector (NFPE)



1 Ground (GND)

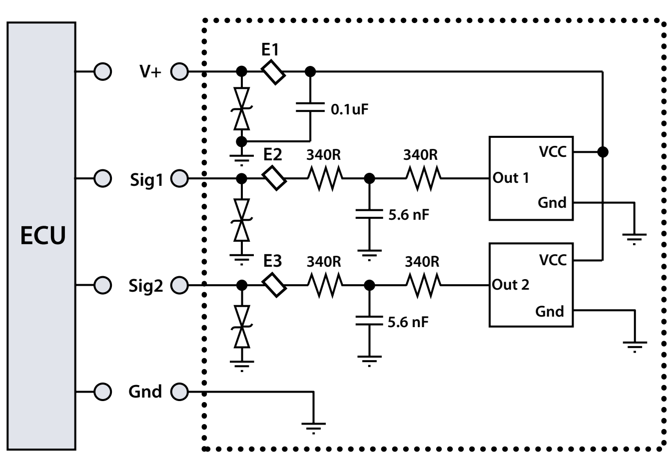
2 Output Signal 2 (SIG 2) – Secondary (redundant)

3 Output signal 1 (SIG 1)

4 Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Interface with ECU (NFPE)



Minimum recommended load resistance is 100 kΩ.

Control Options

Control Cut Off Valve (CCO)

The H1 pump offers an optional control cut off valve integrated into the control. All EDC, NFPE and MDC controls are available with a CCO valve. This valve will block charge pressure to the control, allowing the servo springs to de-stroke both pumps regardless of the pump´s primary control input.

There is also a hydraulic logic port, X7, which can be used to control other machine functions, such as spring applied pressure release brakes. The pressure at X7 is controlled by the control cut off solenoid. The X7 port would remain plugged if not needed.

In the normal (de-energized) state of the solenoid charge flow is prevented from reaching the controls. At the same time the control passages and the X7 logic port are connected and drained to the pump case. The pump will remain in neutral, or return to neutral, independent of the control input signal. Return to neutral time will be dependent on oil viscosity, pump speed, swashplate angle, and system pressure.

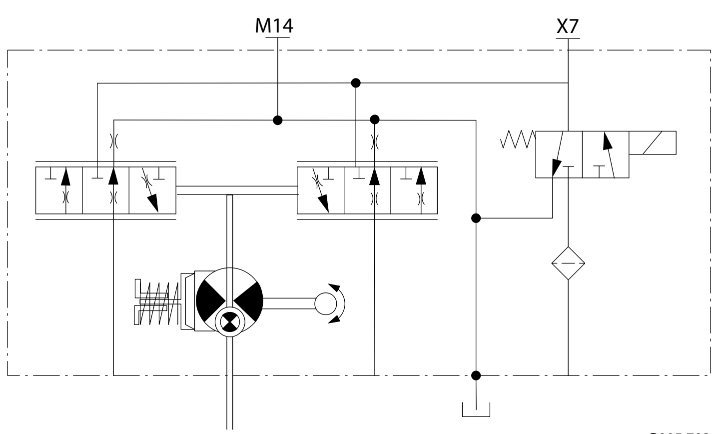
When the solenoid is energized, charge flow and pressure is allowed to reach the pump control. The X7 logic port will also be connected to charge pressure and flow.

The solenoid control is intended to be independent of the primary pump control making the control cut off an override control feature. It is however recommended that the control logic of the CCO valve be maintained such that the primary pump control signal is also disabled whenever the CCO valve is de-energized. Other control logic conditions may also be considered.

The CCO valve is available with 12 V or 24 V solenoid.

The response time of the unit depends on the control type and the used control orifices.

CCO schematic (MDC shown)



Brake gauge port with MDC

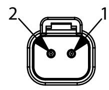
Caution

It is not recommended to use brake port for any external flow consumption to avoid malfunction of CCO function.

Control Options

CCO Connector (MDC)

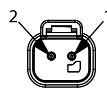
Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

H1P CCO Connector (EDC, NFPE)

Connector CCO DEUTSCH, 2-pin with key C



Description	Quantity	Order number
Mating connector	1	DEUTSCH DT06-2S-C015
Wedge lock	1	DEUTSCH W2SC-P012
Socket contact	4	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	11212714

CCO solenoid data

Nominal supply voltage		12 V	24 V
Supply voltage	**Maximum**	14.6 V	29 V
	Minimum	9.5 V	19 V
Bi-directional diode cut off voltage		28 V	53 V
Nominal coil resistance at 20 °C		10.7 Ω	41.7 Ω
Supply current	**Maximum**	850 mA	430 mA
	Minimum	580 mA	300 mA
PWM frequency	**Range**	50 – 200 Hz	
	Preferred	100 Hz	
Electrical protection class		IP67 / IP69K with mating connector	

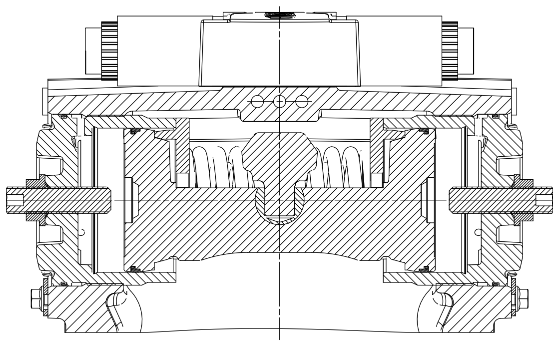
CCO solenoids are design for battery voltage application within the voltage range in the table above, in consideration of a wide range of environmental temperature common for known hydraulic applications. Closed loop PWM current supply can be also applied and is helpful in case that the voltage range is exceeded, or ambient temperature could rise in an unusual manner.

Control Options

Displacement Limiter

H1 pumps are designed with optional mechanical displacement (stroke) limiters factory set to max. displacement. The maximum displacement of the pump can be set independently for forward and reverse using the two adjustment screws to mechanically limit the travel of the servo piston down to 50% displacement.

Adjustments under operating conditions may cause leakage. The adjustment screw can be completely removed from the threaded bore if backed out to far.



P003 266

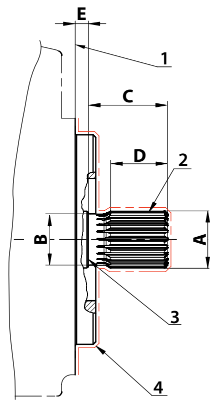
H1P 147/165 Displacement Change (approximately)

Parameter	Size 147	Size 165
1 turn of displacement limiter screw	12.4 cm^3 [0.76 in^3]	13.9 cm^3 [0.85 in^3]
Internal wrench size	6 mm	
External wrench size	22 mm	
Torque for external hex seal lock nut	80 N•m [708 lbf•in]	

For more information, see *H1 Axial Piston Pumps, Service Manual,* **AX152886482551**, the section “Displacement Limiter Adjustment”.

Dimensions and Data

H1P Input Shaft Option G2 (SAE D, 27 teeth)



1. Mounting flange 152–4 per ISO 3019-1; surface to be paint free
2. **Spline Data:** 27 teeth, Pressure angle: 30°, Pitch: 16/32, Ø42.863 [1.688]; Fillet root side fit per ANSI B92.1-1996, Class 5
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø44.36 ±0.09 [1.746 ±0.004]	Ø39.5 ±0.25 [1.555 ±0.01]	67.0 [2.638]	42.0 [1.654]	8.05 [0.317]

1) Minimum active spline length for the specified torque ratings.

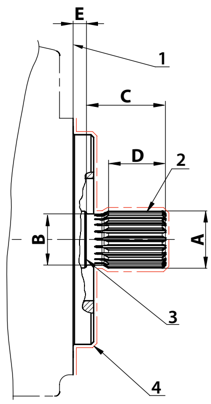
Torque rating

Rated torque	Maximum torque
1615 N•m [14 300 lbf•in]	3000 N•m [26 550 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P Input Shaft Option G3 (SAE D, 13 teeth)



1. Mounting flange 152–4 per ISO 3019-1; surface to be paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 8/16, Ø41.275 [1.625]; Fillet root side fit per ANSI B92.1-1996, Class 5
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø44.4 ±0.09 [1.746 ±0.004]	Ø36.4 ±0.25 [1.433 ±0.01]	67.0 [2.638]	39.5 [1.555]	8.0 [0.316]

[1)] Minimum active spline length for the specified torque ratings.

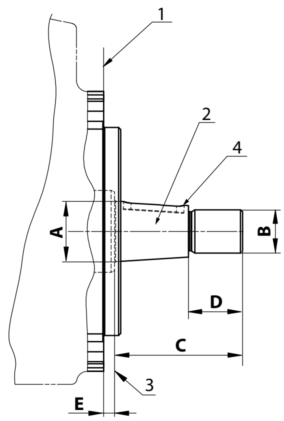
Torque rating

Rated torque	Maximum torque
1442 N•m [12 800 lbf•in]	2206 N•m [19 500 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P 147/165 Input Shaft Option F3, Code 44–3



1. Mounting flange 152–4 per ISO 3019-1; surface to be paint free
2. **Tapered shaft:** Conical keyed shaft end, code 44–3 (similar to ISO 3019-1 code 38–3) without key, no through-hole in the end of the shaft. Suitable key: 7/16 x 7/16 x 1¾ per ANSI B17.1; surface to be paint free
3. Coupling must not protrude beyond this point
4. **Cone:** 125 ±0.5:1000

Dimensions

A	B	C	D	E
Ø44.45 ±0.09 [1.746 ±0.004]	1¼–12	93.7 ±1 [3.689 ±0.039]	39.7 ±1 [1.563 ±0.039]	8.0 [0.316]

Torque rating

Rated torque[1)]	Maximum torque[2)]
1766 N•m [15 630 lbf•in]	2354 N•m [20 830 lbf•in]

[1)] Rated torque includes just the capability of the press-fit in accordance with an assumed fastener grade 5.

[2)] Mating part must maintain a minimum gap width of 1.0 mm with the shaft shoulder after installation of the part. Transmittable torque will be reduced if the minimum gap requirement is not met.

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Tapered shaft customer acknowledgement

The Danfoss H1 tapered shaft has been designed using the industry standard ISO 3019-1, minus the through-hole in the end of the shaft. Danfoss guarantees the design and manufactured quality of the tapered shaft.

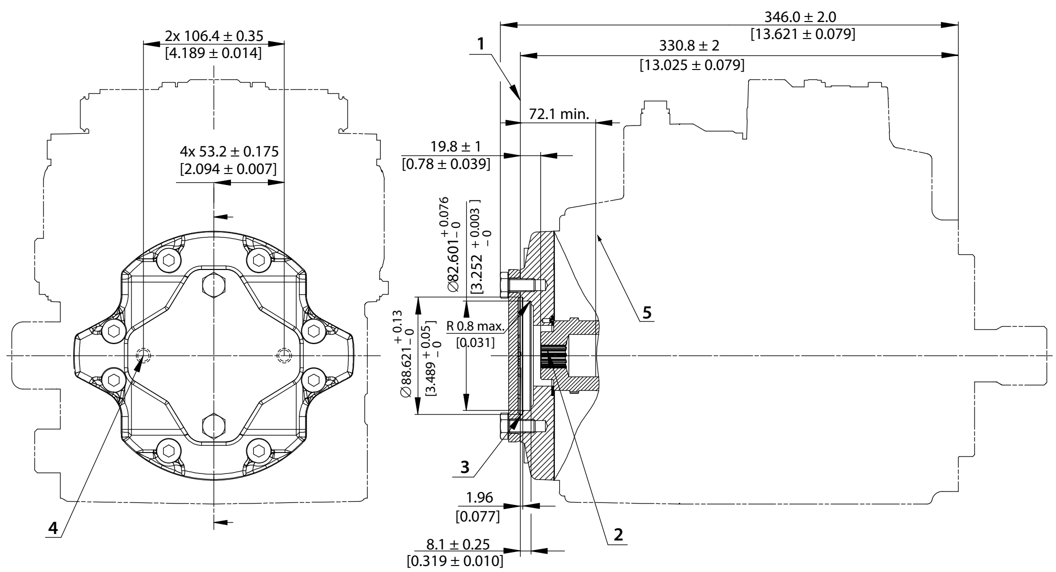
Danfoss recommends a self-locking nut instead of a castle nut and pin. The nut and mating square-cut key are customer supplied. The specified torque rating of the tapered shaft is based on the cross-sectional diameter of the shaft, through the keyway, and assumes the proper clamp and fit between shaft and coupling. The customer is responsible for the design and manufactured quality of the mating female coupling and key and applied torque on the nut. Danfoss has made provisions for the key in accordance to the ISO specification with the understanding that the key is solely to assist in the installation of the mating coupling.

Caution

Possible hazard because torque or loading inadvertently transmitted by the customer supplied key may lead to premature shaft failure. Torque must be transmitted by the taper fit between the shaft and it’s mating coupling, not the key.

Dimensions and Data

H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth)



1. Auxiliary mounting pad for mating flange 82-2 per ISO 3019-1 (SAE A); Paint free
2. **Spline Data:** 11 teeth, Pressure angle: 30°, Pitch: 16/32, Ø17.463 [0.6875]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 10.5 mm
3. O-ring seal required; Ref. Ø82.22 [3.237] ID x 2.62, cross section
4. Thread: M10x1.5-6H; 16 [0.63] min. depth; Recommended screw-in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	296 N•m [2620 lbf•in]

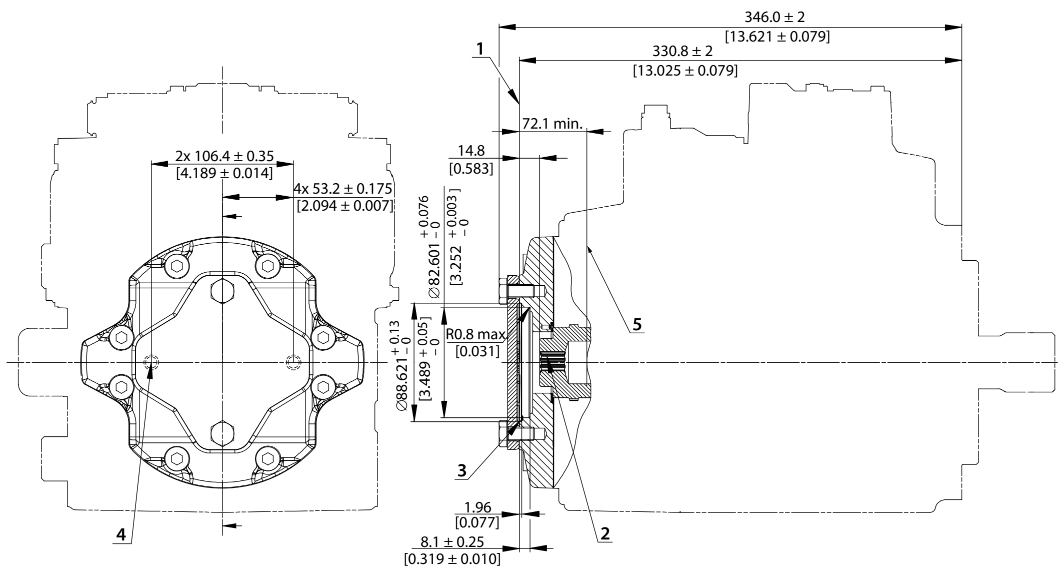
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth)



1. Auxiliary mounting pad for mating flange 82-2 per ISO 3019-1 (SAE A); Paint free
2. **Spline Data:** 9 teeth, Pressure angle: 30°, Pitch: 16/32, Ø14.288 [0.5625]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 8.6 mm
3. O-ring seal required; Ref. Ø82.22 [3.237] ID x 2.62, cross section
4. Thread: M10x1.5-6H; 15 [0.59] min. depth; Recommended screw-in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	162 N•m [1430 lbf•in]

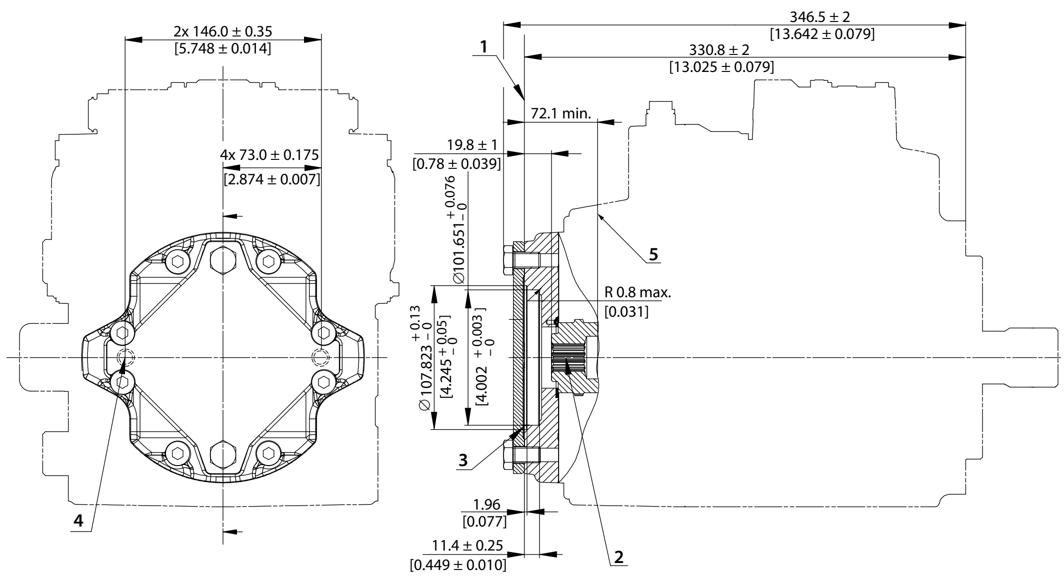
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 16/32, Ø20.638 [0.813]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 12.4 mm
3. O-ring seal required; Ref. Ø94.92 [3.737] ID x 2.62, cross section
4. Thread: M12x1.75-6H; 25 [0.787] min. depth; Recommended screw-in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Bolt length > 19.75 mm could result in a leak or damage to the unit.

Maximum Torque	395 N•m [3500 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

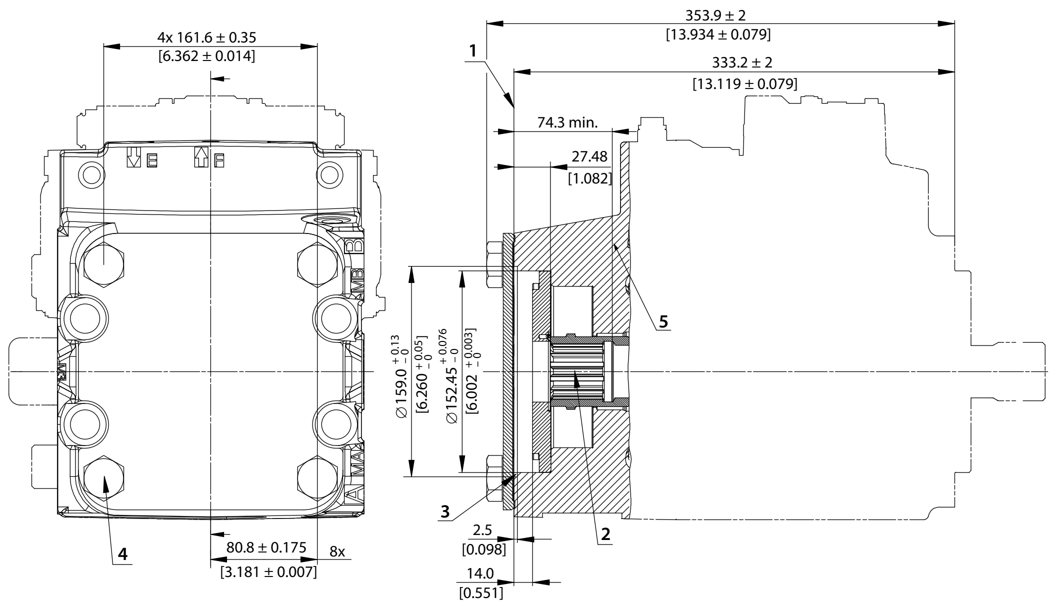
Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H4 (SAE D, 13 teeth)

Option H4, ISO 3019-1, flange 152-4 (SAE D, 13 teeth)



1. Auxiliary mounting pad for mating flange 152-4 per ISO 3019-1 (SAE D); Paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 8/16, Ø41.275; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 12.4 mm
3. O-ring seal required; Ref. Ø150 ID x 3, cross section
4. Thread: M20x2.5-6H; 30 [1.181] min. depth; Recommended screw-in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	2206 N•m [19 525 lbf•in]

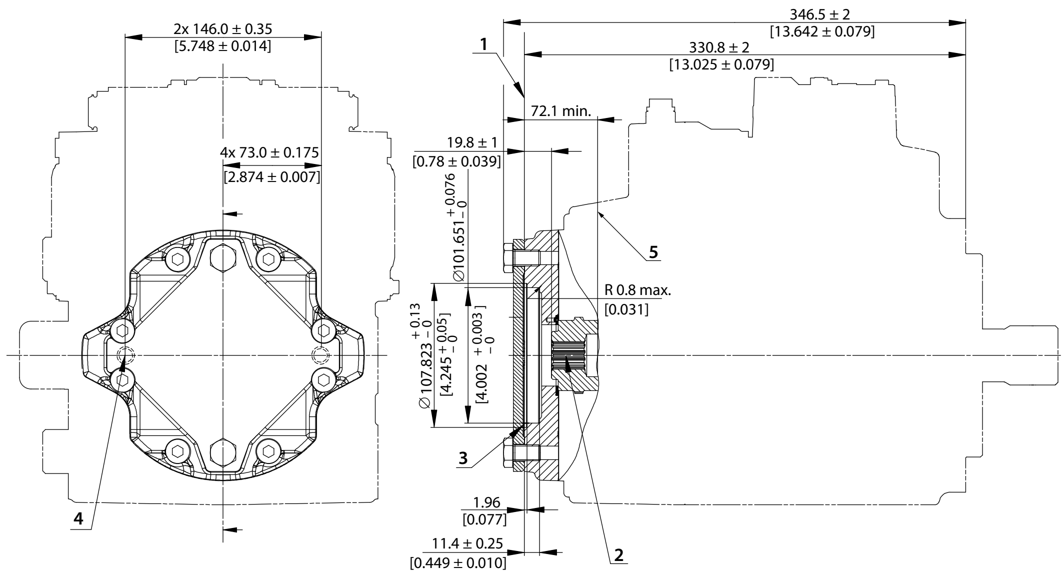
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 15 teeth, Pressure angle: 30°, Pitch: 16/32, Ø23.813 [0.938]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 14.3 mm
3. O-ring seal required; Ref. Ø94.92 [3.737] ID x 2.62, cross section
4. Thread: M12x1.75-6H; 25 [0.787] min. depth; Recommended screw-in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	693 N•m [6130 lbf•in]

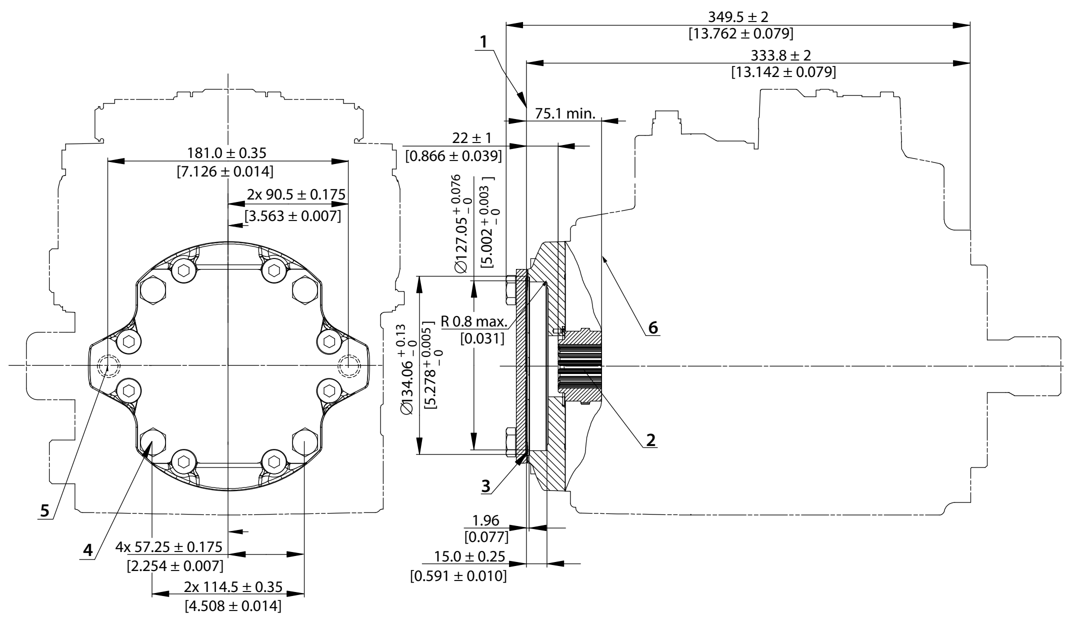
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth)



1. Auxiliary mounting pad for mating flange 127-4 per ISO 3019-1 (SAE C); Paint free
2. **Spline Data:** 14 teeth, Pressure angle: 30°, Pitch: 12/24, Ø29.633 [1.667]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 17.8 mm
3. O-ring seal required; Ref. Ø120.32 ID x 2.62, cross section
4. Thread: M12x1.75-6H; 21 [0.827] min. depth; Recommended screw-in depth 1.5 x thread dia (4x)
5. Thread: M16x2-6H; 25 [0.984] min. depth; Recommended screw-in depth 1.5 x thread dia (2x)
6. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum torque	816 N•m [7220 lbf•in]

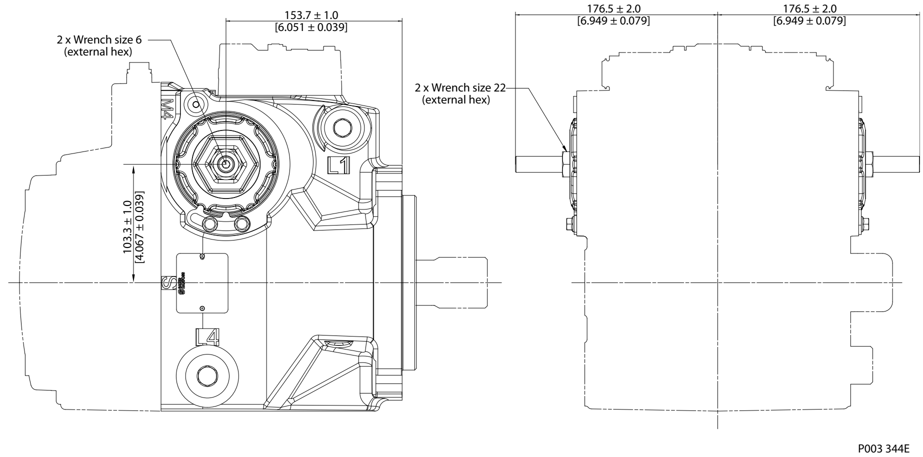
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Displacement Limiter, Option B



1. Displacement limiter screw (2x)
2. Displacement limiter seal nut (2x)

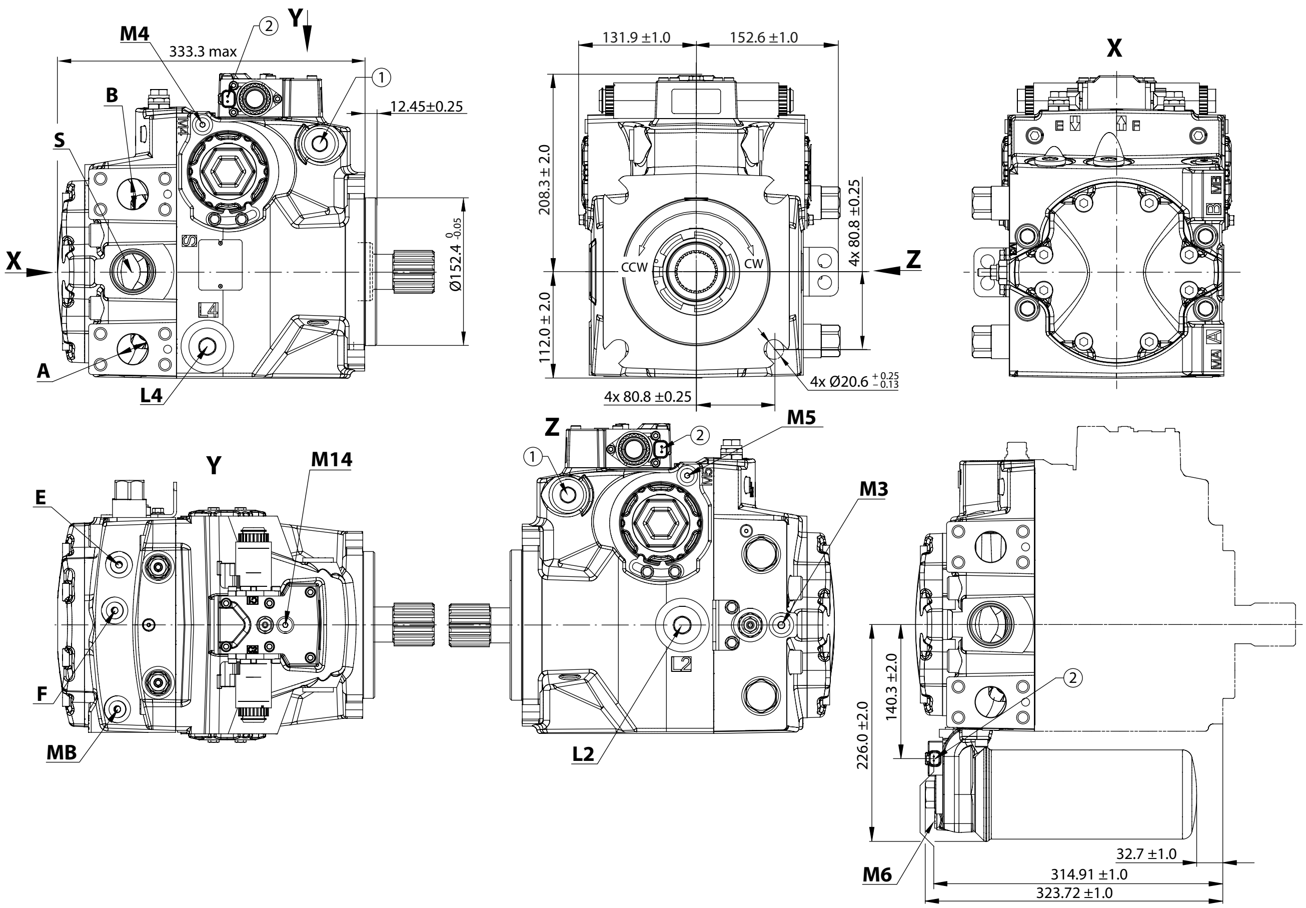
Wrench size, torque

Wrench size for DL screw	Wrench size for DL seal nut	Torque
6 internal hex	22 external hex	80 N•m [708 lbf•in]

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Single Pump Ports



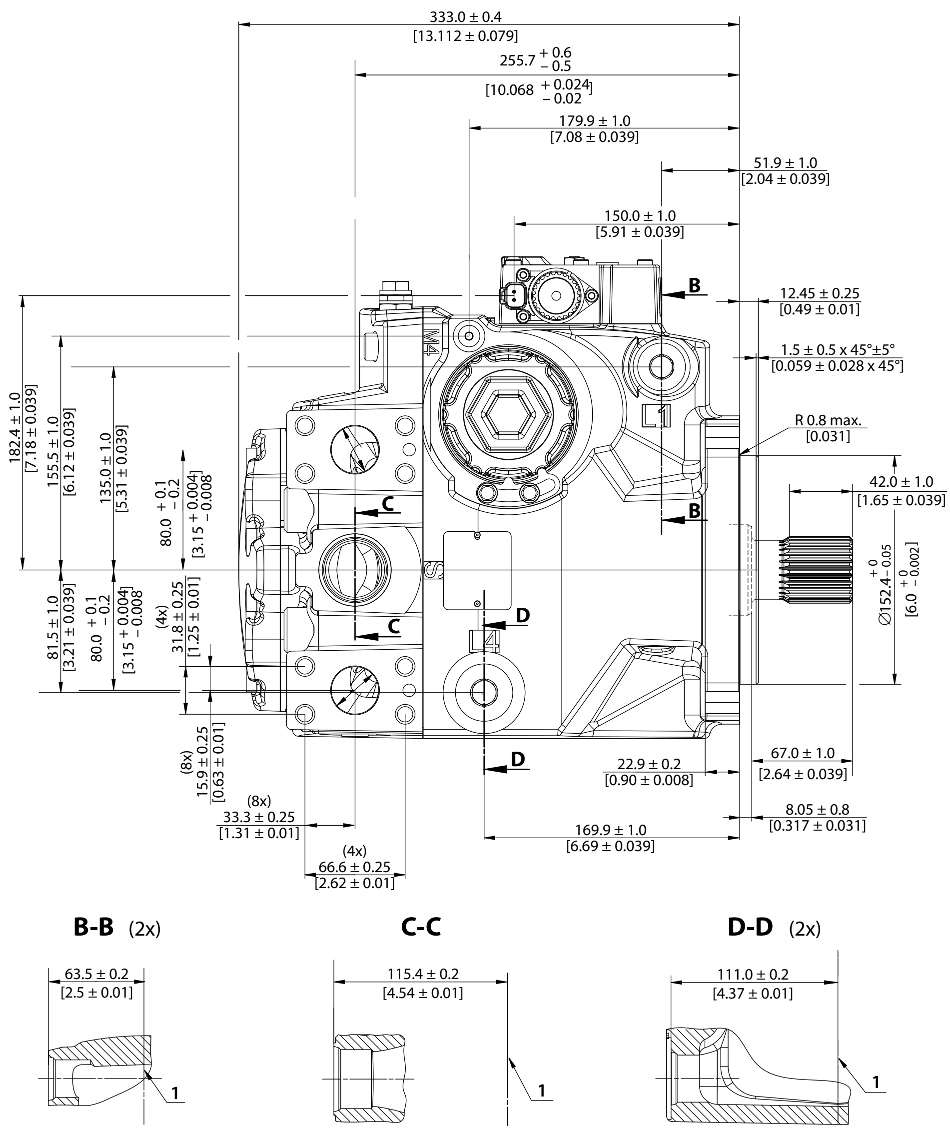
Ports per ISO 11 926-1

Port	Description	Size
A, B	System ports	Ø31.5 mm; M12 x 1.75; 20 min. full thread depth Recommended screw in depth 1.5 x thread dia
L2, L4	Case drain ports	$1\frac{5}{16}$–12
MA, MB	System **A/B** gauge ports	$\frac{9}{16}$–18
E/F	Charge filtration ports	$1\frac{1}{16}$–12
M3	Charge pressure gauge port	$\frac{9}{16}$–18
M4, M5	Servo gauge port	$\frac{7}{16}$–20
M14	Case gauge port (EDC, FNR, NFPE)	$\frac{7}{16}$–20
S	Charge inlet port	$1\frac{5}{8}$–12 Recommended screw in depth 1.5 x thread dia
1	Case pressure port	$1\frac{1}{16}$–12
2	Connector DEUTSCH DT04-2P; Paint free	

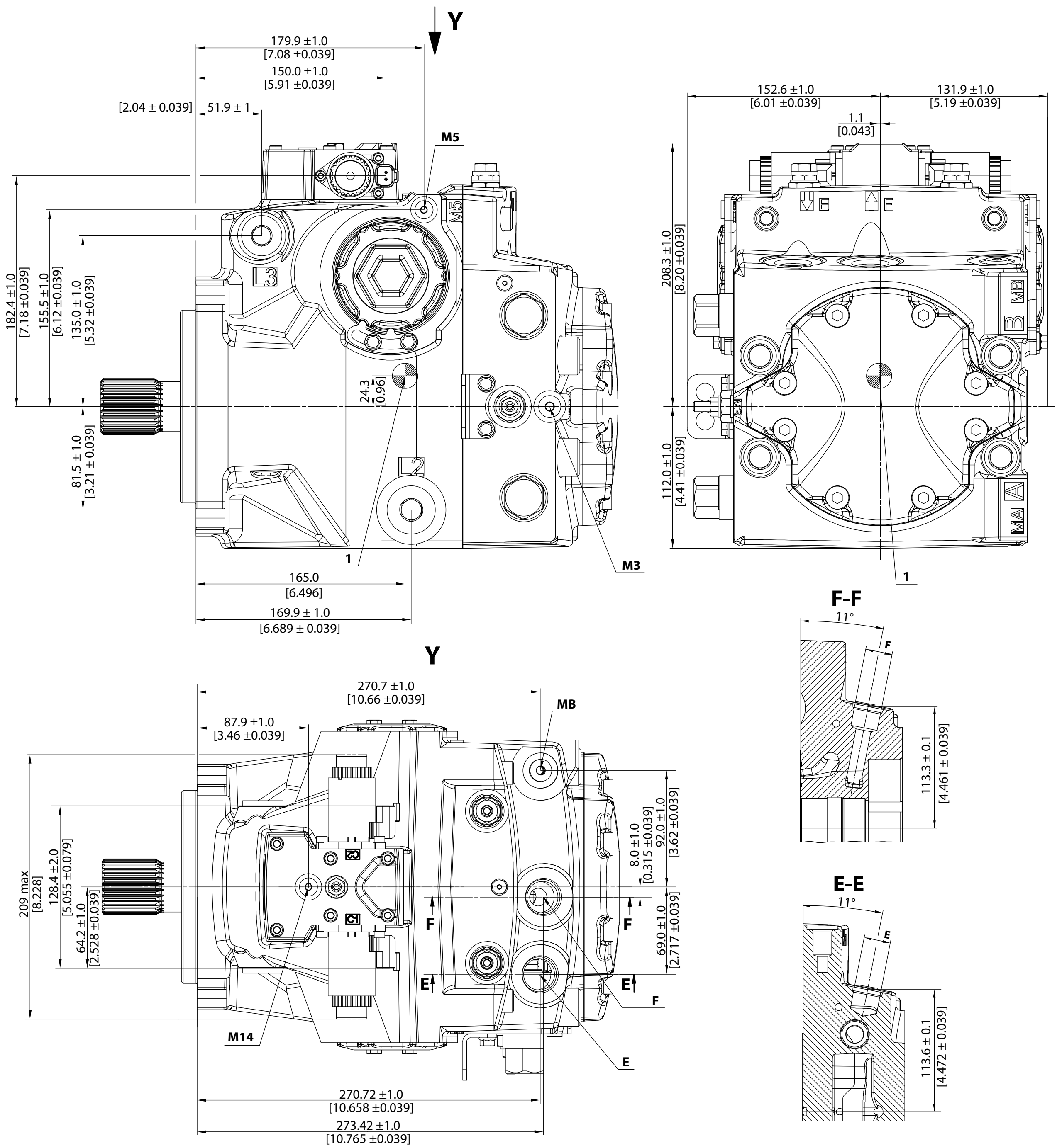
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

H1P Dimensions

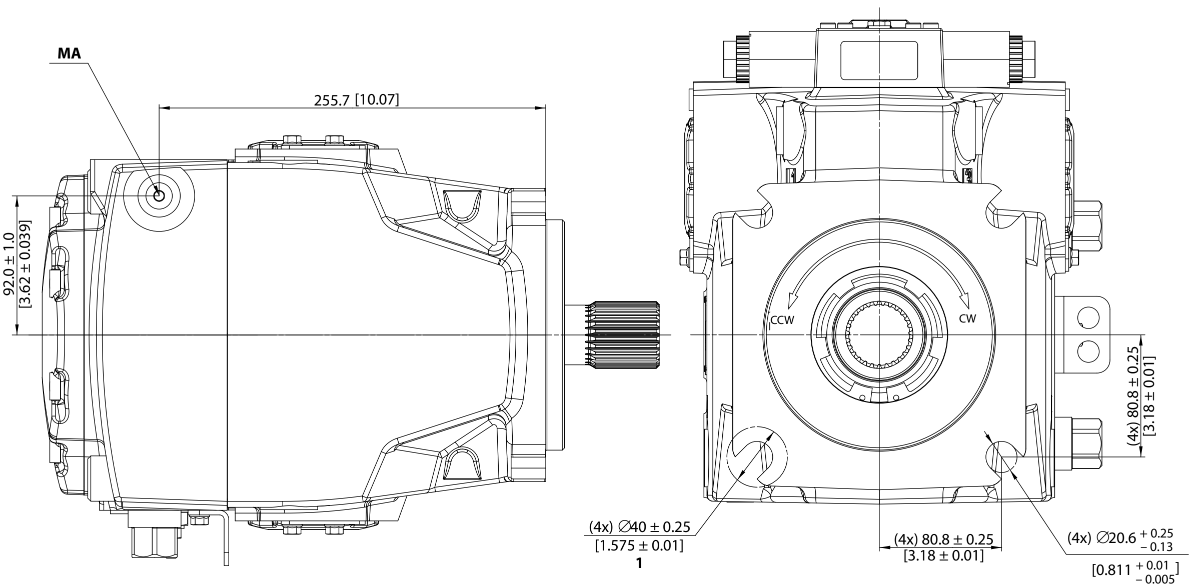


Dimensions and Data



1 — Approximate center of gravity

Dimensions and Data

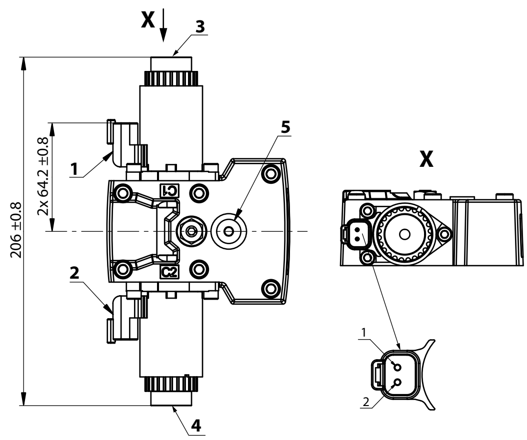


1 — Other side screw head space

Dimensions and Data

Controls

EDC Options A2 and A3 (12/24 V)



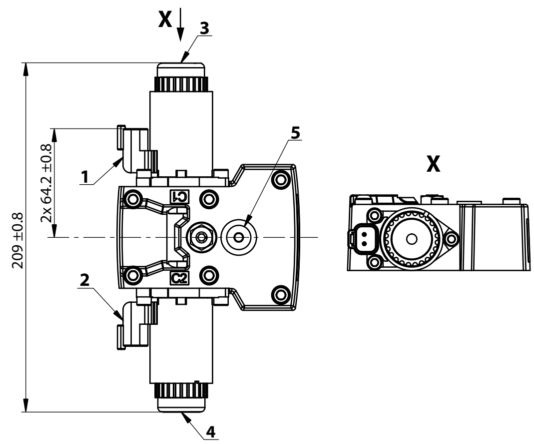
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^7/_{16}$–20

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

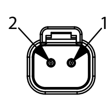
EDC with MOR, Options A4 and A5 (12/24 V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

*Connector **C1/C2**: DEUTSCH DTM04-2P*

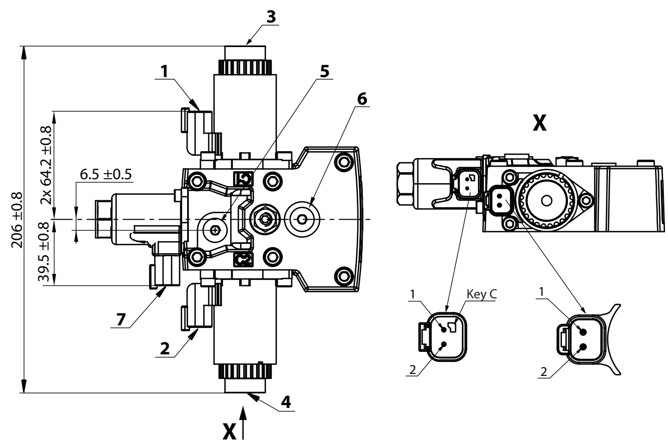


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

EDC with CCO (key C), Options E7 and E8 (12/24 V)



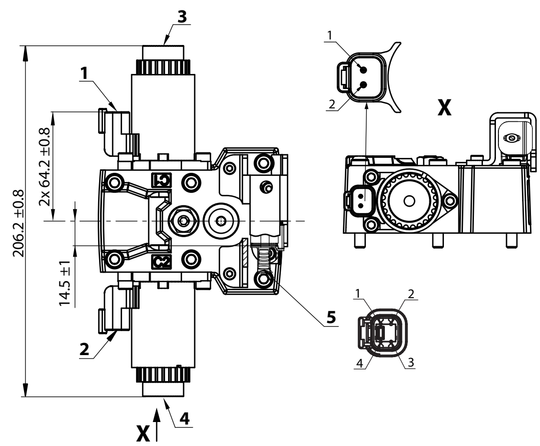
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
6. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

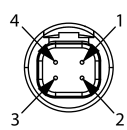
Dimensions and Data

EDC with ASNSR, Options: H2 and H3 (12/24 V)



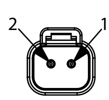
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Angle sensor connector **S2** DEUTSCH DT04-4P, paint free

Connector DEUTSCH, 4-pin



4-pin assignment:
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connector C1/C2: DEUTSCH DTM04-2P

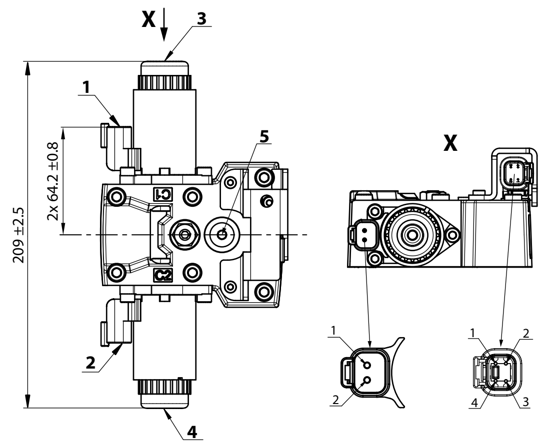


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

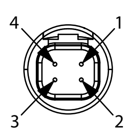
Dimensions and Data

EDC with MOR and ASNSR, Options H6 and H7 (12/24 V)



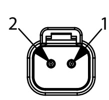
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Connector DEUTSCH, 4-pin



4-pin assignment:
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connector C1/C2: DEUTSCH DTM04-2P

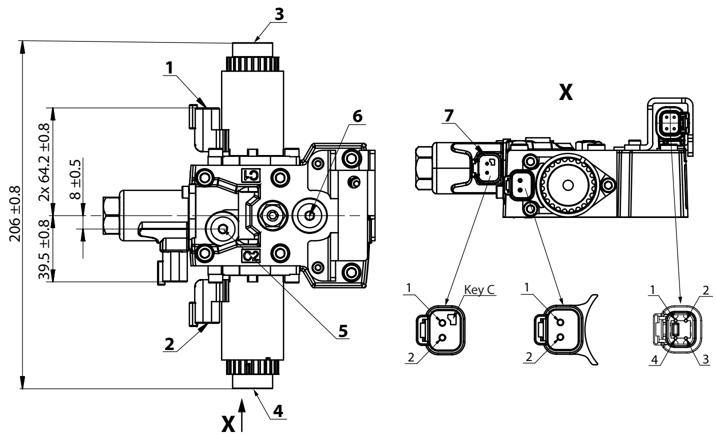


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

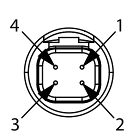
EDC with CCO and ASNSR, Options H8 and H9 (12/24 V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
6. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

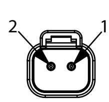
Connector DEUTSCH, 4-pin



Angle sensor connector S2: DEUTSCH DTM04-4P

1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connectors C1/C2/C4: DEUTSCH DTM04-2P

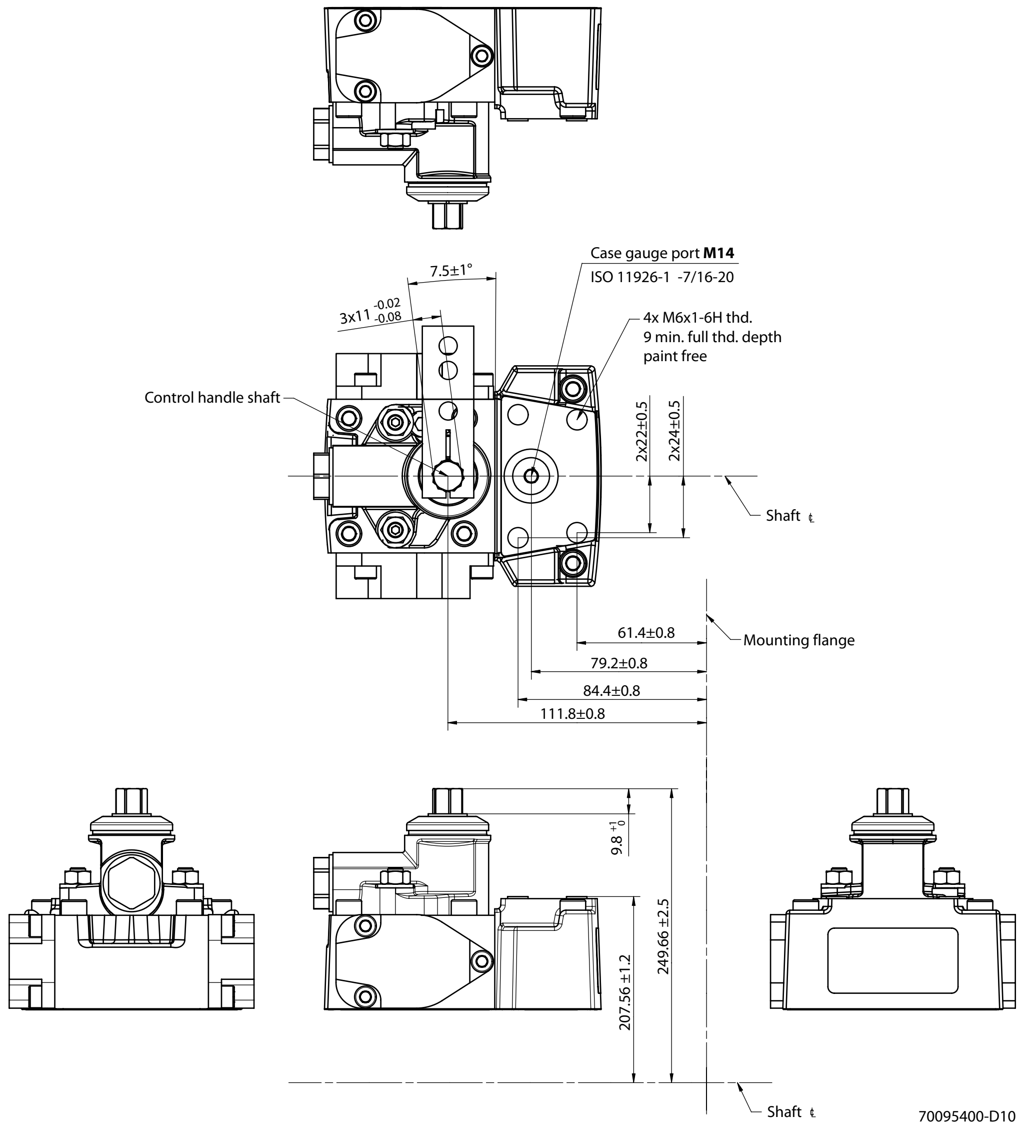


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

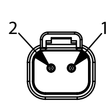
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC Option: M1



Connector DEUTSCH, 2-pin

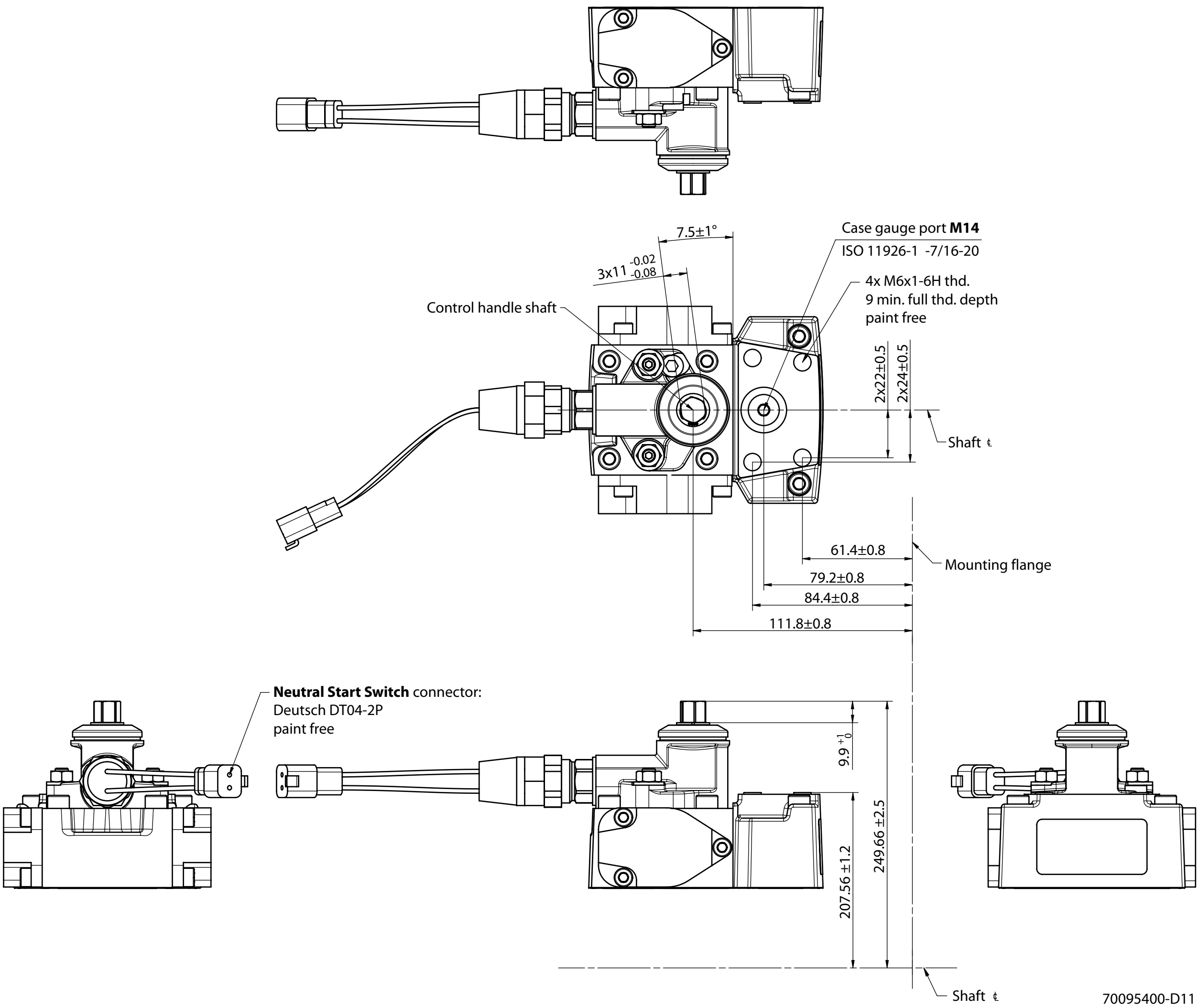


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

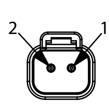
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with Neutral Start Switch Option: M2



Connector DEUTSCH, 2-pin

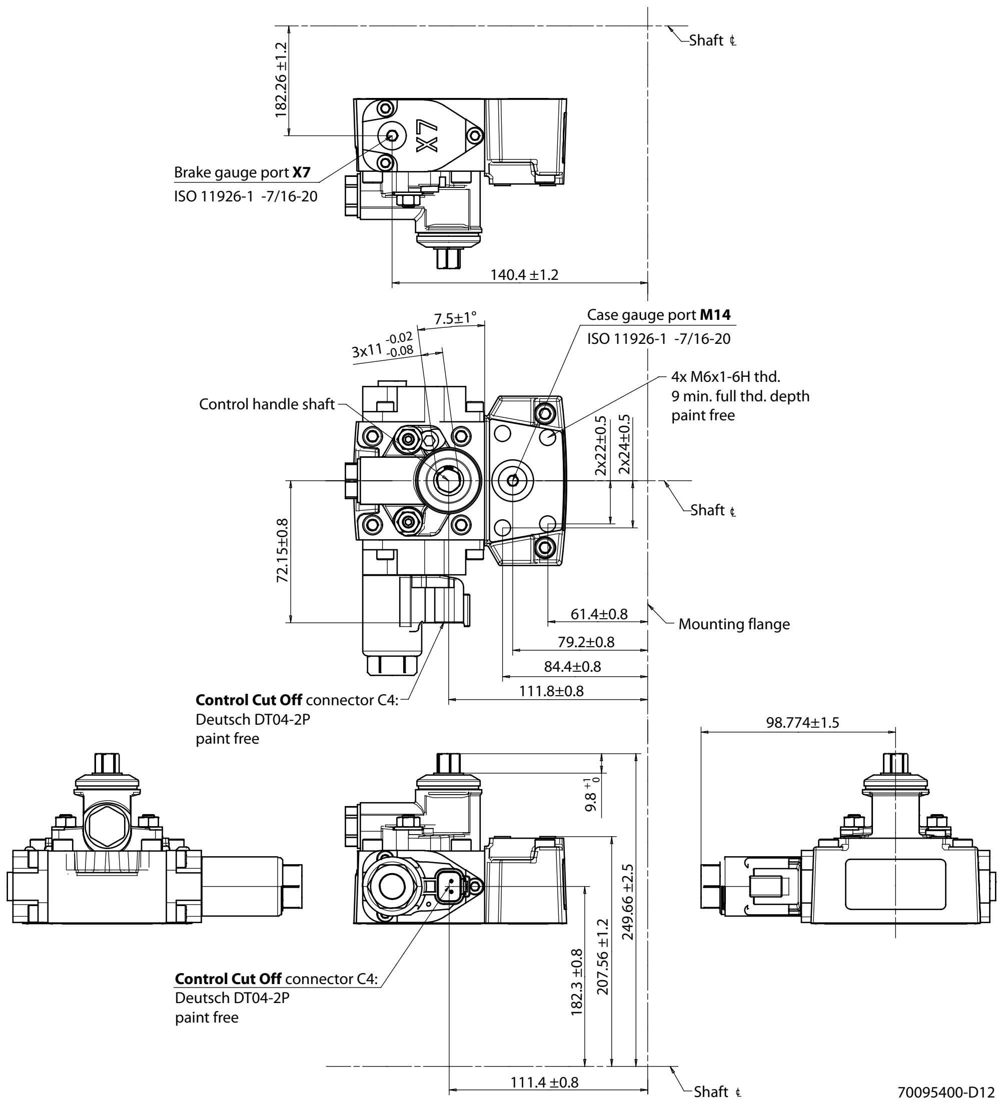


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

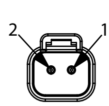
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with CCO, Options: M3, M4



Connector DEUTSCH, 2-pin

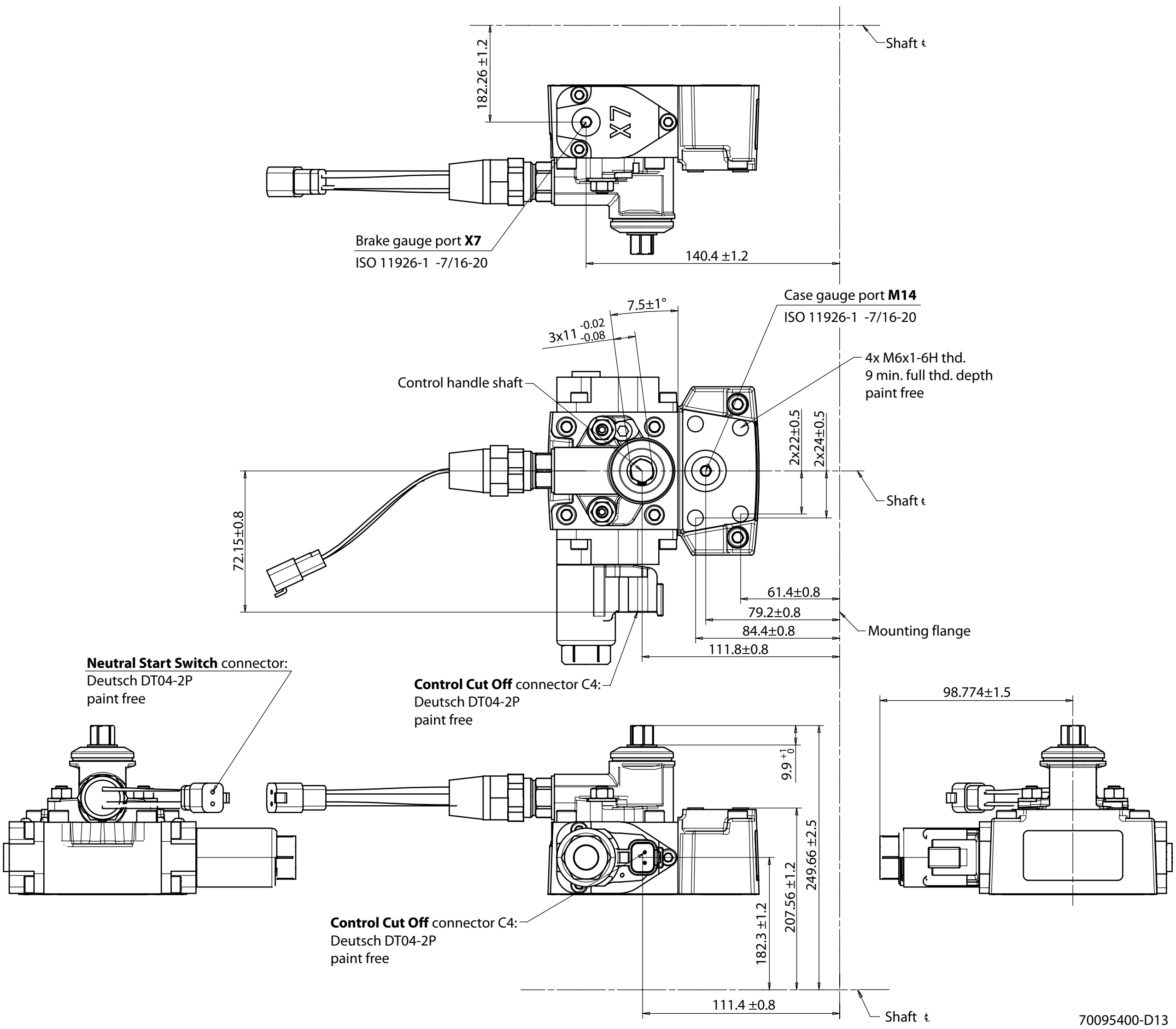


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

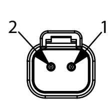
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with NSS and CCO Options: M5, M6



Connector DEUTSCH, 2-pin



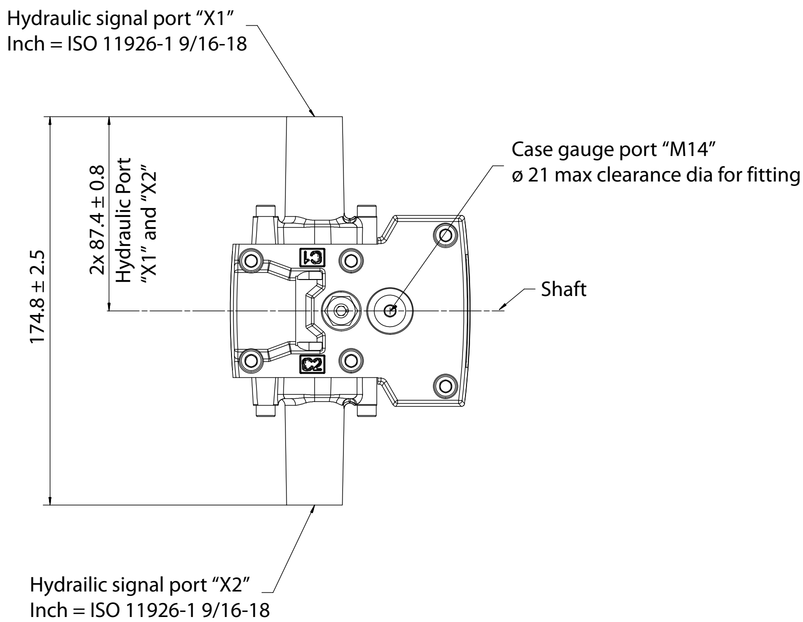
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

H1P HDC, Options: T1, T2

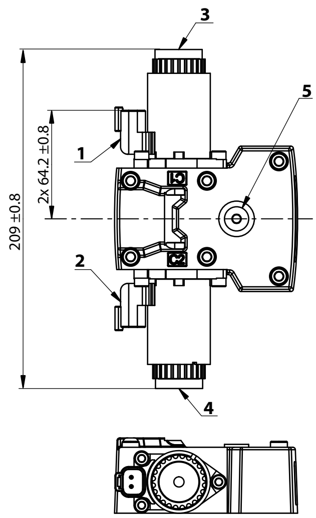
Dimensions in mm



Dimensions and Data

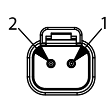
NFPE with MOR, Options: N1, N2 (12/24 V)

Non-Feedback Proportional Electric control with Manual Over Ride options N1 (12 V) and N2 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

*Control solenoid connectors **C1/C2** DEUTSCH DTM04-2P pin/assignment*



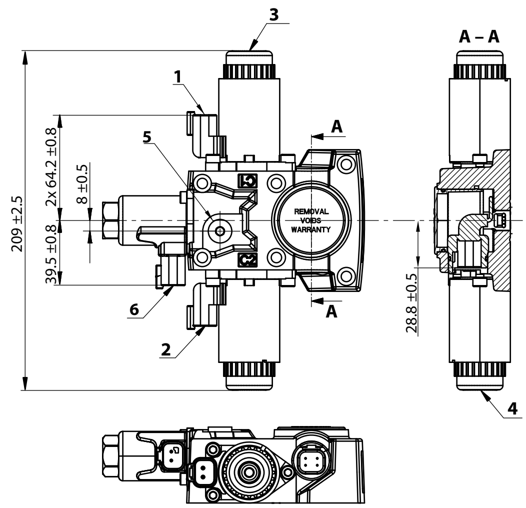
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V)

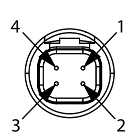
Non-Feedback Proportional Electric control with Control-Cut-Off valve with key C, Manual Over Ride and Angle Sensor, options N3 (12 V) and N4 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
6. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

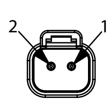
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Control solenoid connectors **C1/C2/C4** DEUTSCH DTM04-2P pin/assignment*



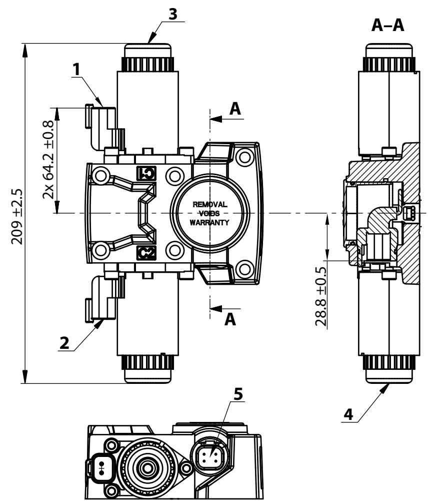
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

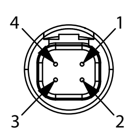
NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V)

Non-Feedback Proportional Electric control with Manual Over Ride and Angle Sensor, options N5 (12 V) and N6 (24 V).



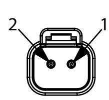
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Angle sensor connector **S2** DEUTSCH DT04-4P, paint free

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

Control solenoid connectors C1/C2 DEUTSCH 2-pin/assignment



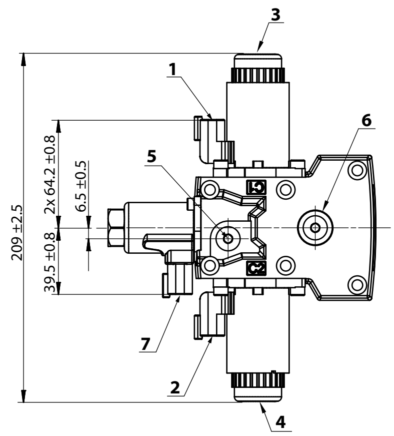
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

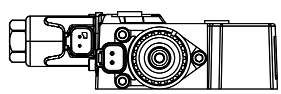
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

NFPE with MOR and CCO, Options: N7, N8 (12/24 V)

Non Feedback Proportional Electric control with Manual Over Ride and Control-Cut-Off valve key C, options N7 (12 V) and N8 (24 V).

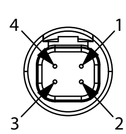




1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Brake gauge port **X7** per ISO 1926-1: $^7/_{16}$–20
6. Case gauge port **M14** per ISO 1926-1: $^7/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

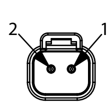
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Control solenoid connectors **C1/C2** DEUTSCH DTM04-2P pin assignment*

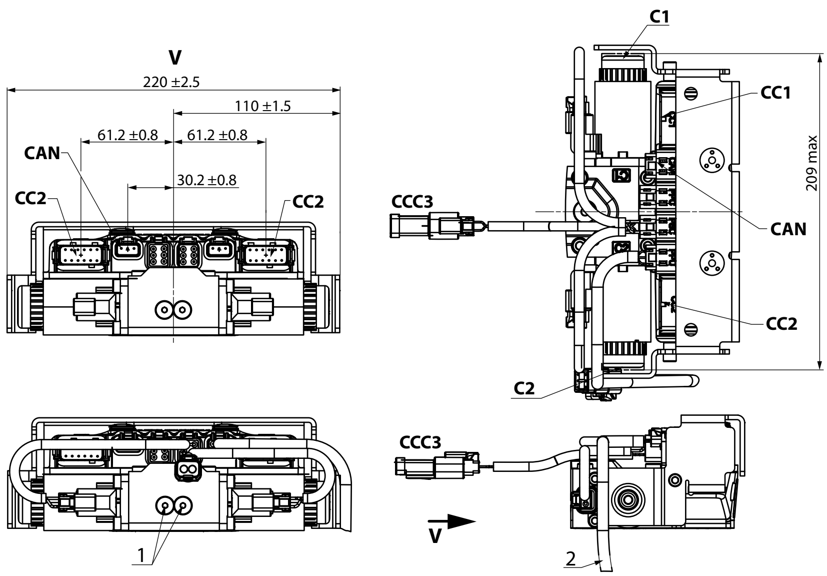


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Automotive control (AC)



1 Plug removing can cause contamination issues

2 PPU wire harness is factory installed to speed sensor

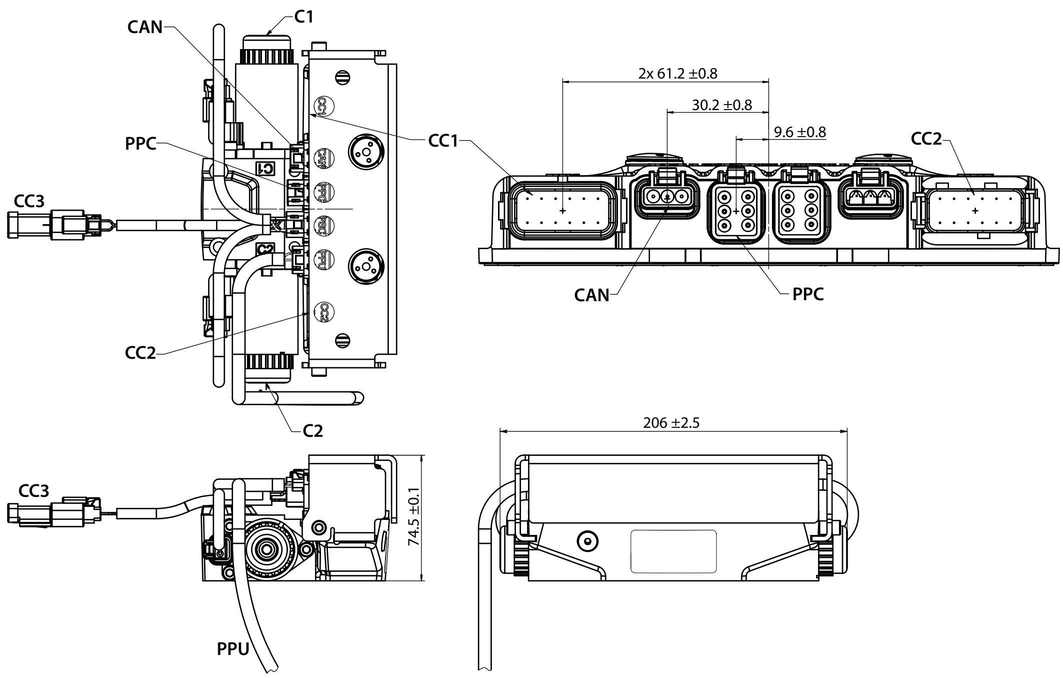
Connectors description

Port	Description
C1 and C2	**1.** Control manual override **C1** **2.** Control Manual Override **C2**
CC1	Port A control connector DEUTSCH DTM04-12P; paint free
CC2	Port B control connector DEUTSCH DTM04-12P; paint free
CC3	Control connector DEUTSCH DT06-2S; paint free; For using connector, the plug may be removed.
CAN	Control connector DEUTSCH DTM04-3P; paint free; For using connector, the plug may be removed.

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

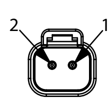
AC connectors dimensions



PPU wire harness is factory installed to speed sensor.

CC3

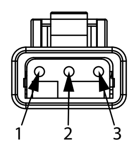
Connector DEUTSCH, 2-pin



1. Digital output A1 (+)
2. Digital output A2 (-)

CAN

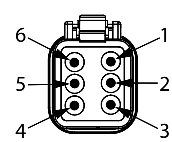
Connector DEUTSCH, 3-pin



1. CAN High
2. CAN Low
3. CAN Shield

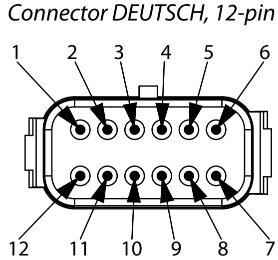
PPC

Connector DEUTSCH, 6-pin



1. Sensor A (+)
2. Analog input A
3. Sensor A (-)
4. Sensor B (-)
5. Analog input B
6. Sensor B (+)

Connector DEUTSCH, 12-pin



CC1

1. Battery (-)
2. Battery (+)
3. Sensor (+)
4. Sensor (-)
5. Motor rpm input (frequency)
6. Forward input (digital)
7. Reverse input (digital)
8. Sensor (+)
9. Sensor (-)
10. Drive pedal input (analog – nominal)
11. Drive pedal input (analog – red)
12. Neural input (digital)

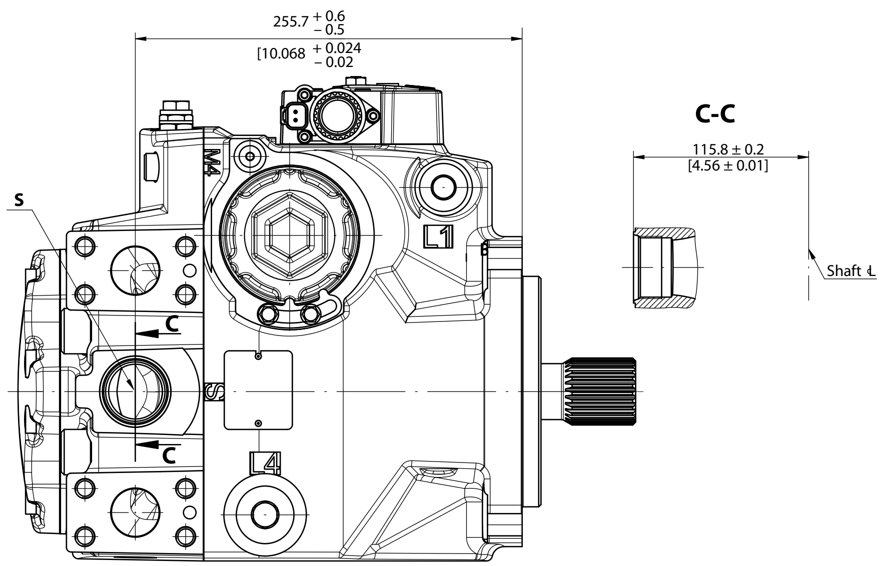
CC2

1. Inch input (analog – red)
2. Mode switch B input (digital – nominal)
3. Motor prop/PCOR driver
4. Motor direction input (analog)
5. Sensor (+)
6. Sensor (-)
7. Inch input (analog – nominal)
8. Motor BPD driver
9. Digital output B2 (-)
10. Digital output B1 (+)
11. Mode switch A input (digital)
12. Mode switch B input (digital – red)

Dimensions and Data

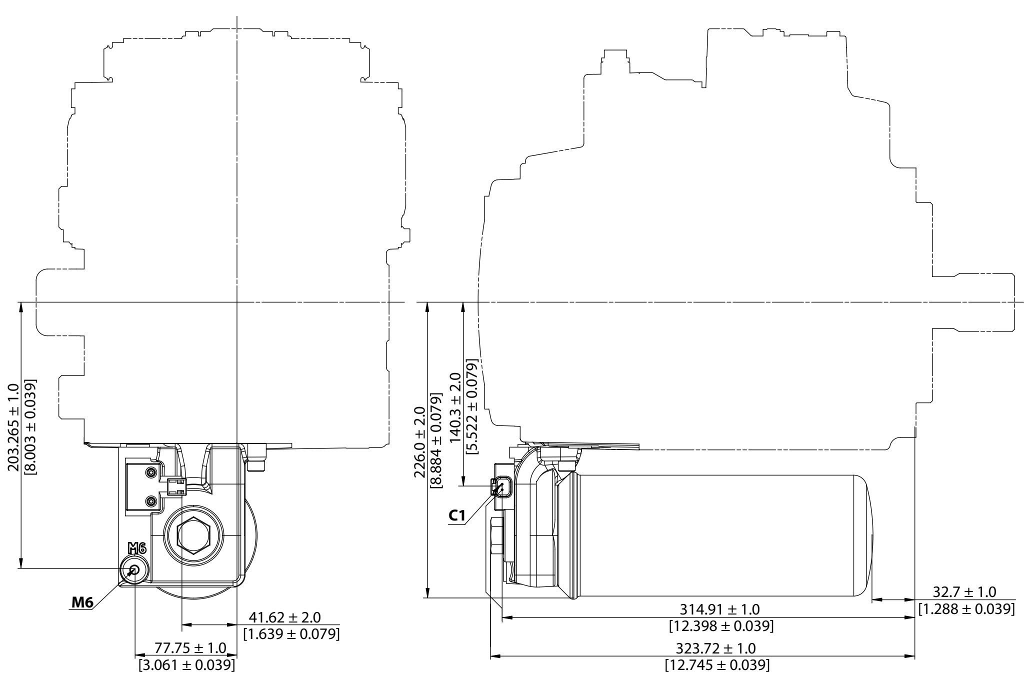
Filtration

H1P 147/165 Suction Filtration Option L



S Charge pump inlet per ISO 11926-1; 1 5/8-12

Integral Full Flow Charge Pressure Filtration, Option M



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ENGINEERING TOMORROW

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ENGINEERING TOMORROW

Technical Information

H1P 210/250/280
Axial Piston Single Pumps

Revision history

Table of revisions

Date	Changed	Rev
May 2022	Corrected HDC control information	1101
December 2021	Added HDC control	1001
June 2021	Updated input shaft errors	0903
April 2021	Corrected interface with ECU (EDC) graphic	0902
January 2021	Added 280cc information	0901
April 2020	Corrected swash plate angle sensor connector and CCO connector descriptions	0804
February 2020	Added NFPE control options and changed document number from BC00000207	0803
June 2019	Major update.	0701
May 2018	Angle sensor for EDC; FDC note added.	0601
July 2017	B option change in MMC.	0503
May 2017	K option change in MMC.	0502
May 2017	NFPE gen. 3 changes.	0501
November 2015	Master Model Code changes.	0401
October 2014	Installation drawings change	0302
September 2014	MDC, CCO, and Swash Angle Sensor options added	0301
Mar 2014	Converted to Danfoss layout - DITA CMS	0201
Aug 2013	First edition	0101

Contents

Technical Specifications

H1 Pumps General Specification......6
Technical Data......6
Operating Parameters......7
Fluid Specification......8
Bearing Life and External Radial Shaft Loads......8
H1P 210/250/280 Mounting Flange Loads......10
Charge pump......11
 Charge Pump Selection......11
 52/60 cm³ Charge Pump – Flow and Power Curves......11

Master Model Code

Displacement, A—Rotation, B—Product Version, Z—Port Configuration......12
D—Controls......13
 Electronic Displacement Controls......13
 Fan Drive Controls......13
 Non-Feedback Proportional Electric (NFPE) Controls......13
 Automotive Controls......14
 Manual Displacement Control......14
 Hydraulic Displacement Control......14
F—Orifices, E—Displacement Limiters......15
G—Endcap......16
H—Mounting Flange, J—Input Shaft, K—Aux Pad......17
M, N—Overpressure Protection Settings......18
S—Charge Pump, T—Filtration, V—Charge Pressure Relief......19
W—Special Hardware, X—Paint, Y—Special Features......20

Control Options

Electrical Displacement Control (EDC)......21
 EDC Operation......21
 Control signal requirements, EDC 210/250/280......22
 Control Solenoid Data......22
 Single Pump Output Flow Direction......22
 Connector......23
 Control response......23
 Response Time, EDC 210/250/280......23
Manual Displacement Control (MDC)......24
 MDC operation......24
 MDC shaft rotation......25
 MDC Torque......25
 Control response......25
 Response time, MDC 210/250/280......26
 Neutral start switch (NSS)......26
 Connector......27
 Case Gauge Port M14......27
 Lever......27
Hydraulic Displacement Control (HDC)......28
 HDC principle......28
 HDC operation......28
 Hydraulic signal pressure range......29
 Pump output flow direction vs. control pressure......29
 Control response......29
 Response time, HDC 210/250/280......30
Non feedback proportional electric control (NFPE)......31
 Control Signal Requirements, NFPE 210/250/280......31
 Control Solenoid Data......32
 Single Pump Output Flow Direction......32
 Connector......32
 Control response......32
 Response Time, NFPE 210/250/280......33

Contents

Automotive Control (AC)....34
- Mode types....34
- Basic functions....34
- Performance functions....35
- Protection and safety functions....35
- Engine control and protection....35
- Installation features....35

Fan Drive Control (FDC)....36
- Control Signal Requirements, FDC 210/250/280....37
- Control Solenoid Data....37
- Single Pump Output Flow Direction....38
- Connector....38
- Control response....38
- Response Time, FDC 210/250/280....38

Manual Override (MOR)....39

Swashplate angle sensor for EDC controls....40
- Swash plate angle sensor parameters (EDC)....40
- Swashplate Angle Sensor Connector....41
- Interface with ECU (EDC)....41

Swash Plate Angle Sensor for NFPE and AC2 Controls....42
- Swash Plate Angle Characteristic....42
- Swash Plate Angle Sensor Parameters (NFPE/AC)....43
- Swash Plate Angle Sensor Connector (NFPE)....43
- Interface with ECU (NFPE)....43

Control Cut Off Valve (CCO)....44
- Brake gauge port with MDC....44
- CCO Connector (MDC)....44
- H1P CCO Connector (EDC, NFPE)....45
- CCO solenoid data....45

Displacement Limiter....46
- Displacement Change (approximately)....46

Dimensions and Data

H1P Input Shaft Option G2 (SAE E, 27 teeth)....47
H1P Input Shaft Option G3 (SAE E, 13 teeth)....48
H1P Input Shaft Option F8 (SAE E, 17 teeth)....49
H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth)....50
H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth)....51
H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth)....52
H1P Auxiliary Mounting, Option H4 (SAE D, 13 teeth)....53
H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth)....54
H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth)....55
H1P Auxiliary Mounting, Option E1 (SAE E, 13 teeth)....56
H1P Auxiliary Mounting, Option E2 (SAE E, 27 teeth)....57
H1P Displacement Limiter, Option B....58
Single Pump Ports....59
H1P Dimensions....60
Suction Filtration Option L....62
Controls....63
- EDC Options A2 and A3 (12/24 V)....63
- EDC with MOR, Options A4 and A5 (12/24 V)....64
- EDC with CCO (key C), Options E7 and E8 (12/24 V)....65
- EDC with ASNSR, Options: H2 and H3 (12/24 V)....66
- EDC with MOR and ASNSR, Options H6 and H7 (12/24 V)....67
- EDC with CCO and ASNSR, Options H8 and H9 (12/24 V)....68
- MDC Option: M1....69
- MDC with Neutral Start Switch Option: M2....70
- MDC with CCO, Options: M3, M4....71
- MDC with NSS and CCO Options: M5, M6....72
- HDC, Options: T1, T2....73

Contents

NFPE with MOR, Options: N1, N2 (12/24 V)........ 74
NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V)........75
NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V)........76
NFPE with MOR and CCO, Options: N7, N8 (12/24 V)........ 77
Automotive control (AC)........78
AC connectors dimensions........ 79

Technical Specifications

H1 Pumps General Specification

Axial piston closed circuit variable displacement pumps of cradle swash-plate design with clockwise or counterclockwise direction of rotation.

Pipe connections

- Main pressure ports: ISO split flange boss
- Remaining ports: SAE straight thread O-ring boss

Recommended installation position

Pump installation position is discretionary, however the recommended control position is on the top or at the side with the top position preferred. If the pump is installed with the control at the bottom, flushing flow must be provided through port M14 located on the EDC, FNR and NFPE control.

Vertical input shaft installation is acceptable. If input shaft is at the top, 1 bar case pressure must be maintained during operation. The housing must always be filled with hydraulic fluid. Recommended mounting for a multiple pump stack is to arrange the highest power flow towards the input source. Consult Danfoss for nonconformance to these guidelines.

Auxiliary cavity pressure

Auxiliary cavity pressure will be inlet pressure with internal charge pump or case pressure with external charge supply. For reference see Operating Parameters. Please verify mating pump shaft seal capability.

H1P 210/250/280 Technical Data

Feature	Size 210	Size 250	Size 280
Displacement	211.5 cm^3 [12.91 in^3]	251.7 cm^3 [15.36 in^3]	280.2 cm^3 [17.1 in^3]
Flow at rated speed (continuous)	549 l/min [145 US gal/min]	654 l/min [172.8 US gal/min]	728 l/min [192.3 US gal/min]
Torque at maximum displacement (theoretical)	3.34 N·m/bar [2042 lbf·in/ 1000 psi]	3.98 N·m/bar [2433 lbf·in/ 1000 psi]	4.46 N·m/bar [2727 lbf·in/ 1000 psi]
Mass moment of inertia of rotating components	0.0606 kg·m^2 [0.1039 slug·ft^2]	0.0606 kg·m^2 [0.1039 slug·ft^2]	0.0606 kg·m^2 [0.1039 slug·ft^2]
Mass (dry–no charge pump)	163 kg [359.4 lb]	163 kg [359.4 lb]	163 kg [359.4 lb]
Oil volume	7.2 l [1.9 US gal]	7.2 l [1.9 US gal]	7.2 l [1.9 US gal]

Shaft, flange and ports description

Input shaft per ISO 3019-1 (outer diameter)	• Outer Ø44 mm – 4 (13 teeth) • Outer Ø44 mm – 4 (27 teeth) • Outer Ø57 mm – 4 (17 teeth)
Mounting flange per ISO 3019-1	Flange 165-4 (SAE-E)
Auxiliary mounting flange with metric fasteners, with shaft outer diameter	• Flanges 82-2 (SAE A, 9 teeth and 11 teeth) • Flanges 101-2 (SAE B, 13 teeth and SAE B-B, 15 teeth) • Flange 127-4 (SAE C, 14 teeth) • Flange 152-4 (SAE D, 13 teeth) • Flange 165-4 (SAE E, 13 teeth and 27 teeth)
Suction port per ISO 3019-1	Ø38 mm, 350 bar split flange boss per ISO 6162, M12x1.75
Main configuration port	Ø38 mm, 450 bar split flange boss per ISO 6162, M16x2
Case drain ports L2, L4 per ISO 3019-1	ISO 11926-1: $1^5/_{16}$-12
Other ports	SAE O-ring boss
Customer interface threads	Metric fasteners

Technical Specifications

H1P 210/250/280 Operating Parameters

<table>
<tr><th colspan="2">Parameter</th><th>Unit</th><th>Size 210/250</th><th>Size 280</th></tr>
<tr><td rowspan="4">Input speed</td><td>Min. for internal[1)] and external[2)] charge supply</td><td rowspan="4">min^{-1} (rpm)</td><td colspan="2">500</td></tr>
<tr><td>Min. for full performance, internal charge supply</td><td colspan="2">1200</td></tr>
<tr><td>Rated</td><td colspan="2">2600</td></tr>
<tr><td>Maximum</td><td colspan="2">2800</td></tr>
<tr><td rowspan="3">System pressure</td><td>Maximum working</td><td rowspan="3">bar [psi]</td><td>450 [6527]</td><td>420 [6091]</td></tr>
<tr><td>Maximum</td><td>480 [6962]</td><td>450 [6527]</td></tr>
<tr><td>Max./Min. low loop</td><td colspan="2">45/10 [653/145]</td></tr>
<tr><td rowspan="2">Charge pressure</td><td>Minimum</td><td rowspan="5">bar [psi]</td><td colspan="2">18 [261]</td></tr>
<tr><td>Maximum</td><td colspan="2">40 [580]</td></tr>
<tr><td rowspan="3">Control pressure</td><td>Minimum (at corner power for EDC, MDC, FNR)</td><td colspan="2">16 [232]</td></tr>
<tr><td>Minimum (at corner power for NFPE, FDC, AC)</td><td colspan="2">25 [363]</td></tr>
<tr><td>Maximum</td><td colspan="2">60 [870]</td></tr>
<tr><td rowspan="3">Charge pump inlet pressure</td><td>Rated</td><td rowspan="2">bar (absolute) [in Hg vacuum]</td><td colspan="2">0.7 [9.0]</td></tr>
<tr><td>Minimum (cold start)</td><td colspan="2">0.2 [24.0]</td></tr>
<tr><td>Maximum</td><td rowspan="4">bar [psi]</td><td colspan="2">4.0 [58.0]</td></tr>
<tr><td rowspan="2">Case pressure</td><td>Rated</td><td colspan="2">3.0 [44.0]</td></tr>
<tr><td>Maximum</td><td colspan="2">5.0 [73.0]</td></tr>
<tr><td colspan="2">Lip seal maximum pressure (external)</td><td colspan="2">0.4 [5.8]</td></tr>
</table>

[1)] Performance (displacement and pressure) may be limited due to limited control pressure.

[2)] Full performance (displacement and pressure) possible at minimum charge and control pressure supply.

Filtration, cleanliness level and β_x-ratio (recommended minimum)

Cleanliness per ISO 4406	22/18/13
Efficiency β_x (charge pressure filtration)	$\beta_{15-20} = 75$ ($\beta_{10} \geq 10$)
Efficiency β_x (suction and return line filtration)	$\beta_{35-45} = 75$ ($\beta_{10} \geq 2$)
Recommended inlet screen mesh size	100 – 125 µm

Technical Specifications

Fluid Specification

Viscosity

Intermittent[1)]	5 mm^2/s [42 SUS]
Minimum	7 mm^2/s [49 SUS]
Recommended range	12 – 80 mm^2/s [66 – 370 SUS]
Maximum	1600 mm^2/s [7500 SUS]

[1)] Intermittent = Short term t < 1 min per incident and not exceeding 2 % of duty cycle based load-life.

Temperature

Minimum [1)]	-40°C [-40°F]
Rated	104°C [220°F]
Recommended range[2)]	60 – 85°C [140 – 185°F]
Maximum Intermittent	115°C [240°F]

[1)] Cold start = Short term t > 3 min, p ≤ 50 bar [725 psi], n ≤ 1000 min-1 (rpm).

[2)] At the hottest point, normally case drain port.

H1P 210/250/280 Bearing Life and External Radial Shaft Loads

All external shaft loads affect bearing life. The pumps are designed with bearings that can accept some external radial loads. The external radial shaft load limits are a function of the load position and orientation, and the operating conditions of the unit.

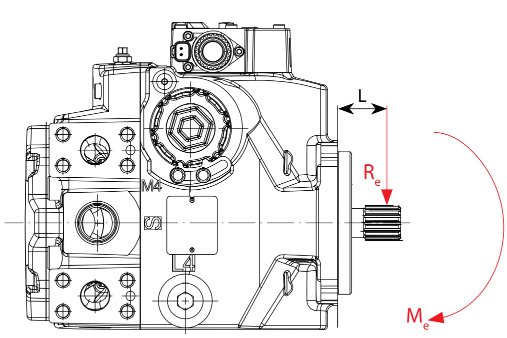
Danfoss recommends clamp-type couplings for applications with radial shaft loads. Contact your Danfoss representative for an evaluation of unit bearing life if you have continuously applied external loads exceeding 25 % of the maximum allowable radial load (R_e) or the pump swash-plate is positioned on one side of center all or most of the time.

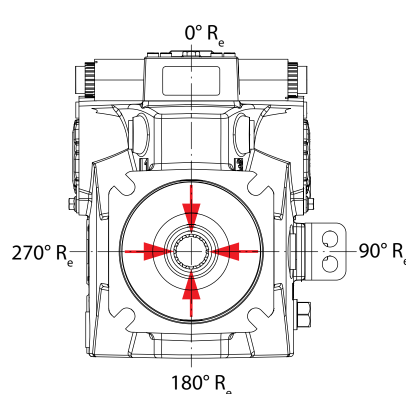
Maximum external shaft load based on shaft deflection

External radial moment	Unit	Size 210	Size 250	Size 280
M_e	N•m [lbf•in]	168 [1478]	167 [1478]	167 [1478]

External radial shaft loads impact lifetime. For lifetime calculations please contact your Danfoss representative. In applications with external shaft loads, minimize the impact by positioning the load at 0° or 180° as shown below.

Radial load position





The maximum allowable radial shaft load (R_e) is based on the maximum external moment (M_e) and the distance (L) from the mounting flange to the load. It may be determined using the following formula:

Technical Specifications

$$R_e = \frac{M_e}{L}$$

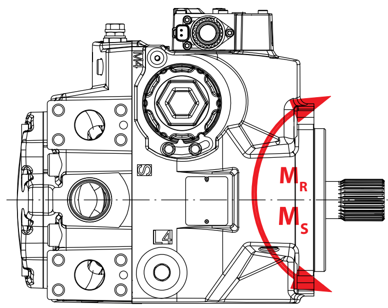
Thrust loads should be avoided. Contact your Danfoss representative in the event thrust loads are anticipated.

Technical Specifications

H1P 210/250/280 Mounting Flange Loads

The Rated and Shock load moments apply for top or side orientation of control.

Mounting flange load with control on top



Rated moment	$\mathbf{M_R}$ = 6176 N•m [54 662 lbf•in]
Shock load moment	$\mathbf{M_S}$ = 13 003 N•m [115 086 lbf•in]

For more information, see *H1 Axial Piston Pumps, Basic Information,* **BC152886483968**, the section "Mounting flange loads".

Technical Specifications

Charge pump

Charge Pump Selection

In most applications a general guideline is that the charge pump displacement should be at least 10% of the total displacement of all components in the system. Unusual application conditions may require a more detailed review of charge flow requirements. System features and conditions which may invalidate the 10% guideline include (but are not limited to):

- Continuous operation at low input speeds < 1500 min^{-1} (rpm)
- High shock loading and/or long loop lines
- High flushing flow requirements
- Multiple low speed high torque motors
- High input shaft speeds

Contact your Danfoss representative for application assistance if your application includes any of these conditions.

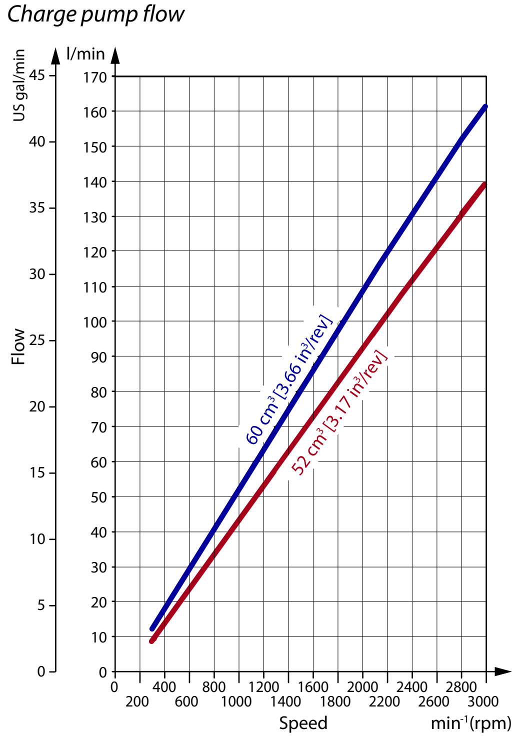
For more information, see *Selection of Drive line Components*, **BC157786484430**.

52/60 cm³ Charge Pump – Flow and Power Curves

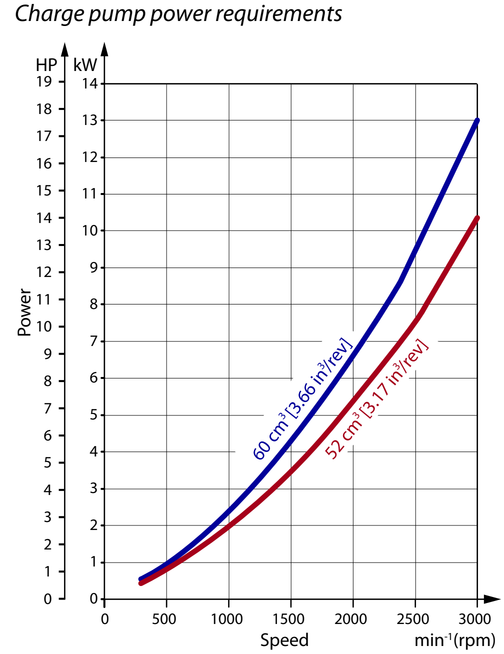
Charge pump flow and power requirements curves shown below at the following conditions:

Charge pressure = 20 bar [290 psi]
Viscosity = 11 mm²/s [63 SUS]
Temperature = 80°C [176°F]

Charge pump flow

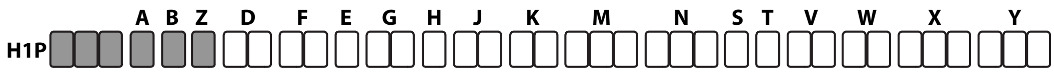


Charge pump power requirements



Master Model Code

Displacement, A—Rotation, B—Product Version, Z—Port Configuration



Displacement

210	211.5 cm^3 [12.91 in^3]
250	251.7 cm^3 [15.36 in^3]
280	280.2 cm^3 [17.10 in^3]

A – Direction of Rotation

L	Left hand (counter clockwise)
R	Right hand (clockwise)

B – Product version

A	Revision code

Z – Port configuration

A	Inch, Customer O-ring port sealing according to ISO 11926-1

Master Model Code

D—Controls

A B Z D F E G H J K M N S T V W X Y

H1P

Electronic Displacement Controls

Code	Control type	Voltage	MOR	CCO with key C	Angle sensor	Connector
A2	EDC	12 V	—	—	—	DEUTSCH
A3	EDC	24 V	—	—	—	DEUTSCH
A4	EDC	12 V	●	—	—	DEUTSCH
A5	EDC	24 V	●	—	—	DEUTSCH
E7	EDC	12 V	—	●	—	DEUTSCH
E8	EDC	24 V	—	●	—	DEUTSCH
H2	EDC	12 V	—	—	●	DEUTSCH
H3	EDC	24 V	—	—	●	DEUTSCH
H6	EDC	12 V	●	—	●	DEUTSCH
H7	EDC	24 V	●	—	●	DEUTSCH
H8	EDC	12 V	—	●	●	DEUTSCH
H9	EDC	24 V	—	●	●	DEUTSCH

● – To be used for the control; — Not to be used for the control

Fan Drive Controls

F1	FDC	12 V	DEUTSCH Connector
F2	FDC	24 V	DEUTSCH Connector

Align with options: **F:** Orifices, **E:** Displacement limiters, **M, N:** Overpressure protection, and **W:** Special hardware.

Non-Feedback Proportional Electric (NFPE) Controls

Code	Control type	Voltage	MOR	CCO with key C	Angle sensor	Connector
N1	NFPE	12 V	●	—	—	DEUTSCH
N2	NFPE	24 V	●	—	—	DEUTSCH
N3	NFPE	12 V	●	●	●	DEUTSCH
N4	NFPE	24 V	●	●	●	DEUTSCH
N5	NFPE	12 V	●	—	●	DEUTSCH
N6	NFPE	24 V	●	—	●	DEUTSCH
N7	NFPE	12 V	●	●	—	DEUTSCH
N8	NFPE	24 V	●	●	—	DEUTSCH

Align with options: **E:** Displacement limiters and **W:** Special hardware.

Master Model Code

Automotive Controls

Automotive Control (AC)

Code	AC type	Voltage	MOR	Speed sensor	Wire harness	Angle sensor	Connector
P6	AC–1	12 V	●	●	●	—	DEUTSCH
P7	AC–1	24 V	●	●	●	—	DEUTSCH
P8	AC–2	12 V	●	●	●	●	DEUTSCH
P9	AC–2	24 V	●	●	●	●	DEUTSCH
P5	AC–1	12 V	●	—	—	—	DEUTSCH
R3	AC–1	24 V	●	—	—	—	DEUTSCH
R4	AC–2	12 V	●	—	—	●	DEUTSCH
R5	AC–2	24 V	●	—	—	●	DEUTSCH

● – To be used for the control; — Not to be used for the control

Manual Displacement Control

Manual Displacement Control (MDC)

Code	Control type	CCO Voltage	CCO	Neutral Start Switch	Connector
M1	MDC	—	—	—	—
M2	MDC	—	—	●	DEUTSCH
M3	MDC	12 V	●	—	DEUTSCH
M4	MDC	24 V	●	—	DEUTSCH
M5	MDC	12 V	●	●	DEUTSCH
M6	MDC	24 V	●	●	DEUTSCH

Align with options **F:** Orifices and **Y:** Settings for adjustment (if applicable).

Hydraulic Displacement Control

Hydraulic Displacement Control (HDC)

Code	Pressure range	Ports
T1	4.2 - 16.2 bar	Inch ports 9/16-18
T2	3.0 - 11.6 bar	Inch ports 9/16-18

Master Model Code

F—Orifices, E—Displacement Limiters

A B Z D F E G H J K M N S T V W X Y

H1P

F – Orifices Options

Orifices options related to control type

Code	Tank (A+B)	P orifice	A/B orifices	EDC, FNR	MDC	NFPE, AC	FDC
C3	No orifice			●	●	–	–
C1	–	–	0.8 mm	●	●	●	–
C2	–	–	1.3 mm	●	●	●	●
C4	–	–	1.8 mm	●	●	●	–
C5	–	–	2.5 mm	–	–	–	–
C6	1.0 mm	–	–	–	●	–	
C7	1.3 mm	–	–	–	●	–	–
D1	0.8 mm	1.0 mm	–	–	●	–	–
D2	0.8 mm	1.3 mm	–	–	●	–	–
D3	1.0 mm	1.3 mm	–	–	●	–	–
D4	1.0 mm	1.3 mm	1.3 mm	–	●	–	–
D5	0.6 mm	0.6 mm	0.8 mm	–	●	–	–
D6	1.3 mm	1.3 mm	–	–	●	–	–

E – Displacement Limiter Options

N	None
B	Adjustable externally
C	No limiters, with nested springs, required for NFPE, AC, FDC*
D	Adjustable externally with nested springs, required for NFPE, AC, FDC*

* Align with option **Y:** Settings for adjustment (if applicable).

Master Model Code

G—Endcap

A B Z D F E G H J K M N S T V W X Y

H1P

G – End-cap Options

Twin port, ISO 6162 split flange ports; Align with T: Filtration

D6	Suction filtration
D8	Remote filtration or external charge supply

Master Model Code

H—Mounting Flange, J—Input Shaft, K—Aux Pad

A B Z D F E G H J K M N S T V W X Y

H1P

H – Mounting options

Mounting to be aligned with option W: Special hardware

C	ISO 3019-1 flange 152–4 (SAE E), 4-bolt
E	ISO 3019-1 flange 152–4 (SAE E), 4-bolt, with speed sensor

J – Input Shaft options

G2	ISO 3019-1, outer Ø44 mm - 4 (27 teeth splined shaft 16/32 pitch)
G3	ISO 3019-1, outer Ø44 mm - 4 (13 teeth splined shaft 8/16 pitch)
F8	ISO 3019-1, outer Ø57 mm - 4 (17 teeth splined shaft 8/16 pitch)

K – Auxiliary Mounting Pad options (ISO 3019-1)

NN	None
H1	Flange 82–2 (SAE A, 11 teeth, 16/32 coupling); shipping cover
H2	Flange 82–2 (SAE A, 9 teeth, 16/32 coupling); shipping cover
H3	Flange 101–2 (SAE B, 13 teeth, 16/32 coupling); shipping cover
H5	Flange 101–2 (SAE B-B, 15 teeth, 16/32 coupling); shipping cover
H6	Flange 127–4 (SAE C, 14 teeth, 12/24 coupling); shipping cover
H4	Flange 152–4 (SAE D, 13 teeth, 8/16 coupling); shipping cover
E1	Flange 165–4 (SAE E, 13 teeth, 8/16 coupling); shipping cover
E2	Flange 165–4 (SAE E, 27 teeth, 16/32 coupling); shipping cover

Master Model Code

M, N—Overpressure Protection Settings

H1P A B Z D F E G H J K M N S T V W X Y

M and N – Overpressure protection options

L	Pressure limiter setting	HPRV with bypass setting[1]
L20	200 bar [2900 psi]	250 bar [3630 psi]
L23	230 bar [3336 psi]	280 bar [4061 psi]
L25	250 bar [3630 psi]	300 bar [4350 psi]
L28	280 bar [4061 psi]	330 bar [4786 psi]
L30	300 bar [4350 psi]	350 bar [5076 psi]
L33	330 bar [4786 psi]	380 bar [5510 psi]
L35	350 bar [5080 psi]	400 bar [5800 psi]
L38	380 bar [5510 psi]	420 bar [6090 psi]
L40	400 bar [5800 psi]	450 bar [6526 psi]
L42	420 bar [6090 psi]	450 bar [6526 psi]
L43	430 bar [6237 psi]	480 bar [6962 psi]
L44	440 bar [6382 psi]	480 bar [6962 psi]
L45	450 bar [6526 psi]	480 bar [6962 psi]
Overpressure protection type and setting for FDC		
F01	150 bar [2175 psi]	250 bar [3630 psi]
F02	150 bar [2175 psi]	300 bar [4350 psi]
F03	150 bar [2175 psi]	350 bar [5076 psi]
F04	150 bar [2175 psi]	400 bar [5800 psi]

[1] Pressure limiter and HPRV with bypass, over-pressure protection type must be the same for both sides “A” and “B”.

K	Pressure setting [1]
K20	200 bar [2900 psi]
K23	230 bar [3336 psi]
K25	250 bar [3630 psi]
K28	280 bar [4061 psi]
K30	300 bar [4350 psi]
K33	330 bar [4786 psi]
K35	350 bar [5076 psi]
K38	380 bar [5510 psi]
K40	400 bar [5800 psi]
K42	420 bar [6090 psi]
K45	450 bar [6526 psi]

[1] Pressure limiter and HPRV with bypass, over-pressure protection type must be the same for both sides “A” and “B”.

Please contact Danfoss Power Solutions for pressures not shown or for applied pressure above max. working pressure.

Master Model Code

S—Charge Pump, T—Filtration, V—Charge Pressure Relief

A B Z D F E G H J K M N S T V W X Y

H1P

S – Charge pump options

R	52 cm^3/rev [3.17 in^3/rev]
W	60 cm^3/rev [3.66 in^3/rev]
N	No charge pump, external charge supply (*Align with options:* **E, T**)

T – Filtration options

Filtration to be aligned with G: End cap selection

L	Suction filtration
P	Remote full charge flow filtration
E	External full charge flow filtration (Align with options **N, S**)

V – Charge pressure relief valve (CPRV) setting

20*	20 bar [290 psi]
22*	22 bar [319 psi]
24*	24 bar [348 psi]
26	26 bar [377 psi]
28	28 bar [406 psi]
30	30 bar [435 psi]
32	32 bar [464 psi]
34	34 bar [493 psi]

* Not to be used for **NFPE, AC** and **FDC** controls.

Master Model Code

W—Special Hardware, X—Paint, Y—Special Features

A B Z D F E G H J K M N S T V W X Y

H1P

W – Special Hardware features

Hardware features to be aligned with options D, E

P4	EDC/FNR/MDC valve plate and speed ring on the cylinder block
PN	EDC/FNR/MDC valve plate
H1	MDC/EDC/FNR valve plate with MDC handle

X – Paint and Name-tag

NNN	Black paint and Danfoss name-tag
C08	Paint none and Danfoss name-tag

Y – Special settings (SIL-2 non-certifiable, without customer files)

Code	CAN J1939	ECO fuel saving mode	Functional option	Cruise control	Control	AC type
D3E	in/out	●	E	–	N1 (12 V_{DC})	AC–1
D3F	in/out	–	F	–		
D4E	in/out	●	E	–	N2 (24 V_{DC})	
D4F	in/out	–	F	–		
D5F	in/out	–	F	–	P8 (12 V_{DC})	AC–2 (with swash plate angle sensor)
D5J	in/out	●	J	●		
D6F	in/out	–	F	–	P9 (24 V_{DC})	
D6J	in/out	●	J	●		
M00	MDC handle standard position					
NNN	None					

● – To be used for the control; — Not to be used for the control

Control Options

Electrical Displacement Control (EDC)

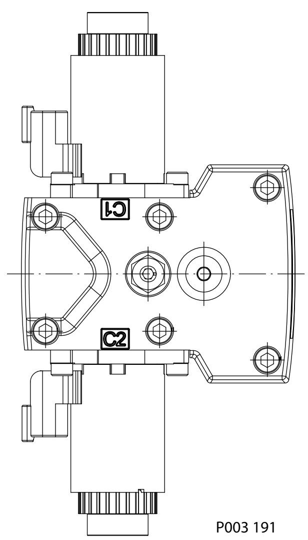
An EDC is a displacement (flow) control. Pump swash plate position is proportional to the input command and therefore vehicle or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

The Electrical Displacement Control (**EDC**) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

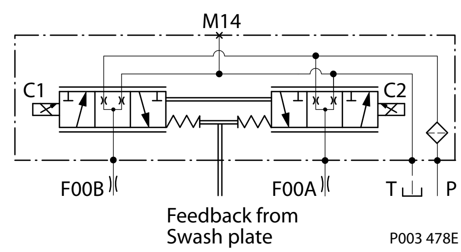
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

Electrical Displacement Control



EDC schematic, feedback from swash plate



EDC Operation

H1 EDC's are current driven controls requiring a Pulse Width Modulated (PWM) signal. Pulse width modulation allows more precise control of current to the solenoids.

The PWM signal causes the solenoid pin to push against the porting spool, which pressurizes one end of the servo piston, while draining the other. Pressure differential across the servo piston moves the swashplate.

A swashplate feedback link, opposing control links, and a linear spring provide swashplate position force feedback to the solenoid. The control system reaches equilibrium when the position of the swashplate spring feedback force exactly balances the input command solenoid force from the operator. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

The EDC incorporates a positive neutral deadband as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold current is reached, the swashplate is positioned directly proportional to the control current. To minimize the effect of the control neutral deadband, we recommend the transmission controller or operator input device incorporate a jump up current to offset a portion of the neutral deadband.

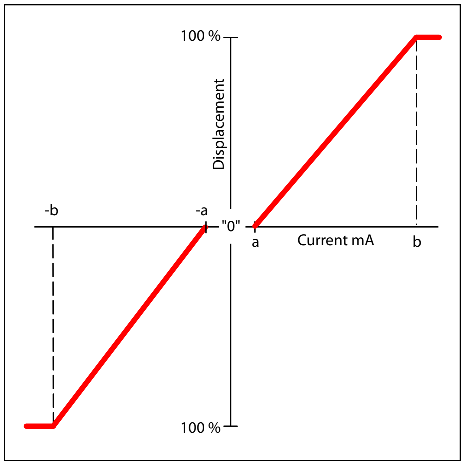
The neutral position of the control spool does provide a positive preload pressure to each end of the servo piston assembly.

When the control input signal is either lost or removed, or if there is a loss of charge pressure, the spring-loaded servo piston will automatically return the pump to the neutral position.

Control Options

Control signal requirements, EDC 210/250/280

Pump displacement vs. control current



EDC control current

Voltage		$12\ V_{DC}$	$24\ V_{DC}$
Minimum current to stroke pump	**a***	640 mA	330 mA
	b	1640 mA	820 mA
Pin connections		any order	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Single Pump Output Flow Direction

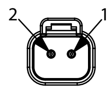
Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	out	in	in	out
Port B	in	out	out	in
Servo port pressurized	M4	M5	M4	M5

* For coil location see installation drawings.

Control Options

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, EDC 210/250/280

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	7.4 s	3.5 s	2.1 s
Full flow to neutral	5.0 s	2.4 s	1.4 s

Control Options

Manual Displacement Control (MDC)

A Manual proportional Displacement Control (**MDC**) consists of a handle on top of a rotary input shaft. The shaft provides an eccentric connection to a feedback link. This link is connected on its one end with a porting spool. On its other end the link is connected the pumps swashplate.

This design provides a travel feedback without spring. When turning the shaft the spool moves thus providing hydraulic pressure to either side of a double acting servo piston of the pump.

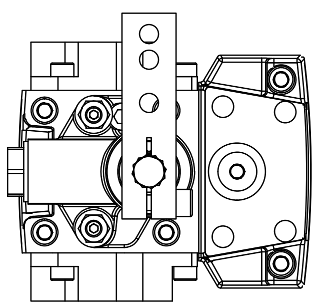
Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement. Simultaneously the swashplate movement is fed back to the control spool providing proportionality between shaft rotation on the control and swash-plate rotation. The MDC changes the pump displacement between no flow and full flow into opposite directions.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

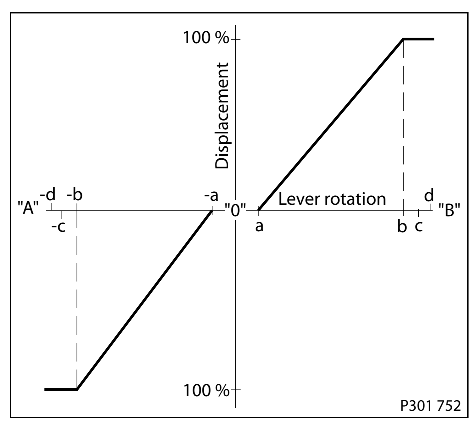
For the MDC with CCO option the brake port (X7) provides charge pressure when the coil is energized to activate static function such as a brake release. The X7 port must not be used for any continuous oil consumption.

The MDC is sealed by means of a static O-ring between the actuation system and the control block. Its shaft is sealed by means of a special O-ring which is applied for low friction. The special O-ring is protected from dust, water and aggressive liquids or gases by means of a special lip seal.

Manual Displacement Control



Pump displacement vs. control lever rotation



Deadband on **B** side: **a = 3° ±1°**
Maximum pump stroke: **b = 30° +2/-1°**
Required customer end stop: **c = 36° ±3°**
Internal end stop: **d = 40°**

MDC operation

The MDC provides a mechanical dead-band required to overcome the tolerances in the mechanical actuation. The MDC contains an internal end stop to prevent turning the handle into any inappropriate position.

The MDC provides a permanent restoring moment appropriate for turning the MDC input shaft back to neutral position only. This is required to take the backlash out of the mechanical connections between the Bowden cable and the control.

High case pressure may cause excessive wear and the NSS to indicate that the control is not in neutral position. In addition, if the case pressure exceeds 5 bar there is a risk of an insufficient restoring moment. The MDC is designed for a maximum case pressure of 5 bar and a rated case pressure of 3 bar.

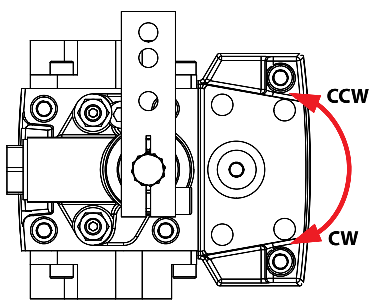
Control Options

- Customers must install some support to limit the setting range of their Bowden cable to avoid an overload of the MDC.
- Customers can apply their own handle design but they must care about a robust clamping connection between their handle and the control shaft and avoid overload of the shaft.
- Customers can connect two MDC's on a tandem unit in such a way that the actuation force will be transferred from the pilot control to the second control. The kinematic of the linkages must ensure that either control shaft is protected from torque overload.

Caution

Using the internal spring force on the input shaft is not an appropriate way to return the customer connection linkage to neutral, or to force a Bowden cable or a joystick back to neutral position. It is not applicable for any limitation of the Bowden cable stroke, except the applied torque to the shaft will never exceed 20 N•m.

MDC shaft rotation



Pump shaft rotation*	Clockwise (CW)		Counter-clockwise (CCW)	
MDC shaft rotation	**CW**	**CCW**	**CW**	**CCW**
Port A	in (low)	out (high)	out (high)	in (low)
Port B	out (high)	in (low)	in (low)	out (high)
Servo port high pressure	M5	M4	M5	M4

* As seen from shaft side.

MDC Torque

Description	Value
Torque required to move handle to maximum displacement	1.4 N•m [12.39 lbf•in]
Torque required to hold handle at given displacement	0.6 N•m [5.31 lbf•in]
Maximum allowable input torque	20 N•m [177 lbf•in]

Caution

Volumetric efficiencies of the system will have impacts on the start and end input commands.

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]

Control Options

Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response time, MDC 210/250/280

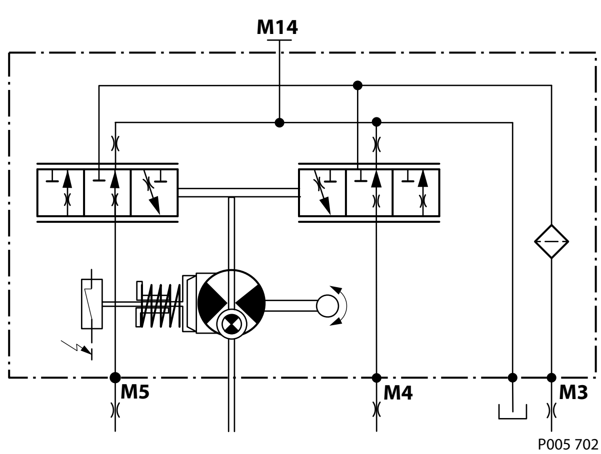
Code	Orifice description (mm)			Stroking direction	
	Tank (A+B)	P	A/B	Neutral to full flow	Full flow to neutral
C3	No orifice			0.9 s	1.0 s
C5	–	–	2.5	0.9 s	1.0 s
C6	1	–	–	3.3 s	2.9 s
C7	1.3	–	–	2.1 s	1.9 s
D1	0.8	1	–	2.1 s	1.5 s
D2	0.8	1.3	–	1.8 s	1.4 s
D3	1	1.3	–	3.8 s	3.2 s
D4	1	1.3	1.3	4.6 s	3.8 s

For further data please contact your Danfoss representative.

Neutral start switch (NSS)

The Neutral Start Switch **(NSS)** contains an electrical switch that provides a signal of whether the control is in neutral. The signal in neutral is Normally Closed **(NC)**.

Neutral start switch schematic



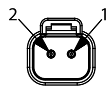
Neutral start switch data

Max. continuous current with switching	8.4 A
Max. continuous current without switching	20 A
Max. voltage	36 V_{DC}
Electrical protection class	IP67 / IP69K with mating connector

Control Options

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Case Gauge Port M14

The drain port should be used when the control is mounted on the unit's bottom side to flush residual contamination out of the control.

Lever

MDC-controls are available with an integrated lever.

Control Options

Hydraulic Displacement Control (HDC)

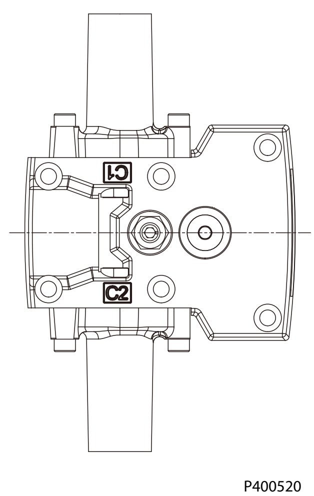
HDC principle

An HDC is a Hydraulic Displacement Control. Pump swashplate position is proportional to the input command and therefore vehicle speed or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

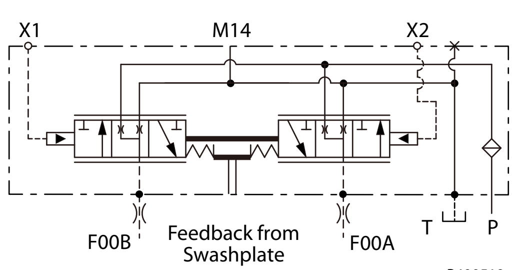
The HDC control uses a hydraulic input signal to operate a porting spool, which ports hydraulic pressure to either side of a double acting servo piston. The hydraulic signal applies a force input to the spool which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction. Under some circumstances, such as contamination, the porting spool could stick and cause the pump to stay at some displacement.

A serviceable 175 µm screen is located in the supply line immediately before the control porting spool.

HDC control



HDC schematic



HDC operation

HDC's are hydraulically driven control which ports hydraulic pressure to either side of a porting spool, which pressurizes one end of the servo piston, while draining the other end to case. Pressure differential across the servo piston moves the swashplate.

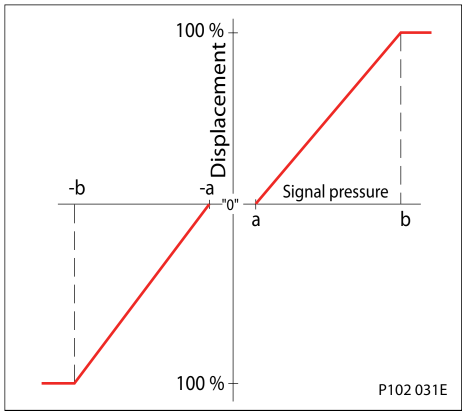
A swashplate feedback link, opposing control linkage, and a linear spring provide swashplate position force feedback to the hydraulic pressure. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

Control Options

The HDC incorporates a positive neutral dead band as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold point is reached, the swashplate is positioned directly proportional to the control pressure.

When the control input is either lost or removed, or if there is a loss of charge pressure, the spring loaded servo piston will automatically return the pump to the neutral position.

Pump displacement vs signal pressure



Hydraulic signal pressure range

Option	Type	a*	b*	Max. pressure
T1	Standard	4.2 bar	16.2 bar	30 bar
T2	Option	3 bar	11.6 bar	30 bar

* Factory test current, for vehicle movement or application actuation expect a higher or lower value.

Pump output flow direction vs. control pressure

Shaft rotation HDC	Clockwise (CW) seen from shaft		Counter Clockwise (CCW) seen from shaft	
Port energized	X1	X2	X1	X2
Port A	Out (high)	In (low)	In (low)	Out (high)
Port B	In (low)	Out (high)	Out (high)	In (low)
Servo port high pressure	M4	M5	M4	M5

For appropriate performance of HDC characteristic, keep the drain pressure of pilot valve to be equal or slightly higher than pump case pressure.

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Control Options

Response time, HDC 210/250/280

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
Neutral to full flow	7.1s	3.2s	1.8s
Full flow to neutral	4.7s	2.1s	1.2s

Control Options

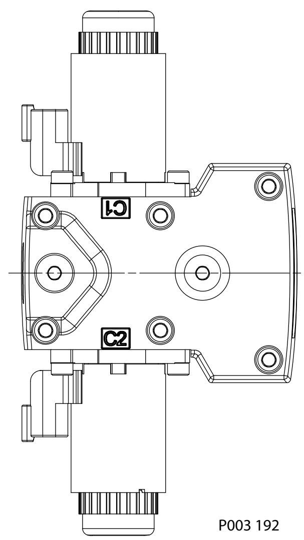
Non feedback proportional electric control (NFPE)

The Non Feedback Proportional Electric (**NFPE**) control is an electrical automotive control in which an electrical input signal activates one of two proportional solenoids that port charge pressure to either side of the pump servo cylinder. The NFPE control has no mechanical feedback mechanism.

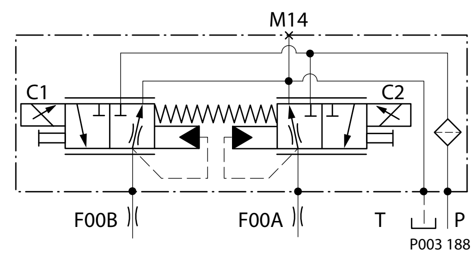
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

NFPE control



NFPE schematic

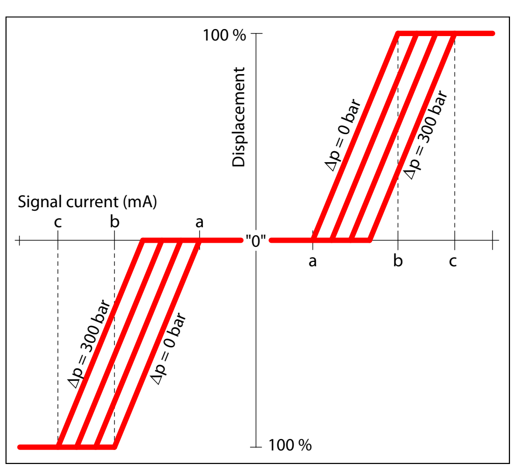


Control Signal Requirements, NFPE 210/250/280

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash-plate angle as system pressure increases.

A typical response characteristic is shown in the accompanying graph below:

Pump displacement vs. input signal



Control Options

Control current requirements

Voltage*	a	b	c	Pin config.
12 V_{DC}	666 mA	1168 mA	1540 mA	any order
24 V_{DC}	320 mA	600 mA	770 mA	

* Factory test current, for vehicle movement or application actuation expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

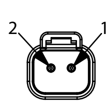
Single Pump Output Flow Direction

Shaft rotation	Clock-Wise (CW)		Counter-Clock-Wise (CCW)	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

* For coil location see installation drawings.

Connector

Connector DEUTSCH, 2-pin



Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Control Options

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

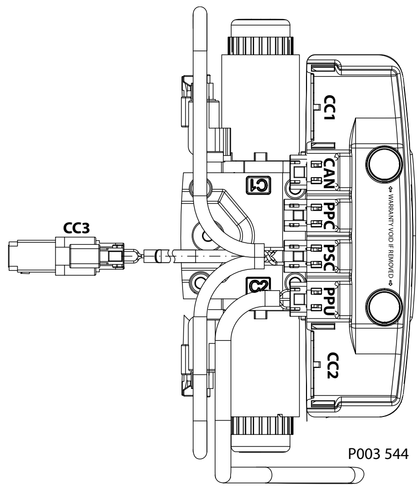
Response Time, NFPE 210/250/280

Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	2.3 mm [0.09 in] orifice
Neutral to full flow	9.6 s	3.7 s	1.1 s
Full flow to neutral	5.9 s	2.5 s	0.6 s

Control Options

Automotive Control (AC)

The H1 **A**automotive **C**ontrol (AC) is an electric NFPE Control with an integrated micro-controller, installed on the pump. The integrated micro-controller enhanced control performance with a flexible, configurable control scheme for an entire single path propel transmission. It can be used in combination with fixed and variable displacement hydraulic-motors. With the pre-installed application software and easily changeable control parameters, it is possible to tailor the vehicle's driving behavior to the individual requirements of the customer.



The H1 Automotive Control is divided into 2 systems:

- AC-1
- AC-2

AC-2 is an extension of AC-1 that features an integrated pump swash plate angle sensor and software enabled functions such as Swash Plate Control.

Mode types

The application software provides 3 different hydrostatic propel methods, defined as mode types, which can be used individually.

- **Automotive Load dependent** (torque controlled) driving behavior. Setpoint for the drive curve is the engine rpm.
- **Non-Automotive Load independent** (speed controlled) driving mode. Setpoint for the drive curve is a Joystick or drive pedal signal, independent of the engine rpm. The best performance will achieved with an AC-2 Swash Plate Angle Sensor.
- **Creep-Automotive Load dependent** (torque controlled) driving behavior (like Automotive). Setpoint for the drive curve is the engine rpm. The setpoint can be reduced by the creep potentiometer if a high engine rpm in combination with low vehicle speed is needed.

Basic functions

- Four selectable system modes, selectable via switch.
- Individual settings for forward and reverse driving direction (4 x 2 curves).
- Independent pump and hydraulic-motor profiling and ramping for each mode.
- Electric drive pedal connection
- Electronic inching function without separate control valve
- Electric creep mode potentiometer

Control Options

- Configurable System Mode & Direction change
- Load independent pump displacement control with integrated Swash Plate Angle Sensor (AC-2)
- Hydraulic-motor displacement control including brake pressure defeat function

Performance functions

- ECO fuel saving mode with automatic reduction of the engine speed during transport (Cruise control)
- Vehicle constant speed drive control
- Vehicle speed limitation
- Dynamic brake light, automatic park brake, reverse buzzer and status LED outputs
- Vehicle speed controlled output function.
- Temperature compensation for predictable performance
- Advanced CAN J1939 interface for the information exchange with the vehicle control system

Protection and safety functions

- Safety controlled vehicle start protection with engine speed check, battery check and FNR must be in neutral, etc..
- Operator presence detection
- Hydraulic system overheat and low-temperature protection
- Hydraulic motor over speed protection
- Park brake test mode for roller applications to fulfill SAE J1472 / EN500-4.
- SIL2 compliant

Engine control and protection

- CAN J1939 engine interface
- Engine speed control via drive pedal with safety controlled monitoring function
- Engine antistall protection
- Engine over speed protection during inching
- Engine speed dependent Retarder control
- Engine cold start protection

Installation features

- Factory calibration for hysteresis compensation.
- Starting current adjustment in the factory
- Pre-installed application software and parameter files

For more information, see *Automotive Control for H1 Single Pumps Technical Information*, **BC152986482596**.

Control Options

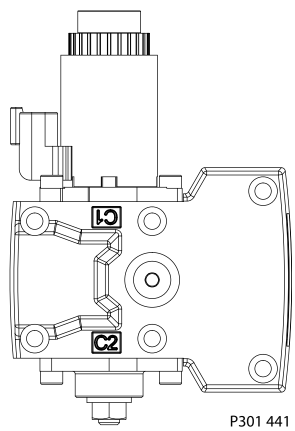
Fan Drive Control (FDC)

The Fan Drive Control (**FDC**) is a non-feedback control in which an electrical input signal activates the proportional solenoid that ports charge pressure to either side of the pump servo cylinder. The single proportional solenoid is used to control pump displacement in the forward or reverse direction.

The control spool is spring biased to produce maximum forward pump displacement in the absence of an electrical input signal. Based on the spring bias spool default forward flow for a CW rotation pump is out of port B while default forward flow for a CCW rotation pump is out of port A.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

FDC control



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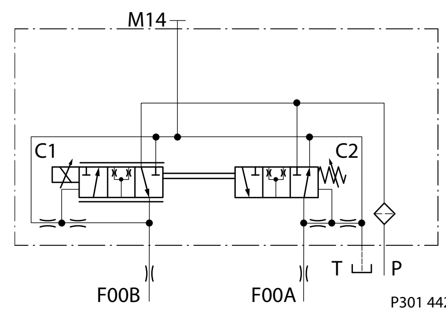
FDC schematic



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The pump should be configured with 0.8 mm control orifices to provide slowest response and maximize system stability. Additionally, pressure limiter (PL) valves are used to limit maximum fan trim speed in both (forward and reverse) directions.

H1 pumps with FDC will be delivered from factory with nominal pressure limiter setting of 150 bar [2175 psi]. The PL must be re-adjusted to ensure that the fan reaches the desired fan speed to satisfy the cooling needs of the system. HPRV setting must be always at least 30 bar [435 psi] higher than PL setting.

For more information necessary to properly size and configure a hydraulic fan drive system, see *Hydraulic Fan Drive Design Guidelines* **AB152886482265**.

Warning

Use in other systems could result in unintended movement of the machine or it's elements. Loss of the input signal to this control will cause the pump to produce maximum flow.
The FDC is for Fan Drive systems only!

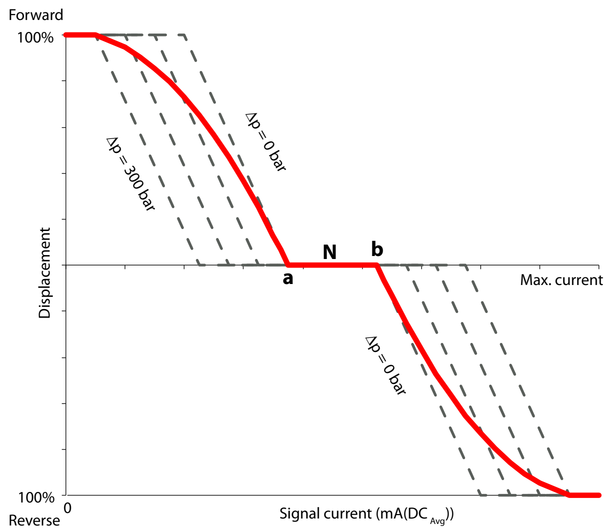
Due to the fail-safe functionality of the FDC control the pump will stroke to max. displacement in case the input signal to the pump control and the Diesel engine will be switched off at the same time. In this situation a low loop event can occur which may damage the pump. Therefore, it's strictly recommended to keep the input signal to the pump control alive while switching off the engine.

For further information please contact your Danfoss representative.

Control Options

Control Signal Requirements, FDC 210/250/280

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash plate angle as system pressure increases. A typical response characteristic is shown in the accompanying graph below:



a – Forward threshold

b – Reverse threshold

N – Neutral override current

Control current requirements

Voltage*	a	N	b	Pin config.
12 V_{DC}	780 mA	1100 mA	1300 mA	any order
24 V_{DC}	400 mA	550 mA	680 mA	

* Factory test current, for fan movement expect higher or lower value.

Control Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Control Options

Single Pump Output Flow Direction

Pump output flow direction vs. control signal

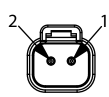
Shaft rotation		**ClockWise**			**CounterClockWise**		
Control Logic	**12 V**	**0-780 mA**	**1100 mA**	**1300-1800 mA**	**0-780 mA**	**1100 mA**	**1300-1800 mA**
	24 V	**0-400 mA**	**550 mA**	**680-920 mA**	**0-400 mA**	**550 mA**	**680-920 mA**
Port A		in	no flow	out	out	no flow	in
Port B		out	no flow	in	in	no flow	out
Servo port pressurized		M5	n/a	M4	M5	n/a	M4

Warning

Loss of input signal to the control will cause the pump to produce maximum flow.

Connector

Connector DEUTSCH, 2-pin



Description	**Quantity**	**Order data**
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

Control response

H1P controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm^2/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

Response Time, FDC 210/250/280

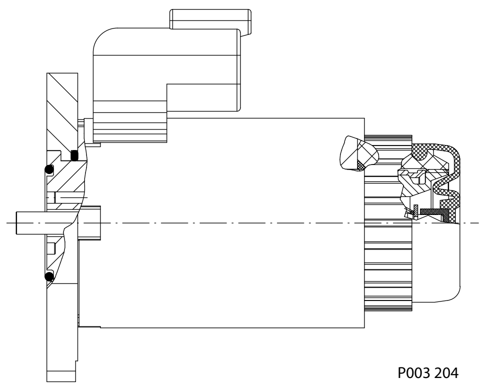
Stroking direction	**0.8 mm [0.03 in] orifice**
Full flow to neutral	3.9 s
Full forward flow to full reverse flow	5.6 s

Control Options

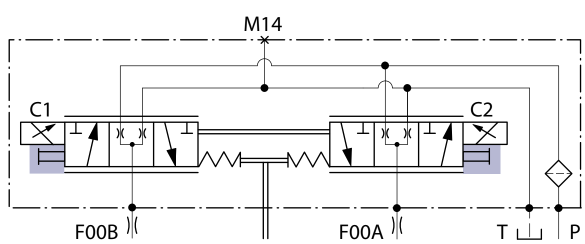
Manual Override (MOR)

All controls are available with a manual override functionality, either as a standard or as an option for temporary actuation of the control to aid in diagnostics.

Control with manual override



MOR schematic (EDC control shown)



Feedback from swash plate.

The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke. The MOR should be engaged anticipating a full stroke response from the pump.

An o-ring seal is used to seal the MOR plunger where initial actuation of the function will require a force of 45 N to engage the plunger. Additional actuation typically require less force to engage the MOR plunger.

Proportional control of the pump using the MOR should not be expected.

Warning

Unintended MOR operation will cause the pump to go into stroke; *example:* vehicle lifted off the ground. The vehicle or device must always be in a safe condition when using the MOR function.

Refer to control flow table for the relationship of solenoid to direction of flow.

Control Options

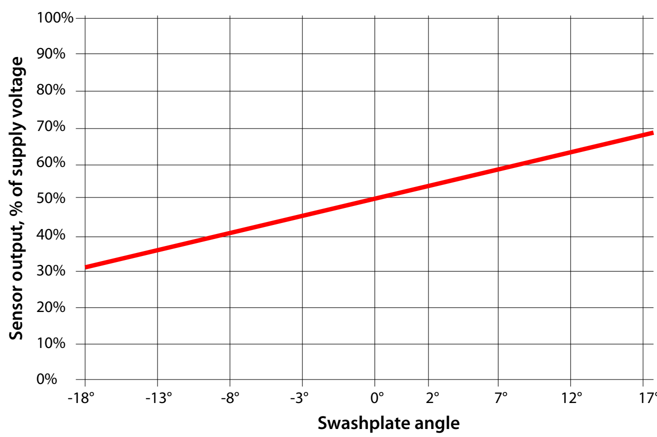
Swashplate angle sensor for EDC controls

The angle sensor detects the swash plate position with an accuracy dependent upon the calibration effort done for the application and direction of rotation from the neutral position. At minimum the sensor can be used for forward, neutral and reverse (FNR) detection.

The sensor works on the hall-effect technology. The implemented technology is based on a measurement of the magnetic field direction in parallel to the chip surface. This field direction is converted to a voltage signal at the output.

Enhanced calibration of the non-linear behavior leads to more exact calculation of the pump swashplate angle. The 4-pin DEUTSCH connector is part of the sensor housing. The swashplate angle sensor is available for all EDC controls for 12 V and 24 V.

Swashplate angle vs. output of supply voltage



Warning

Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

Contact your Danfoss representative in case the angle sensor will be used for safety functions.

Swash plate angle sensor parameters (EDC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.5 V_{DC}	5 V_{DC}	5.5 V_{DC}
Supply protection	–	–	18 V_{DC}
Pump neutral output (% of supply voltage)	–	50%	–
Working range (swash plate angle)	–18°	–	18°
Required supply current	–	–	30 mA
Output current signal	–	9 mA	11 mA
Working temperature	–40 °C	80 °C	115 °C

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector
EMC Immunity	ISO 11452-2	100 V/m

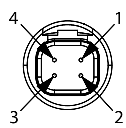
Control Options

Calibration of the sensor output within the software is mandatory. Vehicle neutral thresholds in the software (±0.5°) are vehicle dependent and must consider different conditions, example: system temperature, system pressure and/or shaft speed.

For safety function: If the sensor fails (invalid signal <10% or >90% of supply voltage), it must be sure that the ECU will go into a diagnostic mode and shift into limited mode in order for the driver to take the full control or the mechanical breaks should be activated. Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

H1P Swash Plate Angle Sensor Connector

Connector DEUTSCH, 4-pin



1 Ground (GND)

2 Not connected

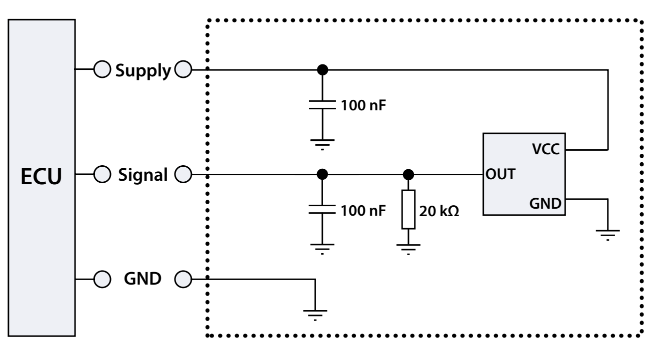
3 Output signal 1 (SIG 1)

4 Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Interface with ECU (EDC)

Interface with ECU diagram

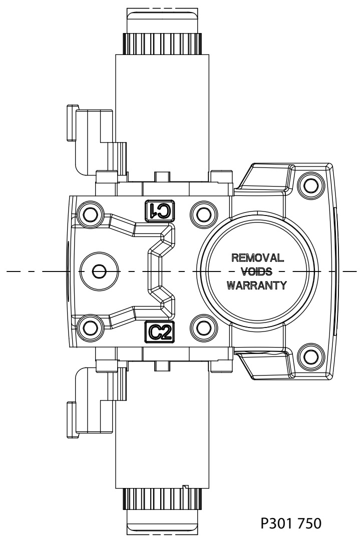


Control Options

Swash Plate Angle Sensor for NFPE and AC2 Controls

The angle sensor detects the swash plate angle position and direction of rotation from the zero position. The swash angle sensor works on the AMR sensing technology. Under the saturated magnetic field, the resistance of the element varies with the magnetic field direction.

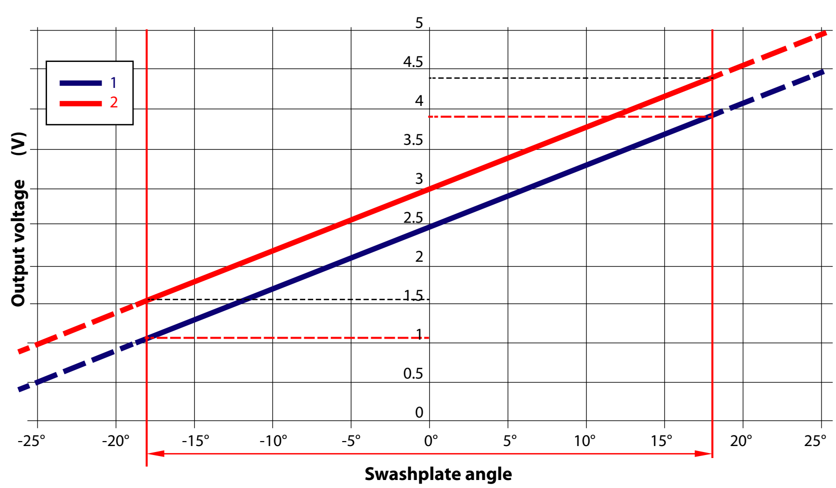
The output signal give a linear output voltage for the various magnet positions in the sensing range.



Swash Plate Angle Characteristic

The volumetric losses depend on pump max. displacement, actual displacement, speed, delta pressure, viscosity and temperature.

Swashplate angle vs. output voltage (calibrated at 50 °C)



1. Signal 1 (nominal)
2. Signal 2 (redundant)

The displacement can be calculated by:

$$V = \frac{\tan\alpha \cdot V}{\tan 18°} \ (cm^3)$$

The corresponding flow is:

$$Q = \frac{V \cdot n \cdot \eta_{vol}}{1000} \ (l/min)$$

Control Options

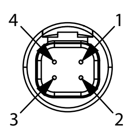
Swash Plate Angle Sensor Parameters (NFPE/AC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.75 V	5 V	5.25 V
Supply protection	–	–	28 V
Supply current	–	22 mA	25 mA
Output current (Signal 1, 2)	–	0.1 mA	–
Short circuit output current to supply or GND[1)]	–	–	7.5 mA
Sensitivity	70.0 mV/deg	78.0 mV/deg	85.8 mV/deg
Working range (swash plate angle)	−18°	0°	18°
Correlation between signals 1 and 2[2)]	475 mV	500 mV	525 mV

[1)] Up to duration of 2.5 seconds at 25°C

[2)] Signal 1 (nominal) is lower than signal 2 (redundant)

H1P Swash Plate Angle Sensor Connector (NFPE)



1 Ground (GND)

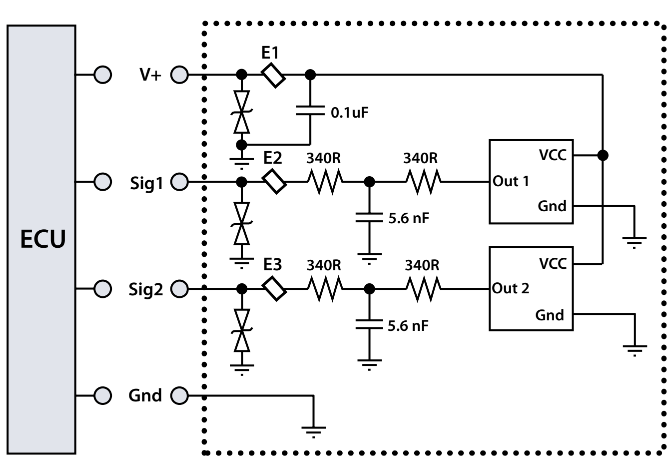
2 Output Signal 2 (SIG 2) – Secondary (redundant)

3 Output signal 1 (SIG 1)

4 Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Interface with ECU (NFPE)



Minimum recommended load resistance is 100 kΩ.

Control Options

Control Cut Off Valve (CCO)

The H1 pump offers an optional control cut off valve integrated into the control. All EDC, NFPE and MDC controls are available with a CCO valve. This valve will block charge pressure to the control, allowing the servo springs to de-stroke both pumps regardless of the pump´s primary control input.

There is also a hydraulic logic port, X7, which can be used to control other machine functions, such as spring applied pressure release brakes. The pressure at X7 is controlled by the control cut off solenoid. The X7 port would remain plugged if not needed.

In the normal (de-energized) state of the solenoid charge flow is prevented from reaching the controls. At the same time the control passages and the X7 logic port are connected and drained to the pump case. The pump will remain in neutral, or return to neutral, independent of the control input signal. Return to neutral time will be dependent on oil viscosity, pump speed, swashplate angle, and system pressure.

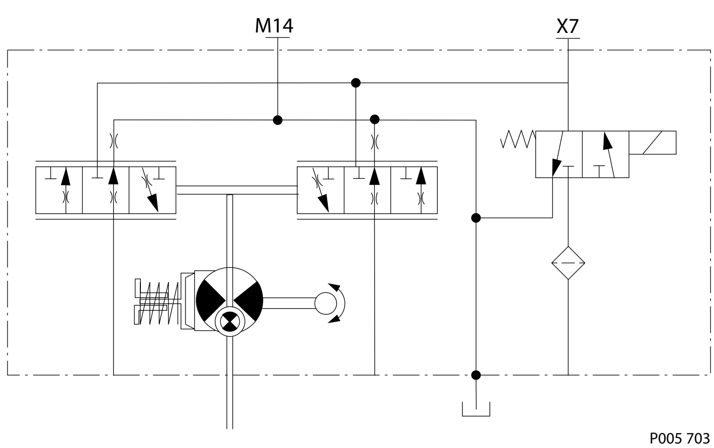
When the solenoid is energized, charge flow and pressure is allowed to reach the pump control. The X7 logic port will also be connected to charge pressure and flow.

The solenoid control is intended to be independent of the primary pump control making the control cut off an override control feature. It is however recommended that the control logic of the CCO valve be maintained such that the primary pump control signal is also disabled whenever the CCO valve is de-energized. Other control logic conditions may also be considered.

The CCO valve is available with 12 V or 24 V solenoid.

The response time of the unit depends on the control type and the used control orifices.

CCO schematic (MDC shown)



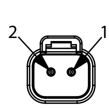
Brake gauge port with MDC

Caution

It is not recommended to use brake port for any external flow consumption to avoid malfunction of CCO function.

CCO Connector (MDC)

Connector DEUTSCH, 2-pin

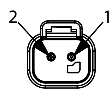


Control Options

Description	Quantity	Order data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16–18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

H1P CCO Connector (EDC, NFPE)

Connector CCO DEUTSCH, 2-pin with key C



Description	Quantity	Order number
Mating connector	1	DEUTSCH DT06-2S-C015
Wedge lock	1	DEUTSCH W2SC-P012
Socket contact	4	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	11212714

CCO solenoid data

Nominal supply voltage		**12 V**	**24 V**
Supply voltage	**Maximum**	14.6 V	29 V
	Minimum	9.5 V	19 V
Bi-directional diode cut off voltage		28 V	53 V
Nominal coil resistance at 20 °C		10.7 Ω	41.7 Ω
Supply current	**Maximum**	850 mA	430 mA
	Minimum	580 mA	300 mA
PWM frequency	**Range**	50 – 200 Hz	
	Preferred	100 Hz	
Electrical protection class		IP67 / IP69K with mating connector	

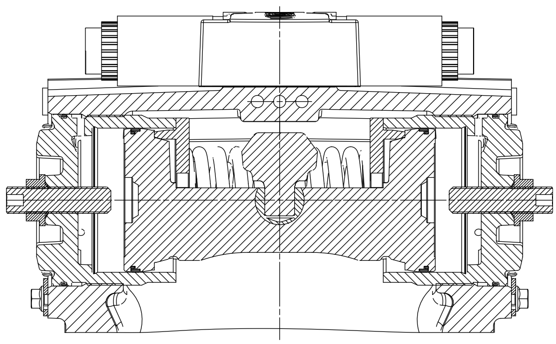
CCO solenoids are design for battery voltage application within the voltage range in the table above, in consideration of a wide range of environmental temperature common for known hydraulic applications. Closed loop PWM current supply can be also applied and is helpful in case that the voltage range is exceeded, or ambient temperature could rise in an unusual manner.

Control Options

Displacement Limiter

H1 pumps are designed with optional mechanical displacement (stroke) limiters factory set to max. displacement. The maximum displacement of the pump can be set independently for forward and reverse using the two adjustment screws to mechanically limit the travel of the servo piston down to 50% displacement.

Adjustments under operating conditions may cause leakage. The adjustment screw can be completely removed from the threaded bore if backed out to far.



P003 266

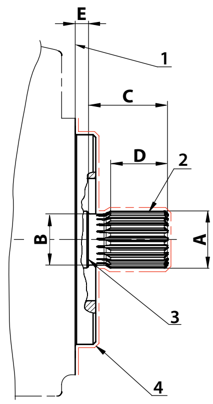
H1P 210/250/280 Displacement Change (approximately)

Parameter	Size 210	Size 250	Size 280
1 turn of displacement limiter screw	17.4 cm^3 [1.06 in^3]	20.6 cm^3 [1.26 in^3]	23.1 cm^3 [1.41 in^3]
Internal wrench size	6 mm		
External wrench size	22 mm		
Torque for external hex seal lock nut	80 N·m [708 lbf·in]		

For more information, see *H1 Axial Piston Pumps, Service Manual*, **AX152886482551**, the section “Displacement Limiter Adjustment”.

Dimensions and Data

H1P Input Shaft Option G2 (SAE E, 27 teeth)



1. Mounting flange 165 – 4 per ISO 3019-1 (SAE J744–E); surface to be paint free
2. **Spline Data:** 27 teeth, Pressure angle: 30°, Pitch: 8/16, Ø42.863 [1.688]; Fillet root side fit per ANSI B92.1-1996, Class 5
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø44.36 ±0.09 [1.746 ±0.004]	Ø36.4 ±0.025 [1.433 ±0.01]	67.0 ±0.8 [2.638 ±0.03]	42.0 ±0.5 [1.654 ±0.02]	8.05 ±0.8 [0.317 ±0.03]

[1)] Minimum active spline length for the specified torque ratings.

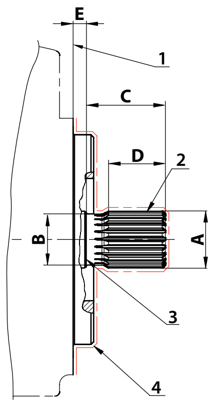
Torque rating

Rated torque	Maximum torque
1615 N•m [14 300 lbf•in]	3000 N•m [26 550 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P Input Shaft Option G3 (SAE E, 13 teeth)



1. Mounting flange 165 – 4 per ISO 3019-1 (SAE J744–E); surface to be paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 8/16, Ø41.275 [1.625]; Fillet root side fit per ANSI B92.1-1996, Class 5
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø44.36 ±0.09 [1.746 ±0.004]	Ø36.4 ±0.025 [1.433 ±0.01]	67.0 ±0.8 [2.638 ±0.03]	39.5 [1.555]	8.05 ±0.8 [0.317 ±0.03]

1) Minimum active spline length for the specified torque ratings.

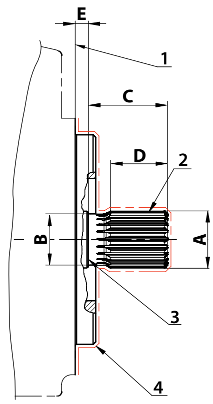
Torque rating

Rated torque	Maximum torque
1442 N•m [12 800 lbf•in]	2206 N•m [19 500 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P Input Shaft Option F8 (SAE E, 17 teeth)



1. Mounting flange 165 – 4 per ISO 3019-1 (SAE J744–E); surface to be paint free
2. **Spline Data:** 17 teeth, Pressure angle: 30°, Pitch: 8/16, Ø48.26 [1.9]; Fillet root side fit per ANSI B92.1-1996, Class 5
3. Coupling must not protrude beyond this point
4. Shaft to be paint free

Dimensions

A	B	C	D[1)]	E
Ø57.15 ±0.09 [2.25 ±0.004]	Ø48.6 ±0.025 [1.913 ±0.01]	80.0 ±0.8 [3.15 ±0.03]	52.5 ±0.5 [2.067 ±0.02]	8.025 ±0.8 [0.36 ±0.03]

[1)] Minimum active spline length for the specified torque ratings.

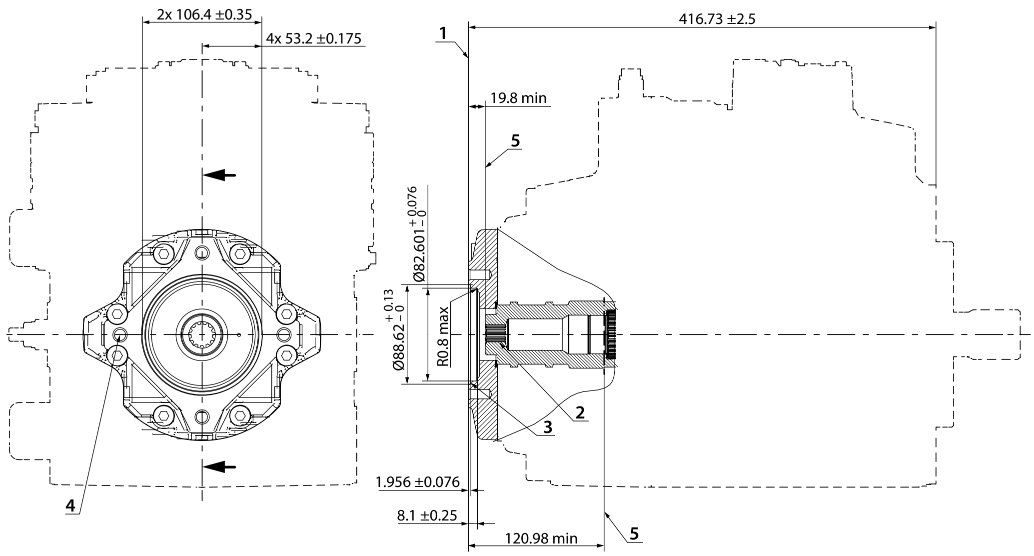
Torque rating

Rated torque	Maximum torque
3226 N•m [28 553 lbf•in]	5946 N•m [52 627 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Dimensions and Data

H1P Auxiliary Mounting, Option H1 (SAE A, 11 teeth)



1. Auxiliary mounting pad for mating flange 82-2 per ISO 3019-1 (SAE A); Paint free
2. **Spline Data:** 11 teeth, Pressure angle: 30°, Pitch: 16/32, Ø17.463 [0.6875]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 10.5 mm
3. O-ring seal required; Ref. Ø82.22 [3.237] ID x 2.62; cross section
4. Thread: M10x1.5-6H; 15 [0.59] min. depth; Recommended screw-in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	296 N•m [2620 lbf•in]

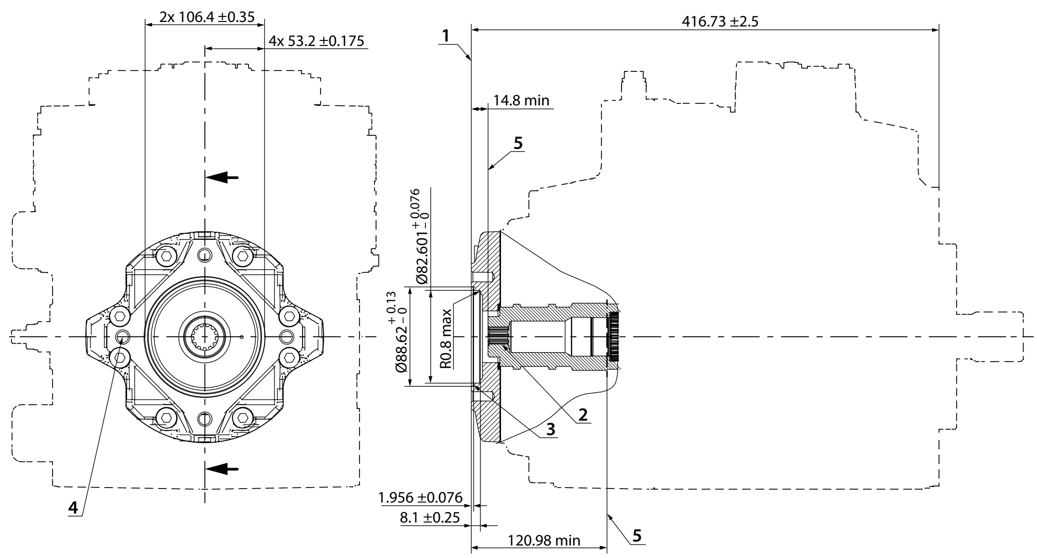
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H2 (SAE A, 9 teeth)



1. Auxiliary mounting pad for mating flange 82-2 per ISO 3019-1 (SAE A); Paint free
2. **Spline Data:** 9 teeth, Pressure angle: 30°, Pitch: 16/32, Ø14.288 [0.5625]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 8.6 mm
3. O-ring seal required; Ref. Ø82.22 [3.237] ID x 2.62; cross section
4. Thread: M10x1.5-6H; 15 [0.59] min. depth; Recommended screw-in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	162 N•m [1430 lbf•in]

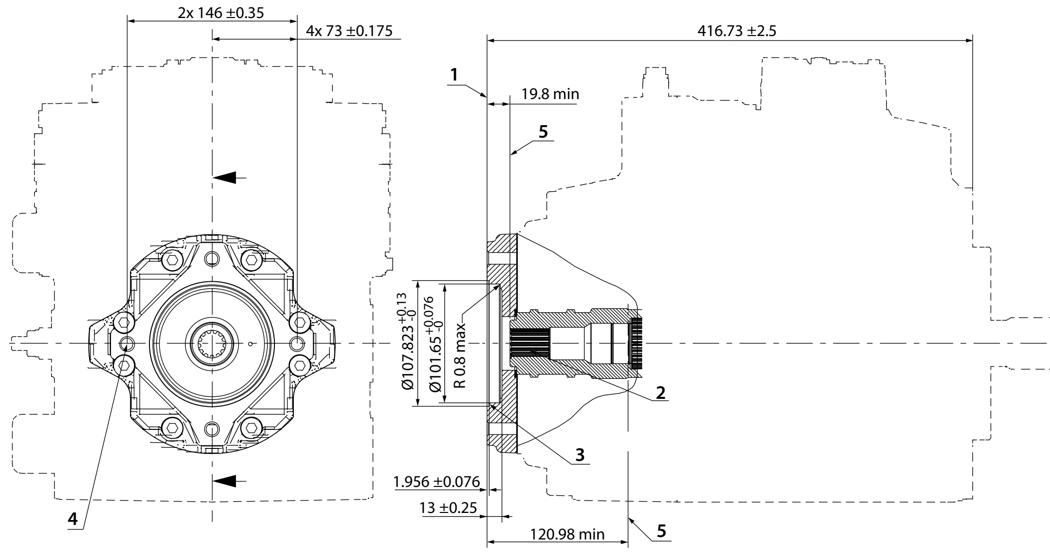
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section "Shaft Torque Ratings and Spline Lubrication".

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H3 (SAE B, 13 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 16/32, Ø20.638 [0.813]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 12.4 mm
3. O-ring seal required; Ref. Ø94.92 [3.737] ID x 2.62; cross section
4. Thread: M12x1.75-6H; 20 [0.787] min. depth; Recommended screw-in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	395 N•m [3500 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

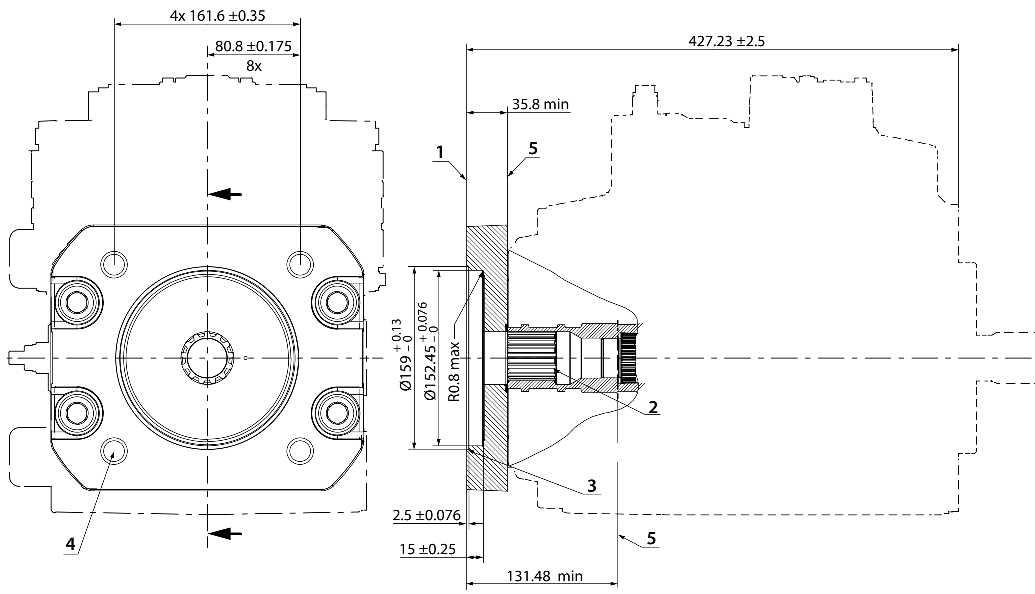
Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H4 (SAE D, 13 teeth)

Option H4, ISO 3019-1, flange 152-4 (SAE D, 13 teeth)



1. Auxiliary mounting pad for mating flange 152-4 per ISO 3019-1 (SAE D); Paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 8/16, Ø41.275; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 12.4 mm
3. O-ring seal required; Ref. Ø150 ID x 3.0; cross section
4. Thread: M20x2.5-6H; 30 min. depth; Recommended screw-in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	2206 N•m [19 525 lbf•in]

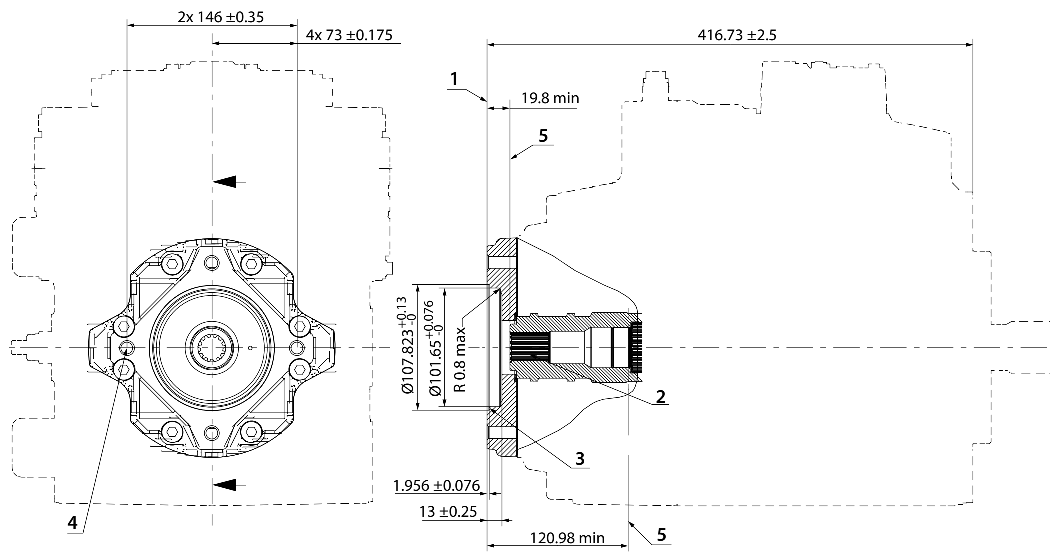
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H5 (SAE B-B, 15 teeth)



1. Auxiliary mounting pad for mating flange 101-2 per ISO 3019-1 (SAE B); Paint free
2. **Spline Data:** 15 teeth, Pressure angle: 30°, Pitch: 16/32, Ø23.813 [0.938]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 14.3 mm
3. O-ring seal required; Ref. Ø94.92 [3.737] ID x 2.62; cross section
4. Thread: M12x1.75-6H; 20 [0.787] min. depth; Recommended screw-in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum Torque	693 N•m [6130 lbf•in]

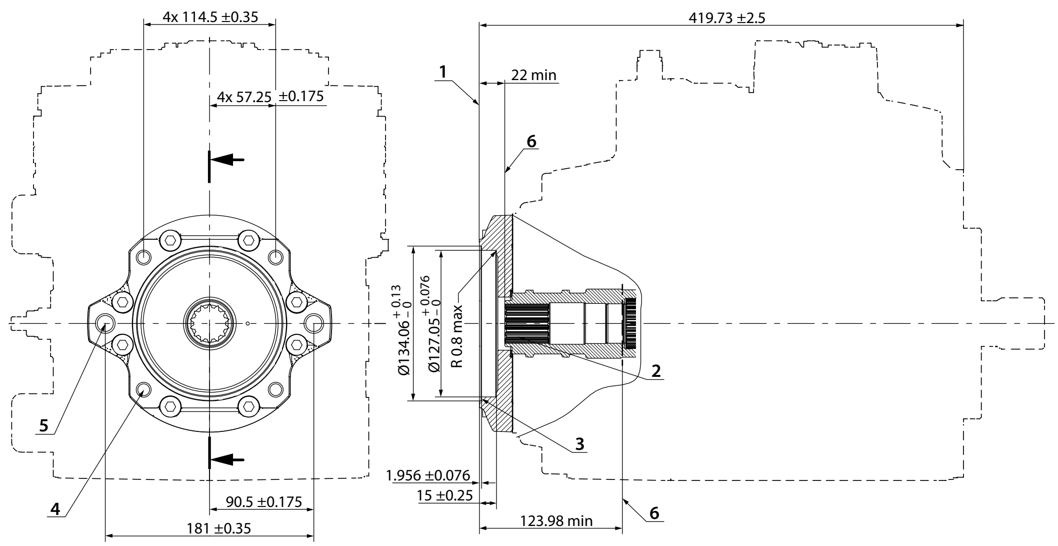
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information,* **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option H6 (SAE C, 14 teeth)



1. Auxiliary mounting pad for mating flange 127-4 per ISO 3019-1 (SAE C); Paint free
2. **Spline Data:** 14 teeth, Pressure angle: 30°, Pitch: 12/24, Ø29.633 [1.667]; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 17.8 mm
3. O-ring seal required; Ref. Ø120.32 ID x 2.62; cross section
4. Thread: M12x1.75-6H; 21 [0.827] min. depth; Recommended screw-in depth 1.5 x thread dia (4x)
5. Thread: M16x2-6H; 25 [0.984] min. depth; Recommended screw-in depth 1.5 x thread dia (2x)
6. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum torque	816 N•m [7220 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

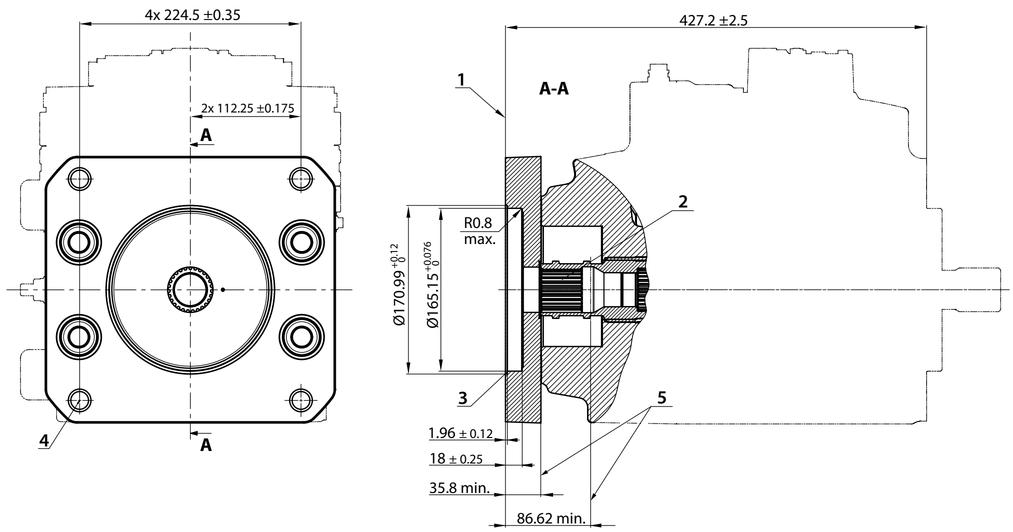
Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option E1 (SAE E, 13 teeth)

Option E1, ISO 3019-1, flange 165-4 (SAE E, 13 teeth)



1. Auxiliary mounting pad for mating flange 165-4 per ISO 3019-1 (SAE E); Paint free
2. **Spline Data:** 13 teeth, Pressure angle: 30°, Pitch: 8/16, Ø41.275; Fillet root side fit per ANSI B92.1-1996, Class 6; minimum active spline length 12.4 mm
3. O-ring seal required; Ref. Ø164.77 ID x 2.62; cross section
4. Thread: M20x2.5-6H; 36 min. depth; Recommended screw-in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum torque	2206 N•m [19 525 lbf•in]

For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

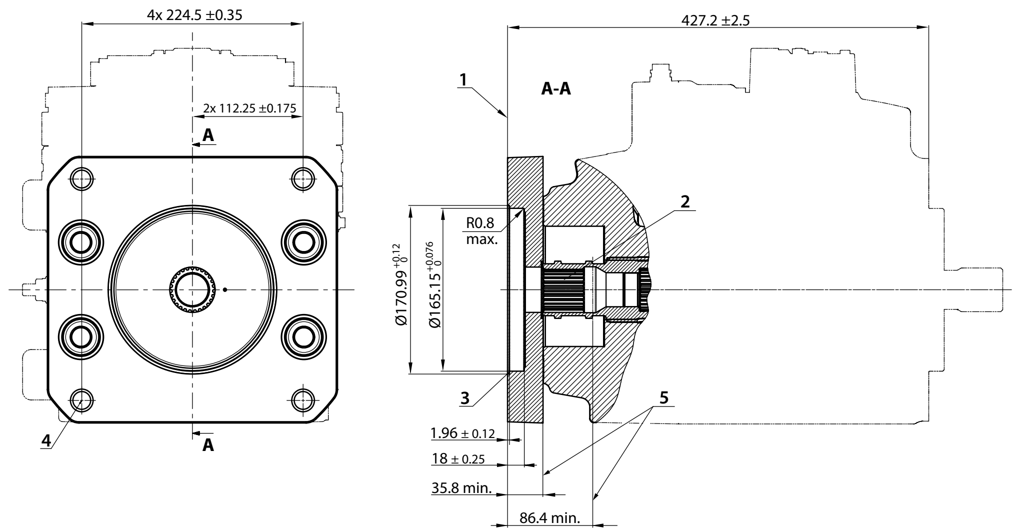
Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Auxiliary Mounting, Option E2 (SAE E, 27 teeth)

Option E2, ISO 3019-1, flange 165-4 (SAE E, 27 teeth)



1. Auxiliary mounting pad for mating flange 165-4 per ISO 3019-1 (SAE E); Paint free
2. **Spline Data:** 27 teeth, Pressure angle: 30°; Pitch: 16/32, Ø42.863; Fillet root side fit per ANSI B92.1b-1996, Class 6; min. active spline length 25.7 mm
3. O-ring seal required; Ref. Ø164.77 ID x 2.62; cross section
4. Thread: M20x2.5-6H; 36 min. depth; Recommended screw-in depth 1.5 x thread dia (4x)
5. Mating shaft and shaft shoulder must not protrude beyond this point

Maximum torque	3360 N•m [29 739 lbf•in]

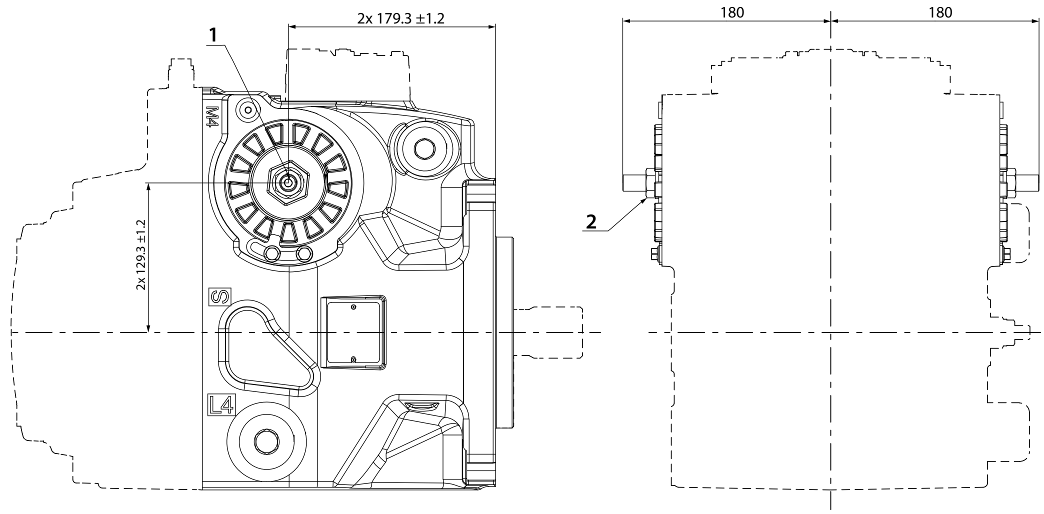
For definitions of maximum and rated torque values, refer to *H1 Axial Piston Pumps Basic Information*, **BC152886483968**, the section “Shaft Torque Ratings and Spline Lubrication”.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions and Data

H1P Displacement Limiter, Option B



1. Displacement limiter screw (2x)
2. Displacement limiter seal nut (2x)

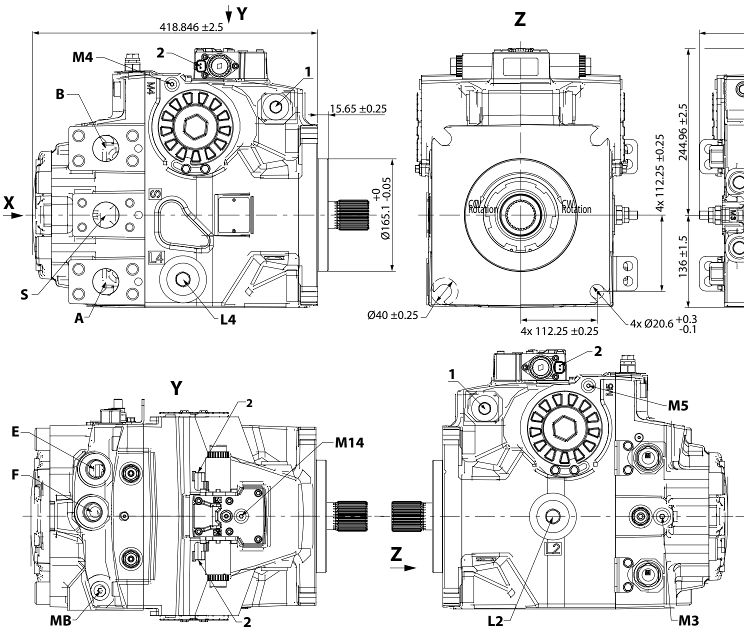
Wrench size, torque

Wrench size for DL screw	Wrench size for DL seal nut	Torque
6 internal hex	22 external hex	80 N•m [708 lbf•in]

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Single Pump Ports



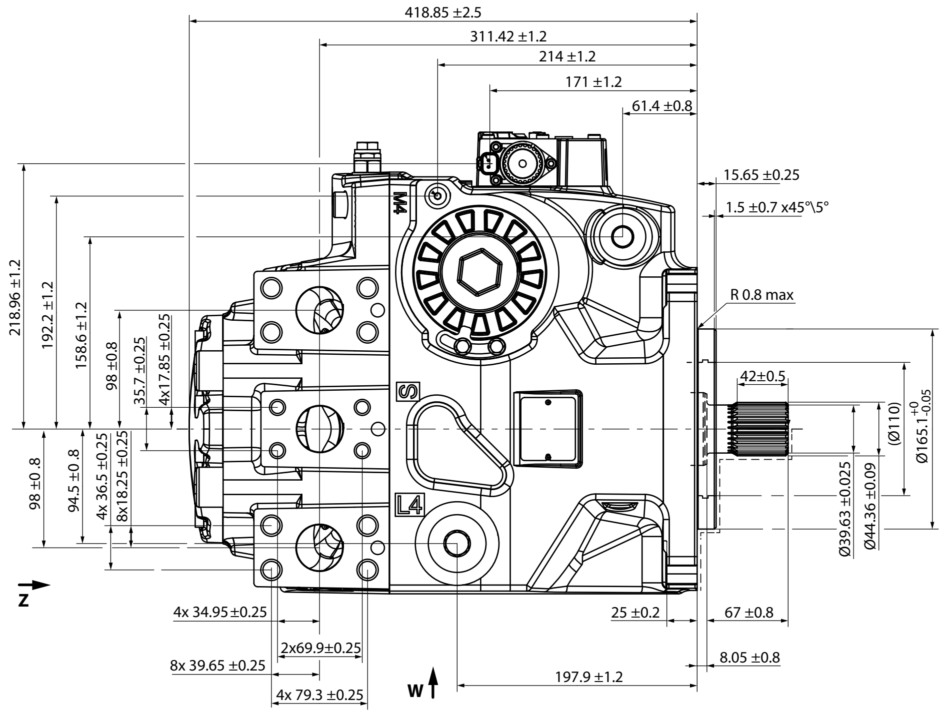
Ports per ISO 11 926-1

Port	Description	Size
A, B	System ports	Ø38 mm, 450 bar split flange boss per ISO 6162, M16 x 2; 27 min. full thread depth Recommended screw in depth 1.5 x thread dia
L2, L4	Case drain ports	$1\frac{5}{8}$–12
MA, MB	System **A/B** gauge ports	$\frac{9}{16}$–18
E/F	Charge filtration ports	$1\frac{1}{16}$–12
M3	Charge pressure gauge port	$\frac{9}{16}$–18
M4, M5	Servo gauge port	$\frac{7}{16}$–20
M14	Case gauge port (EDC, FNR, NFPE)	$\frac{7}{16}$–20
S	Charge inlet port	Ø38 mm, 350 bar split flange boss per ISO 6162, M12 x 1.75; 21 min. full thread depth Recommended screw in depth 1.5 x thread dia
1	Case pressure port	$1\frac{5}{16}$–12
2	Connector DEUTSCH DT04-2P, to be paint free	

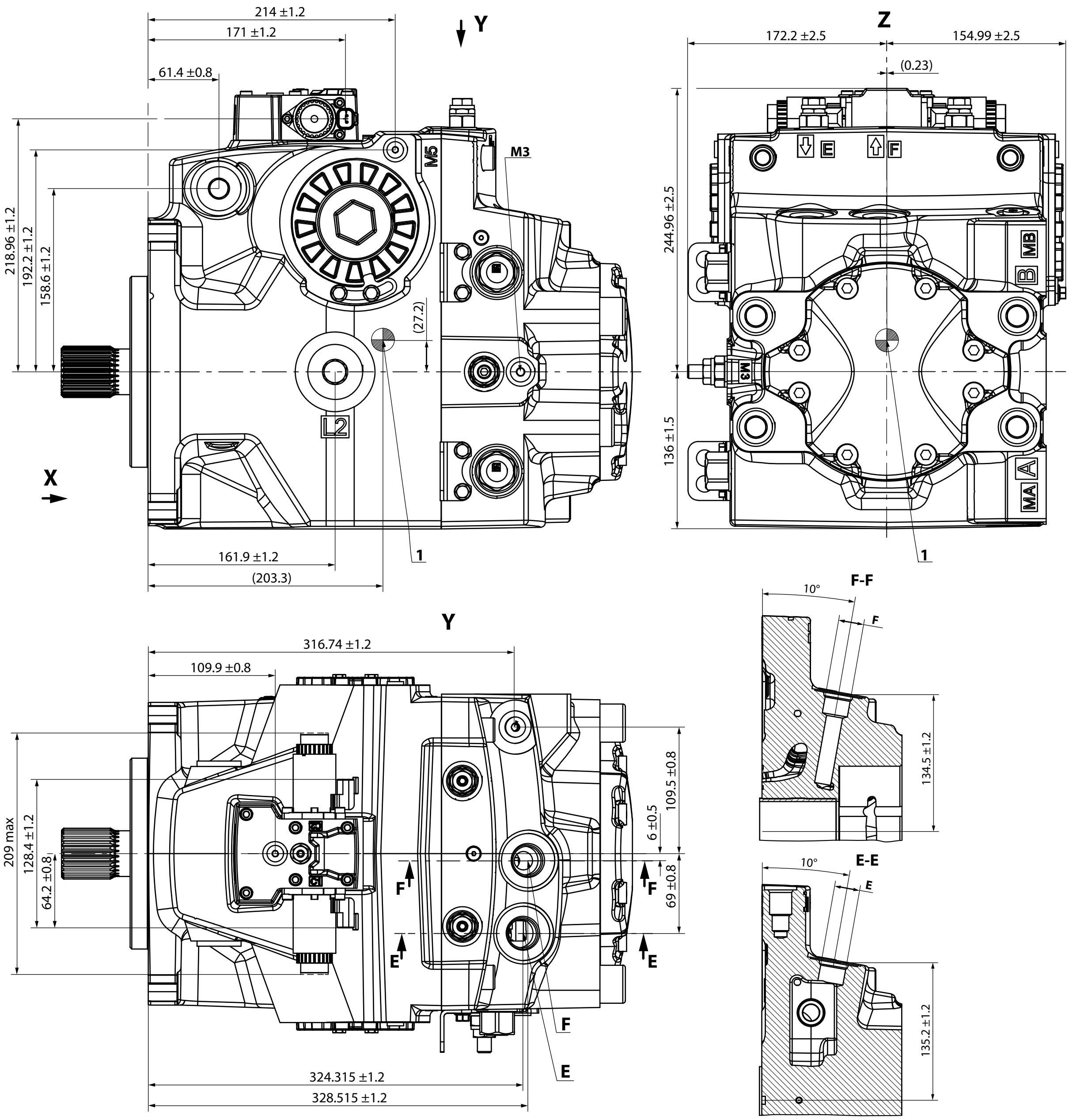
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

H1P Dimensions

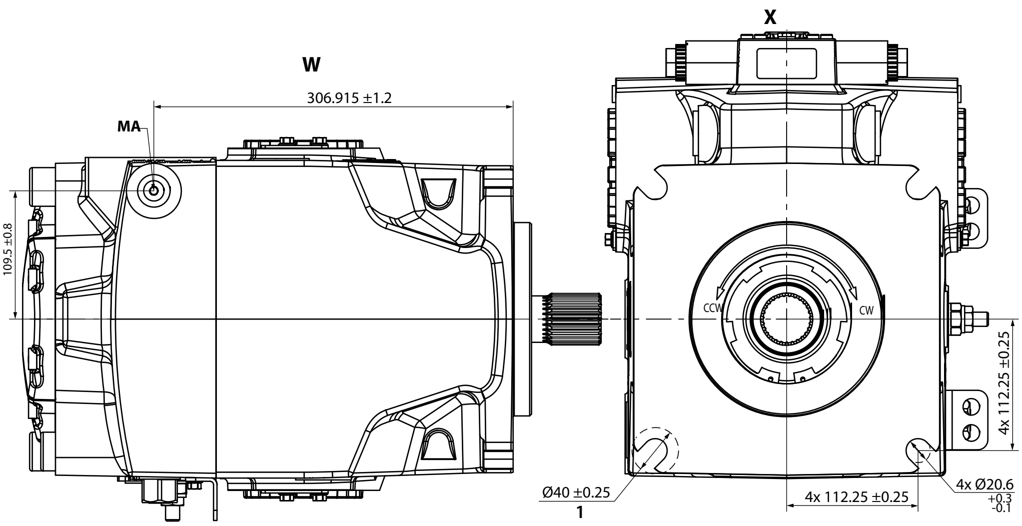


Dimensions and Data



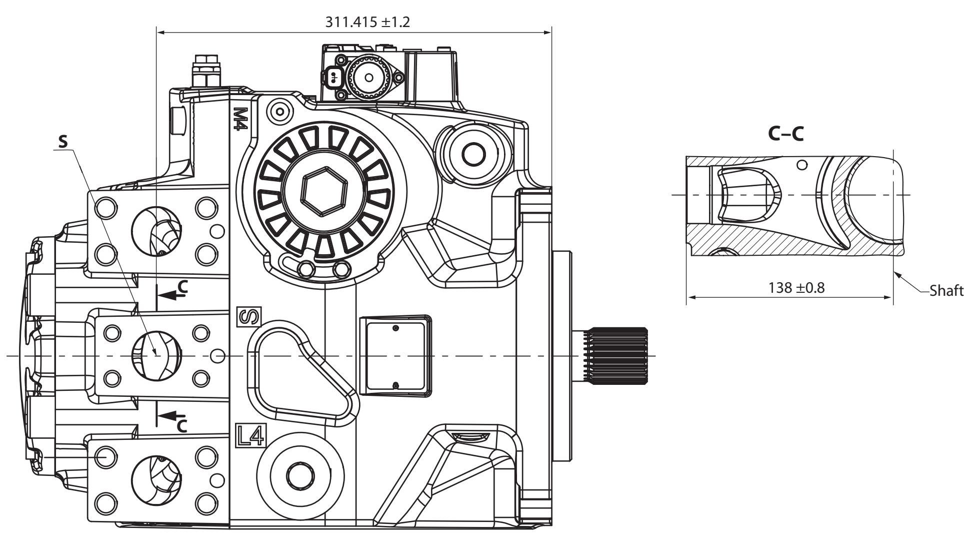
1 — Approximate center of gravity

Dimensions and Data



1 — Other side screw head space

H1P 210/250/280 Suction Filtration Option L

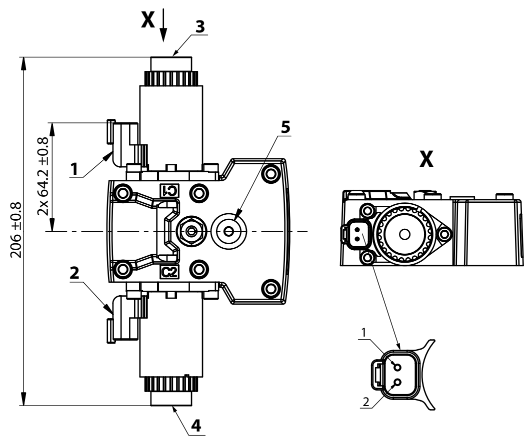


S Charge pump inlet port split flange boss per ISO 6162; M12 x 1.75; 21 min full thread depth

Dimensions and Data

Controls

EDC Options A2 and A3 (12/24 V)



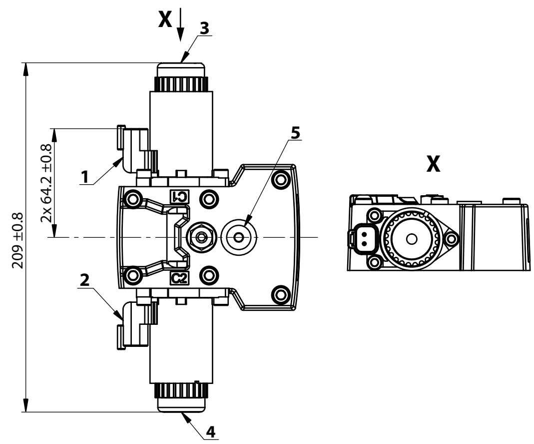
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

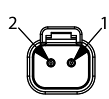
EDC with MOR, Options A4 and A5 (12/24 V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}\!/_{16}$–20

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

*Connector **C1/C2**: DEUTSCH DTM04-2P*

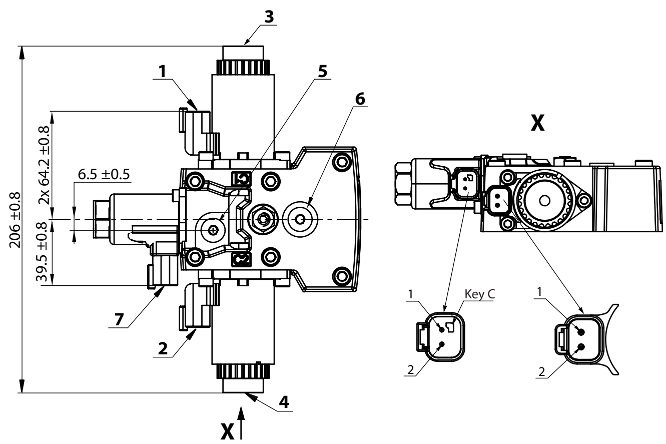


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

EDC with CCO (key C), Options E7 and E8 (12/24 V)



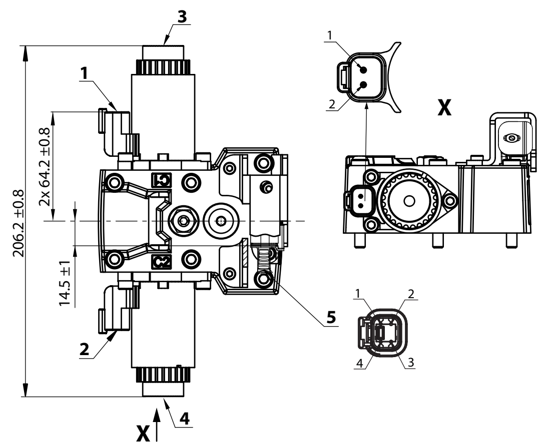
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
6. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

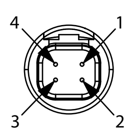
Dimensions and Data

EDC with ASNSR, Options: H2 and H3 (12/24 V)



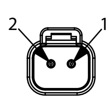
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Angle sensor connector **S2** DEUTSCH DT04-4P, paint free

Connector DEUTSCH, 4-pin



4-pin assignment:
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connector C1/C2: DEUTSCH DTM04-2P

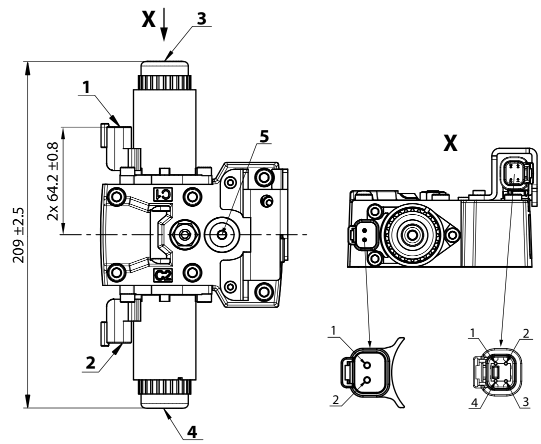


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

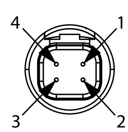
Dimensions and Data

EDC with MOR and ASNSR, Options H6 and H7 (12/24 V)



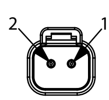
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^7/_{16}$–20

Connector DEUTSCH, 4-pin



4-pin assignment:
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connector C1/C2: DEUTSCH DTM04-2P

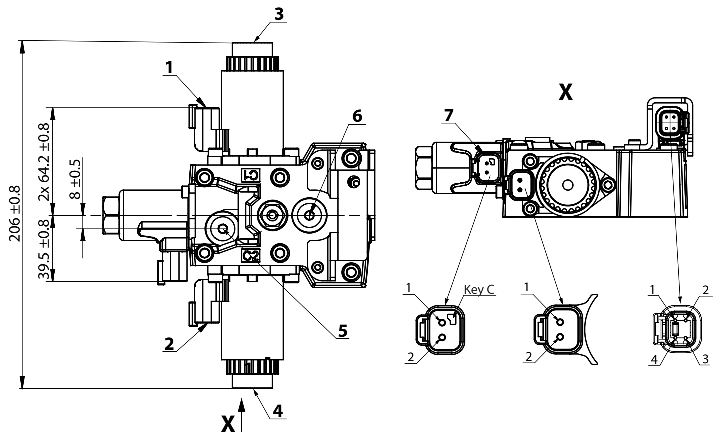


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

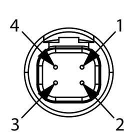
EDC with CCO and ASNSR, Options H8 and H9 (12/24 V)



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
6. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

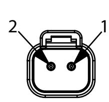
Connector DEUTSCH, 4-pin



Angle sensor connector S2: DEUTSCH DTM04-4P

1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connectors C1/C2/C4: DEUTSCH DTM04-2P

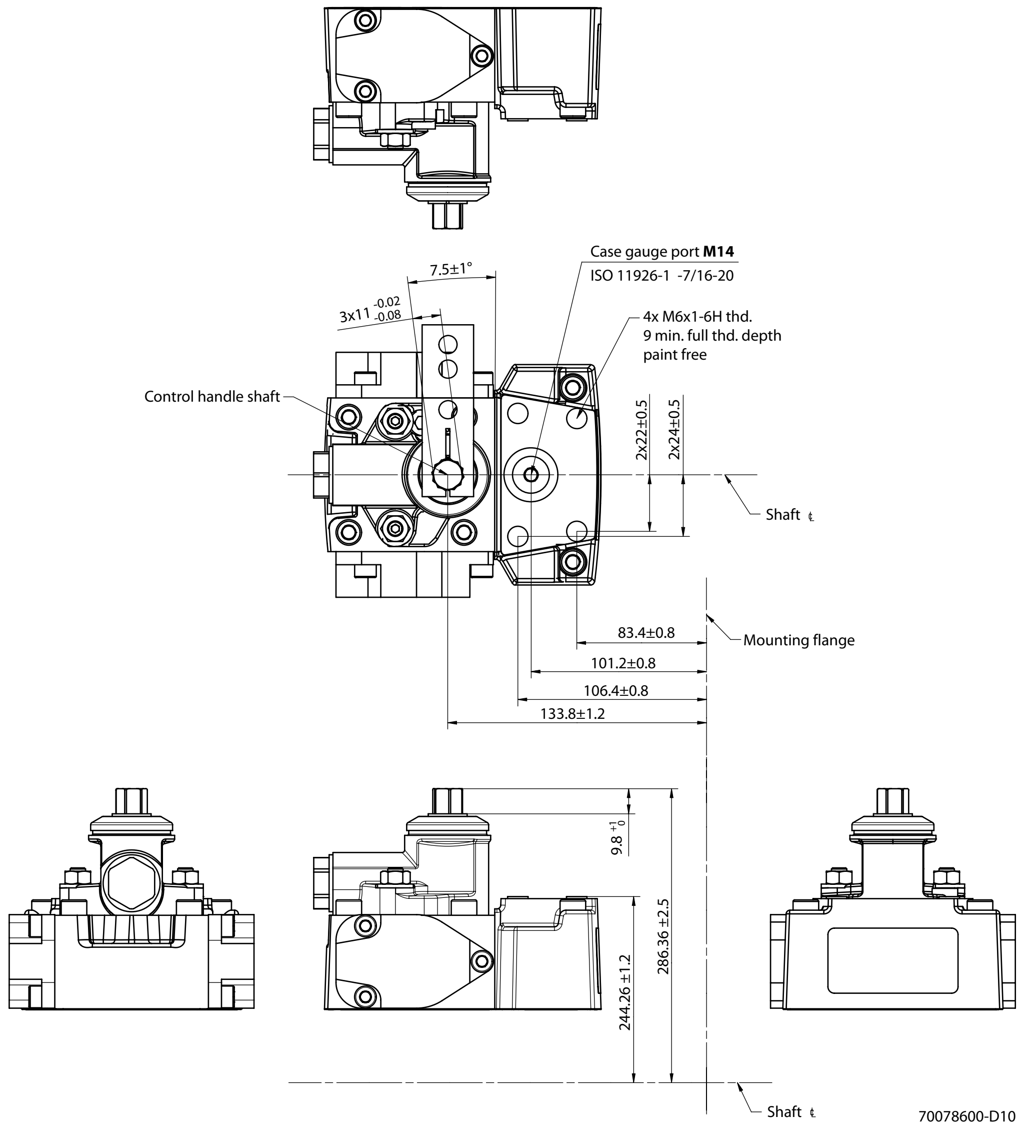


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

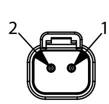
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC Option: M1



Connector DEUTSCH, 2-pin

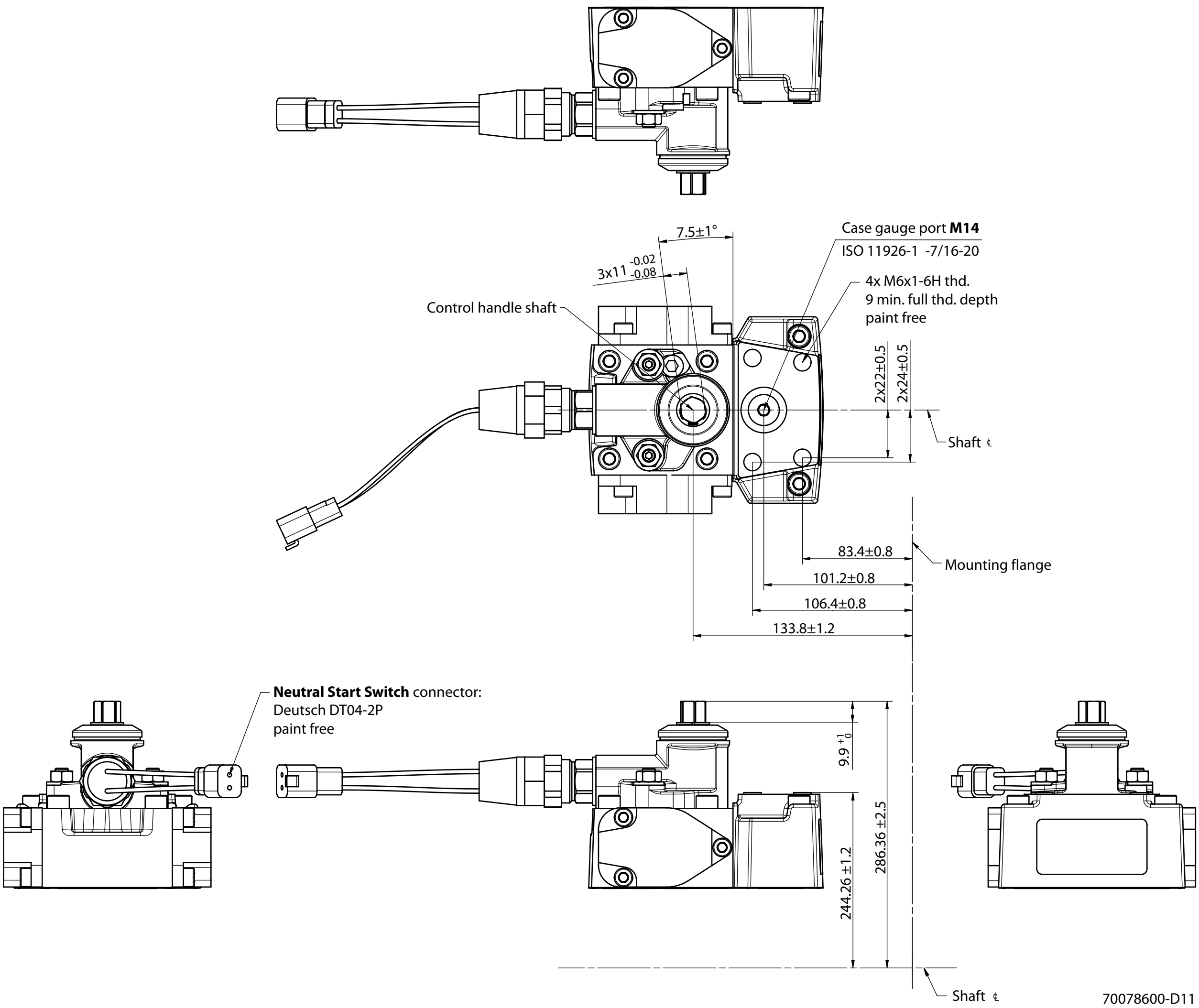


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

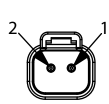
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with Neutral Start Switch Option: M2



Connector DEUTSCH, 2-pin

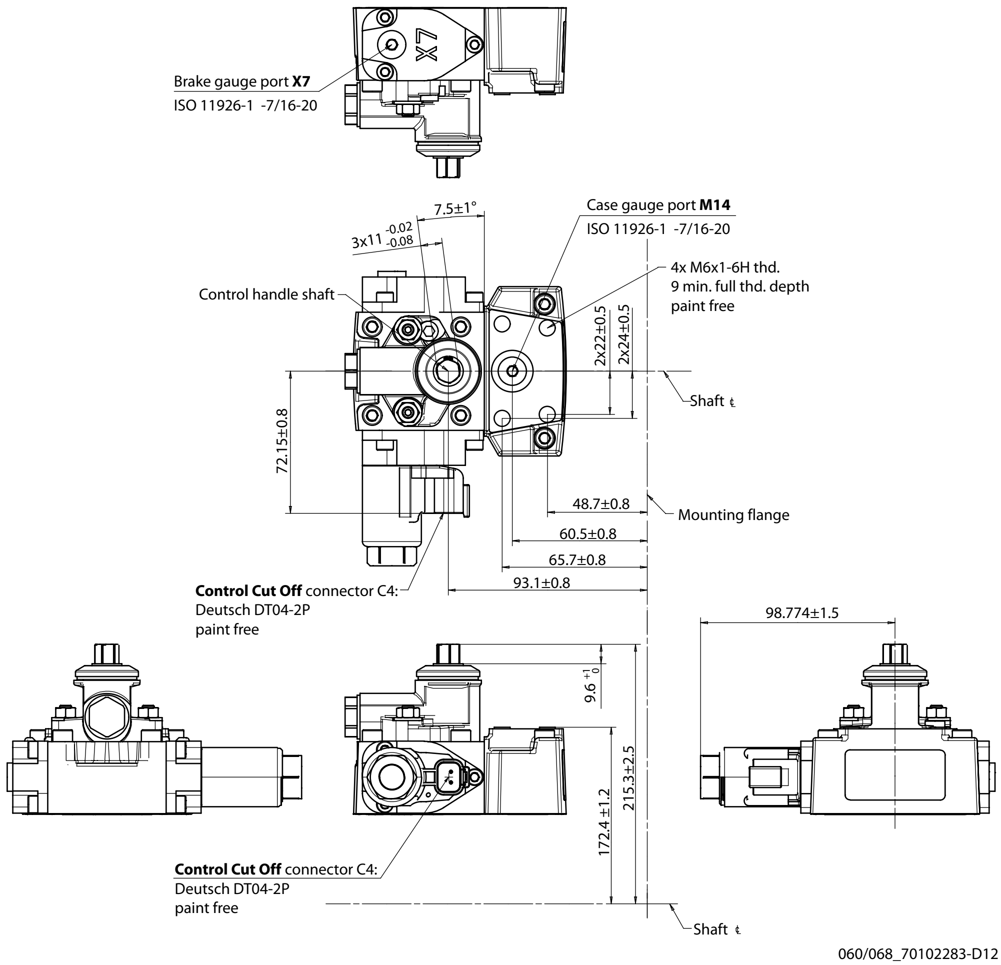


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

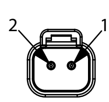
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with CCO, Options: M3, M4



Connector DEUTSCH, 2-pin

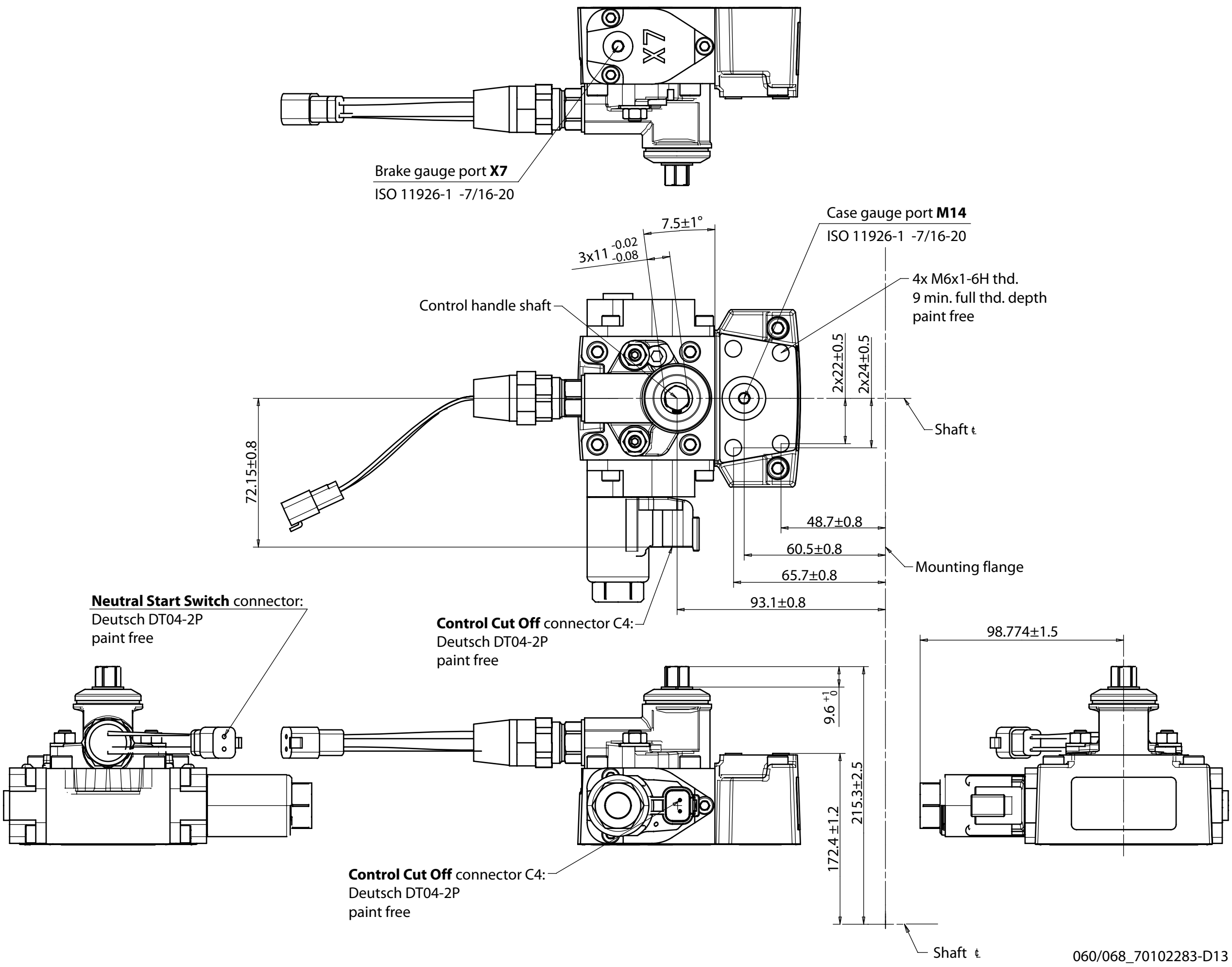


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

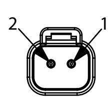
Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

MDC with NSS and CCO Options: M5, M6



Connector DEUTSCH, 2-pin



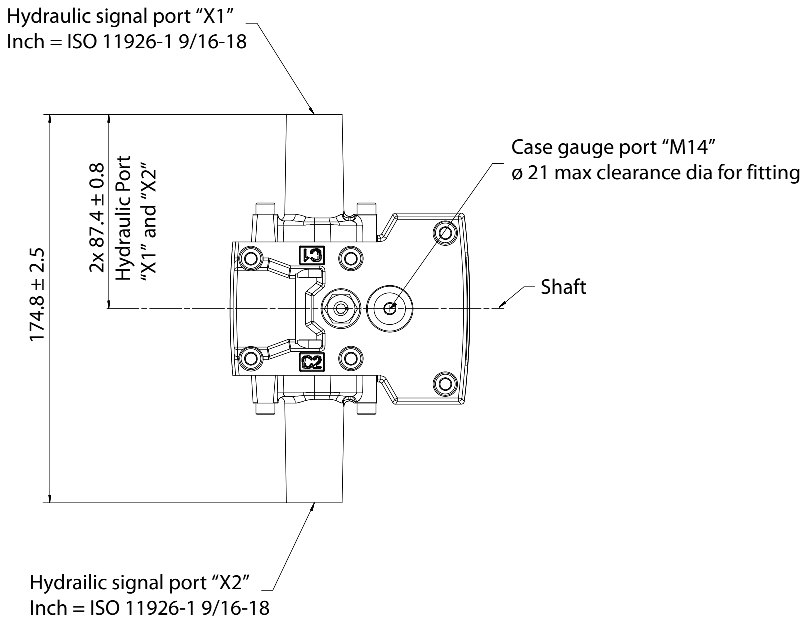
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

H1P HDC, Options: T1, T2

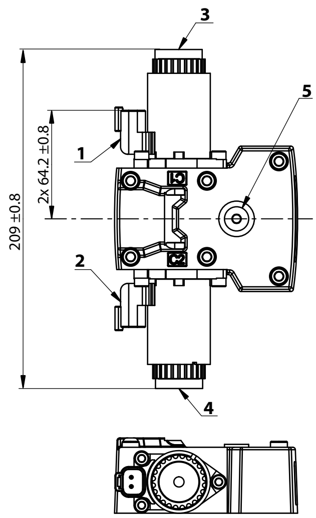
Dimensions in mm



Dimensions and Data

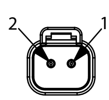
NFPE with MOR, Options: N1, N2 (12/24 V)

Non-Feedback Proportional Electric control with Manual Over Ride options N1 (12 V) and N2 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20

*Control solenoid connectors **C1/C2** DEUTSCH DTM04-2P pin/assignment*



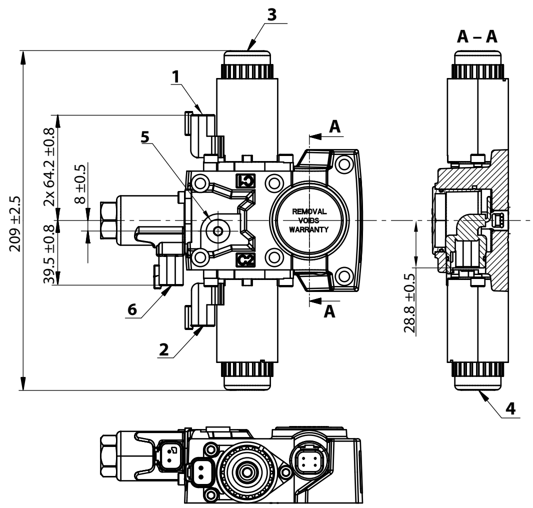
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

NFPE with MOR, CCO, ASNSR, Options: N3, N4 (12/24 V)

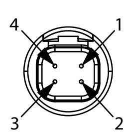
Non-Feedback Proportional Electric control with Control-Cut-Off valve with key C, Manual Over Ride and Angle Sensor, options N3 (12 V) and N4 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
6. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

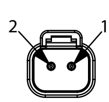
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Control solenoid connectors **C1/C2/C4** DEUTSCH DTM04-2P pin/assignment*



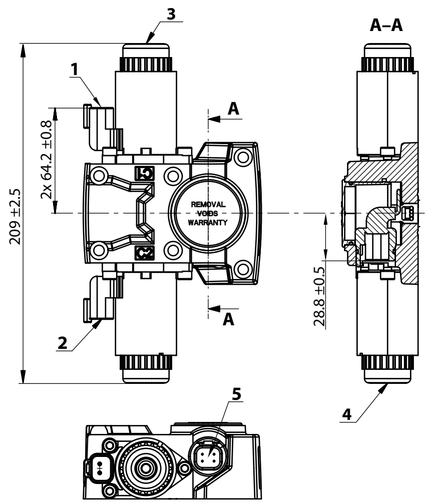
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

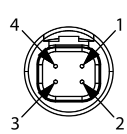
NFPE with MOR and ASNSR, Options: N5, N6 (12/24 V)

Non-Feedback Proportional Electric control with Manual Over Ride and Angle Sensor, options N5 (12 V) and N6 (24 V).



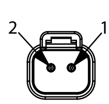
1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Angle sensor connector **S2** DEUTSCH DT04-4P, paint free

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

Control solenoid connectors C1/C2 DEUTSCH 2-pin/assignment



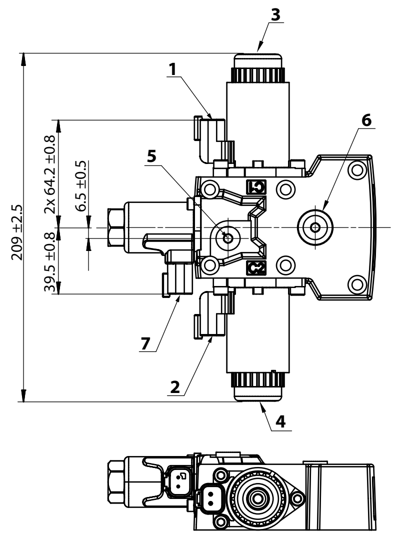
Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

NFPE with MOR and CCO, Options: N7, N8 (12/24 V)

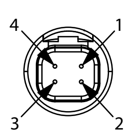
Non Feedback Proportional Electric control with Manual Over Ride and Control-Cut-Off valve key C, options N7 (12 V) and N8 (24 V).



1. Control solenoid connector **C1** DEUTSCH DT04-2P, paint free
2. Control solenoid connector **C2** DEUTSCH DT04-2P, paint free
3. Control Manual OverRide **C1**
4. Control Manual OverRide **C2**
5. Brake gauge port **X7** per ISO 1926-1: $^{7}/_{16}$–20
6. Case gauge port **M14** per ISO 1926-1: $^{7}/_{16}$–20
7. Control-Cut-Off with C-key connector **C4** DEUTSCH DT04-2P, paint free

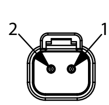
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Connector DEUTSCH, 4-pin



Pin/assignment:
1. Ground (GND)
2. Output Signal 2 (SIG2) – Secondary (redundant)
3. Output signal 1 (SIG 1)
4. Supply (V+)

*Control solenoid connectors **C1/C2** DEUTSCH DTM04-2P pin assignment*

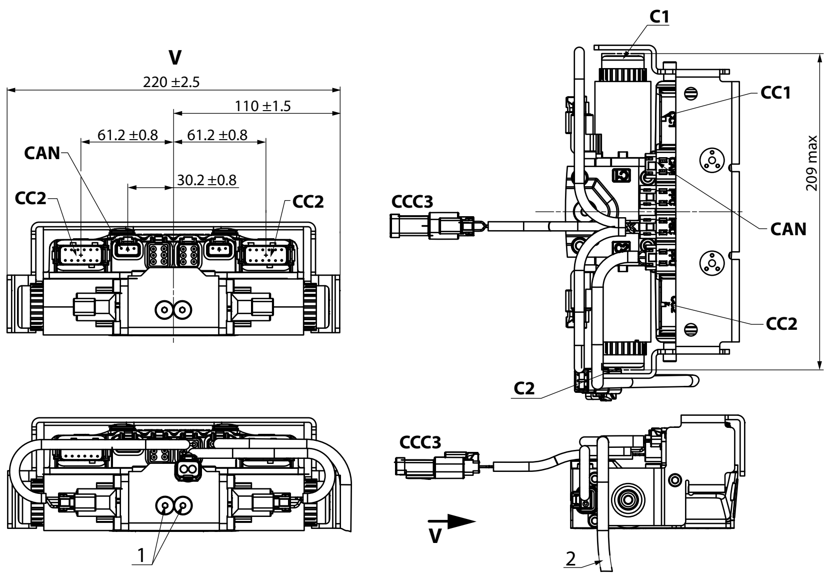


Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

Automotive control (AC)



1 Plug removing can cause contamination issues

2 PPU wire harness is factory installed to speed sensor

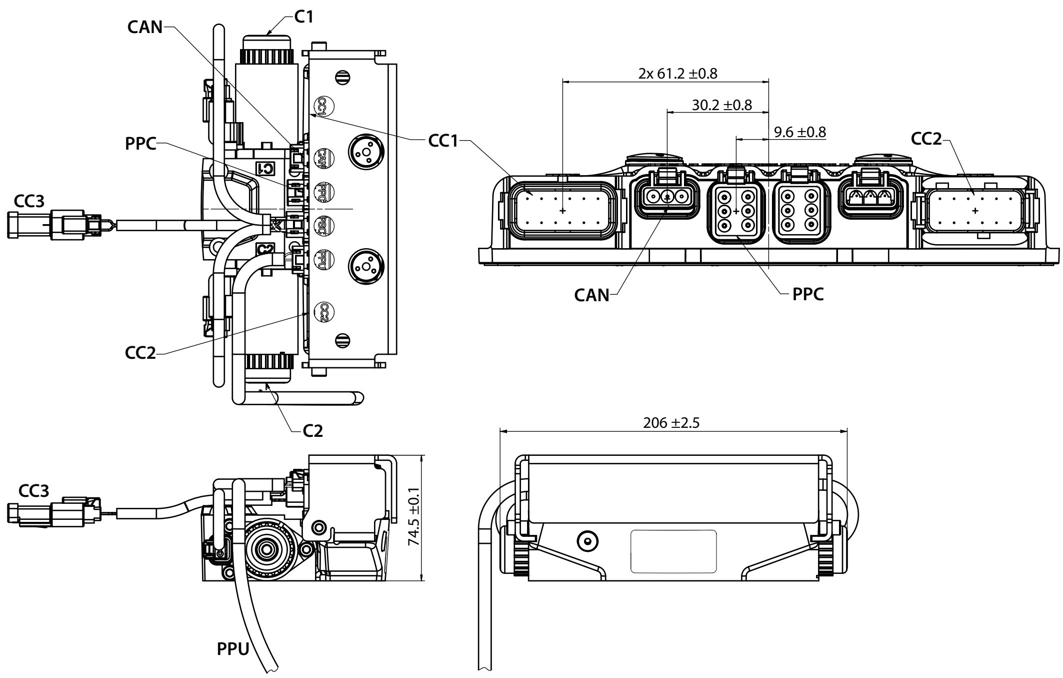
Connectors description

Port	Description
C1 and C2	**1.** Control manual override **C1** **2.** Control Manual Override **C2**
CC1	Port A control connector DEUTSCH DTM04-12P; paint free
CC2	Port B control connector DEUTSCH DTM04-12P; paint free
CC3	Control connector DEUTSCH DT06-2S; paint free; For using connector, the plug may be removed.
CAN	Control connector DEUTSCH DTM04-3P; paint free; For using connector, the plug may be removed.

Please contact Danfoss representative for specific installation drawings.

Dimensions and Data

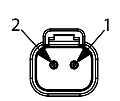
AC connectors dimensions



PPU wire harness is factory installed to speed sensor.

CC3

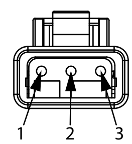
Connector DEUTSCH, 2-pin



1. Digital output A1 (+)
2. Digital output A2 (-)

CAN

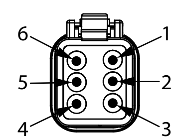
Connector DEUTSCH, 3-pin



1. CAN High
2. CAN Low
3. CAN Shield

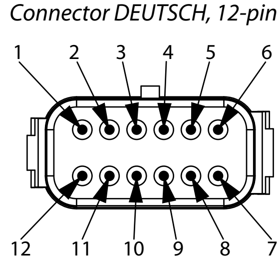
PPC

Connector DEUTSCH, 6-pin



1. Sensor A (+)
2. Analog input A
3. Sensor A (-)
4. Sensor B (-)
5. Analog input B
6. Sensor B (+)

Connector DEUTSCH, 12-pin



CC1

1. Battery (-)
2. Battery (+)
3. Sensor (+)
4. Sensor (-)
5. Motor rpm input (frequency)
6. Forward input (digital)
7. Reverse input (digital)
8. Sensor (+)
9. Sensor (-)
10. Drive pedal input (analog – nominal)
11. Drive pedal input (analog – red)
12. Neural input (digital)

CC2

1. Inch input (analog – red)
2. Mode switch B input (digital – nominal)
3. Motor prop/PCOR driver
4. Motor direction input (analog)
5. Sensor (+)
6. Sensor (-)
7. Inch input (analog – nominal)
8. Motor BPD driver
9. Digital output B2 (-)
10. Digital output B1 (+)
11. Mode switch A input (digital)
12. Mode switch B input (digital – red)

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