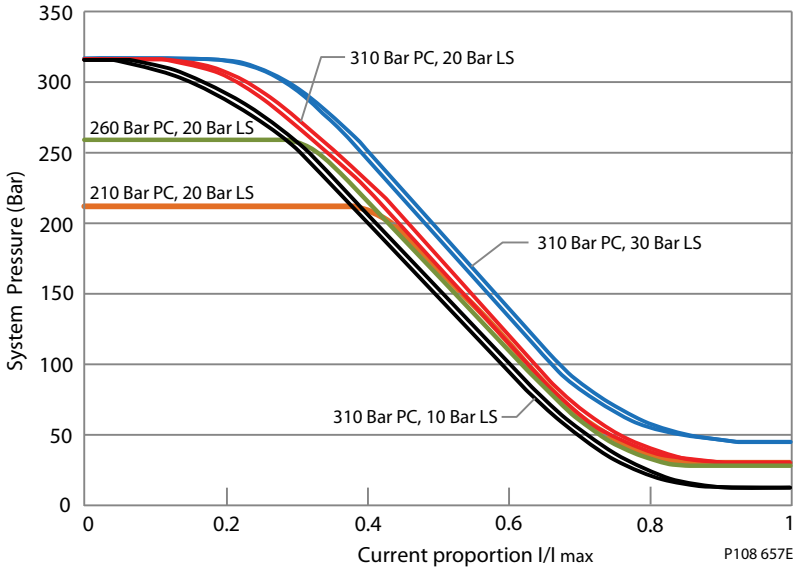
General Information

Operating Pressure vs. Input Current (N.C. EPC)



Solenoid Data – Normally Closed

Voltage	**12V**	**24V**
Maximum Current	1800 mA	920 mA
Inrush Current	1700 mA	800 mA
Coil Resistance @ 20°C [70°F]	7.1 Ω	28.5 Ω
PWM Range	200-300 Hz	
PWM Frequency (preferred)	250 Hz	
IP Rating (IEC 60529 | DIN 40050-9)	IP67	IP67
IP Rating (IEC 60529 | DIN 40050-9) with mating connector	IP69K	IP69K
Operating Temperature	Consistent with Pump Limits: -40°C (-40°F) to 104°C (220°F)	

The available Normally Closed Electric Proportional Controls for the Series 45 are shown below. The allowable Pressure Compensator (PC) and Load Sense (LS) pressure settings are provided for each frame in their respective sections.

Electric Proportional Controls Options – Normally Closed		**Frame**					
Code	Description	L	K	K2	J	F	E
AH	Electric Proportional Pressure Control w/Pressure Comp. (NC, 12VDC) Left			•	•	•	•
AL	Electric Proportional Pressure Control w/Pressure Comp. (NC, 24VDC) Left			•	•	•	•
AV	Electric Proportional Pressure Control w/Pressure Comp. (NC, 12VDC) Right				•	•	•
AK	Electric Proportional Pressure Control w/Pressure Comp. (NC, 24VDC) Right				•	•	•
BH	Electric Proportional Pressure Control w/Pressure Comp. (NC, 12VDC) [>280 bar] Left				•	•	•
BL	Electric Proportional Pressure Control w/Pressure Comp. (NC, 24VDC) [>280 bar] Left				•	•	•

General Information

Electric Proportional Controls Options – Normally Closed		Frame					
BM	Electric Proportional Pressure Control w/Pressure Comp. (NC, 12VDC) [>280 bar] Right				•	•	•
BK	Electric Proportional Pressure Control w/Pressure Comp. (NC, 24VDC) [>280 bar] Right				•	•	•
EM	Electric Proportional Pressure Control w/Pressure Comp. (NC, 12VDC)	•	•				
EN	Electric Proportional Pressure Control w/Pressure Comp. (NC, 24VDC)	•	•				

Notes:

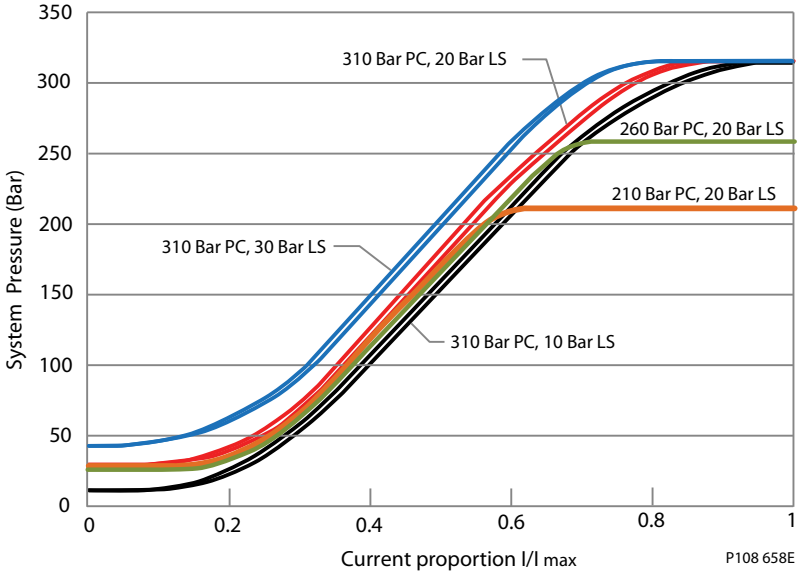
1. Left = E-Frame: CW Only, F-Frame: CW Only, J-frame: CW Axial, CCW Radial
2. Right = E-Frame: CCW Only, F-Frame: CCW Only, J-frame: CCW Axial, CW Radial
3. K/L Frame Controls are not rotation dependent
4. K2 Frame electric controls are limited only for Left orientation and up to 260 Bar

Electric Proportional Control Characteristic – Normally Open

When an electric current is sent to the normally open configuration control, the pump pressure increases proportional to an increase in current. When the load in the system changes, the pump will adjust its displacement to maintain the pressure demanded by the controlling current. This control is especially useful for fan-drives, due to the direct relationship between fan-speed and pump pressure.

Due to the nature of Electric Proportional Controls, the relationship between current and pump pressure is unique for each individual PC/LS pressure setting combination. The relationship between different PC settings and different LS settings on the Pressure vs. Current Characteristic curve are shown below. The hydraulic schematic for the Normally Open Electric Proportional control is shown below as well.

Operating Pressure vs. Input Current (N.O. EPC)



Solenoid Data – Normally Open

Voltage	12V	24V
Maximum Current	1500 mA	665 mA
Inrush Current	1700 mA	800 mA
Coil Resistance @ 20°C [70°F]	7.1 Ω	28.5 Ω

General Information

Solenoid Data – Normally Open (continued)

Voltage	**12V**	**24V**
PWM Range	200-300 Hz	
PWM Frequency (preferred)	250 Hz	
IP Rating (IEC 60529 | DIN 40050-9)	IP67	IP67
IP Rating (IEC 60529 | DIN 40050-9) with mating connector	IP69K	IP69K
Operating Temperature	Consistent with Pump Limits: -40°C (-40°F) to 104°C (220°F)	

The available Normally Open Electric Proportional Controls for the Series 45 are shown below. The allowable Pressure Compensator (PC) and Load Sense (LS) pressure settings are provided for each frame in their respective sections. Note that for Electric Proportional Controls, the Load Sense setting describes the Low Pressure Standby value, not margin.

Electric Proportional Controls Options – Normally Open		**Frame**					
Code	Description	L	K	K2	J	F	E
AX	Electric Proportional Pressure Control w/Pressure Comp. (NO, 12VDC) Left			•	•	•	•
CL	Electric Proportional Pressure Control w/Pressure Comp. (NO, 24VDC) Left			•	•	•	•
AW	Electric Proportional Pressure Control w/Pressure Comp. (NO, 12VDC) Right				•	•	•
CK	Electric Proportional Pressure Control w/Pressure Comp. (NO, 24VDC) Right				•	•	•
BX	Electric Proportional Pressure Control w/Pressure Comp. (NO, 12VDC) [>280 bar] Left				•	•	•
DL	Electric Proportional Pressure Control w/Pressure Comp. (NO, 24VDC) [>280 bar] Left				•	•	•
BW	Electric Proportional Pressure Control w/Pressure Comp. (NO, 12VDC) [>280 bar] Right				•	•	•
DK	Electric Proportional Pressure Control w/Pressure Comp. (NO, 24VDC) [>280 bar] Right				•	•	•
EK	Electric Proportional Pressure Control w/Pressure Comp. (NO, 12VDC)	•	•				
EL	Electric Proportional Pressure Control w/Pressure Comp. (NO, 24VDC)	•	•				

Notes:

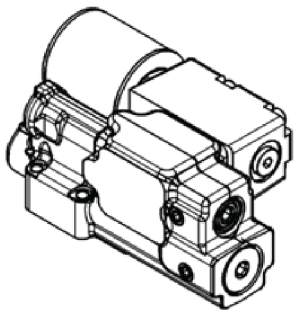
1. Left = E-Frame: CW Only, F-Frame: CW Only, J-frame: CW Axial, CCW Radial
2. Right = E-Frame: CCW Only, F-Frame: CCW Only, J-frame: CCW Axial, CW Radial
3. K/L Frame Controls are not rotation dependent
4. K2 Frame electric controls are limited only for Left orientation and up to 260 Bar

Electric On-Off Controls

PLUS+1 Compliance

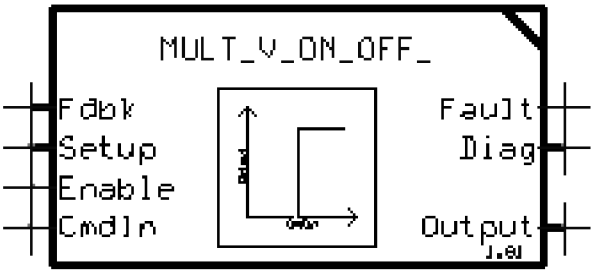
All Series 45 Electric controls have met and passed the Danfoss PLUS+1 compliance standard testing, and as such, this Series 45 control is PLUS+1 compliant. PLUS+1 compliance blocks are available on the Danfoss website, within the PLUS+1 Guide section.

General Information



Electric On-Off Control Principle

The Electric On/Off Control consists of an On/Off solenoid integrated into a Remote Pressure Compensated control. This control allows the pump to be operated at either the Load Sense pressure setting when "On", or the Pressure Compensation pressure setting when "Off".



For fan-drive systems, and systems with motors, use a minimum 15bar LS setting to enhance system stability. As the LS setting is reduced, the risk for system instability may be increased. A 20bar LS setting is recommended as a starting point for all new applications.

Electric On-Off Control Response/Recovery

S45 Electric On/Off Controls are available with two servo control orifice options, as well as without an orifice. The servo control orifice is used to enhance system stability, as well as dampen the pump reactiveness. A smaller orifice diameter will add dampening to the pump reactiveness, while a larger orifice will allow quicker pump reaction.

Module "G" Options for Electric On/Off Controls			
Frame	**"E" - 0.8mm Orifice**	**"F" - 1.0mm Orifice**	**"N" - No Orifice**
All Frames	•	•	•

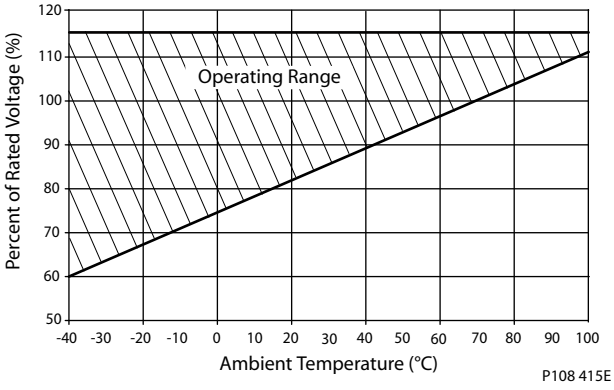
Specific Electric On/Off Control Response/Recovery times are shown for the available servo control orifice options in the control section within each specific frame section. These times represent the response from 75% of rated continuous pressure to 100% of rated continuous pressure, and recovery from 100% of rated continuous pressure to 75% of rated continuous pressure for N.C. configuration per SAE J745 (vice-versa for N.O). As the system pressure approaches the PC setting, the PC function will begin to assist in clipping pressure overshoots during the pump's response, and will decrease the response times of the pump to equal those of the PC response.

General Information

Electric On-Off Control Performance vs. Ambient Temperature Characteristic

The Electric On/Off Controls continuous duty operating temperature range is shown below; this guideline should be followed as well as the maximum current limitations. Note that rated voltage refers to either a 12V or 24V coil. Under high temperature conditions, current required to operate the solenoid increases.

Continuous Duty Operating Temperature



Electric On-Off Control Characteristic – Normally Closed

The normally closed configuration On/Off control directs the pump to its Pressure Compensation pressure setting when no current is applied. When the required electric current is sent to the normally closed configuration control the pump pressure decreases to the Low-Pressure Standby setting. This control does not have Load Sense functionality, but rather acts as a Pressure Compensation control when not energized, or is directed to its low-pressure standby when energized. This control is especially useful for machine startups, as the pump can be directed to its Low-Pressure Standby setting during startup to reduce the load on engine starters.

Solenoid Data – Normally Closed

Voltage	**12V**	**24V**
Maximum Current	1500 mA	665 mA
Inrush Current	1700 mA	800 mA
Coil Resistance @ 20°C [70°F]	7.1 Ω	28.5 Ω
PWM Range	200-300 Hz	
PWM Frequency (preferred)	250 Hz	
IP Rating (IEC 60529 | DIN 40050-9)	IP67	IP67
IP Rating (IEC 60529 | DIN 40050-9) with mating connector	IP69K	IP69K
Operating Temperature	Consistent with Pump Limits: -40°C (-40°F) to 104°C (220°F)	

The available Normally Closed Electric On/Off Controls for the Series 45 are shown below. The allowable Pressure Compensator (PC) and Load Sense (LS) pressure settings are provided for each frame in their respective sections.

Electric On/Off Controls Options – Normally Closed		**Frame**					
Code	Description	L	K	K2	J	F	E
AR	Electric On/Off Pressure Control w/Pressure Comp. (NC,12VDC) Left			•	•	•	•
CR	Electric On/Off Pressure Control w/Pressure Comp. (NC,24VDC) Left			•	•	•	•

General Information

Electric On/Off Controls Options – Normally Closed		Frame					
AG	Electric On/Off Pressure Control w/Pressure Comp. (NC,12VDC) Right				•	•	•
AY	Electric On/Off Pressure Control w/Pressure Comp. (NC,24VDC) Right				•	•	•
BR	Electric On/Off Pressure Control w/Pressure Comp. (NC,12VDC) [>280 bar] Left				•	•	•
DR	Electric On/Off Pressure Control w/Pressure Comp. (NC,24VDC) [>280 bar] Left				•	•	•
BE	Electric On/Off Pressure Control w/Pressure Comp. (NC,12VDC) [>280 bar] Right				•	•	•
BG	Electric On/Off Pressure Control w/Pressure Comp. (NC,24VDC) [>280 bar] Right				•	•	•
EB	Electric On/Off Pressure Control w/Pressure Comp. (NC,12VDC)	•	•				
EE	Electric On/Off Pressure Control w/Pressure Comp. (NC,24VDC)	•	•				

Notes:

1. Left = E-Frame: CW Only, F-Frame: CW Only, J-frame: CW Axial, CCW Radial
2. Right = E-Frame: CCW Only, F-Frame: CCW Only, J-frame: CCW Axial, CW Radial
3. K/L Frame Controls are not rotation dependent
4. K2 Frame electric controls are limited only for Left orientation and up to 260 Bar

Electric On/Off Control Characteristic – Normally Open

The Normally Open configuration On/Off control directs the pump to its Low-Pressure Standby setting when no current is applied. When the required electric current (end current) is sent to the Normally Open configuration control, the pump pressure increases to the Pressure Compensation pressure setting. This control does not have Load Sense functionality, but rather acts as a Pressure Compensation control when energized, or is directed to its Low-Pressure Standby when de-energized. This control is especially useful for machine startups, as the pump can be directed to its Low Pressure Standby setting during startup to reduce the load on engine starters.

Solenoid Data – Normally Open

Voltage	12V	24V
Maximum Current	1500 mA	665 mA
Inrush Current	1700 mA	800 mA
Coil Resistance @ 20°C [70°F]	7.1 Ω	28.5 Ω
PWM Range	200-300 Hz	
PWM Frequency (preferred)	250 Hz	
IP Rating (IEC 60529 | DIN 40050-9)	IP67	IP67
IP Rating (IEC 60529 | DIN 40050-9) with mating connector	IP69K	IP69K
Operating Temperature	Consistent with Pump Limits: -40°C (-40°F) to 104°C (220°F)	

The available Normally Open Electric On/Off Controls for the Series 45 Frame E are shown below, with the allowable Pressure Compensator (PC) pressure range provided for each control. All Electric On/Off Controls are available with the 10-40bar Load Sense (LS) setting range.

Electric On/Off Controls Options – Normally Open		Frame					
Code	Description	L	K	K2	J	F	E
AN	Electric On/Off Pressure Control w/Pressure Comp. (NO,12VDC) Left			•	•	•	•

General Information

Electric On/Off Controls Options – Normally Open		Frame					
CN	Electric On/Off Pressure Control w/Pressure Comp. (NO,24VDC) Left			•	•	•	•
AF	Electric On/Off Pressure Control w/Pressure Comp. (NO,12VDC) Right				•	•	•
AT	Electric On/Off Pressure Control w/Pressure Comp. (NO,24VDC) Right				•	•	•
BN	Electric On/Off Pressure Control w/Pressure Comp. (NO,12VDC) [>280 bar] Left				•	•	•
DN	Electric On/Off Pressure Control w/Pressure Comp. (NO,24VDC) [>280 bar] Left				•	•	•
BF	Electric On/Off Pressure Control w/Pressure Comp. (NO,12VDC) [>280 bar] Right				•	•	•
DF	Electric On/Off Pressure Control w/Pressure Comp. (NO,24VDC) [>280 bar] Right				•	•	•
EA	Electric On/Off Pressure Control w/Pressure Comp. (NO,12VDC)	•	•				
EG	Electric On/Off Pressure Control w/Pressure Comp. (NO,24VDC)	•	•				

Notes:

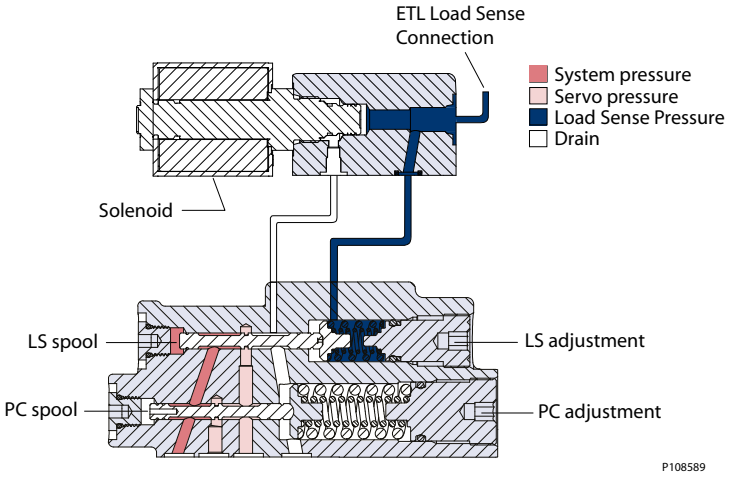
1. Left = E-Frame: CW Only, F-Frame: CW Only, J-frame: CW Axial, CCW Radial
2. Right = E-Frame: CCW Only, F-Frame: CCW Only, J-frame: CCW Axial, CW Radial
3. K/L Frame Controls are not rotation dependent
4. K2 Frame electric controls are limited only for Left orientation and up to 260 Bar

Electric dump valve PC/LS controls

The electric dump valve pressure-compensated/load sense control allows the pump to operate as a PC/LS type control under normal operating conditions. The solenoid dump valve overrides the LS control, allowing the pump to operate in a Low-Pressure Standby mode. This function provides reduced horsepower and torque loss in certain situations. It may be particularly useful to reduce loads on a system during engine start.

When closed, the solenoid valve allows the control to act as a PC/LS control. When open, the solenoid valve allows flow from the incoming load sense pressure to dump to case. This reduces the pressure in the LS spring cavity, shifting the LS spool, and allows the pump to de-stroke to the Low-Pressure Standby condition. This control is for applications needing a PC/LS control with the ability to switch to Low-Pressure Standby electronically. The solenoid valve is only available in a normally closed configuration.

Electric Dump Control (frames E, F and J)

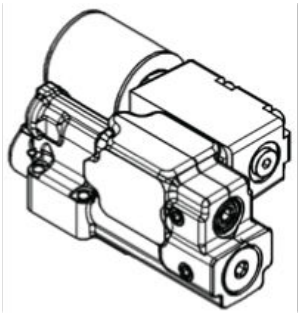


General Information

Electronic Torque Limiting Controls (ETL)

PLUS+1 Compliance

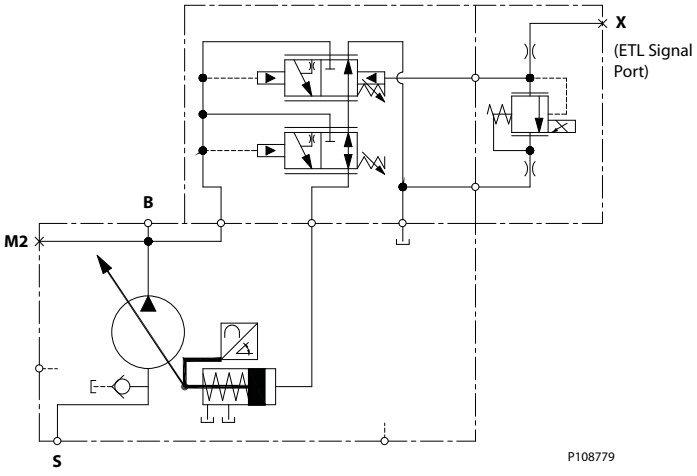
All Series 45 Electric controls have met and passed the Danfoss PLUS+1 compliance standard testing, and as such, this Series 45 control is PLUS+1 compliant. PLUS+1 compliance blocks (software) are available on the Danfoss website, within the PLUS+1 Guide section.



Electric Torque Limiting Control Principle

The Electronic Torque Limiting control consists of a normally closed proportional relief valve (PRV) integrated into a Pressure Compensated/Load Sensing control. This control operates as a PC/LS control, with the additional ability to limit load sense pressure using the integrated PRV by varying the current to the solenoid. When combined with an angle sensor, this control allows for a PC/LS control with electronic torque limiting.

J-frame pump with integrated ETL control



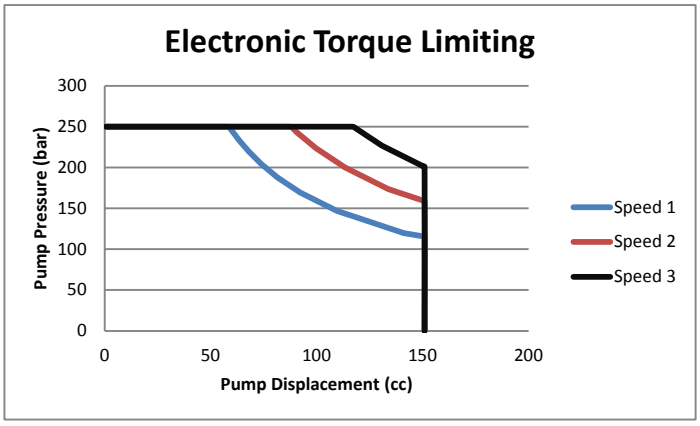
Pump torque consumption is a function of pump outlet pressure, pump displacement, and pump mechanical efficiency. When pump mechanical efficiency is considered constant, the pump torque can be limited when pump displacement is known and pump pressure is controlled. As pump displacement increases, the pump outlet pressure can be limited using the PRV to result in a constant torque limit. Pump outlet pressure is equal to the load sense pressure, which is limited with the PRV, plus the margin pressure setting of the pump.

General Information

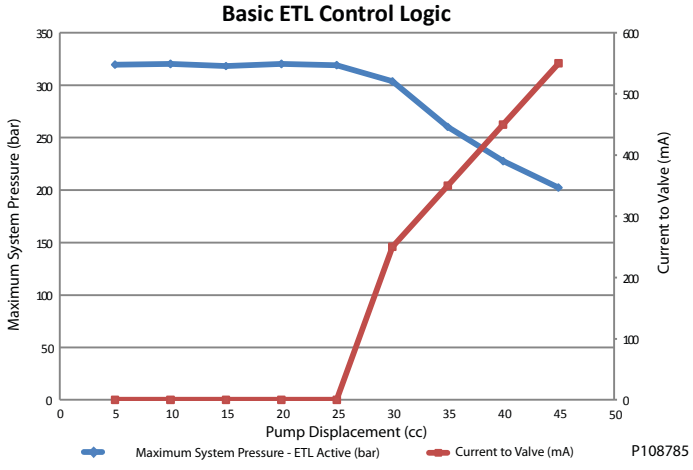
$$Torque = \frac{Pump\ Outlet\ Pressure\ (bar) * Pump\ Displacement\ (\frac{cc}{rev})}{62.8 * Pump\ Mechanical\ Efficiency\ (\%)}$$

Electronic Torque Limiting Control Characteristic

The Electronic Torque Limiting control allows users to limit pump torque consumption electronically by combining a pressure limiting PRV and angle sensor. This torque limit can be changed with varying engine speeds (as shown in the Electronic Torque Limiting graph below), allowing the use of full engine torque at all engine speeds and increasing machine productivity. A microcontroller is required to store engine torque vs speed, receive the pump angle sensor signal, and then calculate and output the pump outlet pressure limit. The basic torque limiting control logic for a single engine speed is shown below. Danfoss offers a PLUS+1 subsystem application block for the Electronic Torque Limiting control option in combination with keyed MC-12 microcontroller hardware. Refer to graph *Operating Pressure vs. Input Current (N.C. EPC)* on page 19 for pressure vs. current information.



P108783



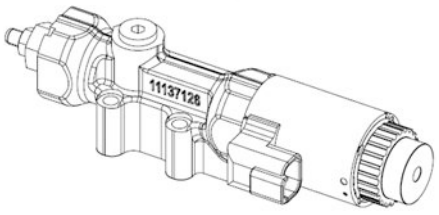
P108785

Fan Drive Control (FDC)

General Information

PLUS+1 Compliance

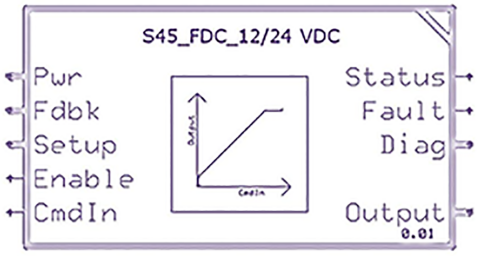
All Series 45 Electric controls have met and passed the Danfoss PLUS+1 compliance standard testing, and as such, this Series 45 control is PLUS+1 compliant. PLUS+1 compliance blocks (software) are available on the Danfoss website, within the PLUS+1 Guide section.



Fan Drive Control Principle

The Fan Drive Control is a unique electrically actuated pressure control solution that consists of a normally closed proportional solenoid and one dual diameter spool sliding in the control housing. System pressure acts on an area between the two spool diameters of the spool lands. This hydraulic force is balanced with forces of springs and the solenoid when the spool is in the metering position. When no current is sent to the solenoid it operates the pump at or below the PC setting which is adjusted mechanically with the adjustor screw and lock nut. Increasing the control current proportionally reduces the pump's outlet pressure until a minimum standby pressure is reached.

Control Block 12V and 24V



The minimum system pressure is given by swashplate moments of the pump and by servo system leakages which produce a pressure drop across the control. In addition, fan motor type and fan inertia impact minimum system pressure.

The Normally Closed Fan Drive Control coupled with a microprocessor allows the pump to operate at an infinite range of operating pressures between a minimum system pressure and PC setting.

We recommend that a relief valve be installed in the pump outlet for additional system protection.

Warning

The Fan Drive Control is intended for fan drive systems only! Use in other systems could result in system component damage or unintended machine movement. The Fan Drive Control is not intended to serve at the primary system pressure relief. Loss of the input signal to this control will cause the pump to produce maximum flow.

General Information

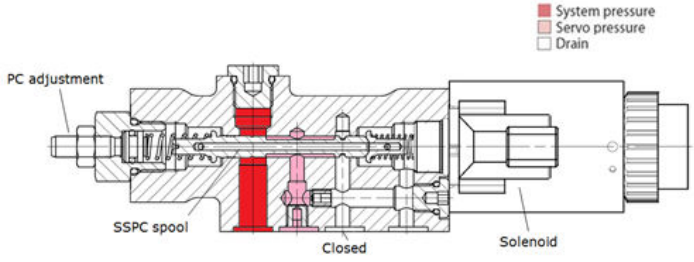
Fan Drive Control System Characteristics

- Constant pressure and variable flow
- High or low system pressure mode based on fan cooling demand
- System flow adjusts to meet system requirements

Unintended Applications for Fan Drive Control Systems

- Applications with frequent PC events (system pressure overshoots)
- Adjustable Load Sensing systems

Fan Drive Control Cross Section

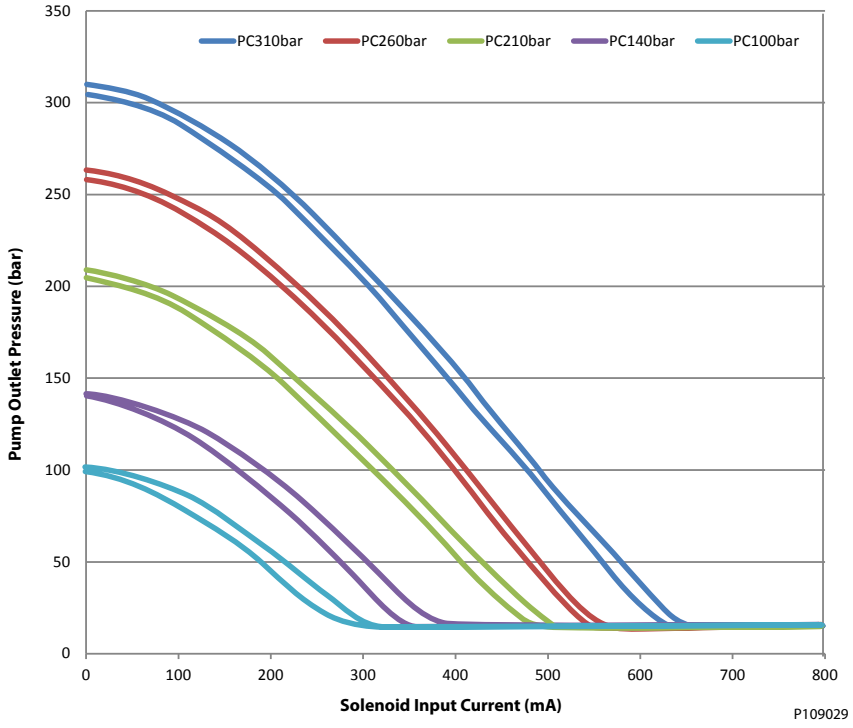


Fan Drive Control characteristic - Normally Closed

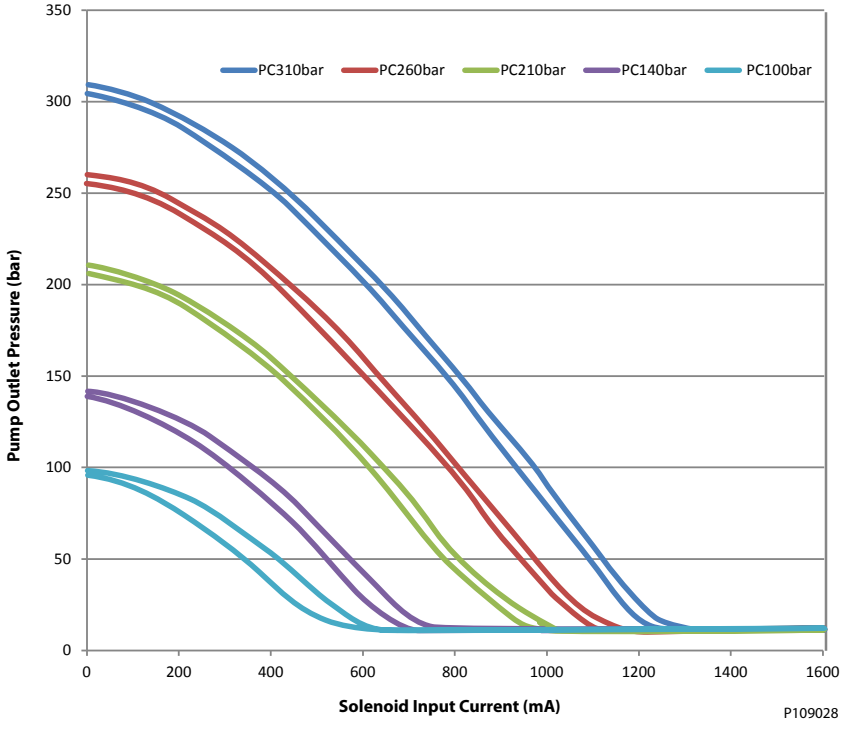
When an electric current is sent to the Normally Fan Drive Control, pump outlet pressure decreases proportionally to the increase in currentt. When the load in the system changes, the pump will adjust its displacement to maintain the pressure demanded by the controlling current. This predictable control is especially useful for fan-drive systems, due to the direct relationship between fan-speed and pump pressure. Due to the nature of the Fan Drive Control, the relationship between current and pump pressure is unique for each individual PC pressure setting combination. The relationship between pump outlet pressure and control input current (for a 24V coil) is shown for various PC settings below. The hydraulic schematic for the Normally Closed Fan Drive Control is shown below as well.

General Information

Pump Outlet Pressure vs. control input current 24V Normally closed FDC (at 100Hz PWM)



Pump Outlet Pressure vs. control input current 12V Normally closed FDC (at 100Hz PWM)

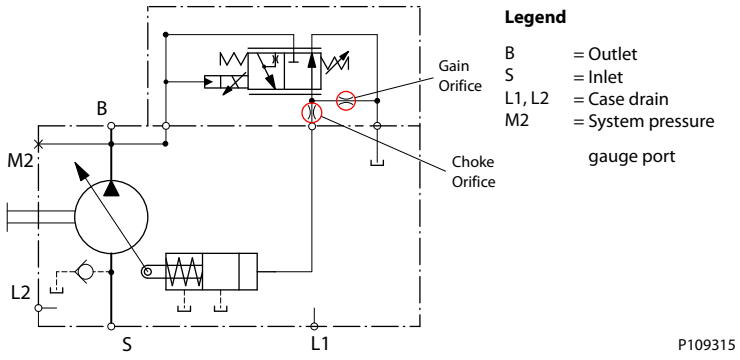


General Information

Attaining remarkably low system pressures is possible with the Fan Drive Control. The minimum system pressure is greatly dependent on individual system parameters such as fan motor type and fan size. This feature is highly desirable in low cooling demand conditions to keep fan speed as slow as possible.

Virtually eliminated control deadband increases controllability and reduces power loss. Control current resolution is greatly improved.

S45 pump with integrated FDC control Schematic



Solenoid data – Normally closed

Solenoid Data – Normally Closed

	12V	**24V**
Connector on solenoid	Deutsch DT04-2P	
Mating Connector (not included)	Deutsch DT06-2S	
Identification by color of nut	Black	Blue
Nominal current	1650 mA	840 mA
Maximum Control Current	1800 mA	920 mA
Environmental rating	IP67 without mating connector, IP69K with mating connector	
Maximum output driver current	2.0 Amps	
PLUS+1 dither frequency	Not recommended	
Useable PWM Frequency Range	50-200 Hz	
Recommended PWM Frequency	200 Hz	
Nominal Resistance at 20°C	3.66 Ω	14.2 Ω
Inductivity (pin at stroke end)	33 mH	140 mH
Minimum voltage	9.5 Vdc	19.0 Vdc
Maximum power	17.9 Watts	18.1 Watts

The Fan Drive Control is designed as a current driven control. It requires a PWM- input signal.

General Information

Fan Drive Control configuration

The available Normally Closed Fan Drive Controls for Series 45 are shown below. The allowable Pressure Compensator (PC) pressure settings are provided for each frame.

C module—Control

Fan Drive Control Options		**Frame**					
Code	Description	L	K	K2	J	F	E
SA	Fan Drive Control (12Vdc), 100-210 Bar, Left			•	•	•	
SB	Fan Drive Control (24Vdc), 100-210 Bar, Left			•	•	•	
SC	Fan Drive Control (12Vdc), 220-310 Bar, Left			•	•	•	
SD	Fan Drive Control (24Vdc), 220-310 Bar, Left			•	•	•	
SE	Fan Drive Control (12Vdc), 100-210 Bar, Right				•	•	
SF	Fan Drive Control (24Vdc), 100-210 Bar, Right				•	•	
SG	Fan Drive Control (12Vdc), 220-310 Bar, Right				•	•	
SH	Fan Drive Control (24Vdc), 220-310 Bar, Right				•	•	

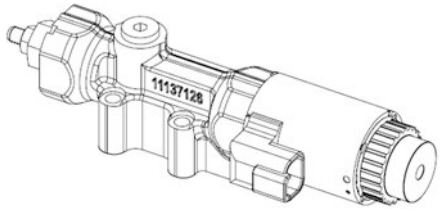
G module options—Choke Orifice

Fan Drive Control options	**Choke Orifice size**
G	0.8 mm (0.031 in)
F	1.0 mm (0.039 in

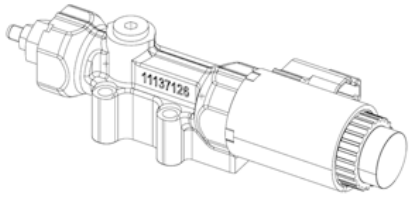
H module options—Gain Orifice

Fan Drive Control options	**Gain Orifice Size**
E	1.2 mm (0.047 in)

NC Fan Drive Control 3D Views



Left



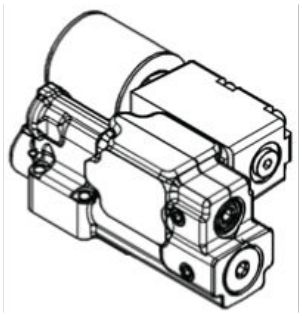
Right

Angle Sensor

PLUS+1 Compliance

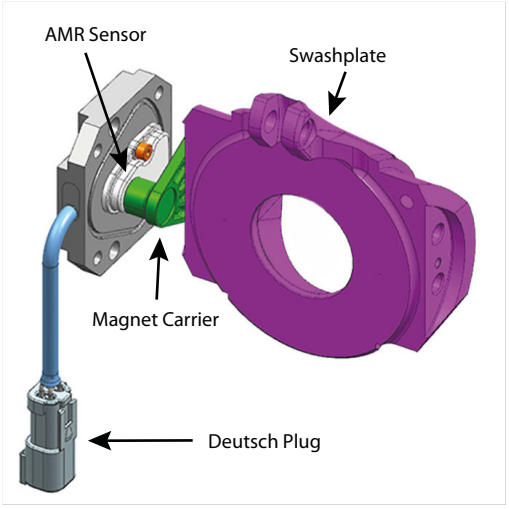
The Electric Angle Sensor has met and passed the Danfoss PLUS+1 compliance standard testing, and as such, this Angle Sensor is PLUS+1 compliant. PLUS+1 compliance blocks are available on the Danfoss website, within the PLUS+1 Guide section.

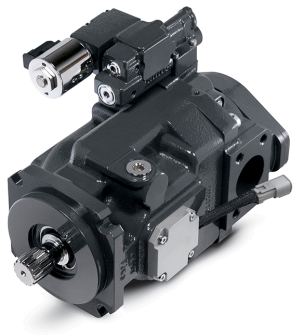
General Information



Angle Sensor Principle

The Series 45 Angle Sensor option allows users to measure the angle of pump displacement. The angle sensor is an electronic sensor mounted to the housing of the pump, which reads the pump stroke angle based on the swashplate position. Interfacing with the angle sensor is achieved through a 4-pin Deutsch DTM04-4P receptacle attached to a flexible connection cable (for a mating connector, use Deutsch® plug DTM06-4S). The sensor is mounted to the pump within an aluminum housing to prevent magnetic interference.





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Angle Sensor Characteristics

The angle sensor package incorporates two sensor signals (primary & secondary), within a single sensor housing. This allows for improved accuracy and troubleshooting. For the 'Angle Sensor – Right' order code in the K module, the sensor is positioned according to the following conventions:

Code	Description	Frame				
K Module - Housing		L	K	J	F	E
A1R	SAE-C Flange 4-bolt, SAE O-ring boss ports, Single seal, Angle Sensor				•	
A2R	SAE-C Flange 4-bolt, SAE O-ring boss ports, Single seal, Angle Sensor			•		•
AFR	SAE-C Flange 2-bolt @45°, SAE O-ring boss ports, Single Seal, Angle Sensor			•		
M Module – Special Hardware						
ANS	Angle Sensor Hardware			•	•	•