Z-Transmission
Compact Hydrostatic Transmission

Displacement
40.6 cm³/r (2.48 in³/r)
49.2 cm³/r (3.0 in³/r)

Peak Pressure
380 bar (5500 psi)
Z-Transmission
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Z-Transmission
Introduction and Application Information

Z-Transmission is a compact axial hydrostatic transmission, which utilizes a variable displacement axial piston pump and fixed displacement axial piston motor connected in closed loop system. Oil is circulated by the pump to the motor and then returned directly back to the pump. A charge supply is used to supplement the closed loop system with oil. The charge flow is supplied by an external source.

Operating Principle
The variable displacement piston pump and a fixed displacement piston motor are held together with the help of a center manifold. The end covers of the piston pump and motor are replaced by the center manifold. It provides the internal oil passages and connects the inlet port of the motor to the outlet port of pump.

The pump is driven by the prime mover, which generates flow to drive the hydraulic motor. The motor is connected to a gear box. If a fixed pump and fixed motor combination is used it simply acts as a gear box that transmits power from one point to another. A variable pump and fixed motor combination is used to regulate speed and torque.

Pressure is built in the system due to the tractive resistance of vehicle and other auxiliary applications. Direction and rotation of the motor depends on the output flow of the pump. Pump flow depends on the speed and displacement of a pump. The displacement of the pump is controlled by the swash plate position.

Advantages
System Integration
- The mechanical coupling of the variable piston pump and motor provides a compact package with fewer leak paths
- Fewer hose connections reduce assembly time.
- A small envelope allows design flexibility.
- Modular construction eases fit-up to a vehicle.
- Noise and vibrations are reduced with “drive-by wire” rather than mechanical linkages.
- Infinite output speed range for given engine speed
- Operator comfort
- Ergonomic machine design

Programmable Vehicle Control
- Joystick or foot pedal command transfer functions are easily tuned to specifications to provide aggressive or mild vehicle acceleration.
- Dynamic hydrostatic braking can be adjusted to provide a more abrupt or a smoother response to operator input.

Optional Control System Upgrades
- Electronic cruise control can be added to the electro-hydraulic Compact Z-Transmission system for greater operator comfort and productivity.
- Programmable anti-stall prevents engine stalling.

Typical applications
Agriculture
Mid-sized Combine Harvester
Compact Tractors

Material Handling
Lift Trucks

Turf care
Small Dozers
Trenchers
Mowers
Z-Transmission
Features and Benefits

Product Identification Number – Z-Transmission

Stamped on each unit.
A – Product Number Description
77122 = Z-Transmission
B – Rotation
R = Right Hand
L = Left Hand
C – Sequential Letter
D – Design Code Number

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump Housing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Durable Cast Iron Design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Multiple Drain Options</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B - Pump Swash Plate Cradle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C – Pump Swash Plate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D – Input Shaft &amp; Mounting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• SAE “B”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Numerous Shaft Options</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E – Pump Shaft Seal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F – Shaft Bearings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G – Swash Plate Bushing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H – Pump Drain Port</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I – Pump Rotating Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 40.6 cm³/r [2.48 in³/r] Displacement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 49.2 cm³/r [3.00 in³/r] Displacement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J – Pump Valve Plate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K – High Pressure Relief Valve</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Prevents Excessive pressure</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

With 72400 Servo Controlled Pump

| L – Centre Manifold            |
| • Houses Pump & Motor Flow Path |
| • Compact Design               |
| • Reduced Plumbing             |
| • Reduced Leak Paths           |
| M – PTO Shaft                  |
| N – Motor Drain Port           |
| O - Motor Valve plate          |
| P – Motor Rotating Group       |
| • 40.6 cm³/r [2.48 in³/r] Displacement |
| • 49.2 cm³/r [3.00 in³/r] Displacement |
| Q – Motor Shaft Seal           |
| R – Output / Motor Shaft       |
| S – Motor Bearings             |
| T – Motor Housing              |
| • Light weight, Aluminum Housing |
| U – Pump Servo Piston Assembly |
| V – Diagnostic Ports           |
| W – Manual Displacement Servo Control Valve |
| X – Charge Pressure Relief Valve |
| Y – External Charge Inlet Port |

Serial Number Code

10 05 06 XXX 1 000

Last Two Digits of Year Built. (10 for 2010 etc.)
Month Built (two digits)
Day Built (two digits)
Specific Number of the Pump
Shift Number
Manufacturing Cell

With 72400 Servo Controlled Pump
Z-Transmission
Features and Benefits

Z-Transmission with 72400 Servo Controlled Pump

With 70360 Direct Manual-Controlled Piston Pump

1 - Flange
2 - Cover Plate
3 - Cam Plate Sub-assembly
4 - Bearing
Z-Transmission
Installation Drawings

With 70360 Direct Manual Controlled Pump - AEY Series
Z-Transmission
Installation Drawings

With 72400 Servo Controlled Pump - AEZ Series

R1 - Relief valve for port A
R2 - Relief valve for port B
R3 - Charge pressure relief valve
S1, S2 - Pump servo control ports
C1 - External charge inlet port
T1 - Diagnostic port for main port A
T2 - Diagnostic port for main port B
T3 - Diagnostic port for charge flow
D1, D2 - Drain port pump (optional)
D5 - Drain port motor

Dimensions are in millimeters [inches], unless otherwise specified.

EATON Z-Transmission Catalog E-TRCD-CC001-E March 2013 7
## Specifications

Two types of Pump control options are available:

- Manual Direct (with 70360 series Pump) with fixed displacement motor
- Manual Servo (with 72400 series Pump) with fixed displacement motor

### Pump Series

<table>
<thead>
<tr>
<th>Displacement – cc/rev (in³/rev)</th>
<th>Motor Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>70360</td>
<td>72400</td>
</tr>
<tr>
<td>40.6 (2.48)</td>
<td>40.6 (2.48)</td>
</tr>
<tr>
<td>49.2 (3.0)</td>
<td>49.2 (3.0)</td>
</tr>
<tr>
<td>74318</td>
<td>74328</td>
</tr>
<tr>
<td>40.6 (2.48)</td>
<td>49.2 (3.0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input Mounting Flange – SAE</th>
<th>70360</th>
<th>72400</th>
<th>72400</th>
<th>74318</th>
<th>74328</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Max Speed – RPM</th>
<th>3600</th>
<th>3600</th>
<th>3600</th>
<th>3000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Pressure - Bar (PSI)</td>
<td>345 (5000)</td>
<td>345 (5000)</td>
<td>345 (5000)</td>
<td>345 (5000)</td>
</tr>
<tr>
<td>Peak Pressure - Bar (PSI)</td>
<td>441 (6400)</td>
<td>441 (6400)</td>
<td>441 (6400)</td>
<td>441 (6400)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Controls</th>
<th>Direct Manual</th>
<th>Manual Servo*, Electronic Proportional, Hydraulic Remote, Proportional Solenoid*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional Features</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>At Max Speed &amp; Nominal Pressure</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Max-Output Power KW (HP)</td>
<td>–</td>
<td>59 (79)</td>
</tr>
<tr>
<td>Max-Output Torque Nm (lbf-in)</td>
<td>–</td>
<td>156 (1383)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weight (kg)</th>
<th>52</th>
<th>52</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Shaft - External splines</td>
<td>20T (ANSI B92.1)</td>
<td>15T (SAE J498b)</td>
</tr>
<tr>
<td>PTO Shaft - External splines</td>
<td>20T (ANSI B92.1)</td>
<td>13T (SAE J498b)</td>
</tr>
<tr>
<td>Output Shaft - External splines</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Speed Sensor</td>
<td>Not Available</td>
<td>–</td>
</tr>
<tr>
<td>Temperature - °C (°F)</td>
<td>107 (225)</td>
<td>107 (225)</td>
</tr>
<tr>
<td>Continuous Allowable Case</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Pressure - Bar (PSI)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>External Charge Pump Displacement -</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>cc / rev (in³ / rev) ***</td>
<td>8.2 (0.5)</td>
<td>9.84 (0.6)</td>
</tr>
<tr>
<td>Charge Relief Settings (Range) -</td>
<td>6.89 – 20.68</td>
<td>13.79 – 20.68</td>
</tr>
<tr>
<td>Bar (PSI)</td>
<td>(100 – 300)</td>
<td>(200 – 300)</td>
</tr>
</tbody>
</table>

* Manual Servo Control with additional control features and Solenoid Control are available on request

** Available on request

*** Contact Eaton representative for specific requirements.

† Nominal Pressure: Max. delta system pressure at which component fatigue does not occur (pump life estimated by bearing life).

† † Peak Pressure: Max. operation pressure which is permissible for a short duration of time (t < 1 sec).
**Z-Transmission**

**Model Code**

<table>
<thead>
<tr>
<th>Code Title</th>
<th>Displacement - Pump</th>
<th>Input Shaft Rotation</th>
<th>Front Mounting</th>
<th>Pump Input Shaft</th>
<th>PTO (Pump Output) Shaft</th>
<th>Charge Pump</th>
<th>Charge Relief Setting And Routing</th>
<th>External Charge Inlet Port</th>
<th>Drain Port Size And Location - Pump</th>
<th>Relief Valve Setting For Main Port A</th>
<th>Relief Valve Setting For Main Port B</th>
<th>Control Supply Orifice (p)</th>
<th>Special Features (Pump)</th>
<th>Pump Control Options</th>
<th>Special Control Options</th>
<th>Motor Displacement</th>
</tr>
</thead>
</table>

**Control Supply Orifice (p)**

- Diameter 0.55 [.021]
- Diameter 0.61 [.024]
- Diameter 0.71 [.028]
- Diameter 0.81 [.032]
- Diameter 0.91 [.036]
- Diameter 1.02 [.040]
- Diameter 1.12 [.044]
- Diameter 1.32 [.052]
- Diameter 1.45 [.057]
- Diameter 1.65 [.065]
- Diameter 1.85 [.073]
- Diameter 2.01 [.080]

**Special Features (Pump)**

- No Special Features
- Speed Sensor (For AEZ Series)

**Pump Control Options**

- Direct Manual Control
- Manual Servo Control
- Hydraulic Remote with 5-15 bar [72-217 lbf/in²] Pilot Pressure Range, 2X .4357-20 UNF-2B SAE O-Ring Port
- Electronic Proportional Control 12 VDC without electronic driver, with Deutsch connector, with fine hi-gain control metering

**Special Control Options**

- No Special Control Options

**Motor Displacement**

- 40 - 40.6 cm³/r [2.48 in³/r] Fixed Displacement Axial Piston Motor
### Motor Output Shaft

**A** - SAE 15 Tooth 16/32 External, Dia. 24.98 [.984]

### Drain Ports Size and Location (Motor)

**1** - Dia 9.6 [.38] Port (D5) - Relieved To Reservior / Housing

### Special Features (Motor)

**0** - No Special Features

### Additional Features

**0** - No Additional Features

### Paint

**00** - Do Not Paint  
**0A** - Red Oxide Primer  
**CD** - Blue (Eaton Standard)

### Identification

**0** - Standard

### Design Code

**B** - B
The charts below are representative of a “AEZ” series Z-trans with 49.2 cm³/r (3.00 in³/r) servo variable pump and 40.6 cm³/r (2.48 in³/r) fixed motor. The tests were run at an oil temperature of 82°C (180°F) with viscosity at 9 - 12 cSt (54 - 66 SUS).
Z-Transmission
Shaft Options

**Pump Input Shaft**
Code Position 8
Selection - A 15T
Max. input torque 338 N·m [2987 lbf·in]

Selection - B 20T
Max. input torque 243 N·m [2151 lbf·in]

**Power Take Off (PTO) Shaft**
Code Position 9
Selection - A 13T
Max. output torque - 210 N·m [1859 lbf·in]

Selection - B 20T
Max. output torque - 243 N·m [2151 lbf·in]

**Motor Output Shaft**
Code Position 25
Selection - A 15T
Max. output torque – 338 N·m [2991 lbf·in]

Dimensions are in millimeters [inches], unless otherwise specified.
Port Identification

Pump Drain Port- (D2)
9.6 [0.38]
Assemble motor to back plate with motor drain port toward top of the assembly

Detail A

Loop - A
System Pressure Diagnostic Port M14X 1.5
111.94 [4.42]

Loop - B
System Pressure Diagnostic Port M14X 1.5
151.33 [5.96]

External Charge Inlet Port- (C1)
M22X 1.5
77.28 [3.05]

Dimensions are in millimeters [inches], unless otherwise specified.
Z-Transmission
Speed Sensor
Code Position 16, Selection D

Mating Packard Connector
Connector Body – 1216 2192
Connector Seal – 1204 0750
Cable Seal – 1204 0751
Socket – 1212 4075

Optional Mating Connectors
Connector Assembly (Body, Cable Seal, Seal) – 1216 2193
Socket (16 – 18 AWG) – 1212 4075
Socket (20 – 22 AWG) – 1212 4076

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temperature Limit</td>
<td>-40 to 150°C [-40 to 302° F]</td>
<td></td>
</tr>
<tr>
<td>Sensor Resistance</td>
<td>25°C (77° F)</td>
<td>1.5 K To 3.5 K Ohms</td>
</tr>
<tr>
<td>Sensor Inductance</td>
<td>25°C (77° F)</td>
<td>0.6 to 3.7 H</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>25°C (77° F)</td>
<td>9.3 Hz @ 2.29mm [.090 inch] Gap</td>
</tr>
<tr>
<td></td>
<td></td>
<td>300 Hz @ 0.25mm [.010 inch] Gap</td>
</tr>
<tr>
<td></td>
<td></td>
<td>400 mVpp Min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80 Vpp Max.</td>
</tr>
<tr>
<td>Air Gaps</td>
<td></td>
<td>0.26 to 2.28 [.010 to .090] mm [inch]</td>
</tr>
<tr>
<td>Vibration Voltage</td>
<td>15G random Vibration</td>
<td>0.4V P-P Max</td>
</tr>
</tbody>
</table>

Dimensions are in millimeters [inches], unless otherwise specified.
### Z-Transmission - Pump Controls

**Manual Control**

**Code Position 17, 18 Selection M0**

<table>
<thead>
<tr>
<th>Control Lever Travel</th>
<th>Standard Band</th>
<th>Wide Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral Zone</td>
<td>2.5°</td>
<td>4.0°</td>
</tr>
<tr>
<td>Maximum Displacement</td>
<td>25.5°</td>
<td>25.5°</td>
</tr>
<tr>
<td>Maximum Over Travel</td>
<td>4.0°</td>
<td>2.5°</td>
</tr>
</tbody>
</table>

*Neutral Detent Feature*

The neutral detent provides a positive, centered feeling to the handle, signaling the operator when the pump is in neutral position.

### Hydraulic Remote Control

**Code Position 17, 18 Selection HA**

R1 - Relief valve for port A  
R2 - Relief valve for port B  
R3 - Charge pressure relief valve  
S1, S2 - Pump servo control ports  
C1 - External charge inlet port  
T1 - Diagnostic port for main port A  
T2 - Diagnostic port for main port B  
T3 - Diagnostic port for charge flow  
D1, D2 - Drain port pump (optional)  
D5 - Drain port motor

**NOTE**

1. Right Hand (Clockwise) Rotation  
   - Pilot Press Port -1 Pressurized...flow From System Press Port -B  
   - Pilot Press Port -2 Pressurized...flow From System Press Port -A

2. Left Hand (Counter Clockwise) Rotation  
   - Pilot Press Port -1 Pressurized...flow From System Press Port -A  
   - Pilot Press Port -2 Pressurized...flow From System Press Port -B

3. Nominal Threshold Pressure .......... 5 bar [72.5 PSI]  
   - Nominal Max Displacement Pressure ...... 15 bar [217.6 PSI]

* Do not touch any of the Control adjustment nuts which are factory set.

**Hydraulic Remote Control Conversion Kit**

Order Part Number 72400-919 Includes: Control sub-assembly (1pc), Socket head cap screws (6 pc), Control housing gasket (1pc)
The Electronic Proportional (EP) displacement control is ideal for applications requiring electronic pump displacement control. The EP displacement control provides the flexibility of three command input choices. Control components include a proportional solenoid actuated valve assembly and an electronic solenoid driver module mounted on the pump.

**EP Displacement Control Features**

- Ease of installation
- Automotive style environmentally sealed Metri-Pack connectors
- Operates from 12 or 24 Vdc power supply
- External fuse (customer supplied): 3A for 12 Vdc system, 1A for 24 Vdc system
- Three choices for command input signal
- Operating temperature range -40°C to +85°C
- Control driver module encapsulated for environmental protection
- Closed loop current control compensates for resistance change of the proportional solenoids due to temperature variations
- Return to neutral for loss of power, or loss of command input signal
- Mechanical feedback of swashplate position for closed loop control
- External neutral adjustment
- Manual override capability
- Control drive module qualification per SAE J1455, SAE J1113, CISPR 25

The control driver module converts a command input signal to a proportional current output to the proportional solenoids resulting in a proportional pump displacement.

The EP displacement control has been designed to withstand the rigors of off-highway equipment environmental conditions.

**SAE J1455 - Recommended Environmental Practices for Electronic Equipment Design**

- Humidity/Temperature Extreme Cycling
- Salt Spray
- Splash & Immersion
- Steam Cleaning/High Pressure Wash
- Vibration
- Mechanical Shock
- Temperature Cycling
- Load Dump Transients
- Inductive Load Switching Transients

**SAE J1113 - Electromagnetic Susceptibility Measurement Procedures for Vehicle Components**

- EMI/EMC - Conducted & Radiated Immunity

**CISPR 25 - International Electrotechnical Commission “Limits and Methods of Measurement of Radio Disturbance Characteristics for the Protection of Receivers used on Board Vehicles”**

- EMI /EMC - Conducted & Radiated Emissions
Z-Transmission - Pump Controls
Electronic Proportional Displacement Control
Code Position 17,18 Selection EP

**Note:** In order to assure the most reliable installation and operation of any electronic control, proper installation methods should be followed with respect to interconnection wiring harness, command signal devices, fusing, and input power switching. Proper care should be taken to prevent damage to all electrical and electronic components due to abrasion, moving objects, heat, moisture or other environmental hazards. For safety critical applications, Eaton recommends that a switch be installed in line with (+ Battery) power to the module so that power may quickly be disconnected in case of emergency. A 2 ampere slow blow fuse should always be installed in the + battery line. It is recommended that during initial start-up and checkout, the machine be placed on jack stands to prevent inadvertent movement of the machine.

<table>
<thead>
<tr>
<th>Command Input Signal</th>
<th>A (max)</th>
<th>B (min)</th>
<th>C</th>
<th>D (min)</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 6 Vdc</td>
<td>1.5 Vdc</td>
<td>3.3 Vdc</td>
<td>3.5 Vdc</td>
<td>3.7 Vdc</td>
<td>5.5 Vdc</td>
</tr>
<tr>
<td>4-20 mA*</td>
<td>-20 mA</td>
<td>-4.5 mA</td>
<td>0 mA</td>
<td>+4.5 mA</td>
<td>+20 mA</td>
</tr>
<tr>
<td>±100 mA</td>
<td>-100 mA</td>
<td>-7.5 mA</td>
<td>0 mA</td>
<td>+7.5 mA</td>
<td>+100 mA</td>
</tr>
</tbody>
</table>

*Note: The +20 mA command input signal configuration operates the pumps in one direction. The customer has to change the polarity on the -20 mA signal to operate the pump in the opposite direction.

**Electronic Proportional Valve Control Guidelines**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>12 VDC</th>
<th>24 VDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal Input *</td>
<td>Resistance at 25°C - Ohm</td>
<td>5.19 ± 10%</td>
</tr>
<tr>
<td>Nominal Inductance</td>
<td>17.5 mH</td>
<td>27.7 mH</td>
</tr>
<tr>
<td>Current (I) at Neutral - Amp</td>
<td>&lt; 0.4</td>
<td>&lt; 0.2</td>
</tr>
<tr>
<td>Current (I) at Full Displacement – Amp (max continuous)</td>
<td>1.5A</td>
<td>0.75A</td>
</tr>
<tr>
<td>Operating Limits</td>
<td>Temperature Ratings</td>
<td>-65°F Min to 140°F Max</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>28W Max</td>
<td></td>
</tr>
</tbody>
</table>

*Coils have no internal diodes, polarity does not affect performance.

**PWM Configuration**
Closed loop current control of the solenoid current via PWM duty-cycle variation.
Note: Coil currents must be limited to not exceed solenoid coil specifications

- Frequency: 70-200Hz
  (100Hz recommended when PWM driver does not have built-in dither capabilities)

**Dither Signal**
The design must provide for a separate dither signal to be added to the input command.

- Waveform: Square
- Frequency: 75 (+ 25, -15) Hz
- Amplitude: 0.250 + 0.100 - 0.050A pk-pk
For 70360 Direct Manual Controlled Pump

Control force for 2.48 cid @ 800 rpm input

Control force for 2.48 cid @ 1000 rpm input

Control force for 2.48 cid @ 2800 rpm input

Control force for 2.48 cid @ 3000 rpm input
Z-Transmission
Hydraulic System Design Calculations

**Basic Formulas**

**Output Flow (Q)**

\[ lpm = \frac{cm^3/r \times rpm}{1000} \quad \text{gpm} = \frac{in^3/r \times rpm}{231} \]

**Input Power (P)**

\[ kW = \frac{l/min \times bar}{600} \quad \text{hp} = \frac{gpm \times psi}{1714} \]

**Shaft Torque (M)**

\[ N-m = \frac{bar \times cm^3/r}{62.8} \quad \text{lb-in} = \frac{psi \times in^3/r}{6.28} \]

**Shaft Speed (n)**

\[ rpm = \frac{1000 \times 1/min}{cm^3/r} \quad \text{RPM} = \frac{231 \times gpm}{in^3/r} \]

**Output Power (P)**

\[ kW = \frac{N-m \times RPM}{9549} \quad \text{hp} = \frac{lb-in \times rpm}{63,025} \]

**Volumetric Displacement**

\[ cm^3/r = \frac{lpm \times 1000}{rpm} \quad \text{in}^3/r = \frac{gpm \times 231}{rpm} \]

**Commonly Used Conversions**

<table>
<thead>
<tr>
<th>To Convert</th>
<th>Into</th>
<th>Multiply by</th>
</tr>
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<tbody>
<tr>
<td>bar</td>
<td>psi</td>
<td>14.5</td>
</tr>
<tr>
<td>cm³</td>
<td>in³</td>
<td>0.06102</td>
</tr>
<tr>
<td>°C</td>
<td>°F</td>
<td>(°C x 1.8) +32</td>
</tr>
<tr>
<td>gallons (US)</td>
<td>liters</td>
<td>3.785</td>
</tr>
<tr>
<td>kg</td>
<td>lbs</td>
<td>2.205</td>
</tr>
<tr>
<td>kgf/cm²</td>
<td>psi</td>
<td>14.2</td>
</tr>
<tr>
<td>kW</td>
<td>hp</td>
<td>1.341</td>
</tr>
<tr>
<td>liters</td>
<td>US Gallons</td>
<td>0.2642</td>
</tr>
<tr>
<td>mm</td>
<td>inches</td>
<td>0.03937</td>
</tr>
<tr>
<td>N-m</td>
<td>lb-in</td>
<td>8.85</td>
</tr>
<tr>
<td>N-m</td>
<td>lb-ft</td>
<td>0.7375</td>
</tr>
<tr>
<td>°F</td>
<td>°C</td>
<td>(°F-32)/1.8</td>
</tr>
<tr>
<td>hp</td>
<td>kW</td>
<td>0.7457</td>
</tr>
<tr>
<td>inch</td>
<td>mm</td>
<td>2.54</td>
</tr>
<tr>
<td>in³</td>
<td>cm³</td>
<td>16.39</td>
</tr>
<tr>
<td>lb-in</td>
<td>N-m</td>
<td>0.113</td>
</tr>
<tr>
<td>lb-ft</td>
<td>N-m</td>
<td>1.356</td>
</tr>
<tr>
<td>lbs</td>
<td>kg</td>
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</tr>
<tr>
<td>psi</td>
<td>bar</td>
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</tr>
<tr>
<td>psi</td>
<td>kgf/cm²</td>
<td>0.070307</td>
</tr>
</tbody>
</table>

Note: Performance charts can be found on subsequent pages.
Z-Transmission
Component Selection

The long service life of Eaton hydrostatic transmissions is largely dependent on the proper selection and installation of the components necessary for transmission operation.

The following components are necessary for transmission operation:

1. Variable Displacement Pump
2. Fixed or Variable Displacement Motor
3. Reservoir
4. Filter
5. Charge Pump Inlet Line
6. Pump and Motor Case Drain Lines
7. High Pressure Lines
8. Heat Exchanger
9. Heat Exchanger Bypass Valve
10. Reservoir Return Line

Variable Displacement Pump
Eaton hydrostatic variable displacement pumps are an axial piston design. They are equipped with standard SAE mounts, shafts and port connections.

Fixed or Variable Displacement Motor
Eaton hydrostatic motors are an axial piston design. They are equipped with standard SAE mounts, shafts and port connections.

Reservoir
The reservoir is an important part of the hydrostatic transmission system. It should provide adequate oil storage and allow easy oil maintenance.

The reservoir must hold enough oil to provide a continuous oil supply to the charge pump inlet. It must also have enough room for the hydraulic oil to expand as the system warms up. Consider charge pump flow when sizing the reservoir: One half (.5) minute times (X) the maximum charge pump flow should be the minimum oil volume in the reservoir. Maintaining this oil volume will give the oil a minimum of thirty (30) seconds in the reservoir. This will allow any entrained air to escape and contamination to settle out of the oil.

To allow for oil expansion, the reservoir’s total volume should be at least six tenths (.6) minute times (X) the maximum charge pump flow.

The reservoir’s internal structure should cut down turbulence and prevent oil aeration.

The line returning flow to the reservoir should be fitted with a diffuser to slow the incoming oil to 1 to 1.2 meters [3-4 feet] per second to help reduce turbulence. The return flow line should also be positioned so that returning oil enters the reservoir below the liquid surface. This will help reduce aeration and foaming of the oil. The reservoir should have baffles between the return line and suction line. Baffles prevent return flow from immediately reentering the pump.

A sixty mesh screen placed across the suction chamber of the reservoir will act as a bubble separator. The screen should be placed at a 30° angle to the horizon. The entrance to the suction line should be located well below the fluid surface so there is no chance of air being drawn into the charge pump inlet. However, the suction line entrance should not be located on the bottom of the reservoir where there may be a buildup of sediment. The suction line entrance should be flared and covered with a screen.

The reservoir should be easily accessible. The fill port should be designed to minimize the possibility of contamination during filling and to help prevent over filling. There should be a drain plug at the lowest point of the reservoir and it should also have a clean-out and inspection cover so the reservoir can be thoroughly cleaned after prolonged use. A vented reservoir should have a breather cap with a micronic filter.

Sealed reservoirs must be used at altitudes above 2500 feet. These reservoirs should be fitted with a two-way micronic filter pressure cap to allow for fluid expansion and contraction.

In both cases the caps must be designed to prevent water from entering the reservoir during bad weather or machine washing.

A hydrostatic transmission with a well designed reservoir will run quieter, stay cleaner and last longer.

Charge Pump Inlet Line
The inlet line to the charge pump should be large enough to keep the pressure drop between the reservoir and charge pump inlet within the limits described in the filter section. Fittings will increase the pressure drop, so their number should be kept to a minimum. It is best to keep fluid velocities below 1.25 meters [4 feet] per second.

Fluid and temperature compatibility must be considered when selecting the inlet line.

Pump and Motor Case Drain
The case drain lines should be large enough to limit the pump and motor case pressures (Medium Duty to 2 bar [25 PSI]) at normal operating temperatures. Fluid and temperature compatibility must also be considered when selecting the case drain lines.

Heat Exchanger
Use of a heat exchanger is dependent on the transmission’s duty cycle and on machine layout. The normal continuous operating fluid temperature measured in the pump and motor cases should not exceed 80½ºC [180½ºF] for most hydraulic fluids. The maximum fluid temperature should not exceed 107½ºC [225½ºF].

The heat exchanger should be sized to dissipate 25% of the maximum input power available to the transmission. It must also be sized to prevent the case pressures in the pump and motor from getting too high. Medium duty case pressure up to 2 bar [25 psi], at normal operating temperatures, are acceptable.
Heat Exchanger Bypass Valve
The heat exchanger bypass valve is a pressure and/or temperature valve in parallel with the heat exchanger. Its purpose is to prevent case pressures from getting too high. The heat exchanger bypass valve opens when the oil is thick, especially during cold starts.

Reservoir Return Line
The same general requirements that apply to case drain lines apply to the reservoir return line.

Startup Requirements
The mounting orientation of pumps and motors is unrestricted provided the case drain of the pump and motor remain full.
Position the case drain such that it assures an oil level at or above unit center line at start-up. The case drain line that carries the flow leaving the pump or motor should be connected to the highest drain port on each of the units. This assures that the pump and motor cases remain full.
The combined torque required to turn two or more pumps must not exceed the torque rating of the input drive shaft of the front piston pump.
Installer to provide centering and a secure neutral for pump swash plate control shaft.
An external support is recommended for all tandems
**Introduction**

Oil in hydraulic system performs the dual function of lubrication and transmission of power. It is a vital element in a hydraulic system, and careful selection should be made with the assistance of a reputable supplier. Proper selection of oil assures satisfactory life and operation of components, especially hydraulic pumps and motors. Generally, oil selected for use with pumps and motors is acceptable for use with valves. Critical servo valves may need special consideration. When selecting oil for use in an industrial hydraulic system, be sure the oil:

- Contains the necessary additives to ensure excellent anti-wear characteristics
- Has proper viscosity to maintain adequate sealing and lubrication at the expected operating temperature of the hydraulic system
- Includes rust and oxidation inhibitors for satisfactory system operation

**Types of Hydraulic Fluids**

Hydraulic fluids are classified by the type of base stock used. Some fluids are further classified by fluid formulation and performance.

**Anti-Wear Hydraulic Fluids**

For general hydraulic service, Eaton recommends the use of the new generation of anti-wear (AW) hydraulic oils containing adequate quantities of anti-wear additive. Eaton requests that fluid suppliers test newly developed lubricants on an Eaton 35VQ25A high pressure vane pump, according to the Eaton ATS-373 test procedure, ASTM Specification D-6973. Lubricants that pass the test are considered superior protection against pump wear and long service life. In addition, they provide good demulsibility, as well as protection against rust.

**Crankcase Oils**

Automotive-type crankcase oils with American Petroleum Institute (API) letter designation SE, SF, SG, SH or higher per SAE J183 classes of oils are recommended for hydraulic service. The “detergent” additive tends to hold water in a tight emulsion and prevents separation of water.

Automotive type crankcase oils generally exhibit less shear stability, which can result in higher loss of viscosity during service life. Multiple-viscosity, industrial-grade hydraulic fluids with better shear stability will provide improved viscosity control.

Other mineral oil-based lubricants commonly used in hydraulic systems are automatic transmission fluids (ATFs) and universal tractor transmission oils (UTTOs).

**Synthetic Hydrocarbon**

Synthetic hydrocarbon base stocks, such as polyalphaolesfins (PAOs), are used to formulate ATFs and UTTOs.

**Environment Friendly Hydraulic Fluids**

Environmental friendliness is becoming a critical need and a number of biodegradable hydraulic fluids are being used more and more in environment sensitive areas.

Biodegradable hydraulic fluids are generally classified as vegetable oil based (HETG), synthetic ester (HEES), polyalkylene glycol (HEPG) and polyalphaolesfin (HEPR). In addition, special water-glycol hydraulic fluids are used in applications in which water miscibility is necessary, along with biodegradable properties.

**Fire-Resistant Hydraulic Fluids**

Fire-resistant fluids are classified as water-containing fluids or synthetic anhydrous fluids. Water acts as a fire-retarding agent in water-containing fluids. The chemical structure of synthetic anhydrous fluids provides fire resistance.

Many applications that are prone to fire hazard, such as steel mills, foundries, die casting, mines, etc., require the use of fire resistant hydraulic fluid for improved fire safety. Fire-resistant fluids may not be fire proof, but they have better fire resistance compared to that of mineral oil.

The alternative fluids are recommended when specific properties, such as fire resistance, biodegradability, etc., are necessary for the application. Keep in mind that alternative fluids may differ from AQ petroleum fluids in properties such as pressure viscosity coefficient, specific gravity, lubricity, etc. Hence, certain pumps/motors may need to be de-rated, some can be operated under full ratings, and others are not rated. Be sure to confirm product ratings with the specific fluid in the intended application.

**Viscosity**

Viscosity is the measure of a fluid’s resistance to flow. Selection of hydraulic oil with a specific viscosity range should be based on the needs of the system, limitations of critical components, or proper performance of specific types of units. At system startup and during operation, Eaton recommends maintaining the oil’s maximum and minimum viscosity ranges (see chart). Very high viscosities at startup temperatures can cause noise and cavitation damage to pumps. Continuous operation at moderately high viscosities will tend to hold air in suspension in the oil, as well as generate higher operating temperatures. This can cause noise, early failure of pumps and motors, and erosion of valves. Low viscosities result in decreased system efficiency and impairment of dynamic lubrication, causing wear.

It is important to choose the proper oil viscosity for your particular system in order to achieve the startup viscosity and running viscosity range (see chart) over the entire temperature range encountered. Confirm with your oil supplier that the oil viscosity will not be less than the minimum recommended at the maximum oil temperature of your application.

A number of anti-wear hydraulic oils containing polymeric thickeners (Viscosity Index Improvers (VII)) are available for use in low temperature applications. Temporary or permanent viscosity loss of some of these oils at operating temperature...
may adversely affect the life and performance of components. Before using polymer containing oils, check the extent of viscosity loss (shear stability) to avoid hydraulic service below the recommended minimum viscosity. Oil with good shear stability is recommended for low temperature applications.

Multi-grade engine oils, ATFs, UTTOs, etc., also contain VIIs, and viscosity loss will be encountered during use.

**Cleanliness**
Fluid cleanliness is extremely important in hydraulic system. More than 70% of all failures are caused by contamination, which can reduce hydraulic system efficiency up to 20% before system malfunction may be recognized. Different hydraulic components require different cleanliness levels. The cleanliness of a hydraulic system is dictated by the cleanliness requirement of the most stringent component in the system. OEMs and distributors should provide their customers with cleanliness requirements for Eaton hydraulic components used in their system designs. Refer to Eaton product catalogs for specific cleanliness requirements of individual components.

**Fluid Maintenance**
The condition of a fluid has a direct bearing on the performance and reliability of the system. Maintaining proper fluid viscosity, cleanliness level, water content, and additive level is essential for excellent hydraulic system performance. In order to maintain a healthy fluid, Eaton recommends performing periodic check on the condition of the oil.

**System Design Considerations**
When designing a hydraulic system, the specific gravity of the hydraulic fluid needs to be taken into consideration. If the specific gravity of the fluid is higher than that of mineral oil, be sure the reservoir oil level is adequately above the pump inlet to ensure a minimum of 1.0 bar absolute pressure at the pump inlet.

**Filters**
Proper filter type and size, which vary depending on the type of fluid used in a system, are essential for healthy system function. The primary types of filter materials are paper, cellulose, synthetic fiber, and metal.

Filter media, adhesive, and seals must be compatible with the fluid used in the system. To lengthen fluid change out intervals, special absorbent filter media may be used to remove moisture and acids from phosphate esters.

**Seals/Elastomers**
Select seal/elastomer materials that are suitable for the application, minimum and maximum operating temperature, and compatibility with the type of fluid used in the hydraulic system. The effect of hydraulic fluid on a particular elastomer depends on the constituents of the fluid, temperature range, and level of contaminants.

**Replacing Hydraulic Fluid**
Although sometimes valid, arbitrary hydraulic fluid change-outs can result in wasted good oil and unnecessary machine downtime.

A regularly scheduled oil analysis program is recommended to determine when oil should be replaced. The program should include inspection of the oil’s color, odor, water content, solid contaminants, wear metals, additive elements, and oxidation products. Clean the system thoroughly and flush with fresh, new fluid to avoid any contamination with the previous fluid/lubricant. Replace all seals and filters with new, compatible parts. Mixing two different fluids in the same system is not recommended.

Feel free to contact your Eaton representative with questions concerning hydraulic fluid recommendations.
# Z-Transmission

## Viscosity Requirements

<table>
<thead>
<tr>
<th>Product Line</th>
<th>Minimum Range</th>
<th>Optimum Range</th>
<th>Maximum Allowed Startup</th>
<th>ISO 4406:99 Cleanliness Requirements</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy-Duty Piston Pumps and Motors</td>
<td>*45 SUS (6 cSt)</td>
<td>60-180 SUS (10-39 cSt)</td>
<td>10,000 SUS (2158 cSt)</td>
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<tr>
<td>Medium-Duty Piston Pumps and Motors Charged Systems</td>
<td>*45 SUS (6 cSt)</td>
<td>60-180 SUS (10-39 cSt)</td>
<td>10,000 SUS (2158 cSt)</td>
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<tr>
<td>Medium-Duty Piston Pumps and Motors Non-Charged Systems</td>
<td>*45 SUS (6 cSt)</td>
<td>60-180 SUS (10-39 cSt)</td>
<td>2,000 SUS (432 cSt)</td>
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<td>Light-Duty Transaxes Transmission, Pumps and Series 1150 Transaxes</td>
<td>*60 SUS (10 cSt)</td>
<td>82-180 SUS (16-39 cSt)</td>
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<tr>
<td>Char-Lynn® J,R,T and S Series Motors, Disc Valve Motors and VIS Motors</td>
<td>*70 SUS (13 cSt)</td>
<td>100-200 SUS (20-43 cSt)</td>
<td>10,000 SUS (2158 cSt)</td>
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<td>Char-Lynn A Series and H Series Motors</td>
<td>*100 SUS (20 cSt)</td>
<td>100-200 SUS (20-43 cSt)</td>
<td>10,000 SUS (2158 cSt)</td>
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<td>Char-Lynn Steering Control Units</td>
<td>*55 SUS (9 cSt)</td>
<td>100-200 SUS (20-43 cSt)</td>
<td>8,000 SUS (1900 cSt)</td>
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<td>When emergency manual steering is required, maximum viscosity is 2000 SUS (450 cSt)</td>
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<td>Gear Pumps, Motors and Standard Cylinders</td>
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<td>Global Gear (A-Al) Products</td>
<td>52 SUS (8 cSt)</td>
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<td>Vane Pumps (Industrial)</td>
<td>60 SUS (10 cSt)</td>
<td>82-188 SUS (16-40 cSt)</td>
<td>4000 SUS (860 cSt)</td>
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<td>Vane Pumps (Mobile)</td>
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<td>Open-Circuit Piston Pumps PVM, PVH, PVE</td>
<td>60 SUS (10 cSt)</td>
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<td>Open-Circuit Piston Pumps PVQ, PVB</td>
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<td>Hydrokraft™ Pumps PVW, PFW, PVX, PFX, TVX, TVW</td>
<td>60 SUS (10 cSt)</td>
<td>82-349 SUS (16-75 cSt)</td>
<td>4550 SUS (1000 cSt)</td>
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<td>Hydrokraft Motors MVX, MFX, MVW, MFW</td>
<td>60 SUS (10 cSt)</td>
<td>82-349 SUS (16-75 cSt)</td>
<td>4550 SUS (1000 cSt)</td>
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</table>

*Minimum viscosity applies at intermittent condition of 10% of every minute.
# Z-Transmission

## Viscosity Requirements

<table>
<thead>
<tr>
<th>Product Line</th>
<th>Minimum Range</th>
<th>Optimum Range</th>
<th>Maximum Allowed Startup</th>
<th>ISO 4406:99 Cleanliness Requirements</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Directional Valves (DG)</td>
<td>45 SUS (6 cSt)</td>
<td>100-200 SUS (20-43 cSt)</td>
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<td>19/17/14</td>
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<tr>
<td>STAK Valves</td>
<td>45 SUS (6 cSt)</td>
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<td>17/15/12</td>
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<td>Cartridge Valves</td>
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<td>19/17/14</td>
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<td>K Series Proportional (Directional/Throttle)</td>
<td>45 SUS (6 cSt)</td>
<td>100-200 SUS (20-43 cSt)</td>
<td>10,000 SUS (2158 cSt)</td>
<td>17/15/12</td>
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<tr>
<td>DG, CM and Mono Block Directional Control Valves</td>
<td>45 SUS (6 cSt)</td>
<td>100-200 SUS (20-43 cSt)</td>
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<td>CMX and CML Proportional Control Valves</td>
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<td>KDG Proportional Control Valves</td>
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<td>45 SUS (6 cSt)</td>
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<td>Servo Valves</td>
<td>45 SUS (6 cSt)</td>
<td>100-250 SUS (20-54 cSt)</td>
<td>10,000 SUS (2158 cSt)</td>
<td>16/14/11</td>
<td>15/13/10 is recommended for longer life</td>
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