Servo Hydraulic Dynamic/Static Actuator
Introduction

Servo Hydraulic Dynamic/Static Actuators are based on Servo Hydraulic Closed Loop principle and are extensively used for applying dynamic loads or displacements for different applications on structures, automobile components, Structural beams, Columns etc. It is highly advanced system with fully computer controlled operation and also suitable for static loading applications.

Applications

The applications for Servo Hydraulic actuator are diverse and includes-

- Material Testing Machines
- Structural Testing
- Manufacturing Systems
- Fatigue & Endurance Testing of different materials
- Aeronautic (Due to their high power to weight ratio)
- Electromagnetic Marine Engineering
- Robotics

Principle of Operation

An electro hydraulic servo-valve under the control of an electronic controller controls the application of hydraulic power to a linear actuator to provide the programmed force to the test specimen. Hydraulic power is provided by hydraulic power supply which controls the pressure, flow, temperature and provides required filtration for the hydraulic fluid. The out put of the power supply is often interfaced to the servo-valve and actuator by hydraulic accessory module which provides further filtration and minimizes pressure surges in the system.

The electronic servo controller constantly senses error between the command signal and feed back signal. It then acts to minimize this error via its output to the servo-valve. The linear transducer or strain gauge based load cell supply displacement or force feed back as well as readout data to the servo controller to close the servo loop.
The main components of the system are:-

A. Actuator Assembly Unit (Capacity Ranges- +/-10kN to +/-1000kN).
   a) Actuator with Servo valve Manifold
   b) Swivel Base Assembly (For use in Cyclic, Reversing Load applications)
   c) Swivel Head Assembly
   d) Load Cell
   e) Displacement Transducer

B. Hydraulic Power Pack

C. PC based Control system and Control Software
   a) Signal Conditioning and Controlling Unit
   b) Computer for controlling and Data acquisition
   c) Control software

The details of system are given below:-

A. ACTUATOR ASSEMBLY UNIT (AAU)

   a) Actuator with Servo valve Manifold

Actuator is a linear motion device, which gives a controlled motion either on stress basis or strain basis. It is a precision piece of equipment which follows the command signal from the wave generator through the servo valve. It is an equal area ram and piston with surface finish of 0.2 microns. End plates have metallic seals for better side thrust. An inline coaxially mounted LVDT/ Magnetostrictive linear position transducer is fitted in the actuator to measure displacement of actuator and also run the system in displacement control mode. Servo valve is fixed to the actuator.

HEICO manufacturing range covers different type of Actuator such as-

- Model- HI75 series - Double Acting Single Ended with unequal area piston
- Model- HI85 series - Double Acting Double Ended with equal area piston
### Table 1(a)- Double Acting Single Ended Actuators

<table>
<thead>
<tr>
<th>Model</th>
<th>HI75.25</th>
<th>HI75.50</th>
<th>HI75.100</th>
<th>HI75.250</th>
<th>HI75.500</th>
<th>HI75.1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity in Compression (kN)</td>
<td>25</td>
<td>50</td>
<td>100</td>
<td>250</td>
<td>500</td>
<td>1000</td>
</tr>
<tr>
<td>Capacity in Tension (kN)</td>
<td>10</td>
<td>26</td>
<td>45</td>
<td>130</td>
<td>335</td>
<td>665</td>
</tr>
<tr>
<td>Rod Diameter (mm)</td>
<td>40</td>
<td>60</td>
<td>85</td>
<td>100</td>
<td>120</td>
<td>175</td>
</tr>
<tr>
<td>*Total Stroke (mm)</td>
<td>100</td>
<td>150/250</td>
<td>150/250</td>
<td>150/250</td>
<td>150/250</td>
<td>150/250</td>
</tr>
<tr>
<td>Max. Working Pressure (kg/cm²)</td>
<td>210</td>
<td>210</td>
<td>210</td>
<td>210</td>
<td>210</td>
<td>210</td>
</tr>
<tr>
<td>Servo Valve (LPM)</td>
<td>20/40</td>
<td>40/60</td>
<td>40/60/80</td>
<td>40/60/80</td>
<td>40/60/80</td>
<td>40/60/80</td>
</tr>
<tr>
<td>Total Length, L*+</td>
<td>290*+ T.S.</td>
<td>370*+ T.S.</td>
<td>500*+ T.S.</td>
<td>480*+ T.S.</td>
<td>540*+ T.S.</td>
<td>800*+ T.S.</td>
</tr>
<tr>
<td>Base Dimension, A x B (mm)</td>
<td>125 x 125</td>
<td>175 x 175</td>
<td>220 x 220</td>
<td>320 x 320</td>
<td>360 x 360</td>
<td>515 x 515</td>
</tr>
</tbody>
</table>

* Minimum Frequency (Hz) 0.01

* Maximum Frequency (Hz) 50 Hz or even more

### Table 1(b)- Double Acting Double Ended Actuators

<table>
<thead>
<tr>
<th>Model</th>
<th>HI85.10</th>
<th>HI85.50</th>
<th>HI85.100</th>
<th>HI85.250</th>
<th>HI85.500</th>
<th>HI85.1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity in Compression (kN)</td>
<td>10</td>
<td>50</td>
<td>100</td>
<td>250</td>
<td>500</td>
<td>1000</td>
</tr>
<tr>
<td>Capacity in Tension (kN)</td>
<td>10</td>
<td>50</td>
<td>100</td>
<td>250</td>
<td>500</td>
<td>1000</td>
</tr>
<tr>
<td>*Total Stroke (mm)</td>
<td>100</td>
<td>150/250</td>
<td>150/250</td>
<td>150/250</td>
<td>150/250</td>
<td>150/250</td>
</tr>
<tr>
<td>Max. Working Pressure (kg/cm²)</td>
<td>210</td>
<td>210</td>
<td>210</td>
<td>210</td>
<td>210</td>
<td>210</td>
</tr>
<tr>
<td>Servo Valve (LPM)</td>
<td>20/40</td>
<td>40/60</td>
<td>40/60/80</td>
<td>40/60/80</td>
<td>40/60/80</td>
<td>40/60/80</td>
</tr>
<tr>
<td>Total Length, L*+</td>
<td>380*+ T.S.</td>
<td>525*+ T.S.</td>
<td>730*+ T.S.</td>
<td>680*+ T.S.</td>
<td>725*+ T.S.</td>
<td>1050*+ T.S.</td>
</tr>
<tr>
<td>Base Dimension, A x B (mm)</td>
<td>125 x 125</td>
<td>175 x 175</td>
<td>220 x 220</td>
<td>320 x 320</td>
<td>360 x 360</td>
<td>515 x 515</td>
</tr>
</tbody>
</table>

* Minimum Frequency (Hz) 0.01

* Maximum Frequency (Hz) 50 Hz or even more
Test Stroke length depends upon the frequency of operation i.e. it decreases with increase in frequency and vice versa. Therefore, test stroke is to be calculated from the Performance curve of the actuator determined with given hydraulic power pack.

* Stroke length up to 500mm or even more can also be provided as per customer requirement

Note- All Dimensions are approximate and subject to change for better performance of the actuator

**Servo Valve Manifold**

A servo valve with Pressure Line filter & Accumulators is fitted on the manifold block that controls the movement of the ram as per given command signal from controlled electronics.

**Servo Valve**

The servo control valves are throttle valve for 4 way applications. It is two or three stage valve that is suitable for a rated capacity with a pressure drop of 1000 P.S.I (70 Kg/cm²). The output stage is a closed center four way sliding spool.

- Make of Servo Valve - MOOG/STAR
- Flow - 20LPM/40LPM/60LPM/95LPM (Depending upon requirement)

**Some of the salient features of the valve are:-**

- 2 stage design with dry torque motor
Low friction double nozzle pilot stage
High Spool control force
High dynamics
Long life and rugged design
Low hysteresis
Field replaceable first stage disc filter

Pressure Line Filter

It is an interface between hydraulic pump and servo valve. Pressure line filter is attached next to the servo valve. Servo valve is a very sensitive controlling gadget. It has very fine nozzles. If any particle gets into these nozzles, the possibility is that the system will not respond at all. For maintenance the valve has to be sent to the manufacturer. Filtration in the high pressure filter is 3 µ absolute. The position of the filter is such that the cartridge can be replaced without opening any pipe line.

Make - EPE/ Hydrol ine/ Hydac
Filteration-3 µ

Accumulators

Diaphragm type accumulators have been used in the system for -

- Fluid Power Storage
- Counter Balance
- Pulsation Dampner
- Hydraulic Semi Shock Damper
- Emergency energy reserve
- Shock absorber
- Volume compensator
- Hydraulic Spring
- Fluid Separator

The system have basically a steel shell in which is fitted a bladder pre-charged with nitrogen gas. The main components of the accumulator are

1. The sheet which is made of steel in a dome shape
2. Diaphragm an interface between the fluid and the gas
3. Gas valve for pre-charging or releasing the excess pressure
4. Anti extension valve this prevents the diaphragm from getting into the inlet port of the oil

For appropriate efficiency of the system suitable accumulators are used for both the 'A' and 'B' port.
Make- EPE/ Hydroline/ Hydac
Capacity-0.16/0.32/0.5 Litres (Depending upon the capacity of actuator and application)

b) Swivel Base Assembly (For use on Cyclic, Reversing Load applications)
   i) Static Force capacity:- +/-150% of Actuator Capacity
   ii) Dynamic Force capacity:- +/-120% of Actuator Capacity
   iii) Swivel Angle:- +/-75 degree (min.)
   iv) Tilt Angle:- +/-15 degrees (min.)

   c) Swivel Head Assembly
      i) Static force capacity:- +/-150% of Actuator Capacity
      ii) Dynamic force capacity:- +/-120% of Actuator Capacity
      iii) Swivel Angle:- +/-75 degrees (min.)

d) Load Cell
It is a strain gauge based type load cell with full wheat-stone bridge configuration. Structure of the load cell is such
that it can be loaded in Compression/Tension over few million numbers of times. It has Alloy tool steel, electro less
nickel plated structure for outstanding corrosion resistance.

Technical Specification

Capacity : +/-10kN to +/-1000 kN
Make : Adi-Artech/ Sensotronics
Full Scale Output : 2.0 mV/V
Non-Linearity : < ± 0.05% FSO
Hysteresis : < ± 0.05% FSO
Non-Repeatability : < ± 0.05% FSO
Hysteresis : < ± 0.05% FSO
Non-Repeatability : < ± 0.05% FSO
Creep (30 minutes) : < ± 0.03% FSO
Excitation Voltage : 10 Volts DC
Safe overload : 150%
Operating Temperature : 0°C to +60°C
Protection Class : IP68
e) Displacement Transducer

Actuator has integral displacement sensor which is co-axially fitted to the lower part of the actuator. Magnetic ring is fixed to the ram of the actuator. It is contact less linear position transducer with magnetostrictive technology. The absence of Electrical contact on the cursor eliminates all wear and guarantee almost unlimited life.

Salient feature of Linear Transducer:

- ONDA technology
- Optimized mechanical structure
- Strokes from 50 to 4000 mm
- Wide range of connectors for the electrical connection
- Rod, nipple, exagonal flange AISI 316
- Work temperature : -30°...+75°C
- Resistance to vibrations (DIN IEC68T2/6 12g)
- Power supply 24Vdc ± 20%
- Protection IP67
- Immunity to shock, vibration, contamination and electrical noise.
- An absolute output signal

Technical Specification

Range : 100mm to 500mm
Make : Gefran/Balluff
Full Scale Output : 10.0 Volts
Independent Linearity : ± 0.02% of FS
Repeatability : <0.01mm
Hysteresis : <0.01mm
Pressure Withstand : Up to 600 Bars
Excitation Voltage : 24 Volts DC
Sampling Rate $f_{\text{Standard}}$ : 2kHz
Operating Temperature : -30° to +75°C
Protection Class : IP67
B. HYDRAULIC POWER PACK (HPS UNIT)

Hydraulic power supplies are compact in design and are suitable for the supply of required flow and pressure for the actuation of the actuator to carry out various tests as per different standard for dynamic/static tests. It has an oil tank of adequate capacity, a pump powered by a three phase motor. It includes all the accessories like return line filter, oil level, relief valve, pressure gauge, Bye pass valve in case of clogging of the filter etc. Anti vibration mountings are provided as standard along with the HPS.

Features

- Provided with a large reservoir nearly 3 – 4 times the capacity of the pressure pump
- Vane/Gear type pump for better life
- Filtration of 3 microns absolute for the protection of servo valve and also for the smooth functioning of the valve.
- Inter locking at each stage for the protection of the components as well as oil
- Starting at almost zero pressure the switching over to full pressure through solenoid and timer switch provided.
- Submersed inlet with filter for pump protection.

A suitable water cooled heat exchanger (Shell and tube type) or air cooling arrangement is provided for cooling of the hydraulic oil. Temperature controller is provided to prevent overheating of the hydraulic beyond 50°C.

Safety interlocks are also provided as standard with the HPU and trips the system, in case any of the interlock is activated.

- Over heating of the oil (Temperature Controller),
- Contamination of the oil (Clogging Filter),
- Relief Valve for pressure regulation,
- over loading of the motor,
- Phase failure,
- Low oil Level

These supplies are compatible with loading units / actuators of different sizes & capacities manufactured by HEICO.
### Table 2 - Hydraulic Power Pack

<table>
<thead>
<tr>
<th>Model</th>
<th>HI 595.05</th>
<th>HI 595.10</th>
<th>HI 595.15</th>
<th>HI 595.20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow of Pump (LPM)</td>
<td>20</td>
<td>40</td>
<td>53/64</td>
<td>95</td>
</tr>
<tr>
<td>Type of Pump</td>
<td>Vane/gear</td>
<td>Vane/gear</td>
<td>Vane/gear</td>
<td>Vane/gear</td>
</tr>
<tr>
<td>Max. Operating Pressure (kg/cm²)</td>
<td>210</td>
<td>210</td>
<td>210</td>
<td>210</td>
</tr>
<tr>
<td>Make of Pump</td>
<td>Vickers/Dowty/Dennison</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacity of the Oil Tank (Litres)</td>
<td>100</td>
<td>200</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>Motor Rating (HP)</td>
<td>10</td>
<td>20</td>
<td>25/30</td>
<td>50</td>
</tr>
<tr>
<td>Make of motor</td>
<td>NGEF/ABB/Kirloskar/Bharat Bijlee/Crompton</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return line filter (µ)</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Power Supply</td>
<td>440V, 3Phase, 50Hz</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Water supply at the specified flow @ 30-35°C is to be provided by the consignee or Cooling Tower is to be purchased separately in case of water cooling heat exchanger.
**Electrical Control Cabinet**

This Electrical control Cabinet consisting of Electrical Components like:-

1) Contactors
2) Time delay relays
3) Power inlet points
4) Indicating lamps(RYB)
5) Temperature Controller

and other electrical accessories are fixed inside the Electrical Control cabinet having protection class IP65. System will be supplied with necessary cable and fittings for the operation of the machine. Total machine operates on 440VAC 3 phase supply.
C. PC BASED CONTROL SYSTEM AND CONTROL SOFTWARE

Control system provides the digital servo control, Wave generation for the actuator, data acquisition, hydraulic control etc. for the continuous operation of the system.

(a) Signal Conditioning & Controlling Unit

**HEICO Servo controller** basically consists of signal conditioning unit and controlling unit. Signal conditioning unit consists of conditioning modules for various transducers (e.g. Load Cell, Displacement Transducers etc.) that receives the output signal from these sensors and amplifies and process that signal as per the requirement and transfer it to computer through dedicated cables where it is accepted by the data acquisition system. The controlling unit controls the movement of the RAM with respect to the signal input on feed back basis either from **LOAD CELL** or **DISPLACEMENT** sensor (or through an external sensor optional).

It consists of dedicated **Servo-controller card** that gives the desired processed signal through the Automatic P.I.D controller to the servo valve to operate either of the control modes i.e. Load mode or Displacement mode. It also sends the signal to computer and accepts the command from the software to operate in desired manner. The parameters like rate of loading for machine, safety limits for load & displacement can initially be programmed through the software. The programming facility is given to operate the system in **STATIC MODE** at programmed rate of loading in both Load and Displacement controls. In **DYNAMIC MODE** the cycling can be done at a frequency from 0.01Hz-50Hz or even higher.

**Specifications of Controller**

- Auto PID operation with auto zeroing, auto tuning and auto-adjustment feature servo operation
- Closed loop update rate is 10 kHz
- Facility to expand up to 4 Independent Control modules with independent wave generator
- No. of control channels- 3 (Load/Displacement/External Channel (Strain control))
- 12-Additional Analog Input channels to accept analog input signals from different sources such as strain gauge, LVDT, load cells, temperature sensors etc.
- Demand Wave generation - Sine, Triangular, Square, Random wave forms and Ramp signal
- Standalone operation to Start, Stop & Hold the test system
- High speed Data Acquisition card with 100 kHz sampling rate and 16/24 bit resolution acquires data form the signal conditioning and controlling unit
- System accuracy - Load accuracy : ± 0.5% of indicated value of load
  Displacement accuracy: + 0.5% of indicated value of displacement
- Two types of Loading- Dynamic (for fatigue test) and Static (Ramp)
- Dynamic Frequency Range - 0.01Hz to 50Hz or even higher *(Note: The stroke of actuator depends upon)*
the frequency of operation. Performance curve will be provided along with the offer

- Static Ramp rate: Load control mode – Refer Table.
  Displacement control mode- Refer Table.
- Event Detector
- Environmental Temperature- 0°C to +50°C
- Relative Humidity- 10% to 85% non-condensing
- Supply Input- 220-240 VAC, 50 Hz

(b) Computer for Controlling and Data acquisition

System is provided with dedicated computer of latest available configuration with built in data acquisition card and wave generator.

(Note- Latest available model of the computer will be supplied at the time of delivery)

Control Software

Control software is the integral part of the system for precise controlling & Data Acquisition and analysis.

Salient Features

- Windows based user friendly software
- Different types of loading can be given to the sample- Sine, Triangular, Square, Random waveform and Ramp signal with frequency 0.01Hz to 50Hz
- Programmable Loading parameters – Frequency, Base, Amplitude, etc.
- Programmable rate of loading in static mode
- Two types of Tests- Dynamic (for fatigue test) and Static (Ramp).
- Defining test sequences
- Computer/Software programmable Safety Limits for each load & displacement
- Independent Taring of each channel
- Facility to hold the actuator and restart the loading during the test.
- Facility to increase the Base load, frequency and amplitude during the test
- Facility to save the data after the test
- Displays and Store the number of cycles in Dynamic test
- On-line display of Load v/s Displacement, Load v/s Time, Displacement v/s Time graphs
- On-line display of Load, Displacement and additional channels readings
- Auto adjustment of graph scales
- Storing of data of each channel in user defined file/directory that can be directly opened in Excel and Analysis Software
- To analyze the test result Analysis software is given which shows different type of graph and data i.e. load Vs displacement graph, load Vs time graph, displacement Vs time graph for statistical analysis.
### Table 3 - Electronic Controller & Data Acquisition System

<table>
<thead>
<tr>
<th>Model</th>
<th>HI85.10</th>
<th>HI85.50</th>
<th>HI85.100</th>
<th>HI85.250</th>
<th>HI85.500</th>
<th>HI85.1000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electronic Controller</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed Loop Update Rate (KHz)</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of System</td>
<td>4 Independent control module with independent wave generator</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of System Channels</td>
<td>3 (Each control module has 3 control channels)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Parameters</td>
<td>Load/Displacement/External Transducer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waveform Generation</td>
<td>Sine/Haversine/Square/Triangular/Random/Ramp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Loading</td>
<td>Dynamic/Static</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Dynamic Frequency (Min.)</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>*Dynamic Frequency (Max.)</td>
<td>&gt;50</td>
<td>&gt;50</td>
<td>&gt;50</td>
<td>&gt;50</td>
<td>&gt;50</td>
<td>&gt;50</td>
</tr>
<tr>
<td>No. of Data Points per cycle</td>
<td>128 up 10Hz Frequency and 64 above 10Hz Frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static Ramp Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Control (kN/sec)</td>
<td>0.001-0.5</td>
<td>0.01-2.00</td>
<td>0.01-5.00</td>
<td>0.1-5.0</td>
<td>0.1-10.0</td>
<td>0.1-20.0</td>
</tr>
<tr>
<td>Displacement Control (mm/sec)</td>
<td>0.01-5.00</td>
<td>0.01-10.00</td>
<td>0.01-10.00</td>
<td>0.01-10.00</td>
<td>0.01-10.00</td>
<td>0.01-5.00</td>
</tr>
<tr>
<td>Load Accuracy</td>
<td>&lt;0.5% of indicated value of load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Displacement Accuracy</td>
<td>&lt;0.5% of indicated value of displacement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Resolution (kN)</td>
<td>0.001</td>
<td>0.01</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Displacement Resolution (mm)</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>DATA ACQUISITION</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Additional Channels</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Resolution</td>
<td>16/24-bit</td>
<td>16/24-bit</td>
<td>16/24-bit</td>
<td>16/24-bit</td>
<td>16/24-bit</td>
<td>16/24-bit</td>
</tr>
<tr>
<td>Sampling Rate (kHz)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Digital Inputs &amp; Outputs</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>No. of Data Points per cycle</td>
<td>128 up 10Hz Frequency and 64 above 10Hz Frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Temperature (°C)</td>
<td>0-50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply Input</td>
<td>220-240 VAC, 50 Hz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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* The test stroke length depends upon the frequency of operation i.e. it decreases with increase in frequency and vice versa. Therefore, test stroke is to be calculated from the Performance curve of the actuator determined with given hydraulic power pack.

*** User Specification, if differ from the standard ones will be incorporated in the nearest model to suit the user's requirement. Also, the combination of Actuator and Hydraulic Power Pack can be altered depending upon the user's requirements/applications

**OPTIONAL AT EXTRA COST**

1. Water Cooled Heat Exchanger with Cooling Tower for cooling of Hydraulic Oil

   OR

2. Air Cooling system for cooling of Hydraulic oil

3. Loading frame of different capacities & dimensions to mount the actuator can also be supplied as per customer requirement