

Energy Comparison of Servo Electric (SEA) vs Servo Hydraulic 4 Poster with a combined 4-Post/Environmental Chamber test system

Following is a summary of all the basic energy consuming elements of a Servo Electric Actuated (SEA) 4 Poster vs a comparably-sized servo hydraulic 4 Poster system. While the actual hardware may vary, this summary is to be used as a general guide and can be adjusted according to actual components and duty cycle usage.

eMpulse SEA 4 Poster

DURING OPERATION

Data was supplied by one of our OE customers in South Africa, using the eMpulse Test Systems SEA 4- Poster, which is a 41kN with dual 200A motor modules per actuator.

During the test, 4 road profiles and one sine twist profile were run per seating position, per test interval. There are 11 test intervals. The evaluation was run with a mid-size SUV on the 4-Poster, it used 0.57kWh. Over the whole test sequence (4x test per 11 intervals), this would result in using 25.08kWh.

Without knowing the specific power usage for each road profile, or the amount the time the 4 Poster was being run vs hot/cold soaking, some estimates must be made based on data file analysis, motor, and electronics energy parameters: For a road profile with a 25% duty cycle (typical for harsh NVH/light durability), the motors and electronics use:

$$\text{AIM} = 490\text{W} \times 2 = 1.0\text{kW}$$

$$\text{ALM} = (275+71) \times 2 = 0.7\text{kW}$$

$$\text{MOMO} = (425 + 93) \times 8 = 4.1\text{kW}$$

Total Energy Usage during Operation at 25% duty cycle = 5.8kW

In addition to this direct power usage, the energy required for cooling should be included. This does not exceed **10HP (7.46kW)** at full cooling, estimate 25% duty cycle = **1.9kW**.

DURING IDLE

During idle time, the energy consumption of the Active Interface Modules (2), Active Line Module, and Motor Modules are:

$$\text{AIM} = 43.2\text{W} \times 2 = 0.1\text{kW}$$

$$\text{ALM} = 70.9\text{W} \times 2 = 0.14\text{kW}$$

$$\text{MOMO} = 93\text{W} \times 8 = 0.74\text{W}$$

Total Energy Usage during Idle = 0.98kW

The motors use no energy, so the power consumption is 0kW

Servo Hydraulic 4 Poster

Servohydraulic 4-Post System

A rough estimate on a representative hydraulic system would be **15kip (66kN)** actuators with hydrostatic bearings, and servo valves sized to provide about **2m/sec (78.7 in/sec)** peak velocity, ($5\text{in}^2 \times 78.7\text{in}/\text{sec}$, or $393\text{in}^3/\text{sec}$, or 102 gpm). This is most likely achieved using **90-120 gpm 3-stage servovalves**.

The Hydraulic Power Supply is typically sized at 25-40% of peak actuator flow for all 4 actuators to handle the rms content, so the HPS is conservatively estimated at 30% of 400 gpm, or **120gpm**.

The motor/pump HP (KW) requirement for this flow is roughly estimated at 2X the flow rating, or **240 HP (179kW)**.

The Hydraulic Power Supply does not run at peak flow, rather the rms of the waveform content. In this case we estimate the rms content to be approx. 25% of the peak requirements, which is a 4:1 Pk/rms ratio. Applying this to the energy requirement for the Hydraulic Power Supply results in an average power usage of 25% of 240 HP (179kW) = **60 HP (44.76kW)**

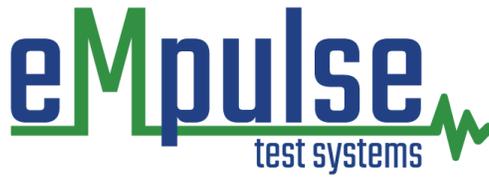
Depending on the type of hydraulic pump used, the energy usage during idle can vary considerably:

- All hydrostatic bearings, piston rod leakage, valves, etc will use flow during idle, this is estimated at 2 gpm per actuator, or 8 gpm total. This equates to **16HP (12kW)**
- The type of hydraulic pump used will affect the power usage when idle:
 - For a fixed displacement pump, virtually all power is lost as heat when sitting at idle
 - For a variable volume pressure compensator pump, approximately 50% is lost as heat
 - For a load compensated (variable displacement) pump, approximately **15-20%** is lost as heat
 - As the hydraulic power supply is an unknown, the energy usage **during idle is estimated at 15% of rated capacity, or 36HP (26.9kW)**.

Finally, the cooling circuit power usage must be considered. This consists of two parts: One to cycle the water through the oil/water heat exchanger, and one to remove the heat from the water.

Typically the water cooling flow rate is 50% of the oil flow rate, or in this case 50% x 120 gpm, or 60 gpm. 60 gpm x 30 psi requires approx. **1 HP (0.746 kW)**. For the heat removal, a separate water-to-air exchanger is used, estimated at **10HP (7.46kW)**. If these units are load-controlled (not typical), we can estimate power usage at 25%, or **1.9kW**.

Additional losses, such as pump and motor inefficiencies, hose and hard line losses, servovalve pressure drop due to flow, return line back pressure, etc. are neglected in this summary, but are additional sources of heat which require additional cooling power.



RESULTS SUMMARY:

The following results are given as kW power usage numbers. In order to calculate the overall energy kWh usage, they can be converted directly by multiplying by the number of hours of operation time.

SEA 41kN DURING 25% DUTY CYCLE OPERATION 7.7 kW – TOTAL POWER REQUIREMENT

SEA 41kN DURING IDLE
1.0 kW – TOTAL POWER REQUIREMENT

SERVO HYDRAULIC DURING 25% DUTY CYCLE OPERATION
45.0 kW - Hydraulic Power Supply
8.2 kW - Cooling Circuits
53.2kW - TOTAL POWER REQUIREMENT

SERVO HYDRAULIC DURING IDLE
26.9 kW – Hydraulic Power Supply
2.6 kW – Cooling Circuits
29.5 kW – TOTAL POWER REQUIREMENT

	DURING 25% DUTY CYCLE	DURING IDLE
SEA 41kN	7.7 kW	1.0 kW
SERVO HYDRAULIC 15KIP 120GPM	53.2 kW	29.5 kW
<i>RATIO SEA / HYDRAULIC %</i>	<i>14.5%</i>	<i>4%</i>

As can be seen from the above, *the servo electric actuated system uses only a small fraction of the energy* when compared to a servo hydraulic system. As the duty cycle usage increases, the energy usage of both systems increases, but is still significantly less than a comparable hydraulic system.

eMpulse Test Systems conservatively estimates the energy costs of a SEA system as *LESS THAN 20% OF A COMPARABLE HYDRAULIC SYSTEM.*