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Factors to Consider When Selecting an LAB HV System

History:

Over the past 80+ years, LAB has been very skilled in the design and manufacturing of mechanical vibration systems and many Electro-Mechanical Vibration Systems. Electro-Mechanical are commonly referred to as Hydraulic Vibration Systems. For this discussion, we are going to talk about LAB Hydraulic Vibration (HV) Systems.

In order to size a system properly, many relationships of the system have to be looked at and calculated. Some the relationships are linear and some nonlinear. Almost all of the variables that have to be considered when selecting the right system are dependent upon each other and cannot be decided upon without considering other components and parameters of operation.

Types of Vertical HV systems that LAB has manufactured: (95% of LAB systems made to operate in the Vertical Motion only)

- Vertical Motion (Smallest)- 24" x24" table with controls, reaction mass, 5,000 Force pound actuator, HPS and all components for operation. It is designed to perform under various sine and random testing specifications.

- Vertical Motion (Largest) 190" x160" table with controls, reaction mass, 30,000 Force pound actuator, HPS and all components for operation. It is designed to perform under various sine and random testing specifications.

- Typically the LAB HV model with a 48x 48" or 60x 60" table is the most common.

- Types of Horizontal HV systems that LAB has delivered: (5% of LAB systems have been made with this Motion). It is designed to perform under various sine and random testing specifications.
- Horizontal Motion 1M x 1M table with controls, reaction mass, 5,000 Force pound actuator, HPS and all components for operation.
- Horizontal Motion 1.2 M x 1.2 M table with controls, reaction mass, 8,000 Force pound actuator, HPS and all components for operation.

Parameters of an HV System:

Displacement of an Actuator

The displacement of the system is the distance the table will travel as driven by the actuator. In most cases, the movement is only vertical. It is called the "peak to peak" displacement which means the total travel up and down of the actuator. A test could require a "peak to peak" displacement of 4".

The higher the frequency, the more difficult it is to have a system with a long stroke (displacement) actuator while maintaining desired performance and control. LAB has made systems with a 10" Stroke (very specific performance) and several with less than .5" stroke. Typically, a short displacement actuator is easier to control and provides significant G levels at High frequency (500+Hz). The shorter the stroke, the faster the actuator can react to the required demand of the system or what is referred to as the System Velocity-"How fast the actuator can go up and down". The less the displacement, the less the oil the system has to move.

How to calculate displacement: A typical LAB actuator is 4" peak to peak.

Displacement (D) is a function of G (Gravity and unit less) and Frequency (F).

G=.0511xF^2xD (D is in inches)

So, D= G/(.0511xF^2)

What does it take to have 5 G's at 1 Hz? **97" of displacement**

What does it take to have 5G's at 20 Hz? **.245" of displacement**

What about G Level?

In order to know what force actuator you need in an HV system, you need to know the following:

Example: LAB HV60 (pounds)

- Mass of the table (1200)
- Mass of the actuator (75)
- Mass of the UUT and the fixtures

Sine Testing:

- To Calculate the required force with a known G level to perform sine testing, you can use this formula (Newton's 2nd law of motion): F=M*A.

What force is required with a LAB HV 60x60 table with a 150 pound payload to operate at 5 G's (Within a frequency range that is possible) in force?

- F=5 x(150x75x1200)= 7100 Force Pounds, 7,100 Static force pound Actuator

What do we allow for system losses and performance variation? LAB uses a factor of .66 for systems losses in energy, efficiency and movement of the reaction mass.

7100/.66= **10,750 Force pounds**

This is the minimum size needed under these conditions.

- Now try the same calculation with a UUT (Unit Under Test) of 2MT (Metric Tons) (4400pounds)

You would require a **42,000 Force pound actuator!**

Random Testing:

To Calculate Force in performing Random testing, you can use this formula: F=3*Grms*(75+1200+150)

Why the multiplying factor of "3"? This accounts for proper replication of the system and employs a 3 sigma value for proper replication of the energy and spectrum. Statically, 3 Sigma is what is typically required mathematically and used by all system designers.

- If we wanted to do ASTM 4169, Level II Truck (.54 Grms) with a 150 pound UUT
  - 2200 Force pounds
- If we wanted to do ASTM 4169, Level II Truck (.54 Grms) with a 2MT UUT
  - 9200 Force pounds
- If we wanted to do ISTA, 2B (1.15 Grms) with a 2MT UUT
  - 20,000 Force pounds

What about Frequency?

Typically a LAB HV system can operate from less than 1hz to 300Hz for package and transportation simulation and up to 500Hz for product evaluation.

Neither air transport nor truck transport require testing over 300Hz. This frequency component is simply not present. Although the transportation environment goes down to 1 Hz, ED (Electrodynamic)

Shakers are hard pressed to get to this frequency within a considerable amount of expense and re-design of the armature system.

The Servo value in a HV system is a mechanical spool type device that pushes the oil one way or the other. The more GPM (Gallons per minute) required by the system, the larger the valve is and the quicker the performance falls off in frequency. The mechanical moving parts in a valve just cannot move fast enough to guide the oil if the valve is a big flow (15-20 GPM) valve. This is why if you have a 5GPM valve the frequency at which it can perform at is much higher than a 25 GPM valve.

What about Table size?

The bigger the table, the more the mass of the table. The more mass, the lower the system resonance becomes and hence the more difficult it is for a controller to drive and control the system past this resonance.

This is why it is much easier to have a 24" x 24" (light table) go to 500Hz than it is for a 2M x 2M (Very heavy) table to get much past 300 HZ.

So what do you have to know to properly size a HV system?

- Maximum Payload in size and Mass
- When performing Sine tests, the G level at different point of frequency are needed so that:
    - The displacement can be calculated
    - The force of the actuator can be calculated at that frequency
    - The required flow of the HPS and the performance of the servo valve can be calculated and matched to the required performance
- When performing Random testing, the Grms level at different points of frequency (As well as the overall Grms level needs to be calculated) so that:
    - The displacement can be calculated
    - The force of the actuator can be calculated at that frequency
    - The flow of the HPS and the performance of the servo valve can be calculated and matched to the required performance

What are the components of a HV system and what has to be considered? (Typical LAB HV Component range)

1. The Actuator (1" to 4" stroke and 5,000 to 12,000 force pounds)
    - Force and Stroke
2. The Reaction mass (5,000 to 16,000 pounds)
    - What size does this have to be to be stable and allow the energy to remain in the system and not get "displaced" while the system is vibrating.
3. The Servo Valve (5 to 25GPM)
    - What is the maximum flow (GPM)

- What frequency does this need to operate at

4. The Table (24x24" to 72x72")
    - How light and small can it be as to lessen the system demand while supporting the demands of the various UUTs.
5. The HPS (30 HP to 75HP)
    - What flow does this system need to deliver to the actuator while testing
    - Is the pump fast enough to react to the changing demands of the system (The bigger the pump, the slower the reaction time will be)

With a variety of test specifications in existence; ISTA, ASTM, Mil-STD and a host of others, a manufacturer has to be diligent in establishing a system that can meet your needs. Very often, a single system cannot be designed to perform from one end of the test spectrum to the other (perform an ISTA 1A test with a significant payload while testing smaller components at higher G levels and higher frequencies). Often, a practical compromise needs to be agreed upon between the end user and LAB.

This is where our many years of experience at LAB Equipment, Inc. will serve you well. We enjoy looking at your applications and needs and have a wide breath of experience reviewing test procedures as well as have countless experiences with various applications throughout the world. We are very confident we can provide with good guidance for all your projects. We may not be your best solution for all your requirements.

Give us a call. We know we can help. Let the sales and technical support people at LAB provide you with a solution that will meet your vibration testing needs today and tomorrow.

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