Engine/Generator Isolation Stand Design Example

For:

Engine = 800 lbs and CG located 14.75 inches from datum (location of mounts on engine side)

Generator = 160 lbs and CG located 34.75 inches from datum

Structure = 100 lbs and CG located 22.5 inches from datum

Distance between Engine Side and Generator Side Mounts = 45 inches

Summing the forces which must equal zero:

Fg = Static Load on Engine Side

Fg = Static Load on Generator Side

2Fg + 2Fe -160 -100 -800 = 0

or Fg + Fe = 530 lbs

Summing the moments about the datum which must equal zero:

(2)(45)Fg - (34.75)(160) - (22.5)(100) - (14.75)(800) = 0

or Fg = 217.9 lbs

and from above, since 217.9 + Fe = 530, Fe = 312.1 lbs

Using this procedure:

https://karman.com/products/selection-steps

and:

Disturbing Frequency = 650 RPM/60 Seconds/Minute = 10.83 Hertz

Required Natural Frequency (for 80% Isolation) = 10.83/SQRT (1/(1 - 80/100) + 1) = 10.83/2.45 = 4.42 Hertz

Required Total Static Deflection = 9.8/(4.42)(4.42) =0.50 inches

Recommended Spring Rate (Engine Side) = 312.1/0.50 = 623 lbs/inch

Recommended Spring Rate (Generator Side) = 217.9/0.50 = 435 lbs/inch

Let's select one common available design spring rate for all the mounts, say 500 lbs/inch. Some research will show that this spring rate is not readily available in standard Karman rubber mounts for the static loads they will experience. However, this issue can be resolved by using two 1000 lbs/inch mounts in series (i.e., using two isolation levels) which in combination will provide our design 500 lbs/inch spring rate with each isolation level experiencing about 0.25 inches of static deflection (0.5 inches required total static deflection divided by 2 isolation levels). Karman Rubber Cylindrical Mount K730-41 are suitable and are 3.125 inches in diameter, 2.25 inches in height, have 1/2-13 inch thread inserts, 1000 lb/in spring rate, and have a 0.40 inch recommended maximum static deflection (which is acceptable for our 0.25 inch design) at a 400 lb static load (which is acceptable for our 217.9 lb and 312.1 lb static load design). Since we have two mounts on each side of each or our two isolation levels, we need eight K730-41 mounts total for this two level isolation stand design.

Predicted Static Deflection (Engine Side) = 312.1/1000 = 0.31 inches for each K730-41 mount which is within the recommended limit. Total static mount deflection on engine side is 0.62 inches. This total static mount deflection is used to determine the natural frequency on this side.

Predicted Static Deflection (Generator Side) = 217.9/1000 = 0.22 inches for each K730-41 mount which is within the recommended limit. Total static mount deflection on generator side is 0.44 inches. This total static mount deflection is used to determine the natural frequency on this side.

Which results in these calculated/predicted isolation stand parameters:
Predicted Natural Frequency (Engine Side) = SQRT (9.8/0.62) = 3.96 Hertz
Predicted Natural Frequency (Generator Side) = SQRT (9.8/0.44) = 4.74 Hertz
Predicted Transmissibility (Engine Side) = 1/[SQ (10.83/3.96) - 1] = 0.154
Predicted Transmissibility (Generator Side) = 1/[SQ (10.83/4.74) - 1] = 0.237
Predicted Isolation (Engine Side) = 100 x (1 - 0.154) = 84.6%
Predicted Isolation (Generator Side) = 100 x (1 - 0.237) = 76.3%
Predicted Overall Isolation Stand Efficiency = (84.6 + 76.3)/2 =80.4%

And here's a calculator to reduce the manual calculation math for designing an isolation stand:

Isolation Stand Design Calculator

The actual isolation stand was constructed in two isolation levels to achieve the required effective 500 lbs/inch spring rate as described above resulting in four K730-41 mounts on the Engine Side (two mounts on each isolation level on this side) and four K730-41 mounts on the Generator Side (two mounts on each isolation level on this side) or eight mounts total for this isolation stand design. Actual/Measured Overall Isolation Stand Efficiency was measured using a piezoelectric accelerometer vibration meter and found to be 96% with a frequency of 2.1 Hz. This additional 15.6% of actual/measured overall isolation stand efficiency beyond the calculated/predicted overall isolation stand efficiency is likely the result of constructing the isolation stand using wood structure between the two isolation levels (which was required to achieve the design mount spring rates given the limited availability of mounts as described above) which resulted in the actual isolation stand natural frequency being significantly lower than the predicted 80% design 4.42 Hz natural frequency. Descriptive photos may be found here:

Listeroid 6/1 Engine & ST5 Generator System Build Photos

Cheers,
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