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DOUBLE AND SINGLE ELASTIC SUPPORT FOR LARGE GENERATOR SETS

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ABSTRACT

Currently, when a high-level vibration and shock attenuation is required, a two-level series isolation (2 degree of freedom system) to get the highest filtration (very characteristic of naval environment). The present document shows a study case from the beginning selecting the best antivibration strategy to reach the targets.

Keywords: *bench, double, vibration, shock, 2DOF***.**

1. INTRODUCTION

Large diesel generator sets generate considerable dynamic forces due to combustion, rotating mass imbalance, and torque pulsations. To prevent the transmission of vibrations and shocks to the surrounding structure, elastic support systems are employed. These systems, often using elastomeric or spring-type isolators, aim to reduce the transmissibility of both steady-state vibrations and transient shocks. In marine and industrial installations, proper mounting design is critical not only for operational efficiency but also for structural integrity, acoustic comfort, and to reduce noise radiated into the water.

This paper presents a comparative analysis between single and double elastic support configurations, focusing on a case study with a 10,000 kg generator set. The study first evaluates three different masses for the base frame in a single elastic support system. Then, a second stage of elastic isolation is introduced by adding an intermediate mass, forming a double elastic support configuration. The results illustrate the influence of support design on vibration isolation performance.

2. THEORETICAL BACKGROUND

2.1 Single Elastic Support

In a single elastic support configuration, the generator and its base frame are mounted on a set of vibration isolators directly coupled to the final foundation (either a ship structure or building). This forms a single-degree-of-freedom (SDOF) system. The vibration isolation depends on the ratio between the excitation frequency and the natural frequency of the mounted system, with better performance achieved when the natural frequency is much lower than the excitation frequency.

The natural frequency is calculated by Eqn. (1):

$$f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \tag{1}$$

Where k is the stiffness of the isolators and m is the total suspended mass.

The transmissibility T of the system, which expresses the ratio of transmitted force to input force, is given by Eqn. (2):

$$T = \frac{\sqrt{1+(2\zeta r)^2}}{\sqrt{(1-r^2)^2+(2\zeta r)^2}} \tag{2}$$

Where:

$$r = \frac{f}{f_n} \tag{3}$$

- ϒ is the frequency ratio
- ζ is the damping ratio
- f is the excitation frequency
- f_n is the natural frequency

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As the excitation frequency increases beyond the natural frequency (especially for $r > \sqrt{2}$), the transmissibility drops below 1, indicating effective vibration isolation.

2.2 Double Elastic Support

A double elastic support introduces an intermediate base frame between two sets of isolators, effectively creating a two-degree-of-freedom (2DOF) system. This configuration allows for two distinct natural frequencies, offering improved isolation over a wider frequency range. However, it also introduces a second resonance that must be carefully managed through system tuning and damping.

Double elastic systems are especially effective in environments with strict vibration or shock limits, such as naval vessels or high-precision industrial setups.

3. CASE STUDY: 10,000 KG GENERATOR SET

3.1 Introduction

The isolators used in this study are Willbrandt SES 5010 series, selected based on the expected load per support and mounting layer:

3.1.1 First layer (primary supports)
Willbrandt SES 5010 55 ShA – designed for lower load per mount and optimized for vibration isolation.

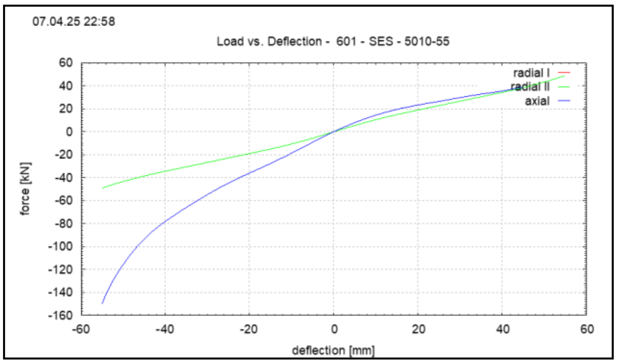

Figure 1. Load vs Deflection SES 5010 55Sh

3.1.2 Second layer (secondary supports):
Willbrandt SES 5010 65 ShA – suited for higher loads and structural damping.

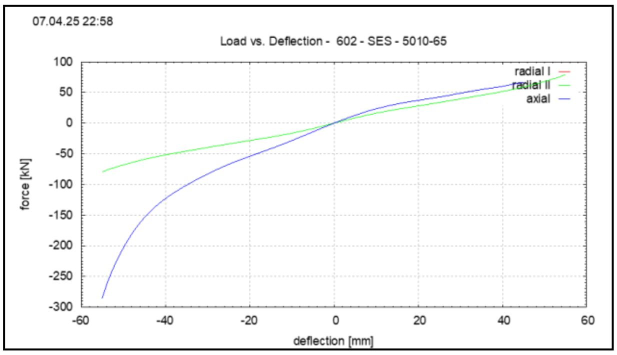

Figure 2. Load vs Deflection SES 5010 65Sh

3.2 Configuration Overview

A generator set with a total mass of 10,000 kg (engine + alternator) is considered. The analysis proceeds in two phases:

3.2.1 Phase 1: Single Elastic Support

The generator is mounted on three different base frames to study the effect of base mass on isolation. The entire set (generator + base) is mounted on a single layer of vibration isolators.

Table 1. Single Elastic Support Configurations

Case	Generator Mass (kg)	Base Frame Mass (kg)	Total Suspended Mass (kg)	Base Mass Ratio
1	10,000	1,000	11,000	10%
2	10,000	2,000	12,000	20%
3	10,000	4,000	14,000	40%

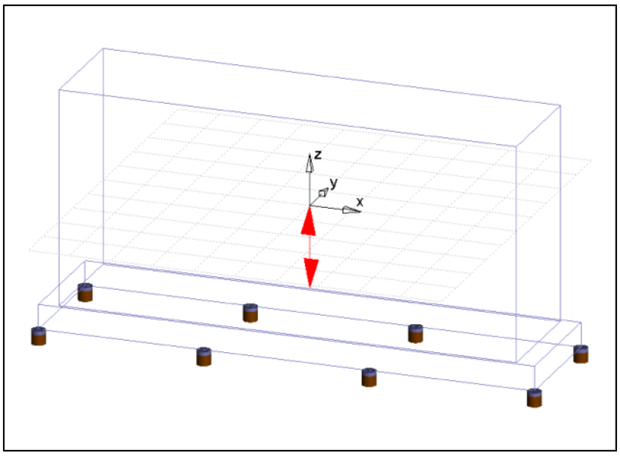

Figure 3. Full assembly view (single elastic configuration)

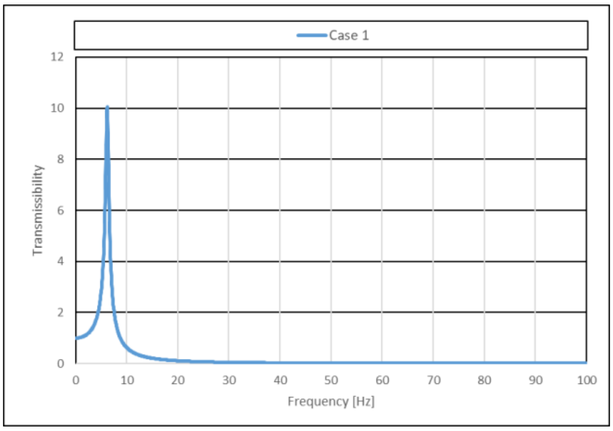

Figure 4. Case 1 transmissibility (vertical axis)

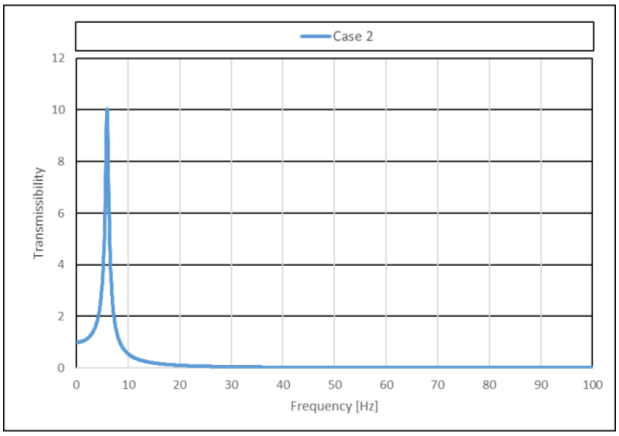

Figure 5. Case 2 transmissibility (vertical axis)

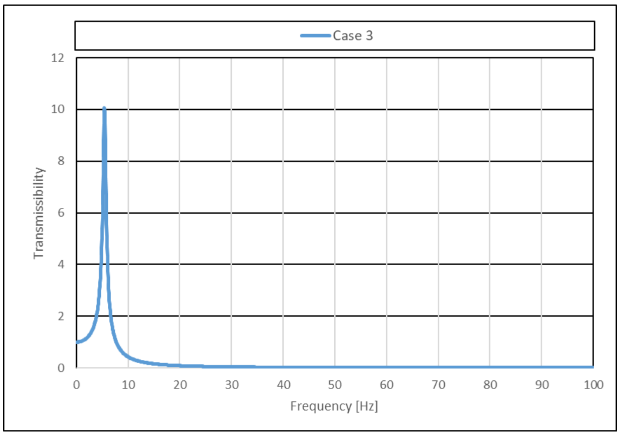

Figure 6. Case 3 transmissibility (vertical axis)

3.2.2 Phase 2: Double Elastic Support

For each configuration from Phase 1, a second base frame weighing 1,000 kg is added below a new layer of isolators. This forms a two-stage isolation system.

Table 2. Double Elastic Support Configurations

Case	**Generator Mass (kg)**	**Base Frame Mass (kg)**	**Total Suspended Mass (kg)**
1+BF2	11,000	1,000	12,000
2+BF2	12,000	1,000	13,000
3+BF2	14,000	1,000	15,000

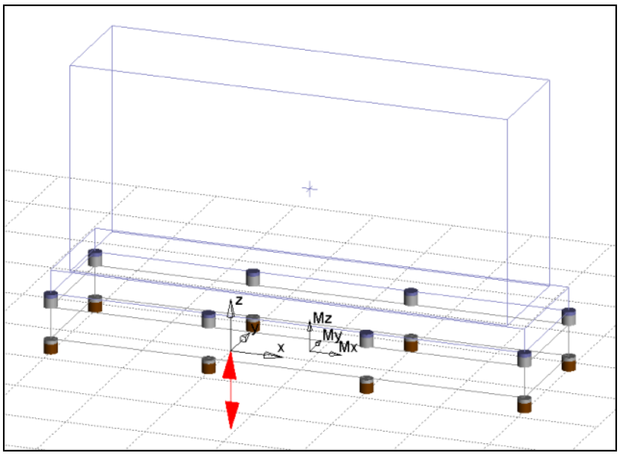

Figure 7. Full assembly view (double elastic configuration)

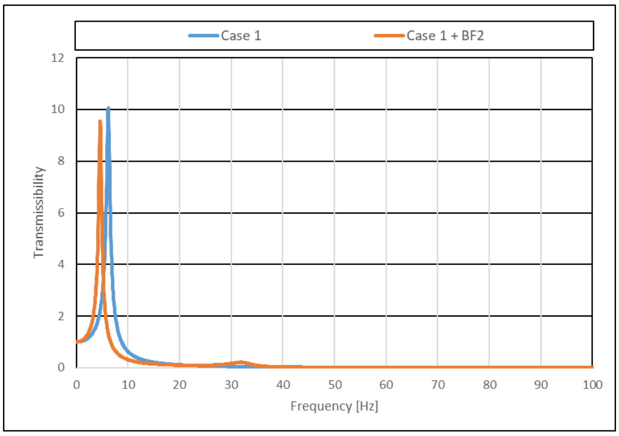

Figure 8. Case 1 and Case 1 + BF2 transmissibility (vertical axis)

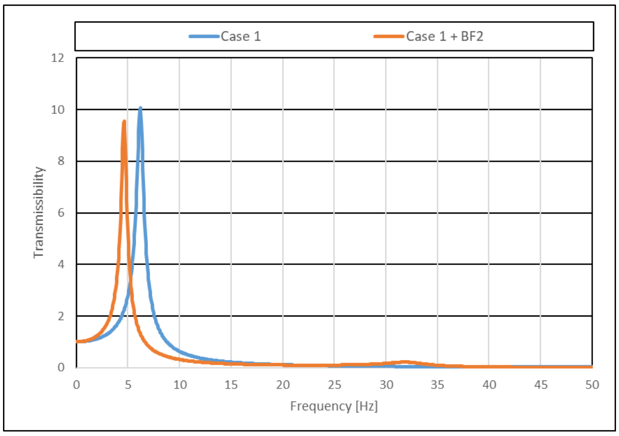

Figure 9. Case 1 and Case 1 + BF2 transmissibility (vertical axis)

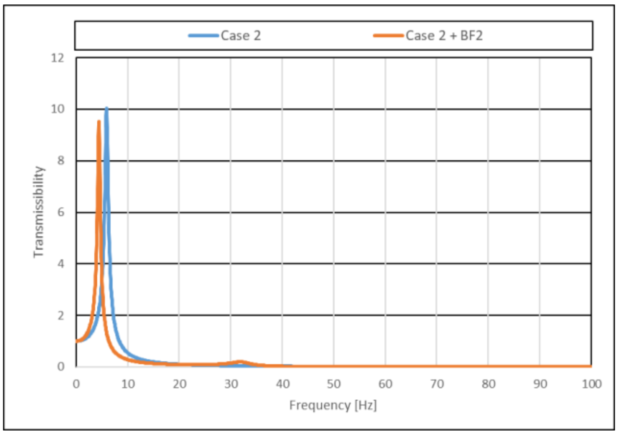

Figure 10. Case 2 and Case 2 + BF2 transmissibility (vertical axis)

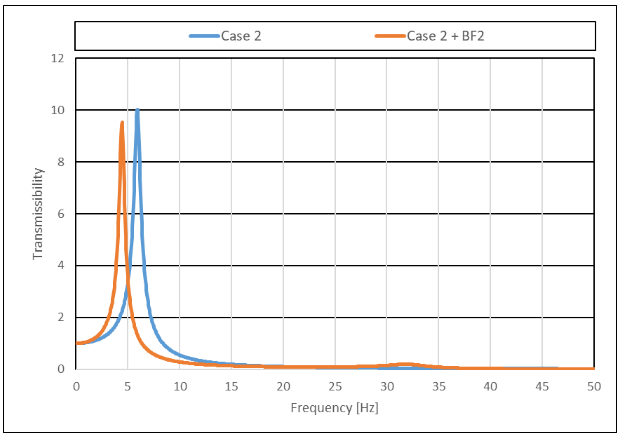

Figure 11. Case 2 and Case 2 + BF2 transmissibility (vertical axis)

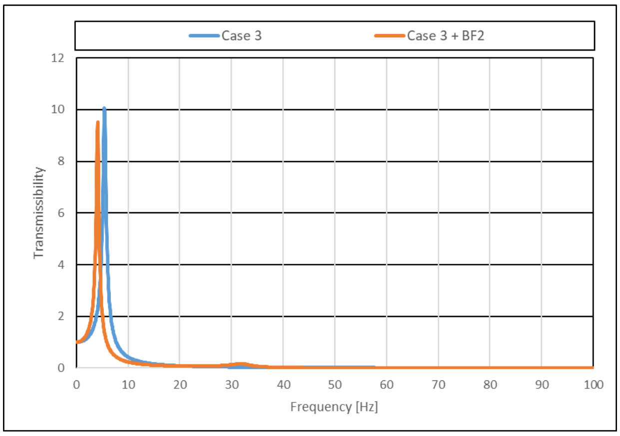

Figure 12. Case 3 and Case 3 + BF2 transmissibility (vertical axis)

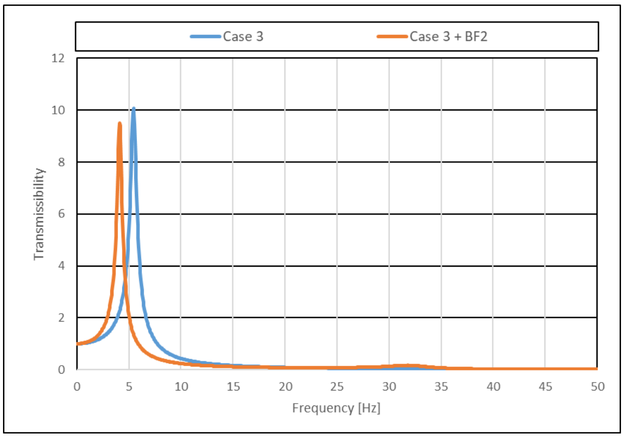

Figure 13. Case 3 and Case 3 + BF2 transmissibility (vertical axis)

4. COMPARATIVE DISCUSSION

The results show that increasing the base frame mass in a single support system effectively lowers the system's natural frequency, improving vibration isolation. However, this comes at the cost of added weight and structural demands. Introducing a second elastic support stage significantly improves isolation, particularly from approximately twice the natural frequency, due to the cascading effect of two mass-spring stages.

The double support reduces transmissibility by increasing system compliance and energy absorption capacity. This makes it ideal for marine environments where shock events are common.

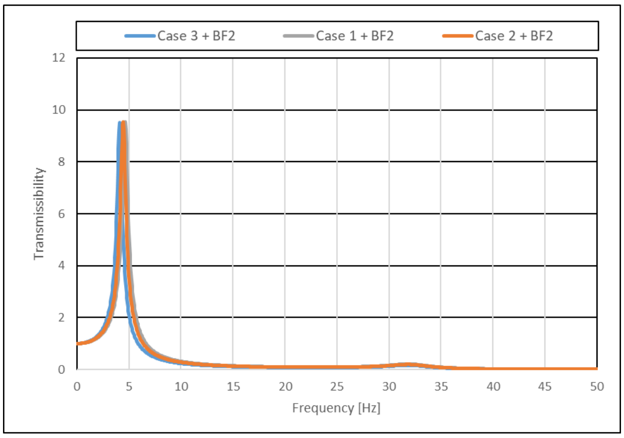

Figure 14. Cases 1, 2 and 3 + BF2 transmissibility (vertical axis)

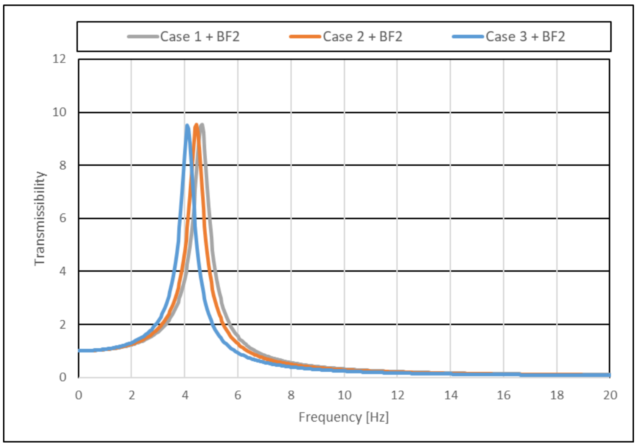

Figure 15. Cases 1, 2 and 3 + BF2 transmissibility (vertical axis)

5. CONCLUSIONS

Elastic mounting systems are essential for protecting structures and machinery from harmful vibrations and shocks. This study demonstrates how base frame mass impacts isolation in single elastic support systems and highlights the superior performance of double elastic support configurations.

For the 10,000 kg generator analyzed, using a base frame of 1,000–4,000 kg already yields substantial improvement, and adding a 1,000 kg intermediate frame further enhances isolation. These results support the adoption of double elastic support in high-demand installations, especially where acoustic, vibratory, or shock criteria are stringent.

6. REFERENCES

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