Paper No.341/2021

STUDY OF THE VIBRATION ISOLATION SYSTEM OF MARINE POWER PLANTS WITH A 5AL 25/30 DIESEL DRIVE

[a)]Minas Minasyan, [b)]Armen Minasyan, [c)]Kyaw Thet Naing

[a)]SMTU, St. Petersburg, Russia, mamsar@mail.ru
[b)]SMTU, St. Petersburg, Russia, menos405@gmail.com
[c)]SMTU, St. Petersburg, Russia, dstamarine@gmail.com

***Abstract**: The article is devoted to the study of the support and side stop vibration isolation system of two marine power plants DGA-500 with a 5AL 25/30 drive diesel engine, in which a hypothesis is put forward about the imperfection of the shock absorption system.*

The purpose of the research is to substantiate the imperfection of the support and side stop vibration isolation system of marine power plants with a 5 AL 25/30 drive diesel engine.

The confirmation of this hypothesis and the achievement of this goal is justified on the basis of presentation of the results of field studies on the project's courts B437/11 and the personal presence during the preparation of DGA-500 to repair at the shipyard.

For the use of unbalanced engines as a drive for ship power plants, the authors, on the basis of a full-scale experimental study and analysis of known works, recommend initially assessing the possibility and purpose of depreciation of the unit according to the Katz unbalance criterion [1].

The objective of fixing the unit with diesel 5AL 25/30 on the criterion of imbalance Katz is soundproof, and the calculation of depreciation should be based on the impact of side stop vibration isolators.

A significant improvement is recommended to the support 36-40 and side stop 41-52 vibration isolation system, elastic pipe fittings 8, support frame 2 and turbocharger bracket 4 (Fig. 1).

***Keywords:** diesel-generator, support and side stop vibration isolators, vibration isolation efficiency*

***DOI:** 10.36336/akustika202139112*

1. INTRODUCTION

In some cases, the problem caused by the increased vibration level from the engines is known to be related not only to the quality of service, but also to errors in the acoustic design and construction of ships [2, 3, 4]. The means of reducing vibration and air noise used after the completion of the general design of ships, in many cases, only partially solve the task and require large costs [3, 4]. To some extent, this is confirmed by the results of a general vibration inspection of nine refrigerated vessels [5], presented in the relevant publications and below by the results on the vibration isolation system of two identical diesel generator sets, but with different support 36-40 and side stop 41-52 vibration isolation systems (Fig. 1).

2. OBJECT AND HYPOTHESIS OF THE STUDY

The object of the study is two DGA-500 diesel generator sets No. 2 and 3 out of four in the ship's power plant, which are located across the engine room, parallel in one row closer to the starboard side with generators facing the bow of the B437/11 project refrigerated vessel, with numbers from the left side to the right.

The hypothesis of the study is that in a marine power plant with a 5AL 25/30 drive diesel engine that does not meet the Katz unbalance criteria [1], the purpose of shock absorption may be sound insulation with the simultaneous operation of support 36-40 and side stop 41-52 vibration isolators (Fig. 1).

The purpose of the study is to substantiate the imperfection of the system of support and side stop vibration isolation of marine power plants with a 5AL 25/30 diesel drive.

3. DGA NO.3

Tab. 1 shows the amplitude of vibration displacement DGA No.3 with standard eight rubber-metal isolators, four 1 m long under diesel engine and four with the length of 0.66 m by the generator before repair and after repair with a new rubber-metal vibration isolators A1 (Fig. 1, 2).

Position of the side stop isolators		9	10	11	12	14	15	18	19	20	21
Unknown (with 8 standard supports before repair)	Before repair										
	Z	0,47	-	-	-	-	0,16	-	0,16	-	-
	Y	-	0,35	-	-	0,42	-	0,14	-	0,55	0,40
	X	-	-	0,43	0,12	-	-	-	-	-	-
Preloaded (with 10 supports A1 after repair)	After the repair with the replacement of the reference vibration isolators										
	Z	0,31	-	-	-	-	-	-	-	-	-
	Y	-	0,12	-	-	0,81	-	-	-	0,99	0,80
	X	-	-	0,27	-	-	-	-	-	-	-
Position of the side stop isolators		22	24	25	26	30	31	32	33	34	35
Unknown (with 8 standard supports before repair)	Before repair										
	Z	-	0,18	0,09	0,14	-	0,09	-	0,06	-	-
	Y	0,32	0,27	0,35	0,20	-	0,08	0,07	-	-	-
	X	-	-	-	-	-	-	-	-	0,25	0,20
Preloaded (with 10 supports A1 after repair)	After the repair with the replacement of the reference vibration isolators										
	Z	-	-	-	0,60	0,07	-	-	0,08	-	-
	Y	-	0,55	0,07	0,40	0,05	-	-	-	-	-
	X	-	-	-	-	-	-	-	-	-	0,24

Tab. 1: The amplitude of vibration displacement DGA No.3

Note: the permissible vibration displacement amplitude is 0,16 mm on the support legs of the marine diesel engine (points 24 and 26 (Fig. 1) and the generator (p. 30 and 31); 0.3 mm on the turbocharger (p. 8-12), cylinder covers (p. 13-17) and on the generator case (p. 33) [3-6].

As follows from Table 1, after the repair of the DGA No. 3, the vibration displacement amplitude of the turbocharger (Fig. 1, points 9, 10 and 11) became less, and for the remaining points, i.e. on the cylinder cover on the side of the diesel flywheel (p. 14), on the cylinder block (p. 20 and 21), on the diesel support leg (p. 24 and 26), on the generator (p. 35 and 33) – the vibration displacement amplitude became greater.

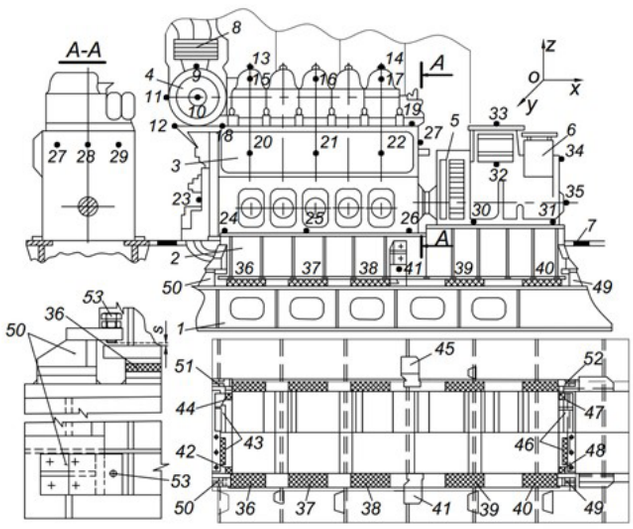

Fig. 1: Diesel generator set with schemes of support and side stop vibration isolation system, safety stops and vibration measurement points. 1 – common ship foundation for two units, 2 – load--carrying frame, 3 – diesel 5AL 25/30, 4 – turbocharger VTR-250, 5 – flywheel casing, 6 – generator, 7 – flooring, 8 – compensator, 9-35 – vibration measurement points, 36-40 – support double--plate rubber-metal vibration isolators, 41, 42, 44, 45, 47, 48 – side thrust two-plate rubber-metal vibration isolators, 43, 46 – stern and bow thrust two-plate rubber-metal vibration isolators, 49-52 – safety stops, 53 – bolt with lock nut.

Fig. 3 shows the vibration spectra before and after the support and side stop vibration isolators of the vibration isolation system DGA No. 3 with two-plate rubber-metal vibration isolators and DGA No. 2 with rubber-metal support vibration isolators HD1.

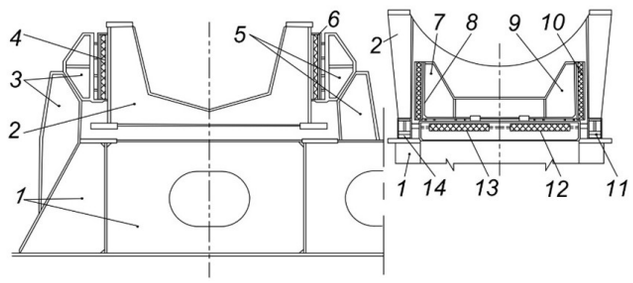

Fig. 2: Side, stern and bow stop dual-plate rubber-metal vibration isolators:
1 – common ship base under two diesel generators, 2 – load-carrying frame, 3, 5, 7, 9 – brackets, 4, 6, 8, 10, 12, 13 – stop dual-plate rubber-metal isolators, 11, 14 – support dual-plate rubber-metal vibration isolators

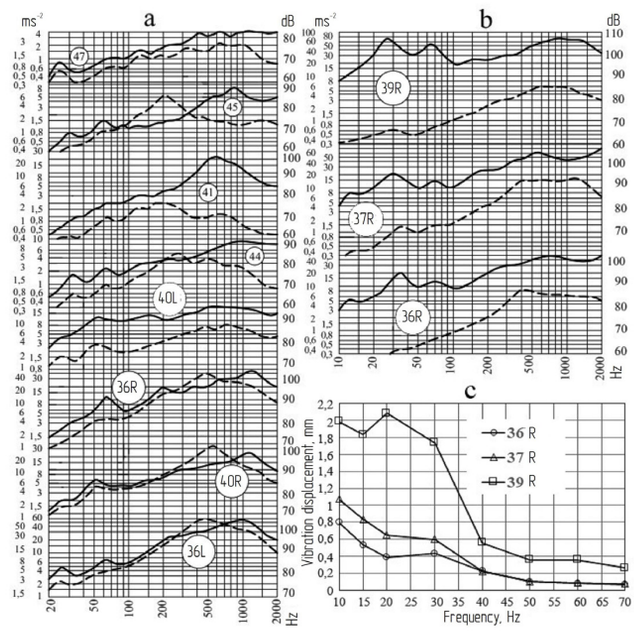

Fig. 3: Vibration spectra before and after the support and side stop vibration isolators vibration isolation system DGA-500: a – DG No.3 with dual-plate rubber-metal isolators, 41, 45 – stop medium side, 44, 47 – stern and bow, 36, 40 – support isolators; b – DG No.2 with rubber-metal support isolators HD1: 36ПБ, 37ПБ, 39ПБ; _____ before, ---------- after isolators; c – spectra of the vibration displacement DG No. 2 to HD1: 36ПБ, 37ПБ, 39ПБ

4. DGA NO. 2

Tab. 2 shows the vibration displacement amplitudes of DGA No.2 after repair with the new sixteen rubber-metal vibration isolators HD1.

Position of the side stop isolators		9	10	11	12	13	14	15	16	17	18	19	20	21
Unknown (with 16 supports HD1)	Z	0,80	-	-	-	0,32	-	-	-	0,42	-	0,22	-	-
	Y	0,45	0,70	-	-	-	0,24	0,49	0,39	-	0,42	-	0,12	0,12

Position of the side stop isolators		22	24	25	26	33	30	31	34	35
Unknown (with 16 supports HD1)	Z	-	0,57	0,35	0,33	0,42	0,85	0,48	-	-
	Y	0,10	0,42	0,37	0,35	-	0,11	0,26	-	-
	X	-	-	-	-	-	-	-	0,25	0,35

Tab. 2: Vibration displacement amplitudes of DGA No.2

From the presented spectra (Fig. 3) and the tables, it follows:

1. Side stop vibration isolators (Fig. 1, a: 41, 44, 45, 47) carry the load both in the absence and during roll and trim, that is, they are constantly pressed against the load-carrying frame of the unit under a certain force. It is important to pay attention to the fact that here, when the ship was on repair, staff supporting dual-plate rubber-metal isolators (4 vibration isolators length 1m under diesel engine and 4 with a length of 0.65 m under a generator) having a high rigidity, were replaced by eight rubber-metal vibration isolators (size, 0,3x0,15x0,06 m) with preservation of the standard side stop vibration isolators.
2. Both the two-plate support (Fig. 1, a: 36LB, 36PB, 40LB, 40PB) and HD1 (Fig. 1, b:36PB, 37PB, 39PB) and the side stop (Fig. 1, a: 41, 44, 45, 47) vibration isolators are loaded unevenly.
3. Satisfactory vibration isolation efficiency only in the reference 41, 47 and side stop 40LB vibration isolators, and in the other vibration isolators, in addition to low efficiency at some frequencies, the efficiency is negative.
4. When the side stop vibration isolators are preloaded, the vibration displacement amplitudes in mm: turbocharger 9Z – 0,31; 10Y – 0,12; 11X – 0,27, casing cylinder cover 14Y – 0,81; cylinder block 19Y – 0,01; 20Y – 0,99; 21Y – 0,8; 24Y – 0,55; 25Y – 0,7; 26Y – 0,4; 26Z – 0,6; generator 30Y – 0,05; 30Z – 0,07; 32Y – 0,07; 33Z – 0,08; 35X – 0,24. However, after a short operation of the unit due to its high vibration and imperfection of preload system of stops the effectiveness of the latter is violated, which leads to a further increase in the vibrational state of the unit.
5. Considering that the rubber-metal vibration isolators HD1 are highly elastic, and the engine is unbalanced [1, 6], as follows from Fig. 1, the obtained vibration displacement spectra significantly exceed the permissible norms (0,16 at the support legs, 0,3 at the upper points of the unit [3-6]). This led to a violation of the gap s=1-1.5 mm between the ends of the bolts 53 and the plane of the shelves of the load carrying frame 2 (Fig.1) at the four safety brackets 49-52. Moreover, during the inspection, the value of the specified gap s was equal to 10 mm with the formation of a spherical recess of about 4 mm.

These results of experimental studies confirm the hypothesis of the need for sound insulation of a ship power plant with a drive unbalanced by the moments of inertia of rotating masses and the moments of inertia of the 1st and 2nd orders of translational moving masses with a 5AL 25/30 diesel engine that does not meet the criteria of Katz A.M. [1, 2].

5. CONCLUSION

1. Maintenance of the stops, safety assemblies, as well as the fasteners of the support legs of the diesel engine, generator and other components of the DGA should be regular.
2. The supports should preferably be sufficiently long, wide and rigid.
3. The calculation of the support vibration isolation system should be carried out taking into account the influence of the stops that come into effect simultaneously with the supports.
4. Improvements to the support and side stop vibration isolation system, exhaust systems, turbocharger bracket, and load carrying frame are required.

REFERENCES

[1] Yamanin, A.I., Zharov A.V.: Dynamics of piston engines. Moscow, Russia, Mashinostroenie, 464 p., 2003.
[2] Tuzov, L.V., Bezyukov, O.K., Afanasyeva, O.V.: Vibration of marine internal combustion engines. St. Petersburg, Russia, Publishing House of the Polytechnic University, 348 p, 2012
[3] Khudyakov, S.A.: The practice of solving the problems of vibration of ship diesels: monograph. Vladivostok, Russia, Publishing House of the Maritime State University, 172 p., 2006
[4] Khudyakov, S.A.: Results of vibration measurements in engine rooms, ISSN 2072-8689, Transport business of Russia – Moscow, Russia, p. 34-38, 2004
[5] Minasyan, M.A., Aung Mio Thant, Minasyan, A.M.: Increased vibration on refrigerated vessels of the B437/11 project and technical proposals for its reduction, ISSN 2073-1574, Vestnik AGTU. Series: Marine engineering and technology – Astrakhan, Russia, p. 58-69, 2018
[6] Minasyan, M.A., Minasyan, A.M.: Vibration isolation of marine diesel power plants. St. Petersburg, Russia, Publishing House of the SPbGMTU, 360 p, 2017

Minas Minasyan *is Doctor of Engineering Science, Professor of Department 'Ship Internal Combustion Engines and Diesel Sets' of the Saint-Petersburg State Marine Technical University.*
Minasyan Minas Armenakovich is a specialist in struggle with vibration in technique, an inventor, the author of over 200 scientific publications and inventions.

Armen Minasyan *is Ph.D. of Engineering Science, Associate professor of Department 'Computer facilities and information technology' of the Saint-Petersburg State Marine Technical University.*
Minasyan Armen Minasovich is a specialist in struggle with vibration in technique, the author and the co-author of over 50 scientific publications and inventions.

Kyaw Thet Naing *is Postgraduate Student of Department 'Ship Internal Combustion Engines and Diesel Engines' of Saint-Petersburg State Marine Technical University.*
Kyaw Thet Naing is the author and the co-author of over 10 scientific publications and inventions.