Advanced self-aligning mounting system

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Summary

This thesis work was done in cooperation with Wärtsilä Ship Power. The work has been to do a pre- study of using air bellows for the engine mounting in ships. The idea with this is to minimize the structure-borne noise in the ship hull. Besides this, Wärtsilä was also interested in getting the engine alignment done with the air bellows. The goal was to investigate different bellows on the market and see if there are any models that can be useful for the design. A major part of the work was the calculation of the forces directed towards the bellows for a W 6L32 engine. This work resulted in a calculation for a vee mounting with air bellows. An Exel calculation was made to optimize the design of the vee mounting with air bellows.

Language: English

Key words: air bellow, engine alignment, vibration, structure noise

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EXAMENSARBETE

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Abstrakt

Detta examensarbete utfördes i samarbete med Wärtsilä Oy Ship Power. Arbetet gick ut på att göra en kort förundersökning om möjligheten att använda luftbälgar som flexibla element vid uppställning av motor i ett fartyg. Detta för att minska struktur buret ljud i fartygets skrov samt för att automatisera linjeringen av en motor. Målet med detta examens arbete var att undersöka olika potentiella bälgar på marknaden och sedan bestämma vilken storlek och modell man skall använda. Kalkylering av krafterna som riktas mot bälgarna var en viktig och stor del i arbetet. Arbetet resulterade i kalkylering av bälgar till en motoruppställning av en W 6L32. Ett program gjordes i Exel för att optimera uträkningarna med variabla parametrar.

Språk: Engelska

Nyckelord: luftbälg, motor linjering, vibration, strukturljud

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OPINNÄYTETYÖ

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Tiivistelmä

Tämä opinnäytetyö on tehty yhdessä Wärtsilä Oy Ship Powerin kanssa. Tämän työn tarkoitus on ollut tutkia mahdollisuuksia käyttää ilmatyynyjä moottorin kiinnitykseen. Tarkoitus olisi, että kun käyttää ilmatyynyjä niin pääsisi struktuuriäänistä, jotka leviävät laivan runkoon, tarkoitus olisi myös että koneen saisi linjattua ilmatyynyjen ansiosta. Opinnäytetyön loppu- tulos on tutkimus siitä minkälaisia ja mallisia ilmatyynyjä on syytä käyttää kyseisessä kokoonpanossa. Suurin osa lopputuloksesta on laskelmia, joiden perusteella on saatu sopivat ilmatyynyt Wärtsilän W 6L32 moottoriin.

Kieli: Englanti

Avainsanat: ilmatyyny, koneen linjaus, värinä, struktuuriääni

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1 Introduction

Vibrations in different forms are something that causes problems in durability and comfort. Today most vehicles and vessels have some kind of vibration insulators. There are many different ways to handle and prevent vibrations and there are also many ways to solve vibration problems with different types of vibration insulators. In a car for example, the shock absorber is used to prevent the car from wobbling after you have driven in to a pothole. This is very important from the driver's point of view, because if you don't take care of the vibrations the pothole caused it will affect the handling of the car badly. Without shock absorbers the car would keep on wobbling a long time after you have passed the pothole.

Engines in nearly all kinds of vehicles and vessels cause vibrations in different forms when they are running. Therefore it is important to insulate the engine from the rest of the construction. It is best for the driver and for the durability. The driver doesn't accept that the engine vibrations are transferred into the car. Who wants to feel vibrations in the steering wheel caused by the engine, or hear vibrating sounds in the interior caused by the engine?

If we look at the problem from the point of view of the durability, we get a longer lifetime for the engine and the components if we insulate the engine. Without vibration insulators the engine and components attached to the engine would vibrate and this could in the worst case cause a total breakdown. The vibrations fatigue the components and that results in cracks and after a while the component will break.

There are many different ways to handle vibration problems. You can prevent vibrations by changing the mass of the component that causes vibrations, build it stiffer or softer, or by insulating it. Vibrations can be insulated with rubber elements, car engines often use that solution. Heavy components are often insulated with springs. How you insulate the vibrations also differs depending on what natural frequency and excitation frequency you have.

1.1 Background

I have done my thesis work for Wärtsilä Oy Ship Power. My work began in late January 2011. They had an idea of using air bellows for the ship engines to isolate vibrations from the ship foundation; besides this, they were also interested in having an automatic self- alignment system, which can be plausible with air bellows. This idea had to be investigated, and maybe it will one day be used with Wärtsilä engine powered ships.

1.2 Goal

The goal of my work is to calculate and design an engine mounting with air bellows for a Wärtsilä W 32 inline 6 cylinder engine. The basic principle is to replace the 14 elements they have today on this engine of vee-mounting design with air bellows.

Today the re-alignment of the engines is a costly operation as they use shims to get the correct alignment. When air bellows are used it should be possible to do this by adjusting the air pressure in the bellows. This re-alignment system will cooperate with the engine control unit and therefore the engine re-alignment is going to be active during engine operation.

2 Design models today

Wärtsilä has a couple of different resilient engine- mounting systems that they use today. They are quite different from each other. The problem with all of them is the re-alignment of the engine. The different resilient mounts have good and bad sides. The customer's demands, the ship type and the engine model decide what kind of resilient mounts would be the best for the ship. /6/

When you design a resilient mounting you assume that the engine or generating set is a rigid body. The ship foundation is given an infinite mass and stiffness. These assumptions are generally valid, but if you have a construction with a foundation that has a low stiffness you must pay attention to design. This can be something you especially have to consider in some offshore structures. /6/

2.1 Sandwich mounts

Sandwich mounts are quite useful because they can be mounted in both vee and vertical configurations. The sandwich mount has quite a simple design. In its simplest form the sandwich mount is a rubber section between two steel plates. To give the mount the necessary properties you can use inserts or interleaves to tune the stiffness and acoustic properties and in that way increase load capacity. A picture of a sandwich mount is shown in figure 1. /6/

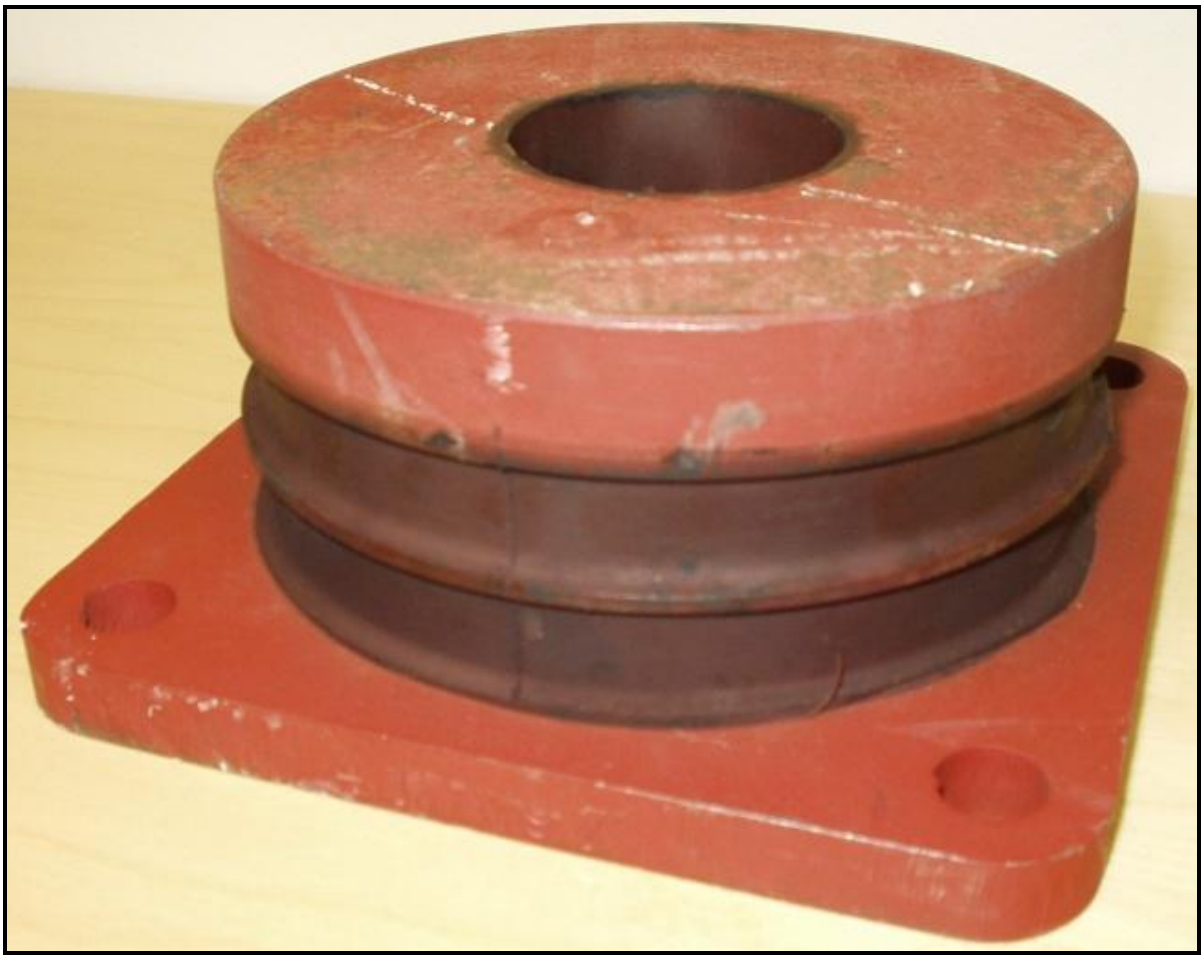

Figure 1. A sandwich mount used by Wärtsilä. /6/

2.2 Conical mounts

Conical mounts are today mostly used for generating sets and smaller main engines. Compared to the sandwich mount these are more developed and have, due to their design, multiple uses. These conical mounts can be purchased with built- in buffers. The buffers are there to take the high force when the rubber is not enough to handle the forces that can arise in extreme conditions. There is also a possibility to adjust the height of the mount in some models. Due to the conical construction the mount has different stiffnesses in the horizontal and vertical directions. The mounts have a higher stiffness in the horizontal plane which means that they have a better stability in the horizontal plane than the sandwich mount. A picture of a conical mount is shown in figure 2. /6/

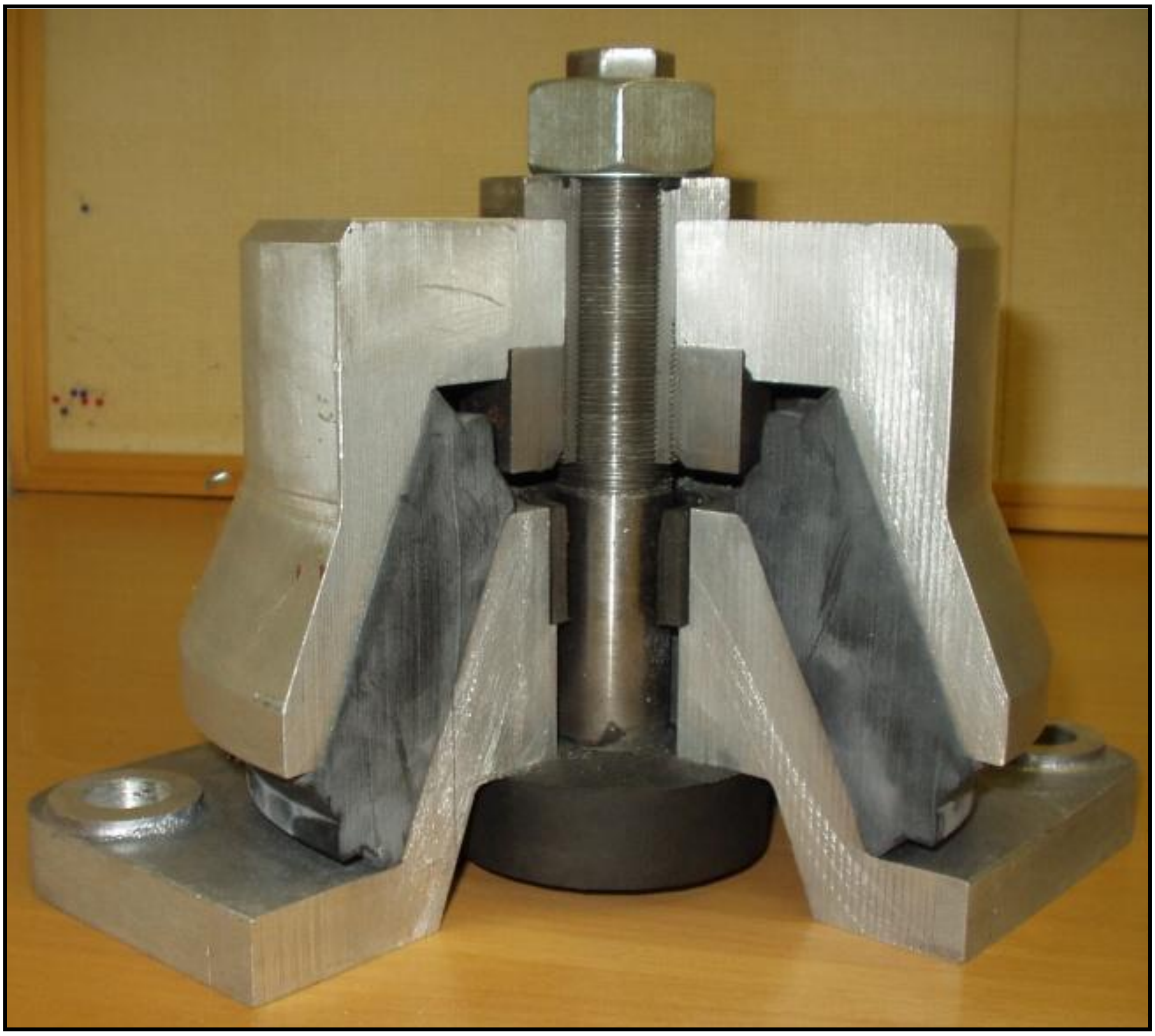

Figure 2. A conical mount used by Wärtsilä. /6/

2.3 Steel spring mounts

Steel springs are normally used on Power Plant generating sets. They are always mounted in vertical configurations. In ships they are normally avoided because springs have a low damping factor. Due to the low damping factor the spring has a high response in case of resonance with the engine and other external excitations. The spring has poor acoustic properties in the frequency range where the spring is surging; this is a problem because it results in a noise transfer to the ship foundation. The big advantage with springs is that they can insulate heavy loads, because rubber mounts have their limits in insulating heavy constructions. A spring- pack mounting is shown in figure 3. /6/

Figure 3. Spring mounting used by Wärtsilä in the test run.

3 Mounting arrangements

Different mounting arrangements give you possibilities to use different mounts and give the possibility to make the mount operate as good as possible due to the whole mounting concept. Some of the mounts can only be mounted in one way while some can be mounted in different ways to solve problems that occur due to the case you have to insulate. /6/, /7/

3.1 Vee mounting

The vee-mounting uses sandwich mounts. By arranging them in a vee-configuration of 90 or 100 degrees, supercritical mounting is achieved. To complete the vee-mounting you often use longitudinal mounts for tuning of natural frequencies and for reducing seaway movements. A picture of a vee-mounting is shown in figure 4. /6/

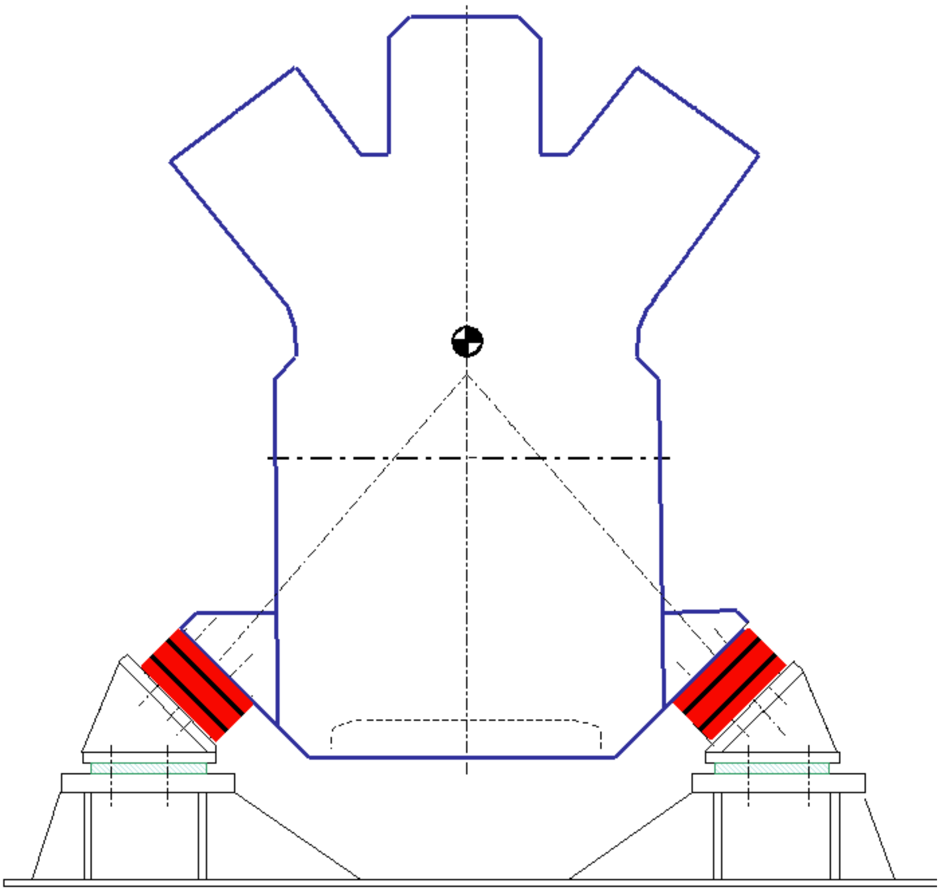

Figure 4. An vee-mounting configuration. /6/

Vee-mounting advantages:

- Low rolling natural frequency
- Rather small movements at the flexible coupling (if the stiffness centre is close to the coupling)
- Good insulation of structure- borne noise, also at low frequencies.

Disadvantages of vee-mounting:

- Large movements (rolling) during start and stop
- Large displacement of exhaust bellows, engine feet and pipe connections due to torque and seaway movements
- Complicated alignment and realignment
- Needs strong collision chocks
- Expensive.

3.2 Vertical mounting

Vertical mounting can be made with spring-, sandwich- and conical mounts. Depending on the demands and problems you choose one of these. In the vertical mounting with sandwich mounts the natural frequencies can vary widely from being supercritical to having most of the natural frequencies above running speed. Vertical mounts are often used together with longitudinal and transversal mounts for tuning the natural frequencies and for reducing the movement caused by the seaway. Compared to vee-mounting the vertical mounting offers an easier alignment and exchange of the mounts. During start and stop the movements are normally smaller compared to vee-mounting systems. The displacement of the mounts is smaller compared to the vee-mounting, but you get a bigger displacement at the coupling instead. Due to the smaller displacement at the mounts, the vertical mounting can use lighter mounts than vee-mounting. Vertical mountings are shown in figures 5 and 6. /6/

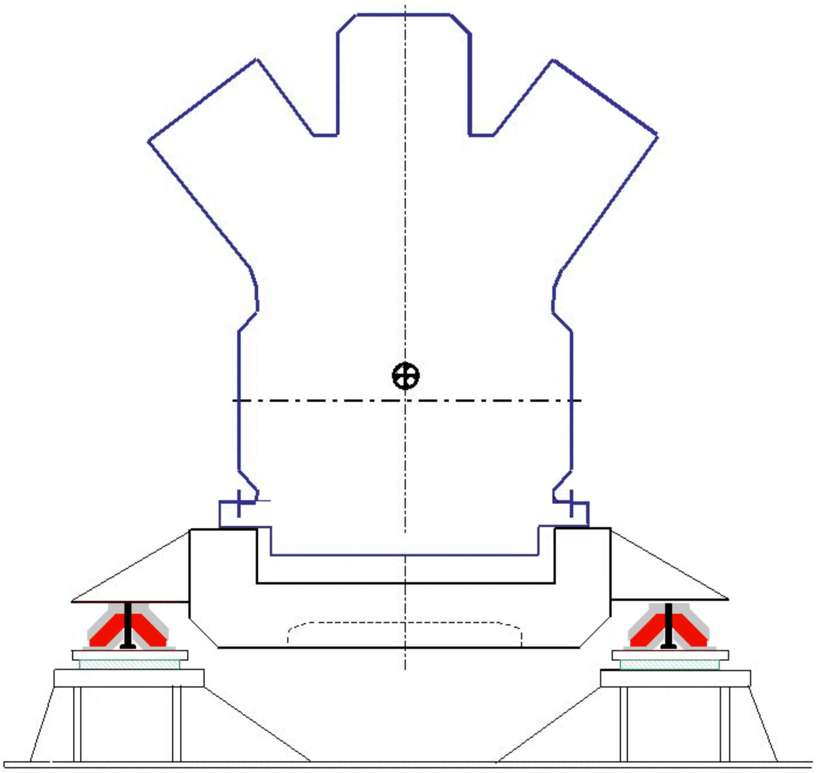

Figure 5. A vertical mounting with conical mounts. /6/

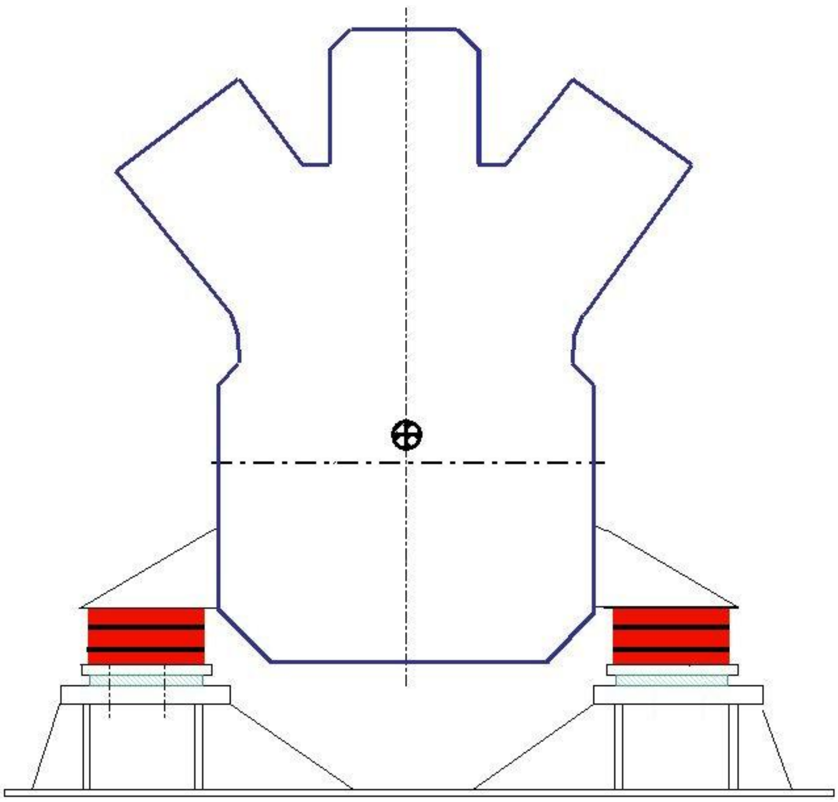

Figure 6. A vertical mounting with sandwich mounts. /6/

3.3 Double elastic mounting

Double elastic mounting means that the engine for example is resiliently mounted to a base frame and the base frame is also resiliently mounted to the ship foundation; this means that you have two different elastic layer mounts. The advantage of this mounting system is that you get a good insulation and the structure- borne noise transfer is less than in the other mounts that have been described earlier. Double elastic mounting is shown in figure 7. /6/

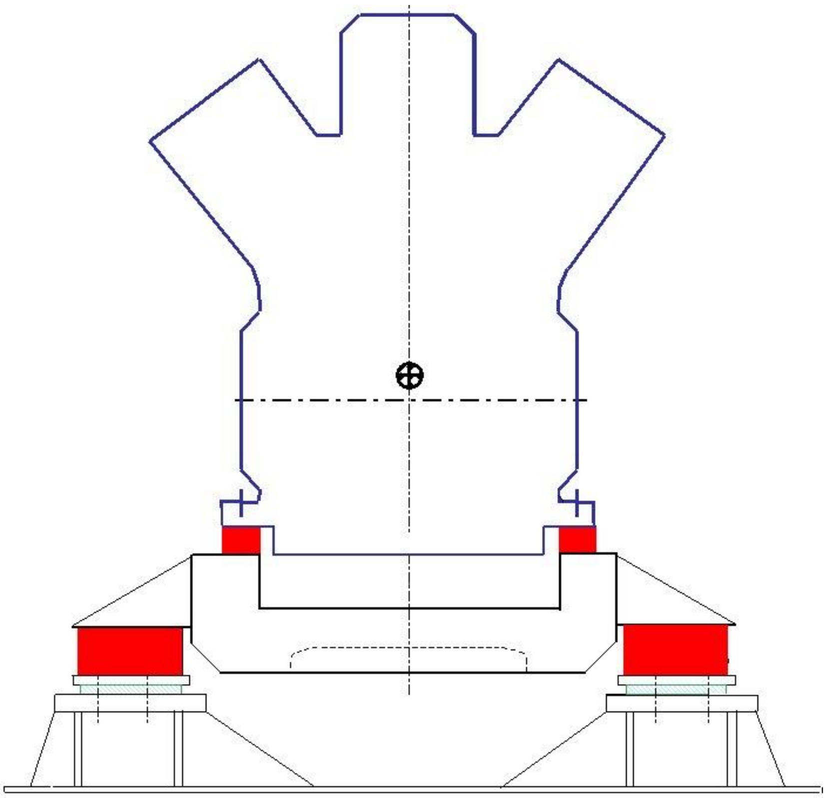

Figure 7. Double elastic mounting with sandwich mounts. /6/

3.4 Creep rate

The creep rate of the rubber results in misalignment and has to be taken care of. Misalignment can cause excitations to the engine frequencies. The rubber creep varies due to the compound, rubber hardness, dynamic loads and strain. The deflection of the rubber happens in the beginning when you load the mounts but the deflection gets smaller by time. Rubber creep rate is shown in table 1. /6/

Table 1. Rubber creep rate. /6/

Time	**Deflection**
6 sec	10.00 mm
1 min (60 sec)	10.20 mm (10.00 x 1.02^1)
10 min (600 sec)	10.40 mm (10.00 x 1.02^2)
17 hours (60000 sec)	10.82 mm (10.00 x 1.02^4)
1,9 year (60000000 sec)	11.49 mm (10.00 x 1.02^7)

4 Vibration

Vibration means oscillations around an equilibrium point in a mechanical system. The oscillations may be periodic such as the motion of a pendulum or random such as the movement of a tire on a gravel road. There are different types of vibration, but the simplest way to describe the vibration is to compare it with a mass spring damper. This is shown in figure 8. /4/, /5/

From physics the following equation is known for the mass spring damper:

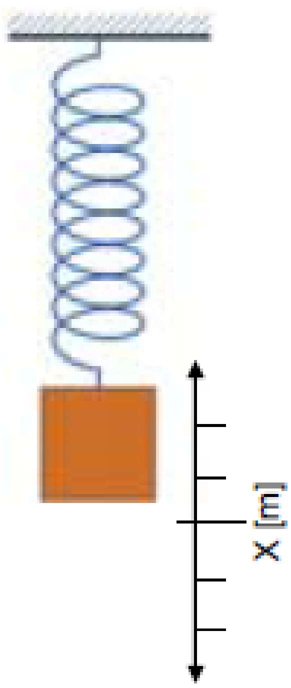

Figure 8. Mass spring damper. /5/

The motion that occurs from the mass spring damper is a sinus curve (shown in figure 9.). For this motion the following is known from physics:

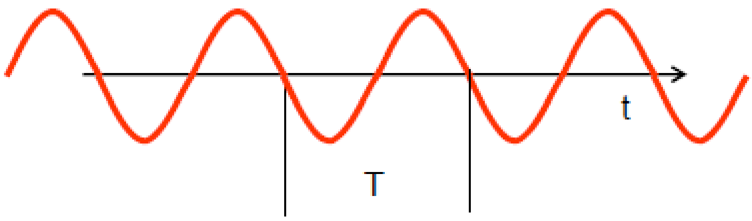

Figure 9. Vibration motion. /5/

With these physical equations you can determine the natural frequency of the motion. The natural frequency is important to know, because the natural frequency gives us the knowledge of the frequency that the system has. It is known in the physics as the following:

4.1 Excitation

Excitation means forces that try to make the vibrations bigger and heavier. These excitations are different depending on the type of the system. But in a combustion engine there are lots of different things that can cause excitations. The following list gives us some main things that are important to consider when calculating vibrations on a combustion engine. /5/

- Imbalance, rotating mass
- Oscillating mass
- Cylinder pressure
- Camshaft and valve mechanism
- Faulty mounting
- Pressure pulses
- Teeth meshing.

Besides the above- mentioned cases with the engine, there are also other things to consider when you are in a ship. The propeller gives vibrations also when it rotates. Therefore you must consider the propeller blade passing frequency. /5/, /6/

4.1.1 Mass forces

Mass forces arise due to the design of a combustion engine with pistons. The crank mechanism produces vibrations caused by rotating- and oscillating masses. The rotating masses caused by pistons, connecting rods and counterweights give vertical and transversal forces. The oscillating masses in the same system give, besides the vertical forces, also a torque. /5/

4.1.2 Gas forces

Gas forces are caused by the pressure in the cylinder. These forces cause torque and bending moments. The gas force causes something called ignition frequency. The ignition frequency can easily be calculated if you know the following parameters. Table 2. shows some ignition frequencies and exciting forces. /5/

- Engine speed [rpm]
- Quantity of cylinders
- Two- or four- stroke engine

When it comes to gas forces you must consider the frequency in multiples of 0,5.

Table 2. The ignition frequency for a couple of Wärtsilä engines, and exciting forces. /6/

Engine	Speed [RPM]	Frequency [Hz]	F_Y [kN]	F_Z [kN]	Frequency [Hz]	M_Y [kNm]	M_Z [kNm]	Frequency [Hz]	M_Y [kNm]	M_Z [kNm]
8L32	720 750	48 50	— —	5.3 5.7	— —	— —	— —	— —	— —	— —
9L32	720 750	— —	— —	— —	12 12.5	44 47	44 47	24 25	26 28	— —
16V32	720 750	48 50	4.6 4.9	3.2 3.5	— —	— —	— —	— —	— —	— —
18V32	720 750	— —	— —	— —	12 12.5	57 62	57 62	24 25	30 32	22 24

— couples and forces = zero or insignificant

4.2 Resonance

A system can have one or more natural frequencies. This means that we must avoid excitation frequencies that are near the system's natural frequencies. Resonance means that the amplitude (size of the vibration) will grow due to the excitation force because the excitation force has the same frequency as the natural frequency. By knowing the mass and stiffness of a system you can calculate the natural frequency. It is important to consider this. You can move the natural- and excitation frequencies by changing the system's stiffness or mass. /4/, /5/, /6/

6 Results

The work had some starting points mainly in the basic design of the engine mount bed. Wärtsilä has used a vee-mounting design on some of their engines and wanted to continue using this model with the new mounting. The vee-mount has a great advantage in ships due to the roll and trim that occur in ships. Besides this, it will also obstruct the force that the engine produces due to torque. With the vee-mount you get a stable mounting that itself prevent the engine from rolling. Wärtsilä also wished that the design should use 14 air bellows, one bellow pair per main bearing.

6.1 Deciding the bellow type

There are many different manufacturers on the air bellow market. I decided together with Wärtsilä that we should compare two different worldwide- known manufacturers, to see if there are big differences in models and prices. I looked up the manufacturers on the internet and found quite fast that the two biggest manufacturers of bellows that suit our project were Continental and Firestone.

When investigating their products you find that they both have quite the same type of bellows in their product range. When looking at their bellow range you find that they have bellows that may be suitable for this design. The following step was to locate the accurate type of bellow. The manufacturers give parameters on what forces the bellows can handle in the bellow's axial direction. The bellows' vertical forces that they can handle vary from 30 to 60 % of the axial load. There are many different types of bellows on the market. But if you have a look at the information they give for the bellows, you find that there is just one model that can handle big loads, and that is the single convolution air bellow.

In the calculations you must determine the force that the bellows are exposed to during their lifetime in a ship. The manufacturers give the vertical and horizontal force that the bellow can handle. Besides this, you must pay attention to the roll (18^{o}) and trim (6^{o}) of the ship, as the bellows are exposed to more force in these cases. With more roll and trim there are going to be buffers that handle the forces. The engine must remain in its bed even if the ship turns upside down; this is handled by the buffers also. This means that the bellows don't have to handle exceptionally high forces caused by more than 6 degrees roll and 18 degrees trim. The high forces need to be identified in order to size the buffers. Wärtsilä already has different kind of existing buffers that they can supply, so my work was not to design any new type of buffers. Different types of bellows are shown in figure 10. /1/, /3/

Figure 10. Different air bellows. No. 1 is a single convoluted bellow and no. 2 is a double convoluted bellow. /3/

6.2 Force calculation

I started to calculate the forces for 0^o roll and 0^o trim. This is calculated to determine the forces during a smooth operation. The next step was to determine the forces with both 6^o roll and 18^o trim at the same time. To determine these forces and to optimize the design I made an Excel calculation that allows you to adjust the distance between the point where the bellows' hypothetical centerlines cross each other and the center of gravity, as well as variable roll and trim angles. Besides this, I have also included the torque caused by the engine. The forces caused by the torque are considered in the calculation of the forces directed towards the bellows. I have calculated the worst theoretical case, which means that the bellow that is compressed the most during roll and trim is also compressed by the force caused by the torque. /2/

6.2.1 Force system

To determine all the forces acting on the bellows can be very complex. It takes time and lots of thinking to determine the appropriate force model. The facts you know are the following:

- Engine weight
- Torque caused by the engine
- All distances on the engine and mounting arrangement
- Roll and trim.

6.3 Forces in horizontal plane

The first step was to determine the forces that the bellows are exposed to when the engine is in horizontal position. Figure 11 shows a schematic picture of the forces.

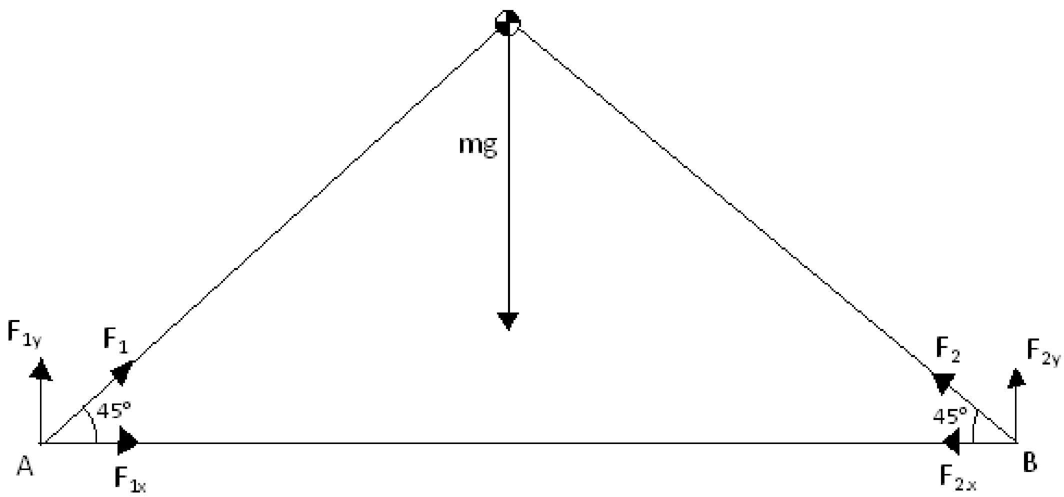

Figure 11. The forces with engine in horizontal plane.

Vertical:

Horizontal:

Due to the 45 degrees' angle, the horizontal force vectors must be the same size as the vertical vectors.

To determine the force vectors for the torque caused by the engine I made the following sketch. The distance x for the force vectors is the distance from the torque center to the bellow center. Figure 12 shows a schematic picture of the torque.

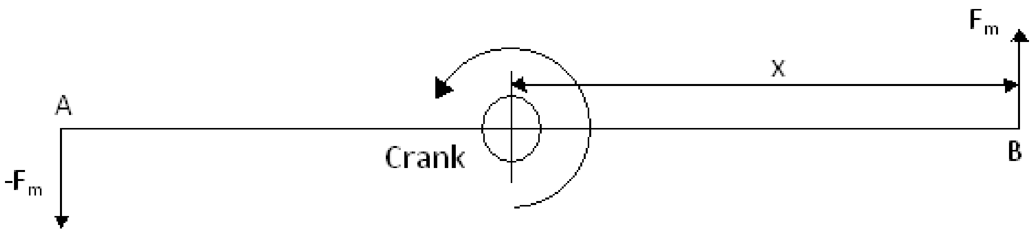

Figure 12. The torque caused by the engine.

The force vectors caused by the torque are added to and subtracted from the y-component force vectors caused by the engine weight.

6.4 Forces with roll and trim

To calculate both the trim and the roll force together I have first projected a new force from the center of gravidity (*mg*) due to the trim, and then calculated the roll with the projected *m'g.* Figure 13 shows a schematic picture of the new *m'g* with a 6 degree trim.

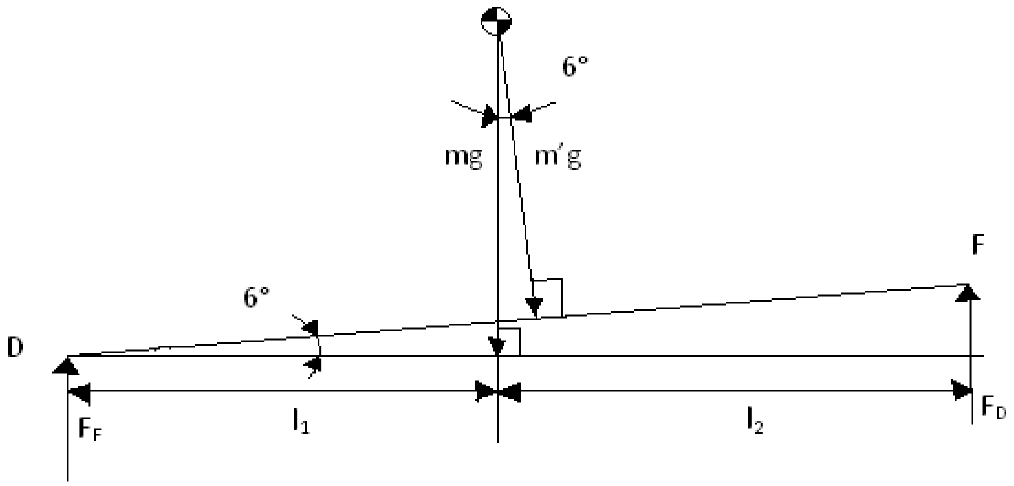

Figure 13. The projected m'g due to the trim of the ship.

With these forms and calculations I have made the Exel calculation that can calculate the forces that the bellows are exposed to, both axially and transversally. The Exel calculation is enclosed in the end of the thesis.

6.5 Deciding the final bellow

The manufacturers give the forces the bellows are allowed to handle in the axial direction. The transversal direction force is not mentioned but they allow 30 to 60 % of the axial load in the transversal direction. In this case with quite big transversal forces due to the 45 degree mounting, the transversal force is the one that determines the bellow model. One suitable model could be FS-960-12 from Continental. In appendice 2 you will find an information leaflet of the bellow FS-960-12.

With a pressure of 8 bar the bellow can handle an axial load of 78.1 kN. If you allow 50 % of the axial load, you will find that the transversal load will be 39.05 kN. With the maximal trim and roll in my calculations, the transversal load is 38.8 kN so it will manage the load with a small marginal. /1/

6.6 Air system

The bellows need air to operate accurately; there is already air available in the engine room in the ship. But the question is if it is enough to feed the 14 bellows and if we use the air we have got, will it affect something else in the engine room? It is possible that we need to have an extra compressor for the bellows only. The air system also needs some valves and gauges to control the pressure in the bellows.

6.1.1 Air consumption

The maximal air consumption can be estimated by asking how much air is recuired to fill 50% of the bellows in a time of 10 sec. This corresponds to a roll of the ship during 10 sec. The air that is needed for the engine alignment is not as much as the roll we assume.

The max volume per bellow with the recommended height is 13.5 liters and with 7 bellows per engine side it means that the air supply should be 567 liters/ minute. This air consumption is needed to raise one engine's one side in 10 seconds. It should not be a problem to achieve this. /7/

6.1.2 Height control

To make it possible to adjust engine height and align the engine with the bellows you need to know the bellow's height in some way. Electrical sensors at the bellows would be a good way to register the height. These sensor signals would be sent to the engine controller unit (ecu) and the ecu would give output signals which control the bellow's air supply through valves. It would be best to measure with potentiometers; they are often used with bellows and are quite cheap and reliable when it comes to measuring heights. /4/

7 Discussion and conclusion

When I began my thesis work for Wärtsilä I didn't have any knowledge of ships and engine mountings in ships. When the work was presented to me I found it very interesting. The problem during this thesis work was that nobody around me had experience of the air bellows we were going to use. The first big problem that came up was the calculation of the forces. I had my theory and others had theirs. After a couple of months and a meeting between Jan Holmberg (Wärtsila), Kaj Rintanen (Novia) and myself we came up with the final calculation that satisfied all of us and that seems to be the right model for solving the forces that the bellows are exposed to. The calculation has been the biggest work to do in this thesis, including the Exel calculation.

There are some problems with the design of the engine mounting. To place the bellow's in a 45 degree angle is not the best way from the manufacturers' point of view, because they don't recommend installations like that, they always prefer to mount them vertically or horizontally. This means that the manufacturer can't give any guaranties for the life time of the bellows. Already in the horizontal mounting with a 45 degree angle, the bellows are constantly exposed to a big load in the radial direction of the bellow. To be sure that the bellow's strength is enough you have to oversize the bellow for the axial load to get a bellow that manages the radial load. When doing this the bellow's diameter increases. It would be good to investigate the possibilities to mount the bellows in a vertical mounting also, and compare these both mountings with each other.

Another problem with is bellows are that the natural frequency varies during the engine operation and seaway. The variations in natural frequencies are caused by the variation in the stiffness of the bellows. The stiffness varies due to the air pressure in the bellows, and without varying the air pressure the engine alignment will not work. You have no control of the excitation frequencies because the engine mounts' stiffness varies all the time. The steering system for the air is very important and it is going to be very advanced because it must, besides controlling air, also control the frequencies of the bellows and the engine and adjust the pressure for the bellows. If it does that, what happens to the engine alignment then?

This work has been a primary study of using air bellows in a 45 degree mounting in ships and the results show that there are some major problems in the mounting. I hope the calculations and investigations I have made will help in the future when air bellows in an engine mounting are considered.

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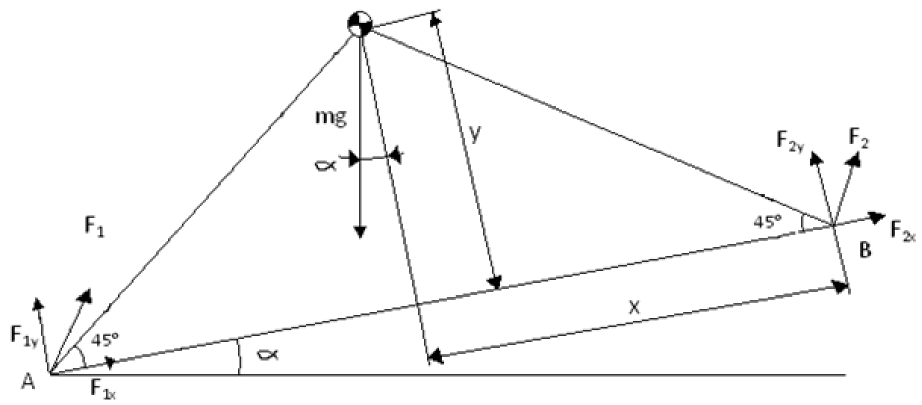
Roll	18	[°]
Trim	6	[°]
Element angle (α)	45	[°]
Engine weight	33300	[kg]
Torque	38200	[Nm]
Distance c.o.g to element center (horisontal)	0,816	[m]
Distance c.o.g to element center (vertical)	0,965	[m]
Bellow diameter	0,4	[m]
Element per engine side	7	
Distance c.o.g to F element	1,175	[m]
Distance F to D element	2,94	[m]

Case Roll			Bellow		
F1	52,90	[kN]	$F1_{axial}$	43,81	[kN]
F2	14,60	[kN]	$F1_{radial}$	29,65	[kN]
			$F2_{axial}$	14,37	[kN]
			$F2_{radial}$	2,55	[kN]

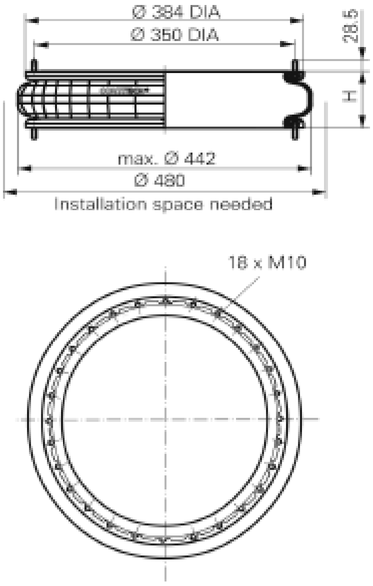
Case Roll and Trim			Bellow		
F1	69,27	[kN]	$F_{A\,axial}$	57,74	[kN]
F2	21,88	[kN]	$F_{A\,radial}$	38,28	[kN]
			$F_{B\,axial}$	21,37	[kN]
			$F_{B\,radial}$	4,66	[kN]

Roll+ Torque		
mg	46,67	[kN]
Fm (to element)	3,34	[kN]
F_{1y}	37,41	[kN]
F_{1x}	7,21	[kN]
β_1	79,09	[°]
F_{2y}	10,32	[kN]
F_{2x}	7,21	[kN]
β_2	55,06	[°]

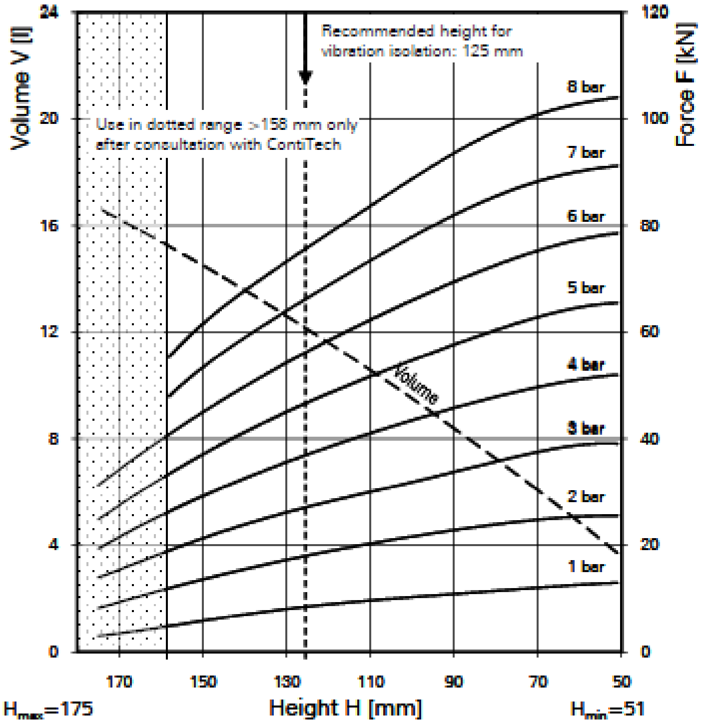
Roll and Trim+ Torque		
x	0,10	[m]
l_1	1,07	[m]
l_2	1,87	[m]
m'g	64,25	[kN]
F_{1y}	48,98	[kN]
F_{1x}	9,93	[kN]
β_1	78,54	[°]
F_{2y}	15,47	[kN]
F_{2x}	9,93	[kN]
β_2	57,31	[°]



FS 960-12 RS CONTI® Single Convolution Air Spring



FS 960-12 RS



Force-height diagram

Purchase order data

Type	Order No.
Rubber bellows only	61775
Bellows with bead rings, 45 mm bolts, nuts and washers	61898

Additional types on request

Service instructions
M 10 = 40 Nm

Technical data

Min. pressure	0 bar
Return force to min. height	≤ 100 N
Overall weight with bead rings, bolts, nuts and washers	5.0 kg

Vibration isolation - dynamic characteristic values

Pressure p	[bar]	3	4	5	6	7	8	Vol V [l]
Force (Load)	[KN]	28.7	38.8	49.0	58.7	68.4	78.1	12.2
Spring rate	[N/cm]	5950	7670	9240	11000	12760	14530	
Natural frequency	[Hz]	2.3	2.2	2.2	2.2	2.2	2.1	

Pneumatic application - static characteristic values

Force F [kN]

Pressure p	[bar]	3	4	5	6	7	8	Vol.[l]
Height H [mm]	158	19.1	26.3	33.4	40.9	48.0	55.4	15.3
	130	25.8	35.8	45.1	54.3	63.9	73.4	12.6
	110	30.0	41.2	51.7	62.3	73.5	83.5	10.6
	90	33.9	45.8	57.7	69.6	82.1	93.6	8.3
	70	37.6	49.6	62.8	75.3	88.2	100.7	6.0