# Machinery Damage

Turkish Shipowner Association

Peter Stalberg – the swedish club


- *Go through slide*

## Agenda

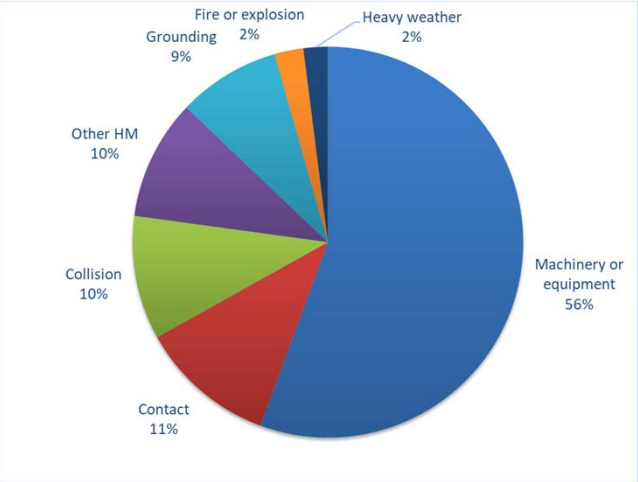
- Hull & Machinery claim statistics
- Focus - Main Engine damage
- Case review
- Focus - Auxiliary engine damage
- Case review
- Damage related to Very Low Sulphur Fuels (VLS)



- ❑ *Go through the agenda.*
- ❑ Please use the functionality to post questions during the presentation. If there is time, and if I can, I'll try to answer questions at the end of the presentation.

## Basic Hull & Machinery statistics (2010-2019)

- 10 yrs period
- 3 340 HM claims reported to the club (> USD 10 000)
- Frequency 0,146
- Total cost $1 170 000 000
- Average cost $350 000
- Deductible ~$140 000

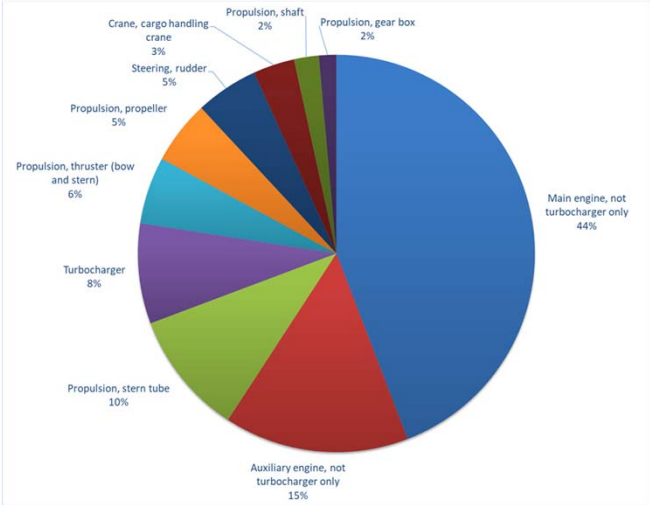





- *Go through the slide*
- *Pie chart showing number of claims (%)*
- Take away >50% machinery claims in Hull & Machinery claim category
- Deductible: USD 140 000

## Machinery & Equipment claim category

- 44% main engine
- 15% auxiliary engine
- Propulsion combined large portion
- **Conclusion: total 25% of all HM claims is about Main Engine damage!**
- (cost: Machinery & Equipment 50% of all HM claims)






- *Go through the slide*
- *Pie chart showing number of claims (%) in machinery category*
- Take away – every 4th claim in hull and machinery category is a main engine damage.
- (*Propulsion is a big share, about stern tubes, oil etc. rise due to EAL (Environmentally Acceptable Lubricants) since 2014)*

## Investigations by the swedish club

- First ME investigation in 2012
- Update 2015 & 2018
- Auxiliary engine investigation 2018

www.swedishclub.com




- *Several investigations over the years, trying to answer some of the questions and give advice.*
- *Available at www.swedishclub.com*

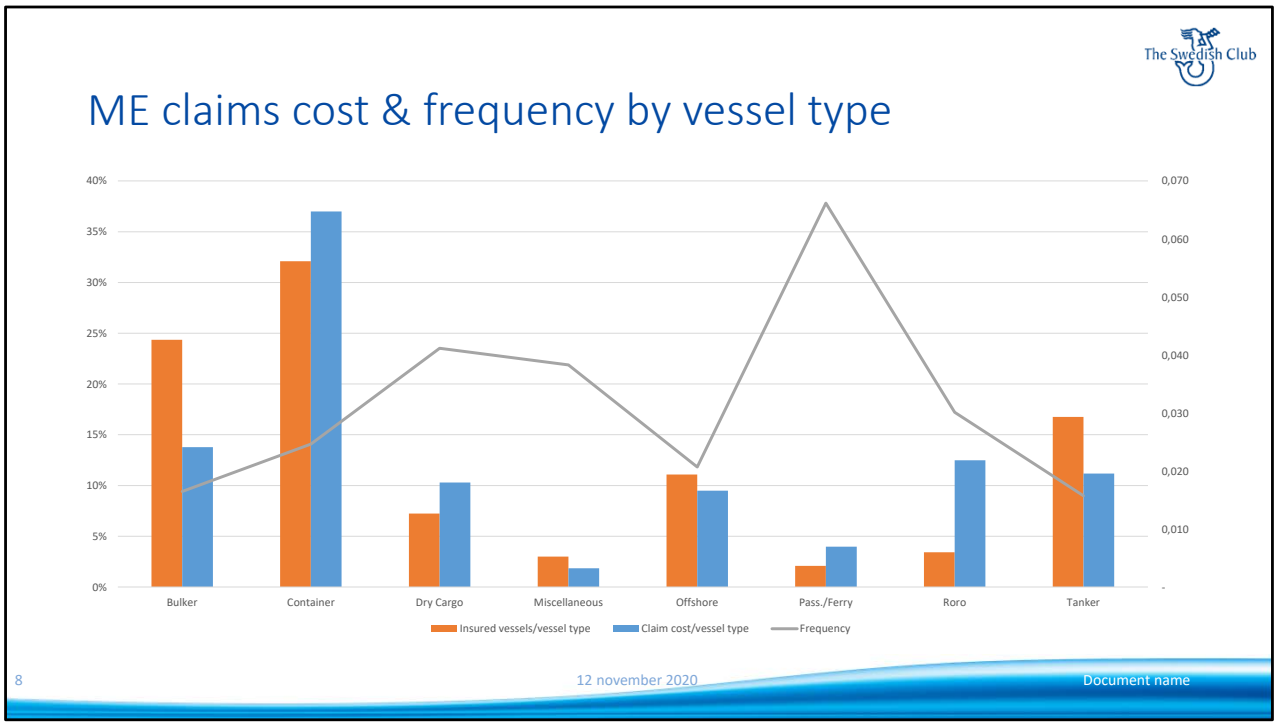
## Main Engine Damage - Basis for presentation

- 1219 Hull & Machinery (HM) claims
- 734 machinery claims
- 202 main engine claims (131 MUSD cost)

- NB! Average deductible USD 140 000

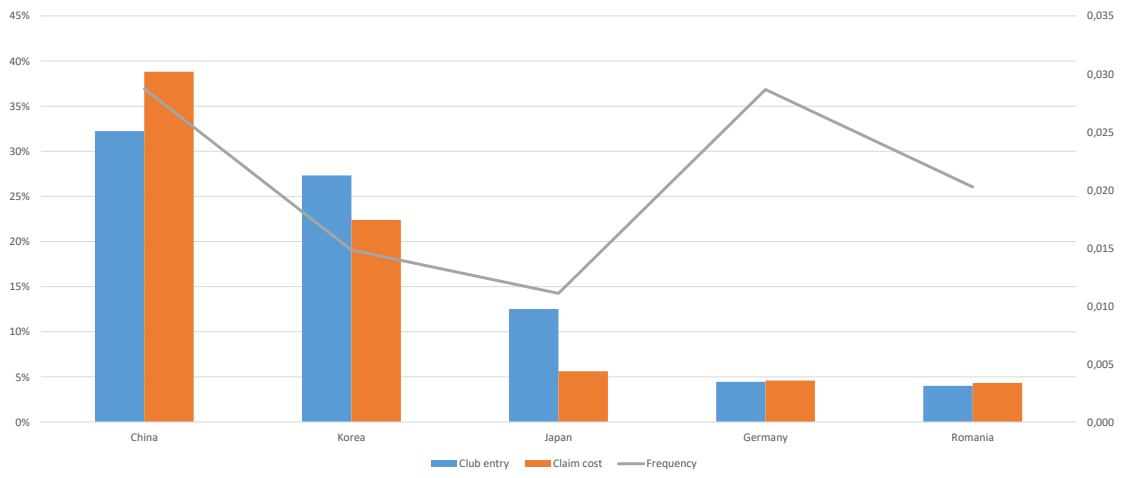


- The Main Engine Damage report from The Swedish Club, sheds light on an expensive category of damage that is all too frequent. Statistically a vessel will suffer between one and two incidences of main engine damage during its life time. Considering the costly consequences for ship owners and their hull insurers, it is important to identify the main causes of this damages and examine how these can be prevented.
- Initially the study aimed to put main engine damage claims into context by examining claims statistics for the Hull and Machinery (H&M) segment. It then examines in detail main engine damage claims - specifically frequency, vessel type, engine manufacturer, engine speed, damaged parts and cause of damage
- Investigation based on 3 yrs of data.
- *Go through slide*
- *Explain about deductible USD 138 000*



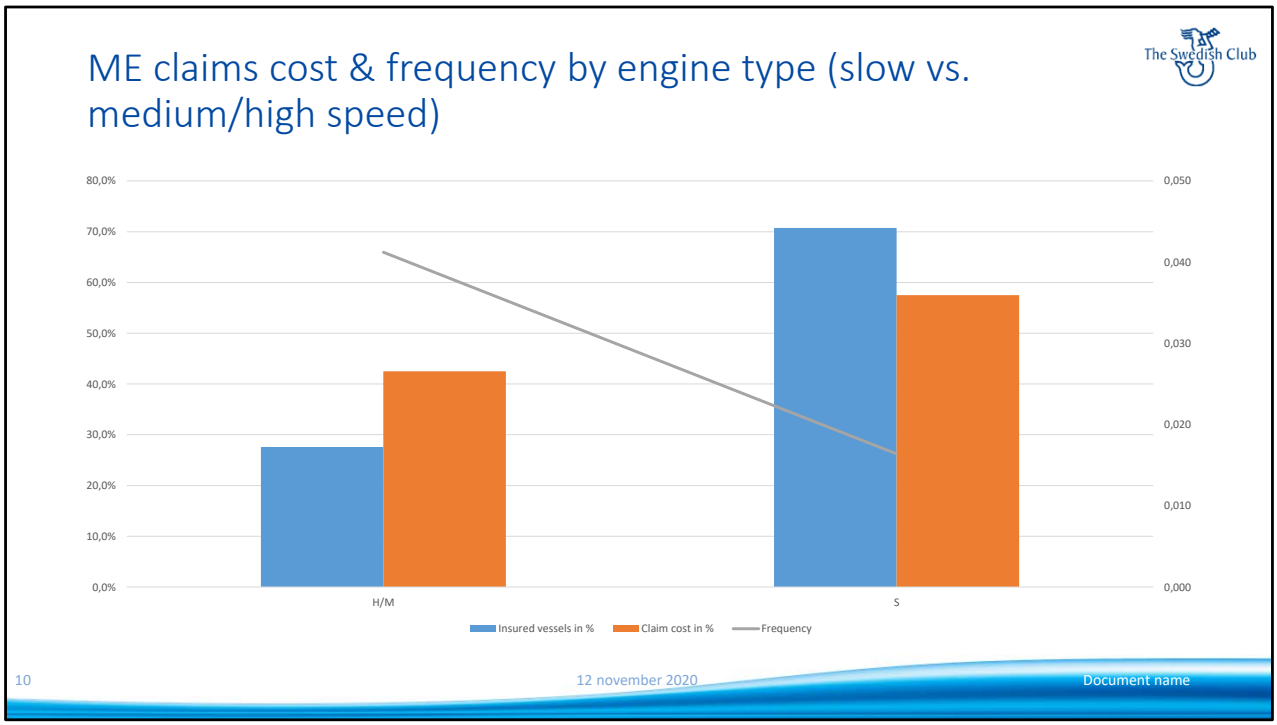

- *Explain graph axis*
- The graph shows that bulkers and tankers are the best performers with regard to claims cost in comparison with Club entry. A majority of these vessels have slow speed engines.
- Passenger vessels/ferries have the highest frequency of main engine claims. Often these vessels have multiple medium speed engine installations. The same is also true for Ro-ro vessels.
- Take away – slow sped engines are better than medium speed engines.

# ME Claims cost & frequency by engine builder country

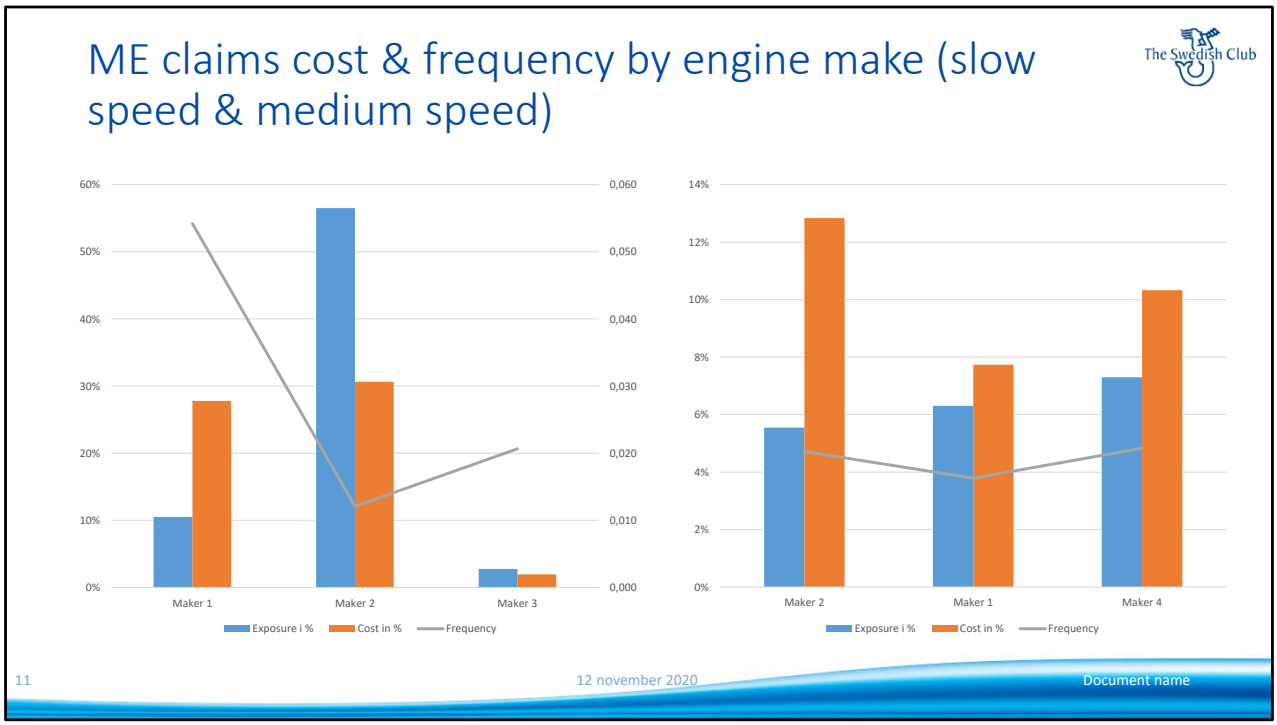





- *Explain graph axis, country of licensee.*
- Take away - engine built in Korea & Japan slightly better than China.

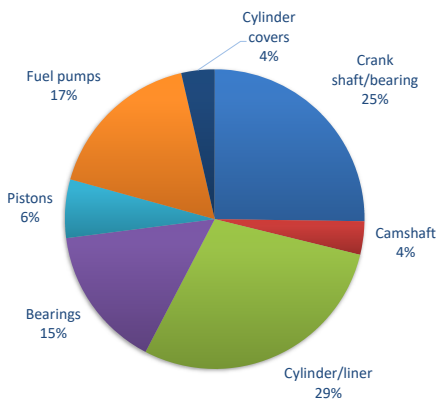


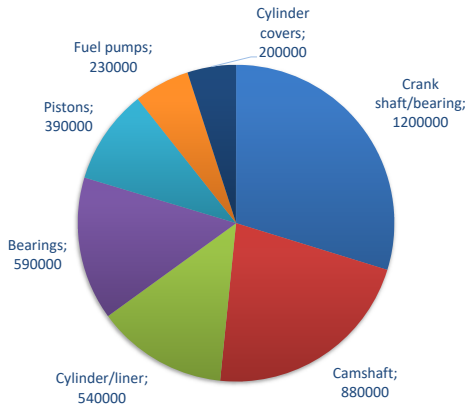

- *Explain graph*
- The take away here is that medium/high speed engines are 2.5 times more frequently damaged compared with slow speed engines. They also have a disproportionate claims cost (43%) in relation to the number of insured vessels (28%).
- So why is medium speed worst compared with slow speed engines? A few reflections;
    - They have a common lube oil system where system oil is used for piston cooling and cylinder lubrication. There is a risk for contamination of oil leading to costly claims.
    - Compared with 2-stroke engines, 4-stroke engines have valves and more moving parts that can fail.
    - In 4-stroke engines you have higher revolution, higher output compared to weight, higher temperature and pressure, sometime gear boxes and generally a less robust design. Anyone who has been working with Pielstick engines know what I'm talking about here.




- *Explain graph, name makers*
- The graphs illustrates the proportions in terms of cost and insured vessels per engine make and speed segment (slow speed to left and medium/high speed to right) for the top three engine makers in both speed segments.
- Almost 60% of all insured vessels during the investigation period were running on a slow speed. They account for 30% of the claims and have a frequency of 0.012 claims per vessel. It is the best performing type of engine in our insured fleet.
- Generally speaking slow speed engines are more robust and have a lower damage frequency compared with medium/high speed engines. Maker 1 slow speed engines break the trend though, with an overrepresentation on the claims side carrying almost 30% of all claims costs but representing only 10% of the insured fleet.
- The medium/high speed engines are in a minority in The Swedish Club's insured fleet. The top three engine makers account for 31% of all the costs in the fleet and 19% of all the insured vessels.
- In particular, and the opposite to slow speed engines, maker 2 high speed engines show a disproportionate result, accounting for 13% of costs but only 5% of insured vessels.
- Obviously, there are several factors influencing the likelihood of a main engine damage and this investigation shall not be used as a "buyers guide" when deciding on engine make. Undisputed though is that 4-stroke engines are less robust compared with 2-stroke engines.

# ME damaged parts, number of claims & average claim cost



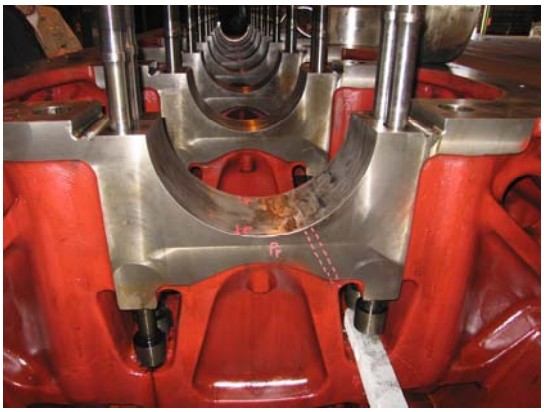






- *Left pie - number of claims (%), right pie average claim cost*
- These charts focuses on the seven most damaged parts. As can be seen, damage to cylinder liners is most common but damage to crank shaft and associated bearings is the most expensive claim as spare parts are expensive and the repairs labor intensive.
- *NB! Only above DD 138 000 USD!*

## ME- cause of damage

- #1: Lubricating failure
- #2: Incorrect maintenance
- #3: Poor fuel management





- Good lubrication is needed between moving parts in an engine. When the lubrication fails the engine fails. The reason for lubrication failure is often because the lube oil is contaminated by water, particles or other impurities. Diging deeper into LO problems we often find that there are human behavior causing the problem. For instance, improper use of oil filters and poor maintenance of lube oil separators.
- Often machinery breaks down just after overhaul. Using non original spare parts, introducing dirt and foreign matters, such as rags, or not following makers instructions when the crew is overhauling machinery can generate big claims.
- As for lube oil, poor fuel management, off spec bunkers and bad separation and filtering, will generate all sorts of costly claims.

## ME damage summary

- 28% in number and 34% in cost relate to ME damage
- Passenger vessel/ferries has the highest frequency.
- 2,5 times higher risk for claim for medium/high speed installations.
- Most expensive is damage to crank shafts, average 1,2 MUSD per claim.



- ❑ Prevention of damage is naturally preferable to cure. A first step to avoiding damage is to have a well implemented and proper management system. This is ensured by facilitating proper training and education of the crew, providing them with the essential knowledge and experience required for ordinary daily work and maintenance according to company procedures.
- ❑ Further, it is highly recommended to have a computer based Planned Maintenance System on board linked with the shore organization. The Planned Maintenance System should be approved and audited by a classification society to ensure a good standard.

## Loss Prevention Essentials

- A robust onboard fuel and lubrication oil management system.
- System checks of purifiers and filters for fuel and lubrication oil systems.
- Follow makers maintenance instructions strictly.
- Bring in makers' expert when required.
- Make sure the engine alarm systems works.




- ❑ What can we do to avoid ME damage? Here are some advices;
- ❑ A robust onboard fuel and lubrication oil management system is essential for the safe operation.
- ❑ At regular intervals, carry out system checks of purifiers and filters for fuel and lubrication oil systems to make sure they work as advertised.
- ❑ Follow makers maintenance instructions strictly. A computer based Planned Maintenance System is recommended.
- ❑ Don't cut corners - bring in makers' expert when required. Perhaps consider a formal service agreement.
- ❑ A fully functional engine alarm system is essential for the safe operation of the main engine. Take alarms seriously and investigate thoroughly.

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# Case # 1- Water in system lubrication oil

- Bulker built 2012 on voyage between Spain & US East coast with project cargo. The vessel is equipped with a single main engine type; M.A.N. / B&W, model 6S50MC-C, two stroke diesel engine with 6 cylinders in line, rated to 9,480 kW.
- On 17th May 14:42 LT , approx. 3 days from destination, a large sea water cooling pipe burst and started leaking heavily. ME stopped, leakage investigated and pipe blanked. (Cause – erosion corrosion due to poor design)
- Water contained on tank-top and disposed off via engine room bilge pumps.
- On 17th May 18:00 ME restarted, and voyage resumed. Shortly thereafter there was an oil mist alarm. ME stopped. Investigation revealed high level of saltwater in system oil.
- Engine cleaned and system oil replaced. Voyage continued with reduced speed.
- Service engineer from MAN attended in US. Renewal of all six crosshead bearings lower half shells. No. 2 crankpin bearing and No. 4 main bearing was opened for inspection and found to be undamaged. **Repair cost - USD 250 00.**

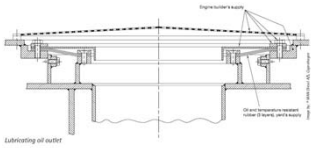
**Could this accident have been avoided?**



- *Read slide text.*

## Case # 1 – continued

- Immediate cause: A defective bellow seal between ME crank case and LO sump.
- Underlying cause: Failure to implement and follow makers maintenance instructions.







- ❑ The bellow seal between the ME and the sump tank is supplied by the yard when the ship is built.
- ❑ The rubber will degenerate when in contact with hot lube oil.
- ❑ As long as there is no water on the tank-top nothing will happen.
- ❑ When flooded, water on tank-top will seep into the main engine and contaminate the system oil. This was what happened here.

- ❑ Engine makers have sent out recommendation to check and renew the rubber seal at every special survey – every 5th year.
- ❑ We, as an insurance company has also sent out recommendations about this.
- ❑ Failing to implement this routine in the maintenance system caused this damage.
- ❑ This is our perhaps our biggest challenge – we have plenty of information from claims but when we find something how can we make sure it will be implemented into the vessels Standard Operating Procedures or ISM system?? Really something to reflect over.

## Case #2 – ignoring engine alarms

- Produckt tanker built 2011 in ballast to UAE. The vessel is equipped with a single main engine type; M.A.N. / B&W, model 6S60MC-C8, two stroke diesel engine with 6 cylinders in line, rated to 12 280 kW at 105 RPM.
- On 16th February 18:20 "High Level" alarm from the FO leakage collecting tank.
- Acknowledged but not investigated. Alarm went off again several times.
- At 23:20h automatic slowdown of ME. Heavy smoke and fire in engine room.
- Crew mustered and CO2 released. Fire extinguished.
- Damage from intensive fire and salvage claim : **USD 3 500 000**

**Could this accident have been avoided?**



❑ *Read slide text.*

## Case # 2 - continued

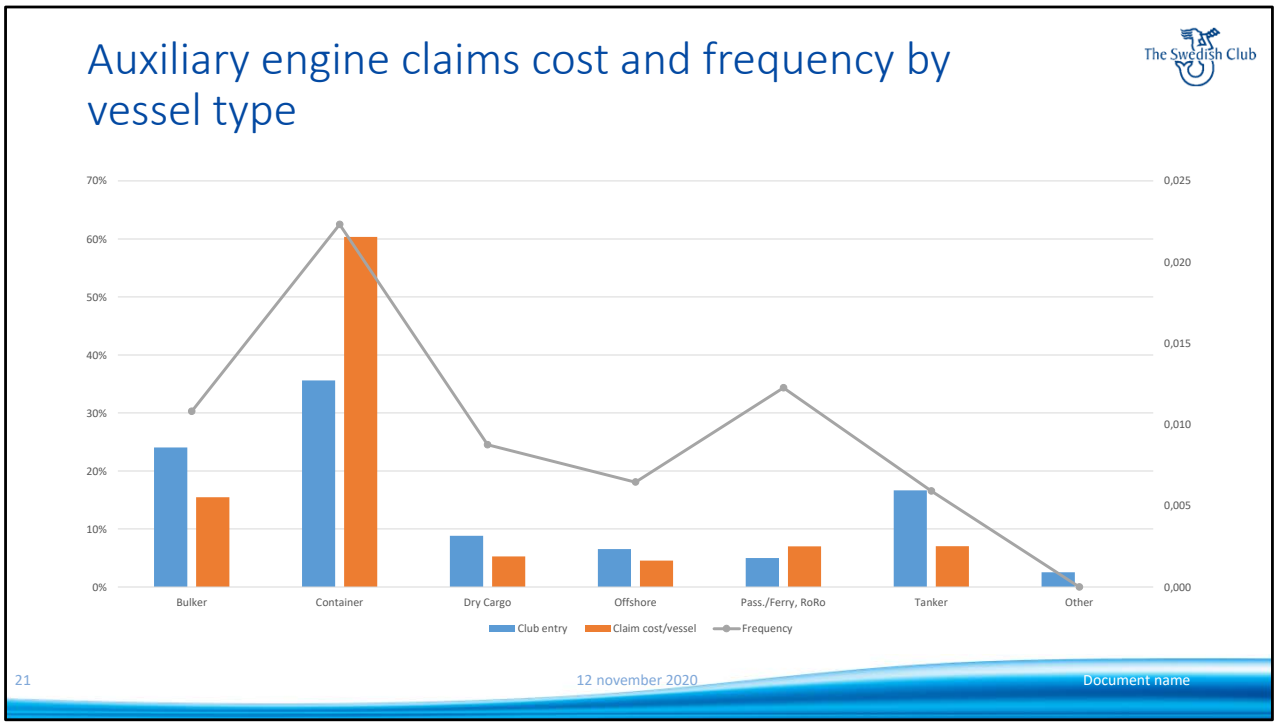
- Immediate cause: Fatigue crack in fuel oil in high pressure fuel oil pipe
- Underlying cause: Failure to react and investigate an engine alarm.



- ❑ Looking at the events leading up to this fire we can see that the first alarm went off at 1630 and there was a series of alarms after that – but the crew didn't do anything and apparently didn't understand what was going on. They were given hours of pre-notice to deal with the situation, but they ignored it.
- ❑ A few hours after the first alarm, the fuel pipe connection burst, there was a huge spray of fuel, and fire broke out.
- ❑ This case is interesting because there are a lot of alarms that can go off for various reasons, to help the engineer protect a ship's technical equipment. You must have your alarm system in order, you must understand what the different alarms are for, and you should never have the attitude of 'that alarm's always going off', and just ignoring it.
- ❑ IMO regulations stipulate that all high pressure fuel piping must be double-skinned so that if the pipe starts leaking, the spray will be contained between the outer skin and the pipe. The fluid is collected into a small tank with a high-level alarm – when that alarm goes off, you know you have a leakage of high-pressure fuel, and you should investigate and take action promptly.
- ❑ This started as a small leak contained within the double skin. The crew had the possibility of averting a fire, if they had responded properly to the alarm. However, once the fire had broken out, the response was good. The crew were mustered within ten minutes, and the fire was promptly extinguished with CO2.

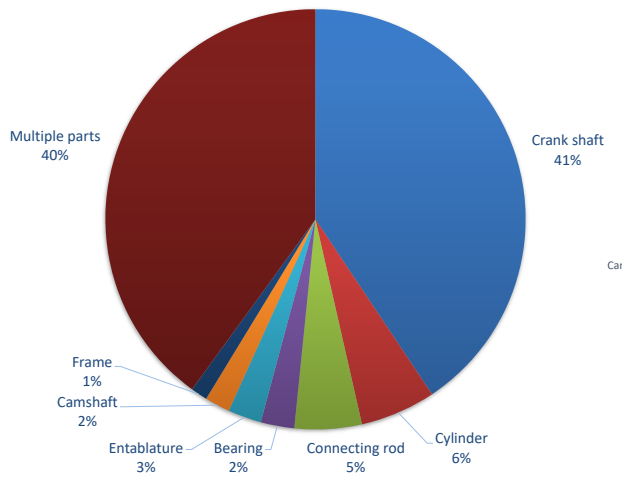
- Now let's talk about auxiliary engines..

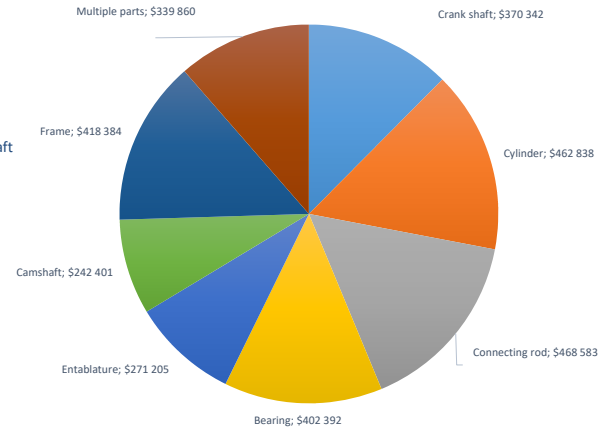

- *Read slide*
- Auxiliary engines run at high revolutions and have a common lubrication system for both cylinder and crank case lubrication. Auxiliary engines are not under the same strict regime from the classification society and maintenance is often carried out by the vessel crew. The Club has seen all too frequently damages.
- The following causes of damage are most common;
  - Incorrect maintenance and repairs, failure to adhere to repair procedures and use of incorrect tools
  - Crew lacking formal engine specific training
  - Inexperienced crew and no expert in attendance
  - Failure to detect contamination of lube oil due to poor lubrication oil management
  - Not following up on results from lubrication oil sampling




- *Explain graph.*
- Container vessels have a significantly higher claims frequency due to the larger number of installed engines on these vessels. In addition, these engines have considerable output, hence the repair cost is greater compared with other vessels

# Auxiliary engine – damaged parts avg. cost






- As can be seen – crank shaft damage and accidents with multiple parts, due to catastrophic failure, happens most often.
- On the cost side auxiliary damage is on average between 250 000 to 500 000 USD per occurrence.


1. Connecting rod bolts, we saw 58 cases of mainly wrong assembly of bolts & nuts for main bearings, connecting rod studs etc.
Most common underlying causes;
a. Improper tightening of connecting rod bolts
b. Hydraulic tool/pump not calibrated
c. Lack of crew training and adherence to procedures

2. Contamination of lubrication oil, we saw 27 cases with oil contaminated with H2O or soot.)
Most common underlying causes;
a. Improper lube oil management
b. Lube oil filters degraded over time
c. Introduction of dirt (rags) during maintenance
d. Damage/leaking lube oil cooling water heat exchanger

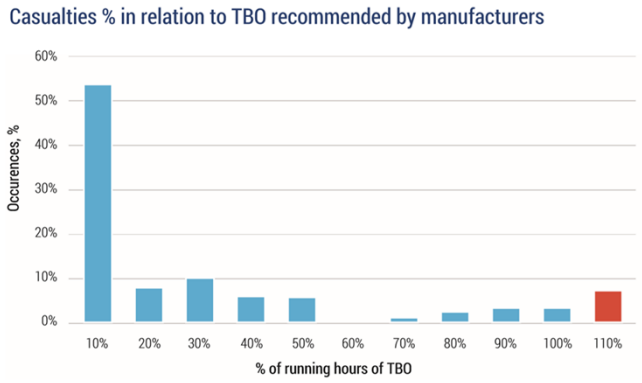
3. Incorrect maintenance & procedures, we saw 25 cases
Most common underlying causes;
a. Incorrect adjustment of valve clearance
b. Installed pistons in wrong directions
c. Installed wrong type of plungers in fuel pumps

d. Mixed up inlet and outlet valves during overhaul
e. Not following manufacturer's service letter regarding required modifications
f. Not installing correct bearings following crankshaft grinding

4. Overspeed, we saw 16 cases
a. Overspeed trips NOT in working condition
b. Wrong assembly after exchange of governor
c. Wrong assembly of fuel linkage
d. Worn out drive system for governor

## Time Between Overhaul (TBO)

- More than 50% of all AUX engine damage occur just after engine overhaul!






- ❑ The chart above demonstrates the time that a casualty occurs in relation to the recommended maintenance interval (TBO) of the engine. The TBO of an auxiliary engine is normally between 12,000-16,000 hours.

- ❑ *Explain graph*

- ❑ As can be seen, most of the casualties, 55%, occur within only 10% of the TBO, corresponding to the first 1,000 hours or so of operation after overhaul. In most cases, the damage occurs only a few hours after start up.

- ❑ Typical cause of damage;
  - tightening of con rod bolts. Very critical assembly, small mistake big consequences.
  - Cleanliness. Introduction of foreign particles causes lubrication failure and consequently machinery breakdown.
  - Other causes are forgot tools and not following makers instructions for overhaul.

- ❑ Take away - Do it right - or don't do it at all!
- ❑ Recommendation is to bring onboard makers expert. Not necessarily a better job but you will have warranty when starting up.

## Aux engine – loss prevention advice

- Ensure the crew have the necessary knowledge and experience before commencing overhaul.
- Always strictly follow makers' instructions.
- Ensure that required tools are available and calibrated as necessary.
- Regularly monitor the quality of the lubrication oil. Take early action.




- ❑ Auxiliary engine claims account for 13% of the total machinery claim costs and 16% of the volume, with an average claim cost of USD 345,000.
- ❑ The frequency for auxiliary engine claims is approximately 1.2% and has been relatively steady for the last few years.
- ❑ Container ships have a higher claim frequency and cost in relation to fleet entry.
- ❑ Approximately 50% of all auxiliary engine damage occurs immediately after maintenance work.
- ❑ Reviewing our records we note that the common factor for these occurrences in most cases is the incorrect assembly of vital engine parts in connection with regular overhaul. In particular, the assembly of connecting rods, bearings and pistons causes severe and costly accidents.
- ❑ Non adherence to procedures, lack of training and experience are major factors. A connecting rod assembly is a critical and highly stressed joint and must be re-assembled exactly in accordance with manufacturer's instructions with proper tools. All too often the Club sees insufficient understanding of the importance of the procedures.
- ❑ Special hydraulic tools are often used for the engine assembly. These tools must be treated with care and need to be calibrated and carefully checked before use.
- ❑ The manager has the responsibility to ensure that crew are competent to undertake such repairs/overhaul. The crew should either be trained on the specific engine types or

alternatively, an expert from the manufacturer should be engaged to attend the overhaul.

- Poor lubrication oil management is also in many cases the predominating factor for an auxiliary engine breakdown.
- Auxiliary engines are 4-stroke engines and as such the engine oil is used for cooling of pistons crowns and lubrication of cylinder liners, bearings, etc. There is an apparent risk that the lube oil will be contaminated with soot and combustion particles, especially if the engine has accumulated some running hours.
- Proper lubrication oil management is critical for minimizing the risk of engine failures. This is essential when operating the engine on heavy fuel oil (HFO). The lubrication oil must be analyzed at regular intervals. Detection of water, soot particles, metal particles, etc. will serve as an early warning for engine problems. Negative results from oil analysis must be investigated and addressed promptly.

PS1

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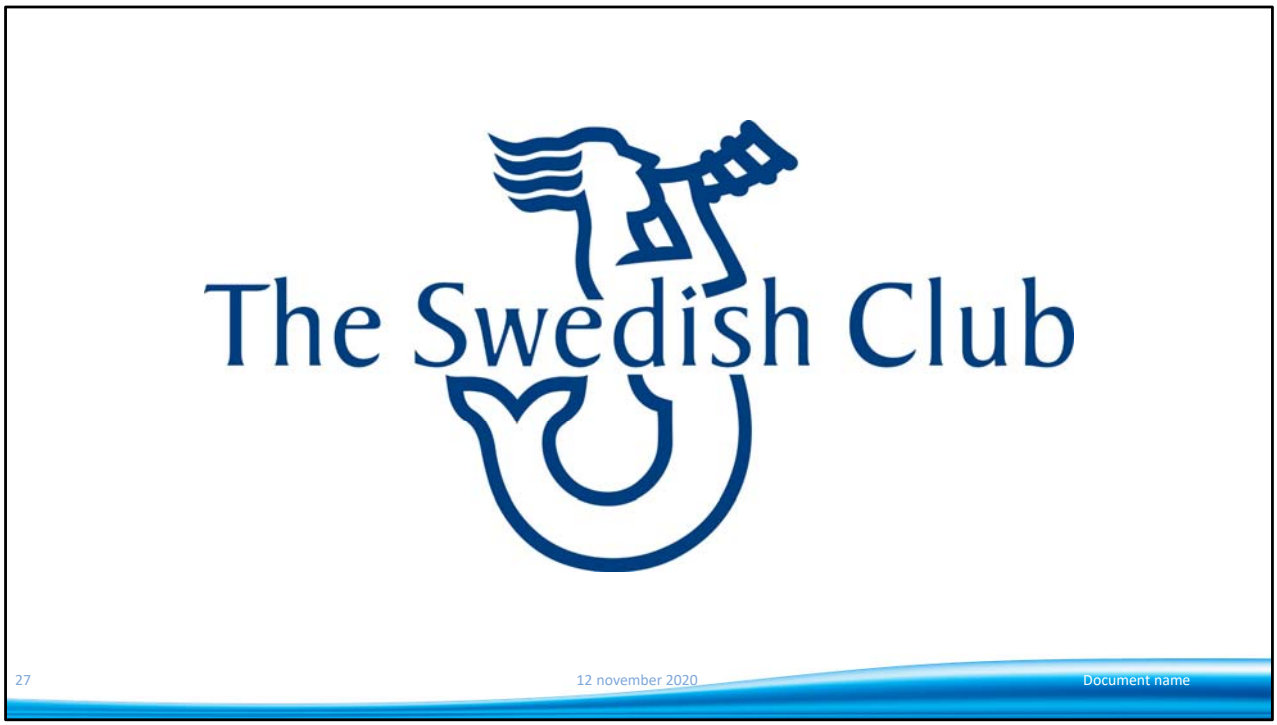
## Very Low Sulphur Fuels

- Approx. 8 cases related to VLS in 2020
- Fuel mostly within ISO spec (otherwise a FDD claim)
- Symptoms;
  - Clogging of fuel pipes, preheaters, separators and filters.
  - Fuel pumps getting stuck.
  - Fuel injection problems.
  - Poor ignition
- Problems with filtration and separation will cause damage to pumps, pistons and liners.
- No damage to scrubbers reported to the club yet…

- There has not been an avalanche of new cases related to the introduction of Very Low Sulphur fuels. We have seen a few cases that indirectly can be connected to VLS fuel. In this context it is not often the fuel itself but rather the fuel management onboard which is not up to pair.
- As you know, a heavy fuel oil, although within ISO specification, can not be used directly – onboard treatment is necessary. We call this fuel management.
- Problem with VLS fuels often relates to comingling and in-combability with other batches causing increased sludge and wax deposits. Consequently, problems with filtration and separation will cause damage to fuel pumps, pistons and liners and this what we have seen in the claim stream.
- Remind you, we only see damage in excess of the deductible, USD 140 000 dollars.
- On a side note – no damage to scrubbers reported to the club yet. Most installations still under warranty but we except to see claims in the future.

## Slide 26

**PS1** Peter Stålberg; 2020-11-12




This concludes my presentation. A lot of facts and statistics but I hope you picked up some “gold grains”. After all, I believe It’s all about attitude how you run your operation.

Thank you!