# The Guide to Slow Steaming On Ships

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**The Guide to Slow Steaming on Ships**

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## What is Slow Steaming?

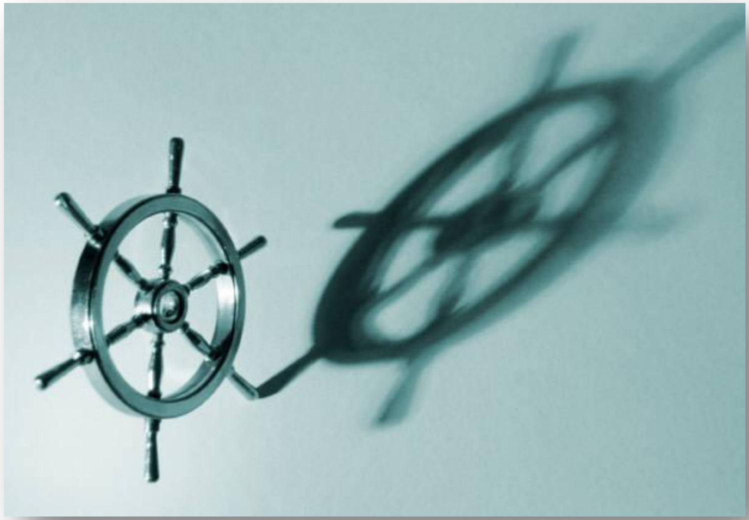
Slow steaming is a process of deliberately reducing the speed of cargo ships to cut down fuel consumption and carbon emissions.

In slow steaming, a container ship travels at a speed of around 12-19 knots instead of  the usual 20-24 knots. This results in reduction of engine power and fuel consumption.

Slow steaming has successfully helped ship owners in reducing the amount of fuel needed to run ships, which in turn has lead to significant decrease in carbon emissions.

Slow steaming has been adopted by majority of companies and ship owners in order to survive in the tough times of rising fuel prices and financial recession.

The pressure to reduce carbon emissions and improve ship efficiency has also pushed shipping companies to implement slow steaming on their ships.



## Brief History of Slow Steaming

Originally started for Container Shipping by Maersk Lines and justified by the cost sheets and economics, the concept of slow steaming has now been borrowed by other types of ships including tankers and dry bulk ships, whose operating speeds are traditionally low.

Long before other ship owners caught on with the concept, Maersk shipping experimented with slow steaming and presented to its customers and ship owners the complete fact sheet of the concept along with the financial viabilities.


Maersk lines even requested all major engine builders to issue a no objection certificate that convinced reluctant Marine Engineers and ship owners that slow speeding is possible and if correctly done would not jeopardize the main engine.

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## Benefits of Slow Steaming

Slow steaming has helped shipping companies to improve their performance, along with reducing their carbon footprints.

Though issues such as longer time to transport cargo and negative effects on the engine have been bothering companies, the overall benefits of the strategy has made them overlook the downsides, at least for the time being. The major benefits of slow steaming have been:

- Higher fuel savings
- Reduction in carbon emissions ($CO_2$, $NO_x$ and Sox)
- Improved reliability
- Increased efficiency

Apart from the benefits, implementing slow steaming on ships also requires a variety of factors such as technical requirements, various modes of slow steaming including super slow steaming, retrofitting, modifications with the upgrade kits and suitability of intelligent marine.

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## Why Marine Engineers are Concerned?

In the transient times of changing standards, stricter regulations and new emerging technology it finally translates to the ship's chief engineer and his team of marine engineers in consultation with the company's technical management to implement the required changes related to slow steaming on the ship.

Ship owners instruct their chief engineers to run the ship on economy speed, also called eco speed or slow steaming.


It is up to the marine engineers, working in the engine room of the ship, to ensure that slow steaming is smoothly implemented and there are minimum damages to the engine. Thus apprehensions regarding the concept are obvious.

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As slow steaming is not a regular affair for marine engineers nor have they been trained for the same, some efforts have to be made to remove the traditional mindset and reluctance of the engine staff by retraining them.

In addition, the engineers have to be instructed about additional routines and inspections of the main engine, which is operating outside its designed optimal range when slow steaming is implemented.

Marine engineers have always been advised by engine manufacturers that low load operation must be avoided.

The engines must be run close to its continuous rating for optimization of all its parameters and allowing the individual components to operate in their designed range.

*"Marine engineers have always been advised by engine manufacturers that low load operations must be avoided."*

Marine engineers usually have the following concerns with regards to slow steaming:

- Frequent and thorough scavenge and under piston inspections must be carried out
- Over lubrication of the cylinder liners is as dangerous as under lubrication. Unless the engine has a load dependent cylinder lubrication system which is suited for slow steaming, the cylinder lubrication rate must be adjusted to optimal value as per manufacturer's advice
- Slow steaming causes fouling of the turbochargers and loss of efficiency
- Turbochargers operating outside their designed range produce less air flow leading to more deposits
- Increased carbon deposits on the injectors compromises with their performance
- Causes fouling of the exhaust gas economizer resulting in reduction of capacity as well as increased danger of soot fire
- Causes reduction in scavenge air pressure resulting in improper combustion
- Leads to improper atomization of the fuel as well as leads to impingement

- Causes increased carbon deposits and maintenance intervals have to be modified likewise
- Causes low exhaust gas temperatures. Running the engine with exhaust gas temperatures below 250 deg C can cause low temperature corrosion
- Causes reduced peak compression pressure
- Damage occurs and becomes imminent when engine is run at full load after long period of slow steaming
- Compromises the piston ring pack efficiency, leading to increased under piston and scavenge deposits
- Increases the risk of scavenge fires and needs extra scavenge and under piston area draining
- Cause loss of heat transfer due to carbon deposits and failure of components due to thermal stresses
- Leads to reduction in the efficiency of the economizer, causing the need of oil fired boiler to operate and adding to extra cost and maintenance

## How to Test Ship's Main Engine for Slow Steaming?

More and more companies are now trying the option of slow steaming to save fuel costs at available opportunities. In the bulk carrier market it is normal to instruct the ship to move at slow or economy speed towards certain destination until the charter is finalized.

Sometimes the charters also demand that the vessel should proceed at slow steaming and a relevant clause is inserted in the charter party.

Normally, ships have a speed v/s consumption table at various RPM in ballast and loaded condition. It is a usual practice that the charterers ask for this data prior to fixing the charter party.

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In today's scenario the charterers may also ask for slow steaming data. In cases when a long anchorage is expected or when the cargo is not time sensitive, it may be profitable to the charterer to run the ship as slowly as possible to save fuel as well as anchoring costs.


It is the duty of marine engineers to ensure that the main engine is run properly without compromising the safety and preventing long term damage. Therefore, a correct and safe economical speed / RPM has to be told to the charterers while finalizing the voyage.

Many times in the event of insufficient data as in old ships, a sea trial has to be done to find the eco speed/RPM and fuel consumption.

## Different Types of Slow Steaming Without Engine Modification

All conventional main engines except intelligent engines and cam less engines with electronic fuel injection can be run in three slow steaming modes namely:

- **Low RPM with auxiliary boiler cut off and auxiliary blower cut off**: Steam demand is handled 100% by exhaust boiler after optimizing usage of steam. Main engine turbocharger can cope up with the air demand and oil fired boiler is cut off.
- **Low RPM with auxiliary boiler firing intermittently and auxiliary blower cut off**: Steam demand is handled mostly by exhaust boiler and the oil fired boiler assisting in between and firing intermittently. Main engine turbocharger can cope up with the air demand.
- **Low RPM with auxiliary boiler firing frequently and auxiliary blower cut in and running**: As exhaust temperatures have fallen, steam demand is met by oil fired boiler firing frequently. Main engine turbochargers cannot cope up due to less enthalpy of exhaust gas and the auxiliary blowers are running.

Due to bad weather and commercial pressures sometimes marine engineers have to run the main engine at manoeuvring RPM with auxiliary blower cut in.

The blowers are put in manual mode to avoid cutting on and off and damaging the motor due to repeated starts and associated high starting current. But these are rare occasions and a Chief Engineer should advice the Master against such operation continuously unless it is unavoidable.

Normally when trying out the engine for low load operations, engineers try to run the main engine at slowest RPM, at which, the exhaust boiler can cope up to, the auxiliary blowers are off, and there are no chances that a sudden load change due to course alteration or change in weather will lower the load and allow the auxiliary blower to cut in intermittently.

As during sailing no fuel is allotted for the boiler firing in the charter party and also to avoid unnecessary maintenance of the boiler it is prudent to report such RPM to the charterers.

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On the next page are the main engine characteristics recorded during an actual sea trial done at sea on a fair weather day to enable reporting the eco RPM/speed to the company and subsequently to the charterers.

In this particular engine the turbocharger exhaust outlet temperature is a limiting factor as at 330 deg C the high temperature alarm is generated and resets at 324 deg C.


The other limiting factors are high cylinder exhaust temperatures; low scavenge pressure and boiler pressure. The oil fired boiler fires when the pressure drops below 5.5 bars.

## Main Engine Characteristics Based on Trial Done at Sea

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| RPM | LOAD | T/C EXHAUST OUT TEMPERATURE | TURBOCHARGER EXHAUST TEMPERATURE ALARM | SCAVENGE PRESSURE | BOILER PRESSURE | TURBOCHARGER RPM | MEAN EXHAUST TEMPERATURE | HIGHEST EXHAUST TEMPERATURE | AUXILIARY BLOWER STATUS | SHIP SPEED |
|---|---|---|---|---|---|---|---|---|---|---|
| 99 | 55 | 322 | OFF | 1.31 | 6.1 | 9000 | 365 | 379 | OFF | 13.4 |
| 98 | 54.5 | 324 | ON / OFF | 1.18 | 6.1 | 8800 | 362 | 379 | OFF | 13.3 |
| 97 | 54 | 328 | ON / OFF | 1.07 | 6.1 | 8500 | 358 | 380 | OFF | 13.2 |
| 96 | 53 | 331 | ON | 0.97 | 6.1 | 8400 | 350 | 381 | OFF | 13.1 |
| 95 | 51 | 334 | ON | 0.90 | 6.1 | 8200 | 365 | 382 | OFF | 12.8 |
| 94 | 50 | 336 | ON | 0.87 | 6.0 | 8000 | 366 | 386 | OFF | 12.7 |
| 93 | 49.5 | 339 | ON | 0.73 | 6.2 | 7800 | 367 | 384 | OFF | 12.6 |
| 92 | 49 | 344 | ON | 0.71 | 5.9 | 7500 | 368 | 384 | OFF | 12.5 |
| 91 | 48 | 347 | ON | 0.70 | 6.1 | 7400 | 369 | 384 | OFF | 12.4 |
| 90 | 47.5 | 345 | ON | 0.68 | 6.1 | 7200 | 365 | 378 | ON | 12.2 |
| 89 | 46 | 332 | ON | 0.75 | 5.9 | 7350 | 350 | 363 | ON | 12.2 |
| 88 | 45 | 326 | ON | 0.7 | 6.1 | 7000 | 345 | 358 | ON | 12.1 |
| 87 | 44.5 | 324 | ON | 0.67 | 6.1 | 6900 | 344 | 356 | ON | 12.0 |
| 86 | 43 | 324 | OFF | 0.63 | 5.8 | 6700 | 343 | 353 | ON | 11.8 |

**Legend:**

- UNSTABLE / UNDESIRABLE
- DEPENDING ON WEATHER
- STABLE / DESIRABLE
- AUXILIARY BLOWER STARTED

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**Remarks:**

- Main Engine can be run stably 99 RPM onwards, over a load index of 55
- Main Engine can run at 98 and 97 RPM if load is 55 and above
- Main Engine can be run continuously at or below 86 RPM with Auxiliary Blowers and two Generators running
- Main Engine cannot be run between 86 to 98 RPM corresponding to a load index of 43 to 55
- Auxiliary Blower starts at around 90 RPM when the load falls to 47 at 0.68 bars scavenge pressure
- Boiler pressure is stable till 87 RPM below which it starts falling
- At 99 RPM the FO consumption will fall between 28 to 29 MT per day, depending on the weather
- Actual Ship's speed may be less than written as measurement was done for short intervals only
- Actual speed will depend on weather experienced. The weather when trial was done is as follows:

  - Heading 140 °
  - Wind W x 4
  - Swell NW x 0.5
  - Current NW x 0.4

The above data is from a 73000 MT dead weight Panamax Bulk carrier fitted with a six cylinder B&W 6S50MC-C main engine with a Maximum Continuous Rating of 14100 BHP @ 119 RPM.

It has a fuel consumption of 35 MT/day at sea speed of 13 knots at 85 % MCR which is 11990 BHP @ 113 RPM.

The trial was done to find out the fuel consumption at various RPM at slow steaming. It also helped to find out the safe eco speed and RPM.


From the above sea trial data we learn the following about the main engine:

As long as the load is above 55 % MCR irrespective of RPM, the main engine can run safely.

Between a load of 54 and 44 % MCR, the main engine cannot run as turbocharger exhaust outlet temperature becomes high.

*“As long as the load is above 55 % MCR irrespective of RPM, the main engine can run safely.”*

Main engine can be run at and below 43 % load corresponding to an approximate 86 RPM, with auxiliary blowers continuously on and two generators running. This extra fuel consumption of 2 MT per day slightly offsets the saving otherwise.

Thus after the analysis of the above data we infer that taking the advice of the manufacturers into account and the associated risks and maintenance involved the best bet is 99 RPM with a fuel consumption of 28 MT/day.

A saving of 7 MT/day of fuel leads to fuel saved amounting to USD 7000.

## Optimization of Ship's Main Engine

As low speed marine engines are not traditionally suited for prolonged slow steaming, a number of precautions need to be taken in case slow steaming operations are adopted without modification.

Checks need to be done, additional maintenance is required and precautions are to be taken so that there are no long term damages to the machinery.

*"Traditionally main engines are designed to run between 70 % to 85 % load range during continuous operation."*

Traditionally main engines are designed to run between 70 % to 85 % load range during continuous operation. The matching and designing of all the auxiliaries is based on this load range operation.

- The exhaust boiler size (surface area) is decided based on the exhaust temperature, volume of exhaust gas flow and the waste heat recovery in this range. Low load operation makes this waste heat recovery system ineffective and there is less production of steam, which increases the load on the oil fired boiler

- The air cooler size (surface area) is selected based on the heat load of the air in this operating range. During low load operation the cooling water to the air cooler needs to be controlled by bypassing the cooler and throttling the water valves to maintain optimum scavenge air temperature. Too much throttling of the water valves reduces the flow velocity of the cooling water thereby increasing the deposit rates of the precipitants, leading to fouling and contamination of tubes

- The turbocharger selection and matching to the main engine is based on the enthalpy of the exhaust gas that needs to be extracted. The other selection criteria is the quantity of the scavenge air that needs to be supplied to the cylinders for optimum combustion. The turbocharger is selected for the normal running load range of 70 to 85 %. Low load operations of the main engine lead to lower running RPM of the turbocharger and less generation of scavenge air. This leads to ineffective and incomplete combustion, increased fouling and makes the cleaning measures like dry grit cleaning of the turbine ineffective

- The propeller is designed to give maximum efficiency for the RPM in this range. Due to lower RPM the propeller efficiency may be affected
- The Specific fuel oil Consumption (SFOC) is optimized for running in this range. Even though the fuel consumption is lower in totality, the SFOC is higher at part loads as injection and combustion is not proper
- The fuel injectors and fuel pumps are designed for this range thus the atomization and penetration may be effected at low load operation
- The operating parameters and their alarm and monitoring system is designed for this range
- The hydrodynamic lubrication is RPM dependent and the grade of oil and its properties like oiliness are selected for this range
- The shaft generators are designed and selected based on this range. Low load operation may make shaft generators unusable

Thus for running the main engine below its normal operating range of 70 to 85 % Maximum Continuous Rating (MCR), the whole system needs to be optimized.

*"Slow steaming up to 50 to 55 % load can be done on most engines without harm in long term if certain precautions are taken."*

Generally it is known that if engine modifications and retrofitting is done on the main engine, then it is safe for slow steaming as well as ultra slow streaming.

Slow steaming up to 50 to 55 % load can be done on most engines without harm in long term if certain precautions are taken. That generally is the point above where the auxiliary blowers cut in.

## Slow Steaming for Ships : Checks and Precautions

As discussed earlier, traditionally main engines are designed to run between 75 % to 85% load range during continuous operation.

However, to run the ship's engine for slow steaming, a number of precautions need to be taken to run the marine engine at low loads.

Let's take a look at various checks and precautions that need to be taken for preparing marine engines for slow steaming.

### Checks for Slow Steaming

Generally, in traditional marine engines (except intelligent engines) few checks are needed to be made if low load operations are carried out.

- Frequent scavenge inspection and under piston area inspections
- Checking piston rings for breakage, fouling and lack of springiness
- Frequent inspection and cleaning of exhaust boiler. Consider using high pressure jet machines for effective cleaning

- Checking cylinder lubrication rate and inspect liners and piston for over and under lubrication and scuffing

- Checking turbocharger RPM as well as the scavenge air pressure. Any drop in RPM or the scavenge air pressure at same load may indicate fouling of the turbocharger

- Checking and recording the temperature difference of the exhaust gas between the inlet and the outlet of the turbocharger. A reduction in the difference may indicate fouling of the turbine

- Checking and recording the funnel stack temperature after the exhaust gas boiler. Any gradual increase in the temperature at same load and decrease in steam pressure may indicate fouling of the exhaust boiler tubes. Any sudden increase many indicate a minor fire

- Taking frequent indicator cards and check main engine performance

- Draining air cooler of water frequently

## Precautions and Maintenance for Slow Steaming of Ships

It is a known fact that most breakdowns related to slow steaming occur not during slow steaming itself but when the engine is again operated in the normal range.

To avoid any breakdown when the main engine is again put back to normal operating mode, certain precautions and routines have to be carried out diligently during slow steaming.


*"It is a known fact that most breakdowns related to slow steaming occur not during slow steaming itself but when the engine is again operated in the normal range."*

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- Dry washing of the turbine wheel and washing of the compressor must be carried out during the load up
- Soot blowing of the EGB must also be carried out additionally during this period
- Avoid water condensation in air coolers and keep scavenge air temperature around 40 to 45 deg C.
- Maintain hot well temperature by cooling water control of the condenser and directly allowing some condensate to the hot well by bypass valve
- Use correct cylinder oil feed rate as per recommendations from manufacturer
- Use cylinder oil having correct and higher BN as recommended by the manufacturer
- Good maintenance must be done for the fuel injectors and revised maintenance intervals should be issued. There is increased fouling and dripping chances during slow steaming
- Cold corrosion can be caused by low exhaust temperatures during very low load operations. Care should be taken to avoid exhaust temperature after the cylinder to drop below 250 deg C. This figure is particularly important as temperature will drop further after extraction of heat in the exhaust boiler

- Frequent washing of exhaust gas boiler and extra soot blowing routines should be implemented
- Main injection viscosity of fuel oil between 12 to 13 CST
- Maintain higher LT temperature (in central cooling plants for optimum scavenge temperature and jacket cooling water temperature)
- Fresh Water Generator may need to be bypassed to maintain Jacket temperature on some ships
- Keep auxiliary blower continuously on (in manual mode) to avoid elevated exhaust temperatures after the cut off and before the cut in period. Exhaust temperatures above 450 deg C can cause hot corrosion and burning of exhaust valves
- Low load operation can cause un burnt fuel and cylinder oil to be accumulated in the exhaust manifold and may suddenly burn causing subsequent over speeding and damage of the turbocharger when load is increased again. Carry out frequent exhaust manifold inspections

Considering the present situation of the shipping industry, successful implementation of slow steaming on a variety of ships require support from more influential people from the industry.

As the total duration of the time for cargo transportation would increase because of slow steaming, a lot needs to be done in order to convince people, especially customers, regarding the benefits of slow steaming. Moreover, marine engineers also need to be educated and trained regarding different aspects of slow steaming in order to get rid of their apprehensions.

As fuel costs are on the rise and pressure to cut down carbon emissions from ships is ever increasing, shipping companies are making every effort possible to adopt to new technologies which would help them to cut their carbon emissions while maintaining their profits.

Slow steaming has helped companies to achieve the desired results by making a few changes in their system. Considering the market demands and present financial condition, it seems that slow steaming is here to stay.

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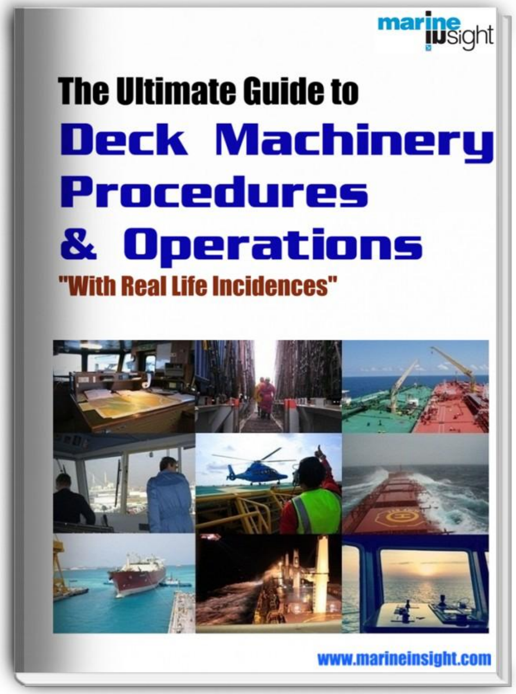


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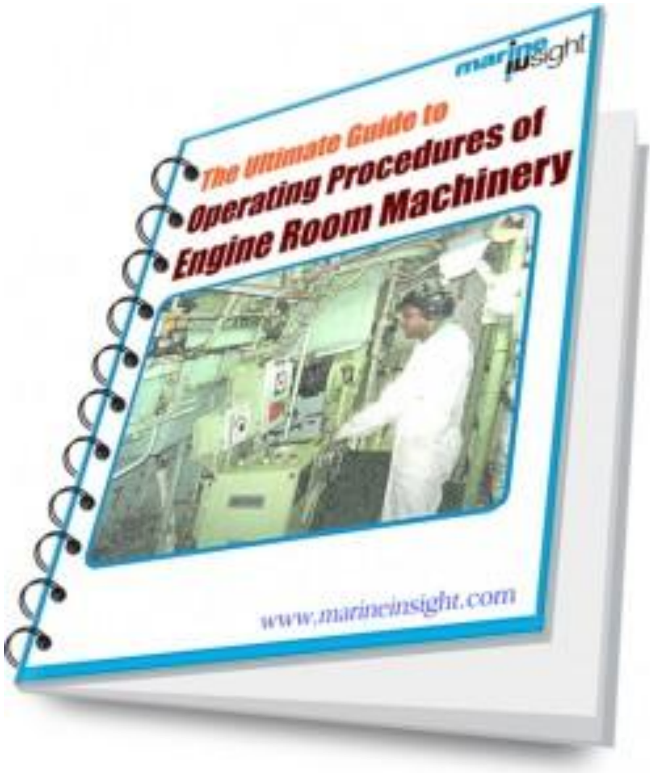


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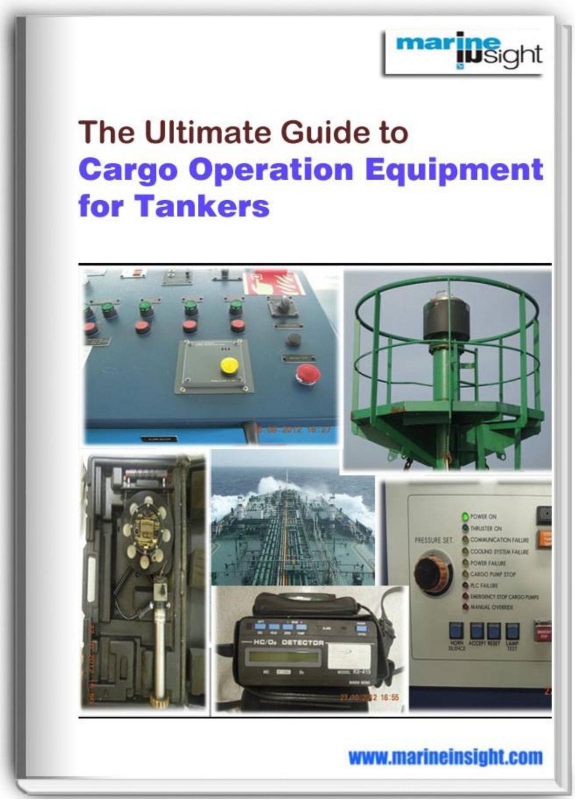


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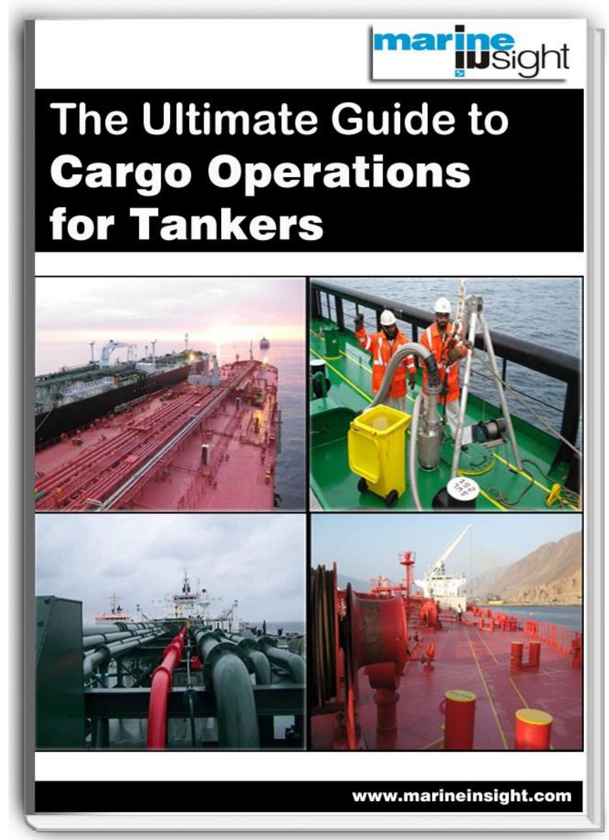


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