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Recommisioning of vessels/Engine room: A Challenge!

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PEMM OIL
Surveys & Consulting

PRODUCER

Pascal OILLIC
PEMM OIL Surveys & Consulting
pascal.oillic@pemmoil.com

Summary

Preamble

The world maritime industry is currently facing an increasing trend for vessel lay-ups and also scrapping. This adverse situation is primarily due to ultra low oil price market, poor freight rates and a stagnant world economy has led to lay-up of numerous not only offshore vessels, but also bulk carriers and container vessels. A vessel lay-up means the suspending use of a ship for a certain period which could be as short as a few weeks and as long as several years.

Reasons for these operational stops are mainly imposed to face and deal with an over-capacity, clearly speaking, wait for better days, either for freight rates or eventually higher scrap prices. Record numbers of vessels are in lay-up with charterers cutting rates or terminating charter-parties altogether.

As a matter of facts, oil price will not increase significantly in the near future and, as some vessels approach the end of charter periods, owners are asking questions about lay-up or looking elsewhere for new business / operations.

End of September 2016, no less than 27% of offshore vessels and 314 containers carriers among other units are in a laid up situation.

The decision of laying up a vessel implies several aspects/decisions.

One in particular is the duration of the lay-up: This is of utmost importance, hence the following qualification, «hot» or «cold» lay-up.

To put is simple, a hot lay-up means that machinery is kept operational and can be re-commissioned within a short time scale (commonly admitted this is the situation whereby a vessel is to be idle for a period of 6 months or less).

Over this period, a cold lay-up is an alternative, i.e. machineries are taken out of service and the vessel is so called electrically ‘dead’.

Various factors depending of the type of lay-up selected have to be cautiously considered i.e., location, mooring arrangements, statutory and operational requirements, weather report monitoring, manning, etc.

The following document «Recommisioning of vessels/Engine room: A Challenge!» only aims to focus on two aspects:

- technical measures which must be followed **when reactivating** either a cold or hot lay-up, i.e. post pure lay-up period
- **only on engine room machineries** (indeed various aspects/equipment like deck machineries, ballast tanks, anchors and chains, structural conditions, firefighting equipment, life savings appliances, navigation and communication, etc… will all have to be adequately and similarly checked out).

I. General statements

Reminder about the main modes of deterioration of a mechanical machine

The machines deterioration modes are extremely numerous. The list of deterioration modes is very long and includes, amongst others, the following: corrosion, spalling, cracking, abrasive wear, adhesive wear, porosities, seizure, fretting, cavitation etc.

Some damages already exist at the commissioning of the machine. For example out of tolerances porosities in casted components. This is a non-quality that will in general not have any influence during a prolonged shutdown of a machine.

Some forms of deteriorations require that the machine is in operation to initiate and develop. This is the case of abrasive or adhesive wear, of severe seizure. There too these deterioration modes will have no influence on a prolonged shutdown of a machine, but their existence should have been identified before the machine is place in shutdown situation, so as not to make it difficult to identify the cause of a possible damage occurring during or after the commissioning after the shutdown.

Some forms of deterioration can develop without the machine being in operation, so during the shutdown. For example corrosion, deformation under static load, ageing, etc. Inevitably it is these forms of wear that present more risks during the shutdown and their effect must be detected and corrected.

And certain forms of deterioration will occur only during transient periods in the operation of a machine. For example adhesive wear between a bearing shell and a crankshaft journal during start or slow turning of an engine. As these starts or slow turnings may have been carried out during the shutdown, the eventual defects generated during these start or slow turning must be identified.

Note on aging lubricants and fuels

Lubricants and fuels are products made of hydrocarbons which are not stable compounds.

Intrinsic degradations of hydrocarbons products are:

- Chemical reactions: oxidation, polymerization, etc.
- Phases separation: evaporation of lighter constituents, separation of the different components of heavy fuel oil, etc.
- Formation of sludge, deposits or gums.

Consequences of these deteriorations are :

- Difficulties during fuel oil separator processing.
- Difficulties for engine starting.
- Bad combustions, which may cause problems of excessive fouling of engine, premature wear or mechanical resistance problems of engine components, etc.

Storage of hydrocarbons without agitation and without manipulation favors the development of these intrinsic degradations, which thus lead to an increased risk for ships in lay-up.

Furthermore, lubricants and fuel oils can be subject to development of microorganisms which are bacteria, yeasts or fungi.

Indeed a capacity containing a hydrocarbon will always be more or less exposed to air at its free surface and will always contain water in more or less quantity. This water may have been introduced during bunkering, be entered in the tank as moisture form conveyed by air driven by natural breathing of the tank, or for example be entered in the tank by a heater leak. The water and the ambient air can contain microorganisms that will find a favorable environment in the tanks for their proliferation, this medium containing oxygen and organic material necessary for the metabolism of microorganisms. If the temperature conditions in the tanks are favorable, the microorganisms can reproduce and multiply to produce harmful effects.

It should be noted that the following factors may promote the development of micro-organisms:

- Storage in calm conditions without agitation favors the development, which therefore gives an increased risk for ships in lay-up.
- Presence of biodiesel (FAME).

The effects of the presence of microorganisms can be the following:

- Create sticky clumps which will clog the fuel filters and can go up to reduce engine power or even stalling.
- Corrosion of the circuit components by the aggressive acids and organic substances produced by microorganisms.
- Accelerated wear of the of the injection pumps elements, injectors and cylinder units.

Lubricants can also be a place for bacterial growth. New lubricants stored on board or lubricants in service in the shutdown equipment are a favorable ground for bacteria development.

The effects on the lubricants can be:

- Formation of deposits and sediments clogging the filters.
- Sticky deposits in the crankcase.
- Corrosion of components exposed to the lubricant.
- Reduction of the effect of separators by reducing the surface tension of the water / oil interface.

- Decrease of the additives content that are consumed by bacteria (phosphorus, nitrogen,...).
- Decrease in the viscosity.

All these effects on lubricants will then bring risks for the machines.

Note on the ageing of torsional vibration dampers

The torsional vibration dampers using fluids are subject to the effects of aging. Indeed the fluid, usually silicon, is subject to aging even if the damper is not used.

Furthermore the damper itself may deteriorate, even if it is not used: Deterioration by ambient vibrations, bonding of the inner mass because of the stationary position, etc.

Note on the ageing of synthetic materials

Synthetic materials are used in many places on the machines on board a ship: Gaskets and seals, flexible hoses, elastic couplings and supports, belts, etc.

When in use, some components made of synthetic materials work in static conditions, such as gaskets, or in dynamic conditions, such as elastic couplings, supports and belts.

As for the lubricant and fuel oils, the synthetic materials sustain the effects of time, even if they are not used under dynamic conditions. This ageing effect is more important if the component is not stored in optimal storage conditions (ambient conditions such as temperature and humidity, protection from light, protection from oil projections, etc.). This is especially the case for components already in use and exposed to the conditions of the equipment on which there are fitted, but which also applies to the components kept as spare parts.

The degradation of synthetic materials are e.g.:

- Physical ageing: Solvent penetration, loss of plasticizers, changes in morphology (e.g. crystallization), stress cracking, etc.
- Chemical ageing: cutting of polymer chains, crosslinking, hydrolysis, oxidation,
- Photochemical attack (UV), biochemical attack (bacteria and fungi), etc.

When a ship is being shut down after use, the components made of synthetic materials have already been exposed to various pollutions and suffered the aggression of their environment. Then when the vessel is stopped, the time has an effect on the material and ageing phenomena continue to deteriorate the components.

Therefore we should consider that more attention should be paid to components made of synthetic materials, and often systematic replacement should be considered.

Note on equivalent hours

Because of the detrimental effect of ageing on lubricants, on fuel oils, and on synthetic materials, as seen above, the time spent in stopped condition must be considered and include this adverse effect on the evolution of the condition of rotating equipment during the period of the shutdown.

Ageing and deterioration of lubricants, fuels and synthetic materials, induce an ageing of the machines during their stay in stopped condition. Taking account of this phenomenon is by made by calculating the equivalent hours. Coefficients are applied to the number of hours spent in stopped condition, which provides a number of hours corresponding to the wear and tear than the engine would have accumulated if it was in operation. The times obtained are the equivalent hours.

The same principle of equivalent hours applies to the number of starts. Indeed, the effects of a startup of a diesel engine are related to lubrication during the transitional phase of the start (boundary lubrication) and thermal variations undergone by the engine from stop condition to hot operation.

This means that at the end of the lay-up it is necessary to sum up the equivalent hours and add this amount to the running hours of the equipment to integrate this amount in the maintenance schedule.

It is commonly accepted that a one year standby of a diesel engine can be equivalent to 1,000 hours of operation and that a start can be equivalent to 25 hours of operation. These values are maximums and are generally to be modulated depending on the conditions in which the standby takes place: engine closed and prepared or simply stopped, engine kept in cold conditions or with preheating, conditions of ambient temperature and humidity, testing the machine during the shutdown period (number of starts), conditions for starts (pre-lubrication, water temperature), kind of test (with or without load), test duration, etc.

This principle of passive ageing is applicable to all machines and not only to diesel engines.

Lubricating oil analysis

The lubricating oil analysis should not be considered sufficient to assess the condition of a machine. A bad test result will indicate a defect but a good test result does not mean the absence of defects.

The decision making on the list of controls and disassembly to be performed, or on the parts to be replaced, must be made on the basis of several opinions with conflicting interests.

The owner will tend to want to re-commission his ship as soon as possible and for the lowest cost. Conversely, and for safety reasons, manufacturers will often tend to want to disassemble everything and replace it with new parts.

Often, the selection of operations to be conducted will be based on the criticality of each machine and on the cost of each preventive operation.

Cooling space sealing rig

NOTICE

Because of the remarks set out above, this document is not an exhaustive and restrictive list. This list must be adapted to the specificities of the installation to be reactivated.

The content of the document is based on a chronological order of operations to be performed.

When an owner has a laid-up vessel and intend to place it back to service, actions to be taken are spread over different steps to be achieved in chronological order. These steps are:

- Audit for re-commissioning. This is mainly to verify the conditions under which the ship was stopped, was held during the lay-up and what are the means available for the re-commissioning.

- Pre-cold commissioning. This is mainly inventories and visual inspections.

- Cold commissioning. It is during this step that will be carried out the checks, disassembly and overhaul of equipments.

- Hot commissioning.

- Sea trials.

- After commissioning controls.

II. Audit for recommissioning

In the tables of operations to be conducted, it was considered three periods of lay-up:

- Less than 6 months.
- Between 6 months and 24 months.
- More than 24 months.

Depending on the actual duration of the shutdown and on the criticality of operations, the need for performing the operations is indicated by the following symbols

X = The operation should be performed.

O = The operation should be perform according to the result of the inspection.

Duration of the lay-up : **up to 6 months**	Duration of the lay-up : **up to 24 months**	Duration of the lay-up : **more than 24 months**	**QUESTIONS**
			The vessel
	X	**X**	What is the age of the vessel? - An older vessel is weaker than a recent one and will therefore be more sensitive to a lay-up. - Beware of the obsolescence of old engines or old equipment for which there might be no more spare parts or expertise among manufacturers or representatives of equipment.
X	**X**	**X**	What was the date of the last dry dock before the shutdown? - Depending on that date it will be necessary to check what the time before the next dry dock is.
	X	**X**	What is the complexity of the vessel? - This question is to be compared with the means which will be implemented by the ship-owner to perform the restart. - And to be compared with time to be spent there. A restart after a lay-up of many years can last many months.

			Audit of the conditions of placing the vessel in lay-up
X	**X**	**X**	Procedures used to place the vessel in lay-up: - Was the shutdown implemented following a documented procedure? - Means implemented: Make sure that the choices made for the cocooning were the right ones. - Who placed the vessel in lay-up condition: the crew, a specialized company, or other...? - For plants fuelled by heavy fuel oil, were the engines stopped with light fuel oil proper rinsing?

			Audit of the lay-up conditions
X	**X**	**X**	Duration of the lay-up: - What was the duration of the shutdown? This question is crucial as it will determine the extent of the checks to be performed during the different phases of the restart. - Was the length of the effective lay-up what was anticipated? This question is important because it determines whether the procedure established for stopping the vessel correspond to the effective length of the lay-up, and it checks if it has been adapted to a possible extension of the duration.
X	**X**	**X**	Procedures of lay-up : - Geographical location of the lay-up : - Extent and nature of the lay-up : hot lay-up (machinery is kept in operation), warm lay-up (machinery is partially kept running and condition of the vessel is controlled), cold lay-up (machinery is out of operation; only emergency generators are in operation or temporary deck generators are installed, vessel is closed)
X	**X**	**X**	Crew attending during the shutdown: - What is the qualification level of personnel responsible for the lay-up? - Was the lay-up followed by a crew of the ship owner, or was it outsourced to a service company? - Does this service company have a certification?

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

X	**X**	**X**	Checks and operations completed during the lay-up: - Do these checks and operations correspond to the initial requirements, (e.g. reloading corrosion protection products)? - What were the results of the checks? Do these results are documented? - Does the temperature and humidity parameters have been controlled or recorded during the period of the lay-up? - Do any incidents occur during the lay-up?
			Inspect the logbooks and maintenance records to see if any maintenance operations were performed during the lay-up.

			Audit the re-commissioning procedure
X	**X**	**X**	Has the ship-owner or its technical department define a return to service procedure? This procedure should include the list of the equipment concerned, the list of controls and tests to perform with their chronological order.
X	**X**	**X**	This procedure must establish the means to record the results of inspections and tests: - List of parts disassembled for inspection. - Note if the components which are disassembled for inspection are refitted or replaced with new ones. - Determination of the condition of components disassembled for inspection. - Using of measurement record sheets from equipment manufacturers. - Shooting photos of disassembled parts for inspections. - Fill reports by manufacturers' representatives.
		X	In the case of very long lay-up, the procedure for return to service must have included the profitability study of re-commissioning for each component: is it more profitable to return it to service or replace it with a new one?
X	**X**	**X**	Does the owner allocate enough time to make the return to service? A return to service after a warm or cold shutdown may last several weeks or even months! It will be essential to allow necessary time for the restart to make it properly.

			Human risks Before placing the vessel back in service one must study the conditions for the return to service with the ship-owner. This will include an inventory of human risks.
X	**X**	**X**	What is the technical service that will be in charge of the re-commissioning of the vessel? Is it the technical service of the ship-owner, a ship manager, etc.?

X = The operation should be performed	O = The operation should be perform according to the result of the inspection

X	**X**	**X**	What is the team that will restart the vessel? Does this team will be properly informed of the re-commissioning procedures?
X	**X**	**X**	Knowledge of the vessel : since employees may leave a company over time and former crew might be transferred to other vessels the following questions must be assessed: - Did the people in charge of the re-commissioning sail/work on the ship prior to the lay-up? - Are the people in charge of the re-commissioning the same than those who placed the ship in lay-up? - Were the people in charge of the re-commissioning part of the crew during the lay-up?
X	**X**	**X**	It is very important that at least some members of the team responsible for the re-commissioning have knowledge of the vessel and its facilities. All vessels have their own specificities, little tricks, hidden valves or switches... Risks related to the forgetting of the previous situation and loss of records: it is indeed necessary to review the status of the maintenance at the time of shutdown and maintenance operations or repairs which remained to be done at this time.
X	**X**	**X**	Knowledge of the type of operation: - Do these people have already performed re-commissioning after lay-up? A return to service after shutdown looks like the commissioning of a new built vessel.
X	**X**	**X**	Assistance to the re-commissioning: - Will the re-commissioning be followed by the classification society? Indeed, the classification rules specify that the owner should notify the classification society when the vessel is taken out of service, in order to modify the status of the vessel. Depending on the duration of the lay-up, the classification society will request a reactivation survey in order to place the vessel back to status ‘’in service’’. - Are the manufacturers of the equipment associated with the re-commissioning?

			Vessel Certificates
X	**X**	**X**	Check the status of certificates and ensure that all due visits will be conducted during the re-commissioning (classification, flag,...).

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

III. Pre-cold commissioning

All inspections mentioned in this chapter are to be taken even before :
- Turn the engine and propulsion line,
- Put the electrical installations on,
- Put the circuits in service.

Duration of the lay-up : **up to 6 months**

Duration of the lay-up : **up to 24 months**

Duration of the lay-up : **more than 24 months**

OPERATIONS TO BE PERFORMED

ENGINE ROOM

			Inventory stocks of fuel remaining on board
X	X	X	Confirm the status of the different tanks: - Empty and clean. - Empty but still containing residues. - Partially filled. - Fully filled.
X	X	X	Determine the remaining quantities and dates of loading of the different batches of fuel oil still on board. If the ship was in cold lay-up, it is likely that all combustible date from before the lay-up.
X	X	X	Find the MARPOL certificates of fuel oil batches still on board.
	X	X	Take samples of all batches of fuel oil and send them for laboratory analysis to assess their quality and consider their possible use (search for a possible deterioration of fuel oil by bacteria) and to detect possible problems on the plant (mainly water ingress into storage facilities). The greatest attention should be paid to the sampling conditions and choice of sampling points to obtain a good representation of the collected samples.
	X	X	Ensure that fuel oils still present on board do not contain biodiesel. This is applicable for light diesel fuel oil that may contain a proportion of biodiesel (FAME, VOME). The new standard ISO 8217-2016 will allow up to 7% FAME content in some light fuel oil. After six months of storage biodiesel can degrade and create problems of fuel oil quality.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

			Stock inventory of lubricants remaining on board
X	**X**	**X**	Determine the remaining quantities and dates of loading of the different batches of lubricants still on board: - In service inside the different machines. - New in reserve. If the ship was in cold lay-up, it is likely that all lubricants date from before the lay-up.
X	**X**	**X**	Take samples of service-lubricants of each equipment and send them for laboratory analysis for assessment of their condition and consider if it is still possible to use them. These analyses will also allow detecting possible problems which could have develop on the equipment during the lay-up.
			Refer to the lubrication chart of the vessel to identify lubricants to control.
	X	**X**	Take samples of new lubricants and send them for laboratory analysis for assessment of their quality and consider their possible use. Indeed the new lubricants stored will age and can deteriorate. Refer to the vessel lubricants inventory to identify lubricants to control.

			Stock inventory of spare parts present on board
X	**X**	**X**	Presence: if the parts that that are supposed to be on board are no longer present after starting the shutdown, there may be a risk of repair impossibility when the first failures will happen.
X	**X**	**X**	Condition of the spare parts: The main risks concerning the spare parts stored on board the vessel during the lay-up are: - Corrosion depending on the conditions of the lay-up and conditions of storage of spare parts. - Mechanical damages of spare parts during handling for landing and boarding. - Obsolescence of spare parts if the lay-up was too long.

			Inventory and condition of the tools
X	**X**	**X**	Redo the inventory of tools, especially special tools specific to the engine or gearbox (mainly hydraulic jacks). It is important to know the state of the equipment before starting the return to service because some of the tests will be conducted with these tools.
	X	**X**	Check the condition of these special tools: e.g. replace gaskets and hydraulic oil of the jacks.
X			Check date of last calibration of measuring tools: torque wrenches, pressure gauges of hydraulic jacks of special tools. If the calibration has expired, re-calibrate the tools.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

	X	X	Re calibrate measuring tools: torque wrenches, pressure gauges of hydraulic jacks of special tools.
X	X	X	If the engine room is equipped with a gantry crane: - Check the condition of the gantry crane. - Check the gantry crane certificates. - Test the gantry crane.
X	X		If the certificates of the engine room gantry crane have expired during the lay-up period, renew the certificates.
		X	Update the gantry crane certificates.

	X	X	Evaluation of potential infestation by rodents or insects and risks for electrical and electronic installations. All cabinets and electrical panels should be opened and inspected visually.

	X	X	Checks that the temporary equipment installed for the lay-up (heaters, air dryers) are still operational and have worked well.
	0	0	If it is discovered that some of the temporary equipment have malfunctioned, it will be necessary to assess the potential impact of this dysfunction and adapt the list of checks to be made.

			Engine room ventilation circuit
X	X	X	Visual inspection of the circuit : - Check the integrity of circuit. - Search dust deposits, particularly sand deposits if the vessel lay-up in a desert country or near a bulk terminal, etc. If deposits are present in large quantities, collect samples of the deposits and store the samples for future analysis if necessary.

RECIPROCATING ENGINES (PROPULSION, GENERATING SETS…)

X	X	X	Check correct locking of the engine to avoid any risk of unexpected start during tests.
X	X	X	Make an external visual inspection of the engine for: - Search for leaks (drips, confirm the ages of those drips), deposits. These defects may indicate an ageing of gaskets or connections.
X	X	X	Search for missing parts on the engine. In case the owner has several ships laid up at the same time, it can happen a phenomenon of cannibalization, thus removed parts on a ship to help another.
X	X	X	Checking the condition of the protective measures (check that the protections installed for the lay-up are still in place and in good condition). The discovery of deteriorated or missing protections will lead to push tougher internal controls and possibly place reservations on potential future damage undetectable during the recommissioning.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

X	**X**	**X**	Perform a crankcase inspection for: - Perform usual inspections required by the normal maintenance table of the engine. - Search for potential traces of water leaks at the bottom of cylinder liners. - Search for potential traces of corrosion. - Inspect the condition of the old varnish and deposits on the internal walls of the engine block. Search for any detachment of these deposits.
	O	**O**	If abnormal deposits or excessive separations from old varnishes are discovered during the crankcase inspection, clean the crankcase.
X	**X**	**X**	Make a bore scope inspection on all cylinders for the search of: - Traces of the presence of water. - Carbon deposits detached from the sky or the cylinder heads or exhaust manifolds that may have accumulated on top of the pistons. This may be more important on vee type engines where deposits can build up on the lower side of the vee banks. If the engine is started before removing accumulations of deposits there may be a risk of deformation of the piston crown by crushing the deposit against the cylinder head. This deformation may then produce a contact of the piston on the liner when the piston will expand under the effect of the engine temperature rise during loading, and lead to a piston and liner seizure. This damage can sometimes occur several hours after the start when the engine has reached its full load. This phenomenon is more likely to appear on the engines with all-aluminum pistons.
O	**O**	**O**	If deposits have accumulated on top of pistons, clean these deposits (rinse with gasoil and turn the engine or remove cylinder heads).
	X	**X**	Collect a sample of silicone of viscous torsional vibration damper and send it for laboratory analysis for assessment of the condition of the silicone and consider if it is still possible to use the viscous torsional vibration damper. This analysis can also make it possible to detect possible problems which could have developed on the damper during lay-up. Make sure not to have exceeded the maximum number of authorized samples so as not to decrease the amount of silicone in the damper and to go below the minimum level.

			For low speed two strokes engines
X	**X**	**X**	Perform an inspection of piston underside space to : - Check the condition of piston rods: search for traces of corrosion on the running surface of the rods. - Inspect piston rods glands boxes. - Check free outlet of piston rods gland boxes leak recovery drains.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

O	**O**	**O**	Cleaning of deposits that could have remained in the piston under side space.
			If necessary dismantling and blowing drain pipes.

			Fuel oil circuit
X	**X**	**X**	Thoroughly drain the fuel tanks to remove water and sediment from the bottom. Record the result of purges for each tank.
X	**X**	**X**	Visual inspection of the circuit: transfer pumps, separators, heating and pressurizing units, filters, etc. - Check the integrity of the circuit. - Check for leaks.

			Crankcase lubrication circuit
X	**X**	**X**	Visual inspection of the circuit: - Check the integrity of the circuit. - Check for leaks. - Remove the dipstick to search for traces of moisture or rust on the dipstick.

			Cylinder lubrication system for low speed two strokes engines (if applicable)
X	**X**	**X**	Visual inspection of the circuit: - Check the integrity of the circuit. - Check for leaks.

			Fresh water cooling circuit
X	**X**	**X**	Check what the nature of the liquid is in the cooling system: fresh water with or without treatment, 4 seasons liquid.
	O	**O**	If the circuit is loaded with treated water, perform an analysis of the content of treatment product.
X	**X**	**X**	Check the temperature that was achieved during the shutdown. Indeed it may have been a risk of exposure to icing for emergency gensets or engines in remote independent rooms (bow thrusters engines in the bottom of forepeak, pump engines in pump room).
X	**X**	**X**	Visual inspection of the fresh water cooling system: - Check the integrity of the circuit. - Check for leaks.

			Seawater circuit
X	**X**	**X**	Under water inspection of sea chests.
		X	Dry-docking for cleaning sea chests.
X	**X**	**X**	Visual inspection of the seawater system : - Check the integrity of the circuit. - Check for leaks.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

			Starting air circuit
X	**X**	**X**	Visual inspection of starting air circuit : - Check the integrity of the circuit. - Check for leaks.

			Electrical starting system
X	**X**	**X**	Check the presence and condition of batteries: Visual condition (deformation, leaks, corrosion of connections, etc.) and charge level.
X	**X**	**X**	Check that the electric starters have not been wet during the lay-up by a leak from above or by a rise of water level in the bilge.

			Turbocharger washing circuit (if applicable)
X	**X**	**X**	Visual inspection of the circuit: - Check the integrity of the circuit. - Check for leaks.

			Charge air cooler cleaning circuit if applicable
X	**X**	**X**	Visual inspection of the circuit: - Check the integrity of the circuit. - Check for leaks.

			Combustion air suction circuit
X	**X**	**X**	Visual inspection of the circuit: - Check the integrity of the circuit. - Check for leaks.

			Crankcase ventilation circuit
X	**X**	**X**	Visual inspection of the circuit: - Check the integrity of the circuit. - Check for leaks.

			Exhaust System
X	**X**	**X**	Visual inspection of the circuit: - Check the integrity of circuit. - Check for leaks. - Check that the funnel outlet is free.

			Electrical control command system
X	**X**	**X**	Inspect all electrical enclosures for signs of moisture or moisture damage. If moisture is present, enclosure must be dried out before power is applied. If moisture damage is found, disassemble, clean and repaint as necessary. All contactors and relay tips, both moving and stationary, should be inspected. If signs of oxidation are present, these signs must be corrected.
	X	**X**	Check the softwares and their updates.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

			Pneumatic control command system
X	X	X	Visual inspection of the circuit : - Check circuit integrity: compressor, tank, pipes, pneumatic components, valves, instruments. - Check for leaks.

GEARBOXES

X	X	X	Check correct locking of the prime mover to avoid any risk of unexpected start during the tests.
X	X	X	Make an external visual inspection of the gearbox for: - Search for leaks (drips, confirm the ages of those drips), deposits. These defects may indicate an ageing of gaskets or connections.
X	X	X	Search for missing parts on the gearbox. In case the owner has several ships laid up at the same time, it can happen a phenomenon of cannibalization, thus removed parts on a ship to help another.
X	X	X	Checking the condition of the protective measures (check that the protections in place for the shutdown are still in place and in good condition). The discovery of deteriorated or missing protections will lead to perform tougher internal controls and possibly placing reservations on potential future damage undetectable during the recommissioning.

			Lubrication circuit
X	X	X	Visual inspection of the circuit: - Check the integrity of the circuit. - Check for leaks. - Remove the dipstick to search for traces of moisture or rust on the dipstick.

			Cooling circuit
X	X	X	Visual inspection of the seawater system : - Check the integrity of the circuit. - Check for leaks.

PROPELLER SHAFT

			Intermediate shaft
X	X	X	Perform an external visual inspection.
X	X	X	Checking the condition of the protective measures (check that the protections in place for the shutdown
			are still in place and in good condition).

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

			Intermediate bearings
X	**X**	**X**	Make an external visual inspection of the gearbox for: - Search for leaks (drips, confirm the ages of those drips), deposits. These defects may indicate an ageing of gaskets or connections.
X	**X**	**X**	Checking the condition of the protective measures (check that the protections in place for the shutdown are still in place and in good condition).
X	**X**	**X**	Open the check doors of the bearings to assess their internal condition.
			Remove the dipstick to search for traces of moisture or rust on the dipstick.

			Stern shaft
X	**X**	**X**	Inspect the condition of the sliding surface of the SKF type connection with intermediate shaft (if applicable).

			Stern tube
X	**X**	**X**	Visual inspection on engine room side: - Drain the lub oil of the stern for presence of water. - Look for leaks. - Inspection the lub oil circuit.

			Stern shaft
X	**X**	**X**	Under water inspection of the propeller

STEAM TURBINES

X	**X**	**X**	Check correct locking of the turbine to avoid any unexpected start during tests.
X	**X**	**X**	Make an external visual inspection of the turbine for: - Search for leaks (drips, confirm the ages of those drips), deposits. These defects may indicate an ageing of gaskets or connections. - Remove the dipstick to search for traces of moisture or rust on the dipstick.
X	**X**	**X**	Checking the condition of the protective measures (check that the protections installed for the lay-up are still in place and in good condition). The discovery of deteriorated or missing protections will lead to push tougher internal controls and possibly place reservations on potential future damage undetectable during the re-commissioning.

GENERATORS AND ELECTRIC MOTORS

X	**X**	**X**	Check correct locking of the prime mover of alternators and of electrical motors to avoid unexpected start during tests.
X	**X**	**X**	Perform an external visual inspection.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

TUNNEL OR AZIMUTAL THRUSTERS

X	**X**	**X**	Check correct locking of the prime mover to avoid unexpected start during tests.
X	**X**	**X**	Make an external visual inspection of the thruster for: - Search for leaks (drips, confirm the ages of those drips), deposits. These defects may indicate an ageing of gaskets or connections. - Remove the dipstick to search for traces of moisture or rust on the dipstick.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

IV. Cold commissioning

Observations made during inspections and disassembly must be accurately recorded with the use of a survey sheet manufacturer or site, and photographs.

Duration of the lay-up : **up to 6 months**

Duration of the lay-up : **up to 24 months**

Duration of the lay-up : **more than 24 months**

			OPERATIONS TO BE PERFORMED
			ENGINE ROOM
X	X	X	Dismantle and remove temporary equipment installed for the lay-up: heating, air dryers.
			Engine room ventilation system
X	X	X	Remove all closings of ventilation openings.
X	X	X	Clean any deposits present in the ducts.
X	X	X	Open and check the operation of the flaps.
		X	Overhaul of operation devices and automatic control of flaps.
X	X		Clean filters.
		X	Replace filters.
X	X	X	Inspect and clean the sea spray separators if any.
X	X	X	Test the complete ventilation system of the engine room
			Important or critical equipment
O	O	O	Install magnetic particle detectors on the lubricating oil circuits of the different equipment.
			RECIPROCATING ENGINES (PROPULSION, GENERATING SETS…)
X	X	X	Check correct locking of the engine to avoid any risk of unexpected start during works and tests.
X	X	X	Remove the protections and closings placed on the equipment and circuits: - Shutters on the combustion air intake. - Shutters on exhaust piping and funnel. - Shutters on the crankcase ventilation. - Plugs on different fluid circuits. Refer to the cocooning procedure in order not to forget any protection, plug or cover.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

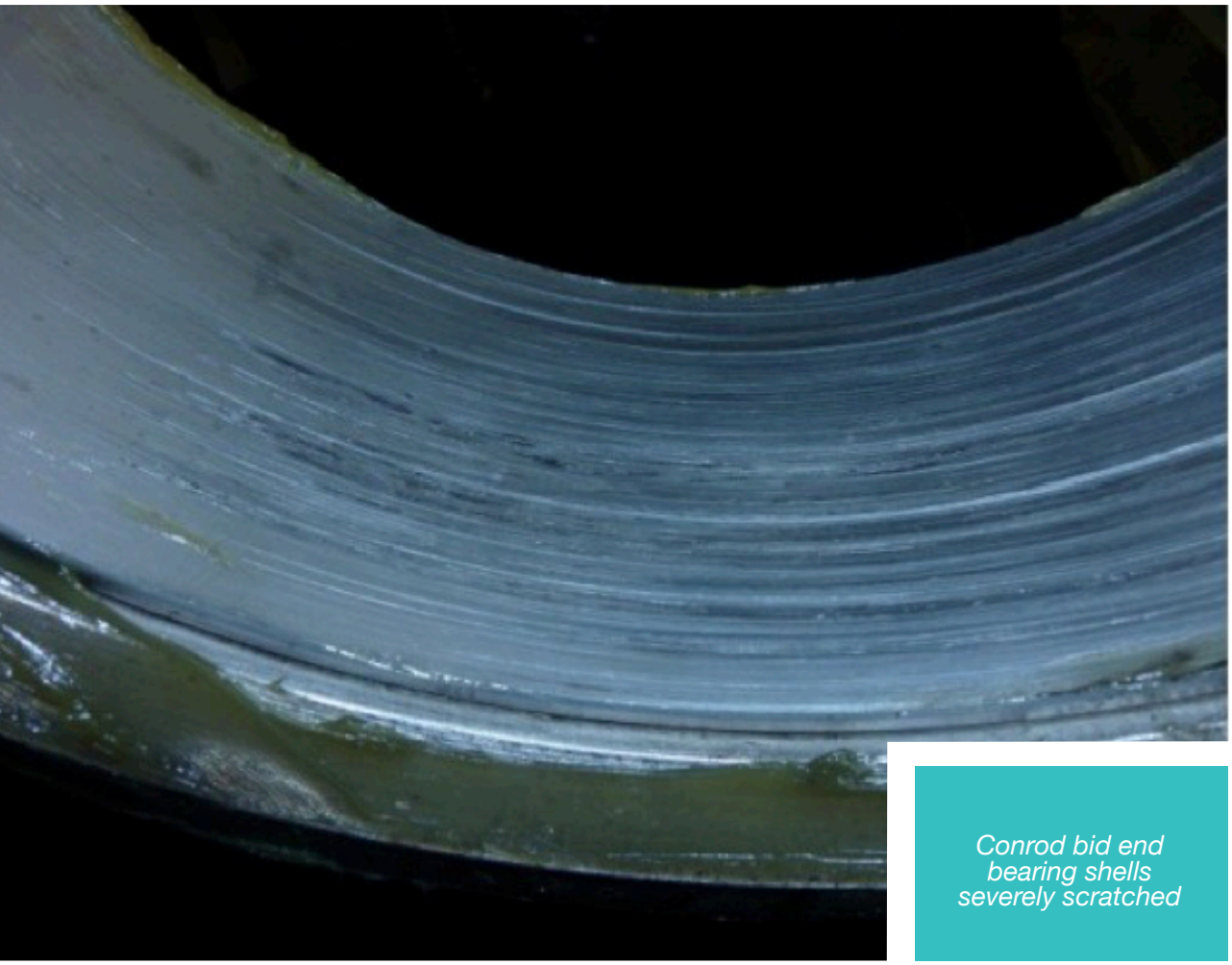
X	**X**	**X**	Remove protective products installed. Refer to the recommendations of the suppliers of these products regarding the risks and the cleaning method.
X	**X**	**X**	Operate and close all vents remained open during the shutdown: - Drain the air intake manifold. - Drain the exhaust manifold or turbocharger. - Drain the crankcase ventilation circuit.
O	**O**	**O**	Repair or replace the damaged drain valves.
X	**X**	**X**	Check the free movement of the valves on all cylinder heads covers by opening the covers and turning the engine on at least two turns. Indeed after a long immobilisation period there is a risk of sticking valve stems in their guide.
	X	**X**	Dismantle one or two cylinders: cylinder head, piston and liner. These sample dismantling will allow assessing the condition of the components of the other cylinders. For each of the disassembled cylinders: Removing and dismantling the cylinder head to : - Look for corrosion damages to the valve springs, between valve stems and guides, on the back and in the housing of the water cooled valve seats, etc. Assess the condition of deposits on the valves and in the intake and exhaust ducts, etc. Removing piston to: - Look for corrosion damage due to water stagnation in the combustion chamber. - Look for corrosion damage to the ring grooves, Assess the condition of deposits and any scrubs, etc. - Look for corrosion damage due to stagnation of the oil between the bearing and the crankpin, lub oil could have been deteriorating and become acid. - Look for scratches or damage by seizing due to slow turning of the engine during the lay-up without pre-lubrication or with insufficient pre-lubrication. Removing the liner to: - Look for signs of corrosion on the water chamber side; assess the condition of the seals, etc.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

Housing of water cooled valve seat

	O	**O**	If the manufacturer recommends it, the big end connecting rods bearing shells removed for inspection will be replaced with new ones. Indeed some types of engines and depending of the bearings technology used, the refitting of a dismantled bearing shell can be banned.
	O	**O**	Depending on the outcome of the inspection of the first cylinders, decision will be taken to inspect the rest of the cylinders.
	X	**X**	Dismantle one or two main bearing shells to : - Look for corrosion damage due to stagnation of the oil between the bearing shells and the journal, lub oil could have been deteriorating and become acid. Also if the bottom seals of the cylinder liner have lost their sealing properties, it is possible that cooling water could have dribble along the engine block and have penetrated between the bearing shells and the journal. - Look for scratches or damage by seizing due to slow turning of the engine during the lay-up without pre-lubrication or with insufficient pre-lubrication.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection



Conrod bid end bearing shells severely scratched

	O	**O**	If the manufacturer recommends it, the main bearing shells removed for inspection will be replaced with new ones. Indeed some types of engines and depending of the bearings technology used, the refitting of a dismantled bearing shell can be banned.
	O	**O**	Depending on the outcome of the inspection of the first main bearing shells, the decision will be taken to inspect other main bearing shells or replace all with new ones.
	X	**X**	During the inspection of the connecting rods big end bearing shells and main bearings shells, inspect crankpins and journals to search for: - Corrosion marks. - Some scratches.
	O	**O**	Depending on the outcome of the inspection of the crankshaft crankpins and journals, it may be necessary to repair the crankshaft (polishing, grinding).

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

	X	**X**	Visual inspection of all the teeth in order to: - Make an inventory of wear or damages existing before the lay-up. - Look for recent corrosion damages on the teeth and cams due to moisture or water ingress into the engine during the lay-up.
	O	**O**	If corrosion pits are observed on the teeth or on the cams and rollers, it will be necessary to quantify and record the extent of damages. If the damages are light, re-commissioning can be continued. If the damages are severe, it will be necessary to assess the need to replace the damaged gears. Indeed, the compression of lubricating oil in the pits will promote the spalling and the corrosion pits modify the distribution of the load on the surfaces and create initiation points for cracks that in a more or less long term will lead to damage of the gears or cams and rollers.
	O	**O**	If inspections of connecting rods big end bearings or main bearings showed damages, it should be considered to control the bearing bushes of the timing gears bearings and camshaft bearings.
			Injection system
X	**X**	**X**	For plants fuelled with heavy fuel oil, was the shutdown performed with light fuel oil with proper rinsing of fuel oil lines?
X	**X**	**X**	Check that there are no stuck injection pumps: - In rotation: push the racks. They must return to the zero position. - In translation: crank engine and check that the injection pumps rollers go down correctly. Check freedom of control linkages of injection pumps.
		X	Post injection pump and send it for review.
		O	Depending on the outcome of the inspection of the first injection pump, it may be necessary to overhaul all injection pumps.
X	**X**	**X**	Check the injectors. Beware of electronic injection engines very sensitive to deposits and varnish formations in the control part of the injectors. Control coils of failures may occur after the re-commissioning.
O	**O**	**O**	Depending on the outcome of the inspection of the injectors, overhaul or replace the injectors.
			Hydraulic governor
X	**X**	**X**	Change the governor oil. Check the operation of the governor in accordance with the instructions of the governor or engine manufacturer.
		X	Remove the hydraulic governor and send it for overhaul.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

			Electronic governor
X	**X**	**X**	Check the condition of the electrical connections of the governor.
	X	**X**	Open and clean the electrical connections of the governor.
X	**X**	**X**	Check the operation of the governor in accordance with the instructions of the governor or engine manufacturer.
			Viscous torsional vibration damper
X	**X**	**X**	Clean the outer surface of the damper if a preservative was applied on these surfaces. Visually inspect the damper.
	O	**O**	Refer to the result of the analysis of silicone viscous torsional vibration damper. If the result is not good, send the damper for overhaul or replace it with a new one.
			Mechanical torsional vibration damper
	X	**X**	Check the operation of the damper according to damper or engine manufacturer's instructions. In particular look for any corrosion or accumulations of deposits or varnishes.
	O	**O**	Depending on the outcome of the inspection of mechanical torsional vibration damper send it for overhaul.
			Turbochargers
			Look at the results of analyses of lubricant samples sent to the laboratory during the preliminary inspections.
	X	**X**	If turbochargers have independent lubrication, replace the oil charge.
X	**X**	**X**	Remove the air filter and inspect the compressor side.
X	**X**	**X**	Disassemble the exhaust bellows and inspect the turbocharger turbine side: detachment of deposits in turbochargers requires cleaning and rebalancing.
X	**X**	**X**	Check the free rotation of the rotor and the axial and radial clearances.
		X	Send the turbocharger for overhaul.

			Rubber components: Elastic coupling, elastic pads, hoses, belts, pump impellers, etc.
	X	**X**	Inspect the elastic coupling according the manufacturer’s instructions.
	O	**O**	Depending on the outcome of the inspection of the elastic coupling replace if necessary.
	X	**X**	Inspect the elastic pads to : - Look for deterioration of rubber parts. - Measure the compressions.
	O	**O**	Depending on the outcome of the inspection of the elastic pads, replace the pads.
X	**X**	**X**	Inspect flexible hoses

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

	O	**X**	Replace flexible hoses by new
O	**X**	**X**	Inspect the pumps rubber impellers (for small high speed engines).
	O	**X**	Replace the pumps rubber impellers by new.
X	**X**	**X**	Replace the belts by new.

			Fuel oil circuit
X	**X**	**X**	Look at the results of analyses of fuel samples sent to a laboratory at the stage of the pre-cold commissioning.
	O	**O**	If the results of the analyses are not good take necessary decisions : - Additional treatment of the fuel oil. - Unload the fuel oil and sent it to destruction.
		X	Search for any corrosion developments in the fuel oil circuit: remove some pipe sections for internal inspection.
X	**X**	**X**	Change and bleed the fuel filters.
X	**X**	**X**	Run and control the components of the fuel oil circuit : valves, transfer pumps, separators, heating and pressurizing units, filters, etc.
O	**O**	**O**	Depending on the outcome of the inspection of the components of the fuel oil circuit, send the components for overhaul.
X	**X**	**X**	Activate the fuel oil system according specific configuration of the vessel circuit. Starting of fuel oil heating, pressurizing the circuit, etc. Warning on some engines does not start fuel circulation on the engine until the lubricating oil is not under pressure (oil dams of injection pumps must be in operation before setting fuel oil pressure).

			Crankcase lubrication oil circuit
X	**X**	**X**	Look at the results of analyses of lubricant samples sent to a laboratory at the stage of the pre-cold commissioning.
O	**X**	**X**	High speed and medium speed engines with wet sump : Change the lubricating oil before starting. Well look at the condition of what will be drained to detect any defects. Avoid changing brand or type of lubricant.
	O	**O**	High speed and medium speed engines with dry sump : Depending of the result of lubricating oil analyses and of the treatment possibilities available on board, change the oil and oil filters before starting. Well look at the state of what will be drained to detect any faults. Avoid changing brand or type of lubricant.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

		X	Search for any corrosion developments in the lubrication circuit: remove some pipe sections for internal inspection.
X	**X**	**X**	Run and control the components of the lubrication oil circuit : valves, pumps, separators, heating and pressurizing units, filters, etc.
O	**O**	**O**	Depending on the outcome of the inspection of the components of the lubrication oil circuit, send the components for overhaul.
X	**X**	**X**	Change and bleed the lubrication oil filters.
X	**X**	**X**	Fill the lubrication oil system according specific configuration of the vessel circuit.
X	**X**	**X**	Activate the lubrication oil heaters and separators.
	X	**X**	Internal lubrication oil circuit flushing: if the engine can be equipped install running-in filters (on the main bearing caps in general). Please note these filters should be installed all at once.
		X	External lubrication oil circuit flushing: the principle is to run the pumps deriving the circuit before the engine inlet and adding temporary flushing filters.

			Cylinder lubrication system for low speed two strokes engines (if applicable)
X	**X**	**X**	Run and control the components of the cylinder lubrication system: valves, nozzles, etc.
	X	**X**	Replace the nozzles diaphragm.
		X	Send the pumps for overhaul.

			Fresh water cooling circuit
	X	**X**	Drain the coolant. Well look at the condition of what will be drained to detect any faults.
		X	Search for any corrosion developments in the fresh water cooling circuit: remove some pipe sections for internal inspection.
X	**X**	**X**	Run and control the components of the fresh water cooling circuit: valves, pumps, coolers, heaters, etc.
O	**O**	**O**	Depending on the outcome of the inspection of the components of the fresh water cooling circuit, send the components for overhaul.
	X	**X**	Inspect and test thermostatic elements and replace them by new elements if necessary.
X	**X**	**X**	Replace the internal anodes of the cooling circuit.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

X	**X**	**X**	Fill the engine and circuit according specific configuration of the vessel circuit. - Bleed the circuit. - Inspection of the water circuit for leak detection: to be done before filling the lubricating oil in the engine in order to better see the potential leaks. Pay attention to the following weak points: Various pipes. Water passage and cylinder heads. Landing surface of cylinder liners on the engine block. Exhaust valves cages. Bottom of cylinder liners through the crankcase. - Heating water circuit.
X	**X**	**X**	Check the cooling water treatment.

			Seawater circuit
X	**X**	**X**	Cleaning of the sea chests.
X	**X**		Test the main valves.
		X	Revision of the main valves.
X	**X**	**X**	Run and control the components of the sea water circuit : valves, pumps, filters, etc.
O	**O**	**O**	Depending on the outcome of the inspection of the components of the sea water circuit, send the components for overhaul.

			Starting air circuit
X	**X**	**X**	Test all closing valves or non-return valves of the circuit.
O	**O**	**O**	Repair or replace the damaged valves or non-return valves.
X			Control of high pressure flexible hoses.
	X	**X**	Replacement of high pressure flexible hoses. Rubber part of the hoses will be aged.
		X	Pressure test of the bottles and circuit for classification.
X	**X**	**X**	Inflating the launch of bottles
	X	**X**	Cleaning of the circuit to the motor and verification
	X	**X**	Blow all pipes up to the engine.
	X	**X**	Overhaul of starting air distributor
	X	**X**	Overhaul of starting valves.

			Electrical starting system
X			If the battery condition is not correct replace the batteries.
	X	**X**	In case of long duration lay-up, replace the batteries.
	X	**X**	Check tightness of electrical connections.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

			Turbocharger washing circuit: if turbochargers are equipped with a water washing circuit
X	**X**	**X**	Run and control the components of the washing circuit : valves, pumps, filters, etc.
	X	**X**	Replace the washing nozzles on the turbochargers. Indeed there is a risk of rupture of a corroded nozzle which could go through the rotor.

			Washing refrigerant circuit charge air: if the charge air cooler is equipped with a washing circuit
X	**X**	**X**	Run and control the components of the washing circuit: valves, pumps, filters, etc.
	X	**X**	Replace the washing nozzles on the charge air cooler.

			Combustion air suction circuit
X			Clean the air filters.
	X	**X**	Replace air filters.
X	**X**	**X**	Check the cleanliness of the air intake ducts. To avoid swallowing objects or sand by the compressor.
X	**X**	**X**	Check the condition and the proper functioning of rigsavers.

			Exhaust System
X	**X**	**X**	Inspect the bottom of the exhaust pipe: open the drain, make sure there is no soot or rust accumulation in the bottom of the pipe.
	X	**X**	Inspect and if necessary clean the exhaust duct before turbocharger to avoid any loose particle to go through the turbocharger.
X	**X**	**X**	Check the condition of the recovery boiler.
		X	Pressure test of the recovery boiler for classification.

			Power control circuit
	X	**X**	Check tightness of electrical connections.
X	**X**	**X**	Overhaul all multi-pin connectors.
	X	**X**	Check the condition of all thermometers, manometers, transmitters, etc.
X	**X**	**X**	Test all alarms and safety devices.

			Pneumatic control circuit
X	**X**		Inspection of control air compressor
		X	Overhaul of control air compressor
		X	Pressure test of air bottles and circuit for classification.
		X	Complete overhaul of the system with disassembly and cleaning of components, blow pipes, replacement of seals and gaskets, etc.
X	**X**	**X**	Pressurise the circuit. Look for leaks.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

GEARBOXES

X	**X**	**X**	Check correct locking of the prime mover to avoid any risk of unexpected start during works and tests.
X	**X**	**X**	Remove the protections and closures placed on the equipment and circuits: - Plugs of different fluid circuits. Refer to the cocooning procedure in order not to forget any protection, plug or cover.
X	**X**	**X**	Remove protective products installed. Refer to the recommendations of the suppliers of these products regarding the risks and the cleaning method.
	X	**X**	Open inspection doors for: Visual inspection of all the teeth in order to: - Make an inventory of wear or damages existing before the lay-up. - Look for recent corrosion damages on the teeth due to moisture or water ingress into the engine during the lay-up.
	O	**O**	If corrosion pits are observed on the teeth, it will be necessary to quantify and record the extent of damages. If the damages are light, re-commissioning can be continued. If the damages are severe, it will be necessary to assess the need to replace the damaged gears. Indeed, the compression of lubricating oil in the pits will promote the spalling and the corrosion pits modify the distribution of the load on the teeth and create initiation points for cracks that in a more or less long term will lead to damage of the gears.
X	**X**	**X**	Look at the results of analyses of lubricant samples sent to a laboratory at the stage of the pre-cold commissioning.
	O		Depending of the result of lubricating oil analyses and of the treatment possibilities available on board, change the oil and oil filters before starting. Well look at the state of what will be drained to detect any faults. Avoid changing brand or type of lubricant.
		X	Change the lubrication oil.
X	**X**	**X**	Change and purge the fuel filters.

PROPELLER SHAFT

			Intermediate bearings
X	**X**	**X**	Look at the results of analyses of lubricant samples sent to a laboratory at the stage of the pre-cold commissioning.
	O		Depending of the result of lubricating oil analyses, change the oil before starting. Well look at the state of what will be drained to detect any faults. Avoid changing brand or type of lubricant.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

		X	Change the lubrication oil.
X	X	X	Change and bleed the lubrication oil filters.

			Stern shaft
		O	Shaft withdrawal according classification recommendation.

			Stern tube
X	X	X	Look at the results of analyses of lubricant samples sent to a laboratory at the stage of the pre-cold commissioning.
		O	Depending of the result of lubricating oil analyses, change the oil before starting. Well look at the state of what will be drained to detect any faults.
		X	Inspection of the condition of the bearings and seals during the shaft withdrawal.
		O	Depending of the result of inspection, replace the seals.
O	O	O	If lubricating oil was changed, bleed the pitch control hydraulic circuit.

FIXED PITCH PROPELLER

X	X	X	Clean the propeller.

VARIABLE PITCH PROPELLER

X	X	X	Clean the propeller.
X	X	X	Look at the results of analyses of lubricant samples sent to a laboratory at the stage of the pre-cold commissioning.
	O		Depending of the result of lubricating oil analyses, change the oil before starting. Well look at the state of what will be drained to detect any faults.
		X	Change the lubrication oil.
	X	X	Overhaul the hydraulic power pack.
		X	Overhaul the hub, replace the blades feet O-rings.
O	O	O	If lubricating oil was changed, bleed the pitch control hydraulic circuit.

STEAM TURBINES

X	X	X	Check correct locking of the steam circuit to avoid any unexpected start during works and tests.
X	X	X	Remove the protections and closings placed on the equipment and circuits: - Shutters on the steam inlet and outlet. - Shutters on drains. - Plugs on different fluid circuits. Refer to the cocooning procedure in order not to forget any protection, plug or cover.
X	X	X	Remove protective products installed. Refer to the recommendations of the suppliers of these products regarding the risks and the cleaning method.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

X	X	X	Look at the results of analyses of lubricant samples sent to a laboratory at the stage of the pre-cold commissioning.
	X	X	Open the turbine for inspection of the rotor and bearings.
	O	O	Depending on the outcome of the inspection overhaul the turbine rotor with rotor balancing if necessary.
X	X	X	Dismantling and overhaul of safety devices: control valve, quick closing valves, safety valves, with test bench and certificate.
	O		Depending of the result of lubricating oil analyses, change the oil before starting. Well look at the state of what will be drained to detect any faults.
		X	Change the lubrication oil.

GENERATORS AND ELECTRIC MOTORS

X	X	X	Check correct locking of alternators and of electrical motors to avoid unexpected start during tests.
X	X	X	Look at the results of analyses of lubricant samples sent to a laboratory at the stage of the pre-cold commissioning.
X	X		Grease lubricated bearings : regrease the bearing Grease sealed bearings: no action. Oil lubricated : relubricate the bearing
		X	Grease lubricated bearings: disassemble, clean, inspect and regrease the bearing. Grease sealed bearings: change the bearing. Oil lubricated : disassemble, clean, inspect and relubricate the bearing
X	X	X	Connection box: open the box and inspect, clean, tighten connections
O	X	X	Megger test.
O	O	O	Depending of the results of the megger tests, dry the alternators or motors.

TUNNEL OR AZIMUTAL THRUSTERS

X	X	X	Check correct locking of the prime mover to avoid any risk of unexpected start during works and tests.
X	X	X	Remove protective products installed. Refer to the recommendations of the suppliers of these products regarding the risks and the cleaning method.
X	X	X	Look at the results of analyses of lubricant samples sent to a laboratory at the stage of the pre-cold commissioning.
	O		Depending of the result of lubricating oil analyses, change the oil before starting. Well look at the state of what will be drained to detect any faults.
		X	Change the lubrication oil.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

X	**X**	**X**	Depending on the results of analyses, especially if water is detected, it may be necessary to decide to send the ship in dry dock to open the thrusters.

Brevel gear upper gearbox azimutal thruster

X	**X**		During dry docking, open inspection doors for: Visual inspection of all the teeth in order to: - Make an inventory of wear or damages existing before the lay-up. - Look for recent corrosion damages on the teeth due to moisture or water ingress into the engine during the lay-up.
		X	Overhaul the thruster: replacement of roller bearings, shaft seals, gaskets, etc.
	O	**O**	If corrosion pits are observed on the teeth, it will be necessary to quantify and record the extent of damages. If the damages are light, re-commissioning can be continued.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

			If the damages are severe, it will be necessary to assess the need to replace the damaged gears. Indeed, the compression of lubricating oil in the pits will promote the spalling and the corrosion pits modify the distribution of the load on the teeth and create initiation points for cracks that in a more or less long term will lead to damage of the gears.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

V. Hot commissioning

The start of various important or essential machines must be attended by representatives of their manufacturers.

The lists below are a minimum and must be completed with the instructions of the manufacturers, the procedures in force at the owner, and the particular circumstances of each installation.

Duration of the lay-up : **up to 6 months**

Duration of the lay-up : **up to 24 months**

Duration of the lay-up : **more than 24 months**

			OPERATIONS TO BE PERFORMED
X	**X**	**X**	Unlock the engine, the turbine or the gear to be started.
X	**X**	**X**	**For all machines:** Testing of safety devices
X	**X**	**X**	**Diesel engines:** Last preparations before starting : - Make sure that all auxiliaries are in good working order. - Check freedom of the fuel rack. - Check the good operation of the over speed safety device. - Check the operation of the cylinder lubrication (turn pumps by hand); control the movement of the balls in the sight glasses. - Turn the engine with the turning gear with open indicator cocks. - Slow turn the engine with open indicator cocks (necessarily with running pre-lubrication). Starting Tests: - Place one operator at the emergency stop lever and one at the turbocharger (to check the good oil pump priming). - Check for cylinder lubrication flow indication at the sight glasses. - Start the engine normally - Check for correct priming of the lubrication of turbocharger. - Run the engine five minutes at idle and unclutched.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

			- Check injection pumps: push each rack individually to listen if the pump delivers and check that the rack comes back freely. - Open slightly and briefly the indicator cocks during this operation. Stop the engine for: - Inspect the bearings (measure the temperature on both edges of the shells, check that the half-shells have not turned), inspect the lateral movement of the big ends of connecting rods. - Check the rotation of valve rotators. Start the engine for fifteen minutes at idle and unclutched. Stop the engine for: - Inspect the bearings (temperature measurement on both edges of the shells, check that the half-shells have not turned). - Inspect the oil filters. Run the engine clutched: - Check that the starting valves pipe does not heat (this would indicate a leak of a starting valve). - Looks for water, lubricating oil, fuel oil leaks: through pumps tell-tell holes, on the coolers, on the engine, etc. - Bleed the degassing circuit. - Check correct operation of the degassing of the cooling circuit. - Check the crankcase ventilation. - Bleed filters (fuel oil, lubricating oil). - Check and record operating parameters. Compare with the original parameters. - Check the correct operation of the torsional vibration damper. If necessary, perform the running-in in accordance with the manufacturer recommended program.
			Steam turbines: Last preparations before starting : - Ensure the proper commissioning of the boiler and of the quality of steam. - Ensure the proper commissioning of the condenser. - Make sure that all auxiliaries are in good working order. - Barring of the the rotor with the turning gear. - Prewarming of the turbine - Drain of the turbine. - Looks for steam, lubricating oil leaks.

X = The operation should be performed	O = The operation should be perform according to the result of the inspection

			Start of the turbine: - Check and record operating parameters. Compare with the original parameters.
			Gearboxes: Make tests in the presence of the manufacturer or his representative. - Looks for water, lubricating oil leaks: through pumps tell-tell holes, on the coolers, on the engine, etc. - Bleed filters - Check and record operating parameters. Compare with the original parameters.
			Stern tube: Check and record operating parameters. Compare with the original parameters.
			Variable pitch propellers: Check and record operating parameters. Compare with the original parameters.
			Electrical equipment: Start and test of all equipment. Thermography.
			Fluid circuits: Start and test of all pipes. Testing of valves.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

VI. Sea trials

Duration of the lay-up : **up to 6 months**	Duration of the lay-up : **up to 24 months**	Duration of the lay-up : **more than 24 months**	**OPERATIONS TO BE PERFORMED**
X	**X**	**X**	Sea trials will allow verifying that the entire propulsion plant is operational and that the performance of the propulsion and vessel are recovered. The tests shall be made on the basis of a formalized test program. Check that this test program is suitable. Sea trials must include a full load operation of all devices. Sea trials must include a record of operating parameters of all circuits and devices. The readings of parameters should be compared to the values recorded during sea trials of the vessel at new building. In addition to the parameters usually measured on the vessel, it may be conducted surveys of vibration measurements, of thermography. For vibration measurements the problem is that there may be no specific reference values to the ship.  Operating parameters values of all circuits and equipment must: - Be consistent with the values of the new building. - Be recorded in the test reports. - Be accepted by all parties to the tests: crew, technical service of the ship-owner, representatives of manufacturers of equipment.  All deviations of operating parameters of all circuits and equipment must be identified, recorded, explained, solved or accepted.
X	**X**	**X**	At the end of sea trials take samples of in services lubricants for assessment of their quality and to detect possible problems on the installation. Result of analyses will part of the sea trial report. Refer to the lubrication chart of the vessel to identify lubricants to control.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

X	X	X	**At the end of the trials a complete re-commissioning report must prepared. This report must include at least:** - **The lay-up procedure.** - **The re-commissioning procedure.** - **The visit reports of each equipment: list of controls and dismantling, condition description of all opened components (should they have been replaced or not), list of replaced components, measurement sheets of overhauled components, test bench reports, etc.** - **The fuel oils, lubricants, cooling waters analyses reports.** - **The running parameters records.** - **All updated certificates (flag, classification).**

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

VII. After commissioning controls

Duration of the lay-up : **up to 6 months**

Duration of the lay-up : **up to 24 months**

Duration of the lay-up : **more than 24 months**

OPERATIONS TO BE PERFORMED

			Operations to be done after the re-commissioning
O	**O**	**O**	After 24 running hours, perform a control the tightening of the fuel circuit components. This is recommended by some engine manufacturers.
O	**O**	**O**	If dismantling works were carried out on the engine during the re-commissioning, don't forget the following operation if they are requested: - Check tightening of connecting rods big end caps and of connecting rods body with big end. This is to be done after a number of hours given by the specific documentation of the engine model. - Final tightening cylinder head. - Control the alignment.
O	**O**	**O**	Remove the running-in filters after the recommended number of running hours. Please note these filters should be removed all at once.
X	**X**	**X**	Do not wait the normal periodicity to redo analysis of oil (after 50 to 100 hours of operation) for diesel engines, steam turbines, gearboxes, azimuthal thrusters, bow thrusters, etc.
X	**X**	**X**	Monitoring of operating parameters.

			If the re-commissioning is correctly conducted, no incidents will occur during the re-commissioning. If an incident occurs after the re-commissioning, possible causes are: - Deterioration which have develop during the lay-up. - Deterioration induced by the disassembly and reassembly during the visits and controls and checks for re-commissioning. - New problems.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

			If an incident occurs after the re-commissioning it will always be difficult to assess whether this incident was due to the lay-up or to a new problem. Make the difference between a problem whose origin is in the lay-up or the origin of which is a new problem may be difficult. To help differentiate it will necessary to refer to the complete re-commissioning report describe at the end of the chapter ''Sea trials''. In case of damage the people in charge of following the file will absolutely have to be informed that the vessel was previously in lay-up and the complete re-commissioning report should be made available to them.

X = The operation should be performed | O = The operation should be perform according to the result of the inspection

VIII. Examples

Electrically controlled injector

A high power high speed engine powered diesel propulsion used on a ship. This engine is equipped with electrically controlled injectors by electric coil. The injectors have remained installed on the stopped engine for several weeks without special protection. During shutdown, gums were formed on the inner parts of the injectors. Upon return to service the engine ran properly, but internal deposits in the injectors made that the power required to move the injector's needles was increased. The control coils of the needles were therefore overloaded. After a few weeks the coils broke down one after the other due to their overloading. This generated shutdowns of the vessel and required the replacement of all complete injectors.

Electronically controlled engine

A medium speed engine equipped with an electronic control used as propulsion engine of a ship. This engine is equipped with smart sensors, electronic cards placed into watertight boxes distributed around the engine, communication buses, etc. After a prolonged shutdown, the engine has suffered many untimely stops putting the vessel in a situation of blackout. The reason was discovered: the multi-pin connectors of the communication buses had slight traces of corrosion developed during the prolonged shutdown. The problem was solved by opening all connectors, cleaning them and replacing all the seals.

False brinelling

False brinelling is a typical case of damage of a component remaining in stopped condition for a long time. Indeed when stopped bearing remains in the same position for a long time, and is submitted to an external vibratory stress (vibrations emitted by a running diesel generator, for example), there is a fretting located at the point of contact of the balls or rollers with the raceways. These localized fretting points will produce deteriorations by spalling several months after their return to service.

Bow thruster

A bow thruster installed in a fore compartment in an unheated compartment of a vessel laid-up for six months. During return to service the lubrication oil stick was found rusty. Subsequent analyses have shown a strong presence of water in the lubrication oil. Dismantling the bearings exhibited beginning of oxidation that could have been a source of deterioration and breakage several months after the restart.

Diesel engine rebuilt in the workshop

A high-speed diesel engine completely rebuilt in a workshop. At the end of the overhaul the engine is tested briefly (running few minutes without load), then stopped and stored on a pallet packed in a plastic film without special precautions (left with its lubrication oil). The engine is stored a year and then returned to service with the same lubrication oil charge. Two months after the return to service a connecting rod bearing is destroyed. The dismantling made after the damage showed signs of corrosion on all bearings (big ends and main bearings). Storage without special specific precautions with lubrication oil and absence of proper controls when returning to service are the cause of the damage that occurred several weeks after the restart.

DISCLAIMER

Present advice's purpose is to inform Marine insurers on the technical problems raised and explained in the present document.

All opinions and information herein contained are provided exclusively as indications.
Issuer of such study cannot be held liable whatsoever in relation with its content.

The information provided:

-are exclusively of a general interest and do not intend to solve a specific case

-are not necessarily comprehensive considering the variety of situation which can be encountered, each equipment being one of a kind, characteristics evolving within a time frame

-are not to be construed as an advice which could substituted the applicable regulation and best professional practices supported by official bodies, equipment's manufacturers and or empowered authorities, for such subjects, whose advices are binding.