
**Ships and marine technology —
Vessel machinery operations in polar
waters — Guidelines**

*Navires et technologie maritime — Exploitation des machines des
navires en eaux polaires — Lignes directrices*

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword	iv
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Cold weather diesel engine operations	1
4.1 General.....	1
4.2 Starting diesel engines in cold weather.....	1
4.3 Cold weather starting aids.....	2
4.3.1 General.....	2
4.3.2 Glow plugs, preheaters, and block heaters.....	2
4.4 Gelling of fuel.....	2
4.5 Other fuel, equipment storage, and operational considerations.....	3
4.6 Proper lubricating oil viscosity.....	3
4.7 Cetane number.....	4
5 Preparations for other engineering systems	4
5.1 Lifeboat engine preparations.....	5
5.2 Cold weather preparations for other lifeboat machinery.....	5
6 Cold weather deck machinery preparations and operations	6
6.1 General.....	6
7 Batteries	6
Annex A (informative) Other important logistical and operational considerations for extremely cold weather	7
Annex B (informative) Battery maintenance considerations for extremely cold weather	8
Bibliography	9

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: [Foreword — Supplementary information](#).

The committee responsible for this document is ISO/TC 8, *Ships and marine technology*, Subcommittee SC 3, *Piping and machinery*.

Ships and marine technology — Vessel machinery operations in polar waters — Guidelines

1 Scope

The intent of this International Standard is to provide guidance to ship design and operational personnel (crew) on the critical issues to consider regarding machinery, prior to and during vessel operations in the extreme conditions of the Earth's polar regions. This International Standard is intended to supplement the IMO Code for Ships Operating in Polar Waters and the IACS UR "I", Requirements Concerning Polar Class. Although the application of this International Standard is primarily concerned only for ships operating in polar regions, some of the design considerations and planning might need to be implemented during construction or in a shipyard environment.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8217, *Petroleum products — Fuels (class F) — Specifications of marine fuels*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply

3.1

cetane number

measure of ignition quality, or ability of a fuel to ignite, in a diesel engine

3.2

CFFP

cold filter plugging point

lowest temperature at which a given volume of diesel fuel will pass through a standard filter in a prescribed amount of time

4 Cold weather diesel engine operations

4.1 General

Operators should review their diesel engine procedures to ensure that they have a special set of operating procedures for the colder months. Procedures for summer conditions might not be adequate in extremely cold conditions.

4.2 Starting diesel engines in cold weather

Diesel engines shall be adequately prepared for starting in lower temperatures. Weak batteries might not crank the starter motor fast enough or long enough to start a cold engine. As the temperature goes down, so does battery capacity. A battery that has all of its power available at 27 °C (80 °F) will have only about 46 % available power at -17 °C (0 °F). Also, the engine will be much harder to start at -17 °C because of cold, thicker oil and resistance to movement of internal moving parts. In effect, an engine is about five times harder to start at -17 °C than at 27 °C. Test weak or suspicious batteries under load before cold weather to help identify potential problems (see [Clause 6](#) and [Annex B](#)). If batteries need

replacement, always replace with a battery equal to or more powerful than the original battery. Turn off any accessories that draw large amounts of current before engaging the starter motor.

4.3 Cold weather starting aids

4.3.1 General

Diesel fuel evaporates much slower than gasoline (petrol) and requires more heat for combustion in the cylinders. In many cold weather installations, additional measures, such as those listed below, are required to ensure proper engine starting and operation.

4.3.2 Glow plugs, preheaters, and block heaters

Glow plugs are normally installed in the pre-combustion chamber of the cylinder head. The glow plug is activated by the ignition switch. On some equipment, a light signals that the glow plug is cycling, which warns the operator to wait between 15 s to 30 s before cranking the engine. The energy created by electrical resistance in the glow plug heats the fuel-air mixture and helps the fuel to ignite.

Preheaters are normally installed in the intake manifold; however, in a two-stroke cycle engine, they are placed in the air passages surrounding the cylinders. The preheater burns a small quantity of diesel fuel in the air before the air is drawn into the cylinders. This burning process is accomplished by the use of either a glow plug or an ignition coil that produces a spark to ignite a fine spray of diesel fuel. The resulting heat warms the remaining air before it is drawn into the cylinders.

Block heaters are electric resistive heaters in the engine block, used when an engine is turned off for extended periods in cold weather in order to reduce start-up time and engine wear. Block heaters are also used for emergency power generators that should rapidly pick up load on a power failure. To save time and electricity, the block heater can be put on an electrical timer set to turn on a couple of hours before the engine is started.

Some older engines use a system to introduce small amounts of ether or other starting fluid into the inlet manifold to start combustion. Recent direct-injection systems that use a common rail and electronic fuel injection are technologically advanced to the extent that pre-chamber systems might not be needed.

4.4 Gelling of fuel

Diesel fuel is prone to *waxing* or *gelling* in cold weather; both are terms for the solidification of diesel oil into a partially crystalline state. The temperature at which this process commences is sometimes known as the "cloud point". The crystals build up in the fuel line, eventually clogging the filter and starving the engine of fuel, causing it to stop running. Electric heaters in fuel tanks and around fuel lines are used to help solve this problem. Most engines also have a *spill return* system, by which any excess fuel from the injector pump and injectors is returned to the fuel tank. Once the engine has warmed, returning warm fuel prevents waxing in the tank. Because of improvements in fuel additive technology, waxing rarely occurs in all but the coldest weather. If fuel has gelled from cold temperatures, change the fuel filter and warm the fuel by using a block heater before attempting to start the engine. Gelled fuel in the filter can block the flow of fuel from the tank to the injector pump.

Similar to cloud point, the "Cold Filter Plugging Point" (CFPP) can also be used as a cold weather fuel reference temperature, below which the diesel fuel will tend to clog and not pass through filters. CFPP can provide a reference temperature below which the fuel will create problems for system operation.

NOTE ASTM D6371 and DIN EN 116 provide test methods to determine CFPP.

Marine Gas Oil (MGO) is known to begin gelling at approximately $-10\text{ }^{\circ}\text{C}$. Biodiesel fuels tend to have higher CFPP temperatures.

Add winter diesel fuel additive to the fuel to lower the possibility of gelling and improve starting.

4.5 Other fuel, equipment storage, and operational considerations

Because of lower viscosity and higher ignition qualities, ISO 8217 marine distillate fuels, or a mix of ISO 8217 marine distillate and low viscosity residual fuels should be used in cold weather if possible. Also, the fuel tank should be kept full to prevent water condensing inside the tank, which can freeze and plug fuel lines from the tank to the engine.

Portable equipment, such as dewatering pumps, should be stored in suitable locations that are heated or warmer than outside temperatures. Only a few degrees warmer temperature can make starting faster and easier. The warmer the battery is, the more power it will provide to the starter motor to crank the engine. The warmer the engine oil is, the less resistance it will have to moving engine parts. After starting the engine on a cold day, allow the engine to warm up a few minutes before putting it under load. Proper engine temperatures ensure more efficient fuel combustion and can prevent damage to cold engine parts. Engine oil flows more readily at operating temperatures and allows proper lubrication of upper engine parts and areas.

Diesel engines are designed to operate under a loaded condition. Engine operation for extended periods of time under a no-load condition (excessive idling), especially in cold climates, can cause significant problems. Low loads on the engine can cause low combustion chamber temperatures, incomplete combustion, and result in increased deposits of material on exhaust system components. Excessive build-up of these deposits can cause exhaust valves to stick either open or closed. A stuck open valve can cause piston damage; a stuck closed valve can cause a bent push rod.

The environment can have a negative effect on the engine, even when the engine is shut down. Deposits formed while the engine was running are still there. The lower the temperature, the thicker this material becomes. It can harden to the point of forming a black, glassy semi-solid. The harder the material becomes, the greater the chances of engine damage. As the engine is placed back into operation, the valves will seat on the hardened solid, frequently causing the material to crack. Solid particles can end up in the lubricating system, causing scoring on cylinder walls. Engine efficiency can be reduced if exhaust valves are not seating properly, which reduces compression pressures.

The following operational items should be considered to decrease the probability of engine damage.

- a) The most significant procedure is *don't idle the engine for extended periods of time*. If the engine doesn't run, it doesn't produce exhaust products.
- b) *Increase engine load*. One engine running at 50 % load is significantly better than two engines at 25 % load. Alternate engines. The more load the hotter the exhaust and less build-up of products. This might be easier to do with generators.
- c) If the engine is run at idle for a portion of the day, make sure to load the engine prior to shutdown to help remove deposits.
- d) *Raise jacket water heater (block heater) temperature*. Increase the jacket water thermostat. This can promote softer deposits.
- e) *Install a higher temperature thermostat*. Increasing thermostat temperature will provide a warmer engine and softer deposits.

4.6 Proper lubricating oil viscosity

Correct lube oil viscosity for the expected ambient operating temperature is essential for proper starting and operation of all internal combustion engines in extremely cold temperatures. [Table 1](#) shows the recommended range of viscosities based on expected ambient operating temperatures

Always refer to the engine manufacturer operating manual for specific requirements on lubricating oil viscosity in extreme temperature conditions. Also, ensure that the lubricating oil is appropriate for the type of engine (two stroke, four stroke, compression-ignition (diesel), or spark-ignition).

Table 1 — Recommended engine oil viscosities for ambient temperatures

Recommended engine oil viscosities for ambient temperatures		
	Ambient Temperature (C-Celsius, F-Fahrenheit)	
Viscosity Grade	Minimum	Maximum
SAE 0W-20	−40 C (−40 F)	10 C (50 F)
SAE 0W-30	−40 C (−40 F)	30 C (86 F)
SAE 0W-40	−40 C (−40 F)	40 C (104 F)
SAE 5W-30	−30 C (−22 F)	30 C (86 F)
SAE 5W-40	−30 C (−22 F)	50 C (122 F)
SAE 10W-30(2)	−18 C (0 F)	40 C (104 F)
SAE 10W-40	−18 C (0 F)	50 C (122 F)
SAE 15W-40	−9,5 C (15 F)	50 C (122 F)

NOTE Synthetic oils generally perform better than conventional oils at both extremely low temperatures, such as arctic conditions, as well as high operating temperatures.

4.7 Cetane number

Cetane number is a critical reference of fuel ignition quality and cold-start capability. The optimum cetane number for fuel, as recommended by the engine manufacturer, should always be used. Use of a lower-than-minimum recommended cetane number can cause starting difficulties, rough engine operations, and increased emissions and soot deposits. There is, however, little performance benefit to using a higher cetane number than recommended.

The greater ignition capabilities of higher cetane fuel are particularly important in cold weather, along with the cloud point temperature. Many diesel fuel blends actually require additives to improve the cetane number to be in the range recommended by engine manufacturers.

NOTE Cetane improver additives might have negative effects on fuel held in storage for long periods

5 Preparations for other engineering systems

The following items should be considered for engineering systems prior to polar operations.

- Install temporary heating around piping, directly inboard of the shell, on overboard discharge and drains above the water line.
- Test heating coils in cargo and fuel oil tanks (when appropriate) in accordance with planned maintenance procedures.
- Test operation of preheaters, reheaters, temperature controls, and condensate traps of heating systems in accordance with maintenance procedures.
- Procure space heaters for temporary shelters topside.
- Install unit heaters in deck cargo handling area.
- Procure burning or electric heaters for warming deck machinery and de-icing ground tackle equipment.
- Ensure that ventilation is adjusted to maintain a slight positive pressure to avoid drafts and conserve heat.
- Prepare foul weather clothing drying rooms.
- If extremely low ambient temperatures are expected, substitute refrigerator fluorescent lighting tubes for the normal ones installed in cargo spaces.

- j) Clean and inspect ventilation systems.
- k) Replace grease in topside electric motors with proper cold weather grease.
- l) Drain, flush, and refill hydraulic winch systems with cold weather fluid.
- m) Secure and drain all weather deck fire plugs and fire mains.
- n) Stow fire hoses and fittings below decks.
- o) Stow all portable, gasoline powered pumps below decks.
- p) Install thermal insulation above and behind main and emergency electrical distribution switchboards to prevent condensation, unless such switchboards are already arranged in a thermally insulated or air-conditioned space.

5.1 Lifeboat engine preparations

The following additional preparations for lifeboat engines should be considered prior to polar operations.

- a) Raise boat engine starting battery's specific gravity to correct level, and keep batteries trickle-charged using ship's service electrical system. Ensure "jumper" cables are available to use if necessary to start engine.
- b) Install antifreeze solution in boat engines to provide protection to -29°C , and keep salt water cooling system drained except during operation.
- c) Cold weather lubricants should be used for engines and transmissions.
- d) Install additional insulation on exposed piping which will not be completely drained when not in use.
- e) Install electric air preheaters on all boat engines.
- f) Install portable heaters in boat engine compartments.
- g) Boat engine heaters (engine block, oil system, or cooling system) will ensure easier starting.
- h) Other means to keep boat engines warm include heat lamps, flood lights, drop lights, and insulation blankets.

5.2 Cold weather preparations for other lifeboat machinery

- a) Lubricate and protect davits and winches.
- b) Boat falls should be kept clean, and winch machinery should be run in order to heat lubricants prior to use.
- c) Fabricate or procure boat covers for each boat.
- d) Covers should protect the entire boat down to the water-line and should be made out of heavy canvas.
- e) During extremely cold conditions, provisions should be made for periodically starting and warming boat engines if no use is expected to be made of them.

6 Cold weather deck machinery preparations and operations

6.1 General

The following additional list of items and procedures should be considered by the ship's deck and engineering departments when preparing for cold weather operations.

- a) Complete preservation of all exposed areas to resist corrosion during any long period when routine maintenance cannot be done.
- b) Designate stowage for additional heavy weather and bulk clothing.
- c) Install temporary shelter or windscreens for exposed personnel and topside watchstanders.
- d) Rig additional life and safety lines.
- e) Ensure that enough de-icing equipment is on board.
- f) Procure ice fenders.
- g) Sluice down all running rigging with low temperature grease.
- h) Store all towing lines, mooring lines, and cargo gear below decks except when in use.
- i) Freshwater in contact with the hull will freeze, including bilge water and condensation.
- j) Frozen bilges will impair the ship's dewatering capability if the bilge suctions are covered.
- k) Hatches and scuttles can become frozen shut from the inside.

7 Batteries

Cold temperatures drastically reduce the output of all types of batteries (dry and wet cells). For example, at -18°C , the ampere-hour capacity of a typical dry cell battery is reduced to about 25 % of the 20°C rated capacity. At this temperature, capacities of lead-acid and nickel-cadmium storage batteries are down to about 35 % and 50 % respectively.

The lowest temperature for reliable cranking is about -18°C . The output of most batteries reaches essentially zero at about -34°C to -40°C . The rate at which storage batteries can accept a recharge is also reduced in cold temperatures. To obtain a good recharge in a reasonable amount of time, the temperature of the battery should be about 15°C or higher.

The sulphuric-acid electrolyte in a discharged acid battery can freeze at -15°C . If the battery is fully charged, the electrolyte freezing point is good to -60°C or below. Freezing can damage the plates, crack the battery case, and split the cover-to-case seal or the terminal-to-cover seal, thus leading to electrolyte spillage. Freezing of electrolyte can also form crystals which can pierce separators, eventually leading to internal short-circuits and premature failure of the battery.

The potassium hydroxide electrolyte in a nickel-cadmium battery does not vary significantly with the state of charge and the freezing point is essentially constant at -60°C . Freezing of this type of battery is not normally a problem.

Storage batteries should be kept fully charged and stowed in a heated space. Flashlight and other dry cell batteries should be kept warm when not in use.

NOTE See [Annex B](#) for additional information on battery maintenance.

Annex A

(informative)

Other important logistical and operational considerations for extremely cold weather

The following list of items and procedures should be consulted for applicability when preparing for extreme cold weather operations.

- a) Ensure that material and repair parts are at full allowance and submit spare parts requests as far in advance as possible.
- b) Ensure that spare boat batteries are on board to allowance.
- c) Ensure special dry cell batteries (for use in temperatures below -17°C or 0°F), low temperature/cold weather greases, anti-freeze, and cold weather fluids are on board.
- d) Ensure that full allowance of materials needed for any special moorings, such as special fittings or mooring lines, are on board.
- e) Ensure that full allowance of extreme cold weather clothing is on board for all crew and passengers.
- f) Prepare a climatological summary on expected conditions prior to voyages to areas of extremely cold weather.
- g) Compute and monitor the Wind Chill Factor when the ambient air temperature is below 0°C , and advise when protective measures are necessary for personnel working in exposed areas.