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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.

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ISO/PAS 18215 was prepared by Technical Committee 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

This Publicly Available Specification provides 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.

It is intended to supplement the IMO *Code for Ships Operating in Polar Waters*, and the IACS UR "I", *Requirements Concerning Polar Class*.

2 Terms and definitions

2.1
cetane number
measure of ignition quality, or ability of a fuel to ignite, in a diesel engine

2.2
cold filter plugging point
CFFP
lowest temperature at which a given volume of diesel fuel will pass through a standard filter in a prescribed amount of time

3 Cold weather diesel engine operations

3.1 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 may not be adequate in extremely cold conditions.

3.2 Starting diesel engines in cold weather

Diesel engines must be adequately prepared for starting in lower temperatures. Weak batteries may 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, they shall always be replaced with a battery equal to or more powerful than the original battery. Any accessories that draw large amounts of current before engaging the starter motor shall be turned off.

3.3 Cold weather starting aids

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.

3.3.1 Glow plugs, preheaters and block heaters

Glow plugs are normally installed in the precombustion 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 must 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 may not be needed.

3.4 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, the fuel filter shall be changed and the fuel shall be warmed 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) may also be used as a cold weather fuel reference temperature, below which the diesel fuel will tend to clog and not pass through filters.

Number 2 diesel fuel is known to begin gelling at approximately –10 °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.

3.5 Other fuel, equipment storage and operational considerations

Because of its higher volatility and ignition qualities, Number 1 diesel fuel, or a Number 1-Number 2 mix, should be used in place of number 2 diesel 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, the engine shall be allowed to warm up a few minutes before being put under load. Proper engine temperatures ensure more efficient fuel combustion and may 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 cause low combustion chamber temperatures, incomplete combustion and result in increased deposits of material on exhaust system components. Excessive build-up of these deposits may cause exhaust valves to stick either open or closed. A stuck open valve may cause piston damage; a stuck closed valve may 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 may end up in the lubricating system, causing scoring on cylinder walls. Engine efficiency may 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 does not run, it does not 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 may 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 may promote softer deposits.

e) *Install a higher temperature thermostat.* Increasing thermostat temperature will provide a warmer engine and softer deposits.

3.6 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

Table 1 — Recommended Engine Oil Viscosities for Ambient Temperatures

Recommended Engine Oil Viscosities for Ambient Temperatures		
	Ambient Temperature	
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.

3.7 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 may have negative effects on fuel held in storage for long periods.

4 Preparations for other engineering systems

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

a) install temporary heating coils around piping, directly inboard of the shell, on overboard discharge and drains above the water line;

b) test heating coils in cargo and fuel oil tanks (when appropriate) in accordance with planned maintenance procedures;

c) test operation of preheaters, reheaters, temperature controls, and condensate traps of heating systems in accordance with maintenance procedures;

d) procure space heaters for temporary shelters topside;

e) install unit heaters in deck cargo handling area;

f) procure burning or electric heaters for warming deck machinery and de-icing ground tackle equipment;

g) ensure that ventilation blowers are operated on low speed to maintain a slight positive pressure to avoid drafts and conserve heat;

h) prepare foul weather clothing drying rooms;

i) 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 electrical distribution switchboards to prevent condensation.

4.1 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.

4.2 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 must protect the entire boat down to the water-line and should be made out of heavy canvas;

e) during very cold conditions, provisions must be made for periodically starting and warming boat engines if no use is expected to be made of them.

5 Cold weather deck machinery preparations and operations

5.1 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 may become frozen shut from the inside.

6 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 may 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 may 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 normally not a problem.

Storage batteries should be kept fully charged and stowed in a heated space or equipped with heaters.

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

A.1 General

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

a) Ensure that material and repair parts are at full allowance and submit 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 special mooring 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.

Annex B
(informative)

Battery maintenance considerations for extremely cold weather

B.1 General

Because the performance of batteries is severely degraded at cold temperatures, personnel who use battery-powered equipment are more likely to become involved with the handling of batteries during a cold weather cruise than under normal conditions. This handling may include recharging batteries, warming up batteries that have become too cold, or replacing batteries that are no longer serviceable. In recognition of the potential serious safety hazards involved in handling batteries and electrolytes, this section describes some of the safety precautions which should be observed at all times.

B.2 Battery maintenance and safety

The following maintenance procedures and intervals are suggested for shipboard batteries:

Weekly. Observe the height of electrolyte in cells, and measure cell specific gravity and temperature readings for all batteries. Fill water batteries only with distilled water if the height of electrolyte is at the low mark. Check charging rate and voltage of engine battery charging systems.

Monthly. Clean batteries and grease terminals with petrolatum as necessary. Examine battery connections and correct faulty conditions such as breaks, frayed insulation or grounds. Inspect for broken or cracked battery cases. Give all batteries an equalizing charge, except those charged from their own generator or being floated.

Quarterly. Give all batteries which are charged from their own generators or are being floated an equalizing charge and take a complete set of voltage, temperature and specific gravity readings.

Semi-Annually. Give each battery a test discharge at a 5-to-10 h rate or as specified on the battery nameplate. A test discharge is the most reliable means of determining battery conditions, but functional testing may be done in lieu of a test discharge.

Functional testing of portable storage batteries for various shipboard applications varies with usage, size of battery and load. Test recommendations are:

a) Engine starting batteries should be capable of starting an engine at least once a week.

b) Portable lantern batteries should be capable of providing sufficient light for a period of 1 min without dimming and should be tested at least once a week.

c) Gyrocompass batteries should be functionally tested for a 20 min period on battery power alone, once a month.

d) Telephone batteries should be functionally tested for 2 h on battery power alone, once a month.

In case of failure, give the battery an equalizing charge, then retest. If the retest fails, replace the failed battery.

Batteries subjected to the cold should be heated, if possible, and must be kept fully charged to prevent freezing. The battery charger should be placed in the same temperature environment as the battery being charged.

Battery chargers used to charge batteries by long leads outside the spaces should have their charging voltage output adjusted for temperature.

B.3 Battery hazards

B.3.1 Electrolytes

Batteries commonly use electrolyte solutions of sulphuric acid and distilled water. Sulphuric acid is very dangerous to personnel and highly corrosive to equipment or materials. Another type of storage battery is the alkaline type containing nickel-cadmium and an electrolyte solution of potassium hydroxide. This electrolyte is also dangerous to personnel and is corrosive to many materials.

Personnel engaged in handling any electrolyte should wear rubber aprons, rubber boots, rubber gloves and goggles or a full face shield so that the electrolyte cannot come in contact with clothing or skin.

Nothing but distilled water should normally be added to a battery. When absolutely necessary a premixed electrolyte may be used.

B.3.2 Hydrogen

Both hydrogen and oxygen gas are given off from batteries, especially during recharging. Because hydrogen mixed with oxygen or air is very explosive, sparks, smoking or flames of any kind must never be allowed in the vicinity of any rechargeable battery. Because hydrogen is colourless, odourless and tasteless, battery compartments should always be thoroughly ventilated before they are entered. When preparing to recharge a battery located in a battery compartment, verify that the ventilating system is operating properly before starting the charge. Stop the charge if the ventilation is interrupted.

B.3.3 Charging

Charge a battery only at the rates given on its nameplate. Reduce the charging rate if the battery electrolyte begins to evolve bubbles.

To prevent dangerous sparks, ensure that no current is flowing into or out of the battery before disconnecting or connecting battery terminals. When batteries are used with one terminal grounded, the grounded terminal should be disconnected first when removing the battery and connected last when replacing the battery. Verify that all terminal connections are tight.

Use only tools with insulated handles to prevent short-circuiting the battery terminals.

When distilled water is added to a battery, the water should be added just before the battery is placed on charge. The water remains on top of the electrolyte until mixed with it by charging. In cold weather, the unmixed water may freeze, causing the battery case to crack and leak electrolyte.

B.3.4 Other battery hazards

Equipment installed to warm batteries should be controlled to keep the battery compartment temperature below 35 °C. Care should be taken not to allow salt-water to splash or leak onto an acid battery, because salt-water entering a battery cell may produce extremely toxic chlorine gas.

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