

# **PART 6**

# **MACHINERY INSTALLATIONS**

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### **MACHINERY INSTALLATIONS**

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## **MACHINERY INSTALLATIONS**

### **Section 6.1 – General requirements (main propulsion)**

- 6.1.1 The requirements for main propulsion are based on the installation of diesel powered units using fuel oil with a flash point of not less than 60°C. In all cases the engine power is to be in accordance with engine Manufacturer's rating to ISO/DIN Standards.
- 6.1.2 Machinery installations are also to comply with "Code of Safe Working Practice for the Construction and Use of 15 Metre Length Overall to Less Than 24 Metre Registered Length Fishing Vessels"
- 6.1.3 Attention is drawn to Chapter 11 of the Code, "Clean Seas", regarding prevention of pollution.
- 6.1.4 Machinery and pressure vessels are to be of a design and construction adequate for the service for which they are intended. Due regard is to be given to moving parts, hot surfaces and other hazards.
- 6.1.5 It is the responsibility of the Shipbuilder to ensure that all relevant information required by the Certifying Authority and MCA is submitted in good time to enable their early consideration.
- 6.1.6 Main engines are to be identified by stamping of tally plate permanently attached to the engine. Details are to include model, serial, power rating and date of manufacture.
- 6.1.7 On vessel completion, a certificate of maximum engine and details of any de-rating and the procedure used is to be supplied by the engine Manufacturer/Supplier.
- 6.1.8 Where risk from over-speeding of machinery exists, provisions are to be made to ensure that the safe speed is not exceeded.
- 6.1.9 Machinery installations are to be arranged with due regard to the safety of crew members, and be so installed and protected as to reduce to a minimum any danger to persons during normal movement about the engine room.
- 6.1.10 Attention is to be given to moving parts, walking areas, hot surfaces and maintenance accessibility. Passageways between main engines, auxiliary sets and switchboards are to be of a sufficient width, and are to be not less than 600mm.
- 6.1.11 All exposed moving parts are to be fitted with suitable protective guards.
- 6.1.12 Machinery spaces are to be designed to provide safe and free access to all parts of the machinery that may require servicing at sea.

- 6.1.13 Main and auxiliary machinery essential for the propulsion and safety of the vessel is to be provided with effective means of control. The machinery is to be capable of being brought into operation from the 'deadship' condition. Machinery spaces that will be periodically unattended at sea are to be provided with proper alarm, detection and machinery control systems.

## **Section 6.2 – Escape arrangements**

- 6.2.1 Two means of escape from the machinery space are to be provided, separated as far apart as practical, and be diagonally opposed where possible. Escape routes are to be clearly marked and be provided with steel ladders or rungs and hand rails for easy access.
- 6.2.2 Each hatch is to have a minimum clear opening of 600mm x 600mm and each doorway a minimum clear opening width of 600mm. Escape routes should be kept clear of obstacles as far as is practicable.
- 6.2.3 Escape hatches and doors are to be constructed of steel or other approved material to A30 fire rating standards, and are to be provided with handles or clips which are operable from both sides. Consideration will be given to the provision of central spindle or linked operating arrangements to escape hatch door clips to enable them to be quickly opened in an emergency.

## **Section 6.3 – Control spaces**

- 6.3.1 Main engines controlled from the engine room should also be controlled from a separate area, soundproofed and insulated from the engine room, and accessible without entering the engine room.
- 6.3.2 The wheelhouse is considered to be an area that meets the requirements of Paragraph 6.3.1.
- 6.3.3 To ensure safety of personnel, arrangements are to be provided to start and stop the main engine(s) from the engine room, in addition to any wheelhouse control.

## **Section 6.4 – Engine starting**

- 6.4.1 Main or essential auxiliary engines are to be capable of being started from the deadship condition without external aid. Such means should be hydraulic, air, hand or electric starting or other means acceptable to the Certifying Authority.
- 6.4.2 Main engine starting arrangements are to be adequate to start the main engine, or engines not less than six times in succession.
- 6.4.3 When the sole means of starting is by battery, provision is to be made, via a changeover switch, to make available an alternative battery as a

safeguard for starting. Charging facilities are to be available for the batteries in accordance with the requirements of Paragraph 8.4.13.

- 6.4.4 Vessels in which machinery essential for the propulsion and safety of the vessel are required to be started, operated or controlled solely by compressed air, should be provided with an efficient air system including an adequate number of air compressors and air storage receivers, and are to be so arranged as to ensure that an adequate supply of compressed air is available under all foreseeable service conditions.
- 6.4.5 Air pressure systems are to be designed, constructed and pressure tested to the satisfaction of the Certifying Authority.
- 6.4.6 Means are to be provided to prevent excess pressure in any part of compressed air systems.
- 6.4.7 The main engine starting air arrangements are to be adequately protected against the effects of backfiring and internal explosion in the starting air pipes.
- 6.4.8 All discharge pipes from starting air compressors are to lead directly to the starting air receivers, and all starting pipes from the air receivers to main or auxiliary engines are to be entirely separate from the compressor discharge pipe system.
- 6.4.9 Provision is to be made to reduce to a minimum the entry of oil into the air pressure system and to drain these systems. Air receivers are to be fitted with drain valves at the lowest point.

## **Section 6.5 – Engine controls and instruments**

- 6.5.1 In vessels where the engine room is to be unattended, and the main engine and auxiliary machinery essential for propulsion and safety is by the electric start method, each engine is to be capable of being started and stopped from the wheelhouse control position and from the engine room.
- 6.5.2 An effective means of communication between the wheelhouse and engine room is to be provided, along with an override system to prevent accidental machinery starting and injury to crew members who may be working on the machinery.
- 6.5.3 The main engine emergency stop should be completely independent from all instrumentation and alarms.

6.5.4 The minimum recommended alarms are as follows:-

Monitor	Item	Alarm
RPM	Engine revolution counter	(Overspeed protection device)
Oil pressure	Engine lubricating oil system	Alarm / low pressure
Oil pressure	Gearbox lubricating oil system	Alarm / low pressure (where applicable)
Temperature	Engine cooling water	Alarm / high temperature
Running time	Engine hour meter	(Incorporated RPM counter)
Charge / discharge	Engine start batteries	Alarm / ammeter / indicator
Charge / discharge	Service / emergency batteries	Alarm / ammeter / indicator
Air pressure	Starting air receivers	Alarm / low pressure
Capacity	Daily service O/F tank	Alarm / high / low level
Temperature	Engine exhaust gas	Indication gauges only

6.5.5 The instruments and gauges are to be clearly marked to indicate abnormal conditions. Where alarms are applicable they should be both audible and visual.

6.5.6 In vessels where controllable pitch propellers are fitted, a propeller pitch indicator is to be installed at the helm position.

6.5.7 Engine stop facility and speed/ahead and astern controls are to be fitted at the helm position.

## **Section 6.6 – Engine seatings, mounting and installation**

6.6.1 The seatings are to be suitable to withstand the maximum thrust and dynamic forces appropriate to the intended service of the vessel and hold the engine in place during all operating conditions.

6.6.2 Engine and shaft alignment is to be as stated by the Manufacturer.

6.6.3 Where the engine and gearbox is installed on flexible mountings, a flexible coupling is to be fitted between the engine/gearbox coupling and the propeller shafting. Care is to be taken to ensure that all connections to the engine are also flexible and will not be damaged by engine vibration and movement.

6.6.4 Engine mountings are to be protected from the possible detrimental effects of oil.

6.6.5 Solid mounting and alignment may be carried out using solid metal chocks under engine and gearbox feet and holding down bolt positions, or by the use of approved resin compounds.

- 6.6.6 Solid steel chocks are to be fitted by hand or machine grinding and be not less than 20mm in thickness. Pourable chocking compounds are to be used by approved personnel and to the Manufacturer's requirements.

## **Section 6.7 – Exhaust arrangement**

- 6.7.1 Exhaust pipes and silencers of all engines are to be adequately cooled or lagged. Oil and fuel pipes are to be kept as clear as practicable from exhaust pipes and turbochargers.
- 6.7.2 Exhaust systems are to be lagged with an approved fireproof material, and where the lagging may be oil absorbing or may permit the penetration of oil, the lagging is to be encased in thin gauge sheet metal or an equivalent protection. The lagging insulation is to be sufficient to prevent contact burn injury to personnel.
- 6.7.3 When dry type engine exhaust piping is fitted outside of machinery spaces or enclosed steel trunkings, contact with flammable materials is to be carefully avoided. The pipework is to be properly lagged and sealed to prevent accelerated corrosion, and all fixings and brackets are to be insulated to prevent the spread of heat to other surfaces.
- 6.7.4 Main engine and auxiliary set exhausts are to be fitted with the minimum number of bends possible, and the pipe is to be of a diameter as required by the engine Manufacturers. All joints are to be gas tight, and the piping system including silencer is to be adequately supported by hangers or brackets designed to allow for expansion and contraction.
- 6.7.5 The exhaust gas is to be dispersed so that it does not detrimentally affect the air cleaner function, the permitted maximum machinery space temperature, and the system must be so arranged as to prevent the entrance of water into the engine or turbo charger.
- 6.7.6 The exhaust pipe connection to the engine is to be made by the use of a flexible bellows arrangement, which may be mounted vertically or horizontally provided it is installed in a straight run of pipe without bends or offset.
- 6.7.7 Wet exhaust systems are to be cooled by the engine's circulating sea water, and are to be self-draining directly overboard. The pipe end is to be fitted with a corrosion-resistant shut-off flap arrangement to prevent water back-flooding the space or entering the engine exhaust manifold. In addition, a water trap or inverted 'U' bend type muffler arrangement is to be fitted in the system.
- 6.7.8 The wet exhaust pipework is to be of an approved marine type flexible rubber exhaust hose, adequately supported to the hull structure.
- 6.7.9 The exhaust outlet is to be sufficient distance from all intakes and ventilation positions to prevent exhaust gasses from re-entering the machinery space.

## **Section 6.8 – Machinery space ventilation**

- 6.8.1 The ventilation of the machinery space is to be adequate for all conditions of operation of the vessel and its machinery without the need for doors or escapes to be opened, and is to meet the requirements of the engine Manufacturers. Ventilation is to provide air for both combustion and cooling requirements. When auxiliary machinery is fitted, additional ventilation is to be provided to ensure sufficient air capacity for the efficient running of all items of machinery.
- 6.8.2 It is essential that the airflow is adequate and properly directed, with the air supply trunked or directed to as low a point as practical in the machinery space, and exhausted from ventilators positioned directly above the main heat sources. Supply air should not be directed towards hot engine components.
- 6.8.3 Where engine starting and lighting batteries are located in the machinery space, they are to be installed in adequate boxes ventilated to outside atmosphere in accordance with Part 8 of these Standards.
- 6.8.4 Ventilation arrangements are to meet the mandatory requirements of the Code, with respect to closing arrangements for fire protection purposes and coaming heights, and closing for weathertight integrity.
- 6.8.5 When electric supply/extraction fans are fitted, adequate means are to be provided for stopping the fans and closing the main inlet and outlet openings of the ventilation systems from a position outside the machinery space. A manual reset button is to be provided at each fan position to prevent accidental restarting from the control position when crew may be working in the vicinity of, or be maintaining, the ventilation fans.

## **Section 6.9 – Engine drive arrangements**

- 6.9.1 Where power 'take-offs' are fitted direct to main propulsion engines and gearboxes for the use of auxiliary driven equipment, the power to be taken off is not to exceed the engine or gearbox Manufacturers' permitted limits. Where clutch arrangements are fitted, they are to be of adequate capacity for the purpose intended and be operable from the engine control position.
- 6.9.2 Power take-off drives fitted to flexibly mounted engines are also to be flexibly mounted and positioned on seatings which are integral with the engine. A flexible coupling of adequate strength is to be fitted between the engine take-off shaft coupling and the driven shaft arrangement, except where the drive is integral with the engine.
- 6.9.3 Where a lay shaft is driven by a pulley and belt arrangement, the driven shaft is to be fitted with bearings of each side of the driver pulley. Drive arrangements to side shafts are to comply with the engine Manufacturer's requirements for permissible side loads.



- 6.9.4 Belt drives are to be arranged with a method of readily adjusting the belt tension; a separate tensioning arrangement is to be provided for each driven item.

### **Section 6.10 – Auxiliary engines**

- 6.10.1 Auxiliary engines are to be fitted to the best marine practice and with system requirements generally as required for main propulsion engines.
- 6.10.2 Auxiliary engines coupled to electrical generators are to be capable of developing the continuous power and speed required to drive the generator at the fully rated output (kW), and of developing an overload power requirement according to ISO/DIN Standards.
- 6.10.3 Each auxiliary engine is to be fitted with an overspeed protection device limiting the engine speed to no more than 15% above the normal running speed.
- 6.10.4 A separate fuel supply arrangement complete with approved duplex filters is to be provided for each auxiliary engine. A separate exhaust system is to be fitted for each engine and be installed as described for the main propulsion engine.
- 6.10.5 Equipment, which is belt driven from an auxiliary engine, is to have suitable arrangements to enable the belt tension to be adjusted for each item of driven equipment. When the driven equipment is not required to be continuously running, a clutch is to be fitted with local control. When the driven equipment is considered essential for safety and control of the vessel, the clutch arrangement should also be capable of remote control from the helm position.

### **Section 6.11 – Propeller, stern gear and shafting**

- 6.11.1 Details of the propeller shaft and intermediate shaft diameters, materials, and installation, are not to be less than that recommended by the stern gear and engine Manufacturer, but in no case less than that required by the formula contained in Paragraph 6.11.9.
- 6.11.2 Propeller shaft bearings, where not of the water lubricated type, are to be fitted with suitable greasing or oiling points positioned for easy access.
- 6.11.3 The distance between the shaft bearings must not be greater than that specified by the formula contained in Paragraph 6.11.11.
- 6.11.4 Where a shaft penetrates a watertight bulkhead, the watertight integrity and strength of the bulkhead is to be maintained.
- 6.11.5 The propeller is to be designed to permit the engine to run at its continuous rating without overload, and with tip clearance to Manufacturer's requirements.

- 6.11.6 The pitch control is to incorporate a stop to prevent over-pitching of the propeller blades at the maximum permitted revolutions and engine power. Where an adjustable pitch propeller is fitted, easy access to the adjustment point should be provided.
- 6.11.7 Suitable arrangements are to be provided for safe access to the stern gland and bearings. Adequate provision is to be made for renewal of stern gland packing.
- 6.11.8 Header tanks for oil-filled stern tubes are to be located in an accessible position, and be complete with level indication or contents gauge.
- 6.11.9 The propeller shaft diameter is to be to the engine Manufacturer's requirements for the engine maximum continuous rating, but in no case less than the minimum diameter required by the following formula:-

$$\text{Required shaft diameter } dp = 100k\sqrt[3]{f}$$

$$\text{where } f = \frac{P}{R} \times \left( \frac{560}{t + 160} \right)$$

$k = 1.22$  where:-

- (i) the propeller is keyless or attached to an integral flange on the shaft; and
- (ii) the shaft is fitted with a continuous liner, or is made from corrosion-resistant material, or is oil lubricated and sea water is excluded from the shaft.

$k = 1.26$  where the propeller is keyed and where note (ii) applies.

$k = 1.30$  where the shaft is of non corrosion-resistant material.

$P =$  power transmitted by the shaft in kW.

$R =$  revolutions per minute of the propeller shaft.

$t =$  specified minimum tensile strength of the material in N/mm<sup>2</sup>.

- 6.11.10 In the case of vessels with long shaft lines, (e.g. with engine sited forward) requiring intermediate shafts to be fitted, the diameter of the intermediate shaft is to be calculated by the formula above excepting that:-

$k = 1.0$  for shafts with integral couplings, flanges or shrunk-on couplings.

$k = 1.0$  for shafts with splines where ' $d$ ' is to be the diameter at the root of the splines.

$k = 1.10$  for shafts with keyways.

$k = 1.20$  for shafts with longitudinal slots having a length of not more than  $1.4d$  and a width of not more than  $0.2d$ , where ' $d$ ' is determined taking ' $k$ ' as 1.0.

- 6.11.11 The distance between the propeller shaft supports (bearings) must not be greater than that specified given by the following formula:-

$$S = 0.142 \times \sqrt[3]{d^2}$$

where 'S' = distance between bearing centres in metres  
'd' = diameter of shaft in millimetres.

## **Section 6.12 – Rudders**

The following requirements are in accordance with the statutory requirements as detailed in the MCA "Code of Safe Working Practice for the Construction and Use of Fishing Vessels 15m Length Overall to Less Than 24m Registered Length" or with any additional statutory requirements subsequently coming into force.

- 6.12.1 Rudders may be of steel, stainless steel or aluminium construction, and of a design strength and area compatible with the size and power of the vessel.
- 6.12.2 Rudders of metal may be either single or double plate type. Blade thickness is to be as determined in accordance with Table 6.14.1. Double plate rudders are to be constructed watertight and fitted with a drain plug. Such rudders may be filled with an approved internal coating or filling. The side plating of double plate rudders are each to be a minimum of 75% of the thickness required for single plate rudders.
- 6.12.3 Steel rudder stocks are to be in accordance with Table 6.14.1 and are to be fitted with welded and keyed or spigoted coupling flanges. The stock is to be continuous from the coupling to the lower pintle.
- 6.12.4 Table 6.14.1 is for balanced and semi-balanced rudders supported with a lower (pintle) bearing in the skeg or stern frame extension, and with an upper bearing fitted at the hull position.
- 6.12.5 The upper or hull bearing is to be fitted with an accessible and adjustable watertight gland, fitted above the waterline where practicable.
- 6.12.6 Rudder bearings are to be fitted with a sleeve and bush of compatible materials, and bearings are to be securely locked in place. Means are to be provided for removal of bearings.
- 6.12.7 Where the weight of the rudder is supported at the top by a carrier, the seating for the carrier bearing is to be stiffened locally to the approval of the Surveyor.
- 6.12.8 Double plate rudders of welded steel or aluminium alloy construction in excess of 600mm deep, are to be fitted with an internal web plate welded to the stock, and welded to each side plate by means of slot or plug welds. The thickness of the web plate is to be that required for single

plate rudders. Where an alternative method of construction is proposed, details are to be submitted for consideration.

- 6.12.9 Rudder coupling bolts are to be of the fitted type, and are to be provided with locking arrangements. For dimensions of coupling flanges and bolts see Table 6.14.1.
- 6.12.10 Where the arrangement of the rudder and stock allows an excessive vertical movement, a removable jumping collar is to be fitted above the rudder coupling flange to prevent the stock lifting out of the pintle bearing, and to avoid contact with the shell by the upper edge of the rudder or coupling.
- 6.12.11 Proposals for active/semi-active rudders are to be submitted for consideration.

### **Section 6-13 – Steering gear**

- 6.13.1 Every vessel should be provided with a main steering gear and an auxiliary means of actuating the rudder to the satisfaction of the Certifying Authority.
- 6.13.2 The main steering gear and the auxiliary means of actuating the rudder should be arranged so that as far as is reasonable and practicable a single failure in one of them will not render the other one inoperative. If electrical power is lost in the wheelhouse, the auxiliary steering should remain operable.
- 6.13.3 In every vessel:
  - i) the main steering gear including any rudder, stock, tiller and associated fitting should be of adequate strength and capable of steering the vessel at the maximum ahead service speed and should be so designed that they are not damaged at maximum astern speed or in any other operating condition;
  - ii) the auxiliary means of steering should be capable of being brought rapidly into action and should enable the vessel to be steered at a navigable speed.
- 6.13.4 The main steering gear should be capable of turning the rudder from 35 degrees on one side to 35 degrees on the other in 30 seconds when the vessel is at navigable speed and from 20 degrees on one side to 20 degrees on the other in 30 seconds when the vessel is at maximum ahead service speed, with the rudder totally submerged.

Every vessel should have a rudder position indicator in the wheelhouse.

### **Vessels fitted with steering devices other than rudders**

- 6.13.5 If a vessel is fitted with a steering device other than a rudder, the construction and operation of such a device should be adequate and suitable for its intended purpose.

### **Electrical and electro-hydraulic steering gear**

- 6.13.6 Where electrical or electro-hydraulic steering gear is fitted, indicators should be provided which will show when the power units of such steering gear are in operation. These indicators should be situated in the machinery control room or other suitable position and in the wheelhouse.
- 6.13.7 Where electrical power is the only source of power for steering, in the event of electrical systems failure, either of the following provisions should be available for emergency steering:
- i) a portable tiller arm that can mount on the top of the rudder stock and be operated by a block and tackle system; or
  - ii) a hand pump powered by a hydraulic system with direct connection via a hydraulic ram to the tiller arm (this may be a helm-mounted pump within the steering system).
- 6.13.8 An efficient form of communication between the main control position and the emergency steering position should be provided.
- 6.13.9 Each circuit should be adequate for the most severe load condition; short circuit protection only should be provided.

## 6.14 Tables

### 6.14.1 Rudders and steering

Table below is for mild steel plate and bar.

Where stainless steel is to be used the grade is to be 316L.

#### Steel

Scantling numeral	Stock diameter mm	Blade thickness mm
100	48	10
150	50	10
200	65	12
250	70	12
300	75	12
400	85	12
500	90	12
600	95	15
700	100	20
800	110	20

#### Aluminium alloy

Scantling numeral	Stock diameter mm	Blade thickness mm
100	60.4	12.7
150	60.4	12.7
200	82.6	15
250	88.9	15
300	95.3	15
400	108	15
500	114.3	15
600	114.3	19.1
700	120.7	25.4
800	133.4	25.4

Refer to Notes on following page.

## 6.14 Tables

### 6.14.1 Rudders and steering (continued)

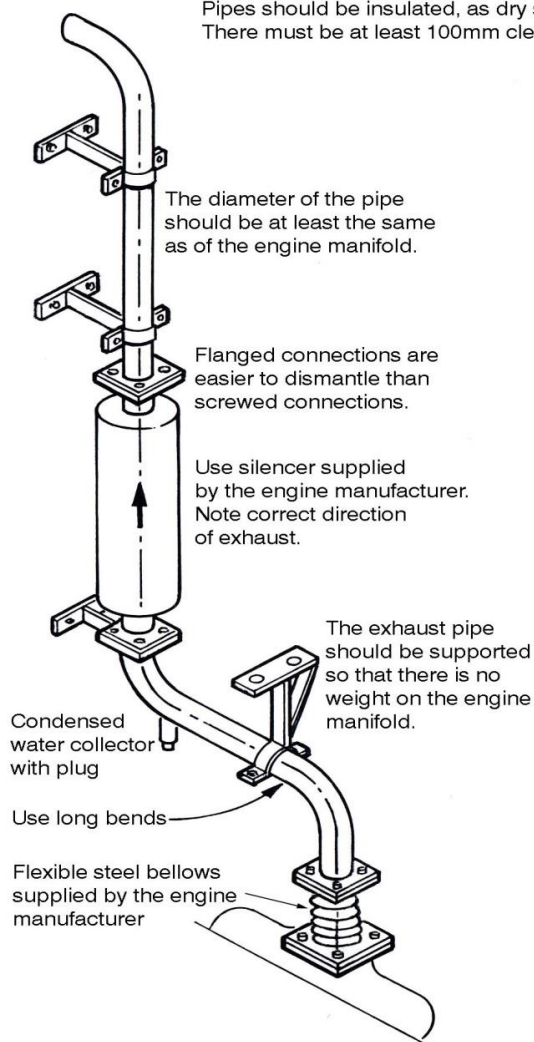
Notes:-

- 1) The diameter of the coupling bolts is to be not less than  $d = 0.65 \times \frac{ds}{\sqrt{n}}$   
Where  $d$  = bolt diameter;  $ds$  = diameter of stock;  $n$  = number of bolts (minimum of 4).
- 2) The pitch circle diameter of the rudder coupling bolts is to be a minimum of twice the diameter of the rudderstock.
- 3) The coupling flange thickness is to be not less than 0.25 times upper stock diameter.
- 4) Where higher tensile steels are proposed for rudderstocks of reduced diameters from those listed above, details are to be submitted for approval.
- 5) Double plate rudders are to be constructed watertight and fitted with a drain plug. Such rudders may be filled with an approved internal coating or filling. The side plating of double plate rudders are each to be a minimum of 75% of the thickness required for single plate rudders.
- 6) Vessels which exceed the scantling numeral of the tables are to provide for approval, drawings of rudder/steering arrangements, and details of formulas used for the determination of scantlings prior to construction.

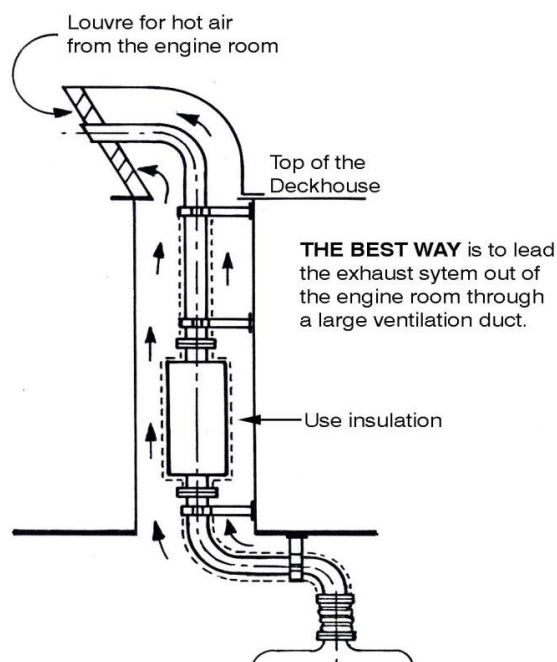
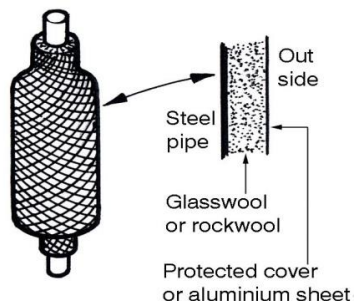
## 6.15 Figures and illustrations

### 6.15.1 Dry exhaust system

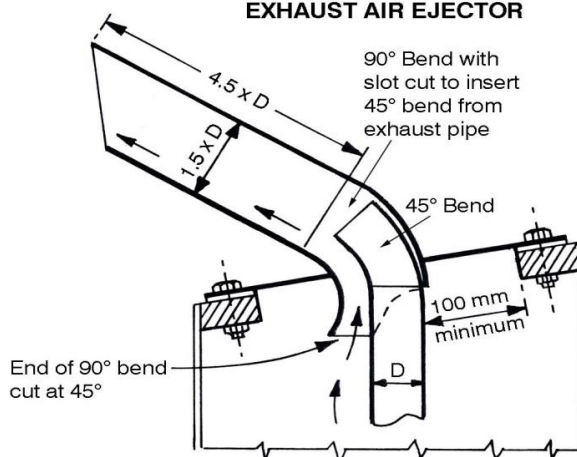
The exhaust system and piping should be leakproof to prevent toxic fumes from fouling the accommodation spaces.  
Pipes should be insulated, as dry system gets very hot.  
There must be at least 100mm clearance for any wood or FRP material.



#### INSULATION



#### EXHAUST AIR EJECTOR



The ejector will suck warm air from the engine room and improve ventilation considerably. Based on recommendations from Caterpillar Diesels Ltd.