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Shipbuilding — Engine-room ventilation in diesel-engined ships — Design requirements and basis of calculations

Construction navale — Ventilation du compartiment machines des navires à moteurs diesels — Exigences de conception et bases de calcul

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 8861 was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 3, *Piping and machinery*.

This second edition cancels and replaces the first edition (ISO 8861:1988), of which it constitutes a technical revision.

Annex A of this International Standard is for information only.

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Shipbuilding — Engine-room ventilation in diesel-engined ships — Design requirements and basis of calculations

1 Scope

This International Standard specifies design requirements and suitable calculation methods for the ventilation of the engine room in diesel-engined ships, for normal conditions in all waters.

Annex A provides guidance and good practice in the design of ventilation systems for ships' engine rooms.

NOTE — Users of this International Standard should note that, while observing the requirements of the standard, they should at the same time ensure compliance with such statutory requirements, rules and regulations as may be applicable to the individual ship concerned.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 31-1:1992, *Quantities and units — Part 1: Space and time*.

ISO 31-3:1992, *Quantities and units — Part 3: Mechanics*.

ISO 31-4:1992, *Quantities and units — Part 4: Heat*.

ISO 3046-1:1995, *Reciprocating internal combustion engines — Performance — Part 1: Standard reference conditions, declarations of power, fuel and lubricating oil consumptions, and test methods*.

ISO 3258:1976, *Air distribution and air diffusion — Vocabulary*.

3 Definitions

For the purposes of this International Standard, the definitions given below, together with those in ISO 31-1, ISO 31-3, ISO 31-4, ISO 3046-1 and ISO 3258, apply.

3.1 engine room: Space containing main propulsion machinery, boiler(s), diesel generator(s) and major electrical machinery, etc.

3.2 ventilation: Provision of air to an enclosed space to meet the needs of the occupants and/or the requirements of the equipment therein.

3.3 service standard power: The continuous brake power which the engine manufacturer declares that an engine is capable of delivering, using only the essential dependent auxiliaries, between the normal maintenance intervals stated by the manufacturer and under the following conditions:

a) at a stated speed at the ambient and operating conditions of the engine application;

b) with the declared power adjusted or corrected as determined by the manufacturer to the stated ambient and operating conditions of the engine application;

c) with the maintenance prescribed by the engine manufacturer being carried out. [ISO 3046-1:1995]

See A.1 in annex A of ISO 3046-1:1995.

4 Design conditions

The outside ambient air temperature shall be taken as + 35 °C.

Temperature rise from air intake to air passing from the engine room up to the casing entrance shall be max. 12,5 K.

The capacity of the ventilation plant should be such as to provide comfortable working conditions in the engine room, to supply the necessary combustion air to the diesel engine(s) and boiler(s), and to prevent heat-sensitive apparatus from overheating.

In order to meet these requirements, the air should be distributed to all parts of the engine room, so that pockets of stagnant hot air are avoided. Special considerations should be given to areas with great heat emission and to all normal working areas, where reasonably fresh and clean outdoor air should be provided through adjustable inlet devices.

When arranging the air distribution, all normal conditions at sea and in harbour for in-service machinery shall be taken into account.

5 Airflow calculation

5.1 Total airflow

The total airflow Q to the engine room shall be at least the larger value of the two following calculations.

a: $Q = q_c + q_h$ as calculated according to 5.2 and 5.3 respectively.

b: $Q = 1{,}5 \times q_c$, i.e. the airflow for combustion + 50 %. The total airflow to the engine room shall not be less than the airflow for combustion [engine(s) and boiler(s)] plus 50 %.

Combustion air to, and heat emission from, all equipment installed within the casing and funnel shall not be taken into account.

The calculations shall be based on simultaneous maximum rating of main propulsion diesel engine(s), diesel generator engine(s), boiler(s) and other machinery under normal sea conditions, and on a temperature increase of 12,5 K.

The calculations should, to the greatest possible extent, be based on information from the manufacturers. Guidance values given in this International Standard should be used only when manufacturers' information is not available.

In order to ensure satisfactory air distribution, combustion air to, and heat emission from, main propulsion diesel engine(s), diesel generator engine(s), generator(s), boiler(s), and possibly other machinery with considerable heat emission, shall be calculated separately including other conditions as necessary.

Spaces separated from the main engine room, such as individual auxiliary engine rooms, boiler rooms and separator rooms, shall also be calculated separately.

5.2 Airflow for combustion

5.2.1 Sum of airflow for combustion

The sum of the airflow for combustion, q_c, shall be calculated, in cubic metres per second, as follows:

$$q_c = q_{dp} + q_{dg} + q_b$$

where

q_{dp} is the airflow for combustion for main propulsion diesel engine(s), in cubic metres per second (see 5.2.2);

q_{dg} is the airflow for combustion for diesel generator engine(s), in cubic metres per second (see 5.2.3);

q_b is the airflow for combustion for boiler(s), in cubic metres per second (see 5.2.4), if relevant under normal sea conditions.

5.2.2 Airflow for combustion for main propulsion diesel engine(s)

The airflow for combustion for the main propulsion diesel engine(s), q_{dp}, shall be calculated, in cubic metres per second, as follows:

$$q_{dp} = \frac{P_{dp} \times m_{ad}}{\rho}$$

where

P_{dp} is the service standard power of the main propulsion diesel engine(s) at maximum continuous power output, in kilowatts;

m_{ad} is the air requirement for combustion for diesel engine(s), in kilograms per kilowatt second;

NOTE — Where specific data for m_{ad} are not available, the following values may be used for calculation:

m_{ad} = 0,002 3 kg/(kW·s) for 2-stroke engines,
0,002 0 kg/(kW·s) for 4-stroke engines.

ρ = 1,13 kg/m^3 (i.e. the density of air, at + 35 °C, 70 RH and 101,3 kPa).

5.2.3 Airflow for combustion for diesel generator engine(s)

The airflow for combustion for diesel generator engine(s), q_{dg}, shall be calculated, in cubic metres per second, as follows:

$$q_{dg} = \frac{P_{dg} \times m_{ad}}{\rho}$$

where

P_{dg} is the service standard power of the diesel generator engine(s) at maximum power output, in kilowatts;

m_{ad} is the air requirement for diesel engine combustion, in kilograms per kilowatt second;

NOTE — Where specific data for m_{ad} are not available, the following values may be used for calculation:

m_{ad} = 0,002 3 kg/(kW·s) for 2-stroke engines,
0,002 0 kg/(kW·s) for 4-stroke engines.

ρ = 1,13 kg/m^3 (i.e. the density of air, at + 35 °C, 70 % RH and 101,3 kPa).

5.2.4 Airflow for combustion for boilers and thermal fluid heaters

The airflow for combustion for boiler(s), q_b, shall be calculated, in cubic metres per second, as follows:

In a case where the total steam capacity of a boiler is known, the following formula is used:

$$q_b = \frac{m_s \times m_{fs} \times m_{af}}{\rho}$$

In a case where the capacity of a boiler or a thermal fluid heater is known in kilowatts, the following formula is used:

$$q_b = \frac{Q \times m_{fs} \times m_{af}}{\rho}$$

where

Q is the maximum continuous rating of the boiler(s), in kilowatts;

m_s is the total steam capacity (maximum continuous rating) of the boiler(s), in kilograms per second;

m_{fs} is the fuel consumption, in kilograms of fuel per kilogram of steam, or in kilograms of fuel per second per kilowatt of thermal capacity;

NOTE — Where specific data are not available, m_{fs} = 0,077 kg/kg may be used for the calculation if the steam capacity is known. If the thermal capacity is known, m_{fs} = 0,11 kg s^{-1} kW^{-1} may be used.

m_{af} is the air requirement for combustion, in kilograms of air per kilogram of fuel;

NOTE — Where specific data are not available, m_{af} = 15,7 kg/kg may be used for calculation.

ρ = 1,13 kg/m^3 (i.e. the density of air, at + 35 °C, 70 % RH and 101,3 kPa).

5.3 Airflow for evacuation of heat emission

The sum of the airflow necessary for heat evacuation, q_h, shall be calculated, in cubic metres per second, as follows:

$$q_h = \frac{\phi_{dp} + \phi_{dg} + \phi_b + \phi_p + \phi_g + \phi_{el} + \phi_{ep} + \phi_t + \phi_o}{\rho \times c \times \Delta T} - 0,4\,(q_{dp} + q_{dg}) - q_b$$

where

ϕ_{dp} is the heat emission from main propulsion diesel engine(s), in kilowatts (see 6.1);

ϕ_{dg} is the heat emission from diesel generator engine(s), in kilowatts (see 6.2);

ϕ_b is the heat emission from boilers and thermal fluid heaters, in kilowatts (see 6.3);

ϕ_p is the heat emission from steam and condensate pipes, in kilowatts (see 6.4);

ϕ_g is the heat emission from electrical air-cooled generator(s), in kilowatts (see 6.5);

ϕ_{el} is the heat emission from electrical installations, in kilowatts (see 6.6);

ϕ_{ep} is the heat emission from exhaust pipes including exhaust gas-fired boilers, in kilowatts (see 6.7);

ϕ_t is the heat emission from hot tanks, in kilowatts (see 6.8);

ϕ_o is the heat emission from other components, in kilowatts (see 6.9);

q_{dp} is the airflow for main propulsion diesel engine combustion, in cubic metres per second (see 5.2.2);

q_{dg} is the airflow for diesel generator engine combustion, in cubic metres per second (see 5.2.3);

q_b is the airflow for boiler combustion, in cubic metres per second (see 5.2.4);

ρ = 1,13 kg/m^3 (i.e. the density of air, at + 35 °C, 70 % RH and 101,3 kPa);

c = 1,01 kJ/(kg·K) (the specific heat capacity of the air);

ΔT = 12,5 K (the increase of the air temperature in the engine room i.e. the difference between inlet and outlet temperature measured at design conditions. The outlet temperature shall be measured at the outlet from engine room to casing or funnel without heat-sensitive installations).

The factor 0,4 is based on the usual arrangements of engine room and ventilation ducts. In a case of special arrangements, the value of the factor should be considered.

6 Calculation of heat emission

6.1 Heat emission from main propulsion diesel engine(s)

The heat emission from main propulsion diesel engine(s), ϕ_{dp}, shall be taken, in kilowatts, as follows:

$$\phi_{dp} = P_{dp} \times \frac{\Delta h_d}{100}$$

where

P_{dp} is the service standard power of the main propulsion diesel engine(s) at maximum continuous rating, in kilowatts;

Δh_d is the heat loss from the diesel engine(s), in percentage.

NOTE — Where specific data are not available, ϕ_{dp} according to 7.1 may be used for calculation.

6.2 Heat emission from diesel generator engine(s)

The heat emission from diesel generator engine(s), ϕ_{dg}, shall be taken, in kilowatts, as follows:

$$\phi_{dg} = P_{dg} \times \frac{\Delta h_d}{100}$$

where

P_{dg} is the service standard power of the diesel generator engine(s) at maximum continuous rating, in kilowatts;

Stand-by units are not to be included.

Δh_d is the heat loss from the diesel engine(s), in percentage.

NOTE — Where specific data are not available, ϕ_{dg} according to 7.1 may be used for calculation.

6.3 Heat emission from boiler(s) and thermal fluid heater(s)

NOTE — For heat emission from exhaust gas-fired boiler(s) and exhaust pipes see 6.7.

The heat emission from boiler(s) and thermal fluid heater(s), ϕ_b, shall be calculated, in kilowatts, as follows:

In the case when the total steam capacity of a boiler is known, the following formula is used:

$$\phi_b = m_s \times m_{fs} \times h \times \frac{\Delta h_b}{100} \times B_1$$

In the case when the demand for heat is covered by a thermal fluid heater or the capacity of a boiler is known in kilowatts, the following formula is used:

$$\phi_b = Q \times B_1 \times \frac{\Delta h_b}{100}$$

where

m_s is the total steam capacity, in kilograms per second;

m_{fs} is the fuel consumption, in kilograms of fuel per kilogram of steam;

NOTE — Where specific data are not available, m_{fs} = 0,077 kg/kg may be used for calculation.

h is the lower calorific value of the fuel, in kilojoules per kilogram;

NOTE — Where specific data are not available, h = 40,200 kJ/kg may be used for calculation.

Δh_b is the heat loss, in percentage, at the maximum continuous rating of the boiler or thermal fluid heater;

NOTE — Where specific data are not available, data according to 7.2 may be used for calculation.

B_1 is a constant that applies to the location of the boiler(s) and other heat exchangers in the engine room (refer to text in 6.7 for value of B_1);

Q is the maximum continuous rating of the thermal fluid heater or boiler in kilowatts.

6.4 Heat emission from steam and condensate pipes

The heat emission from steam and condensate pipes, ϕ_p, shall be calculated, in kilowatts, as follows:

$$\phi_p = m_{sc} \times \frac{\Delta h_p}{100}$$

where

m_{sc} is the total steam consumption, in kilowatts (1 kW ~ 1,6 kg/h of steam);

Δh_p is the heat loss from steam and condensate pipes, in percentage of the steam consumption in kilowatts.

NOTE — Where specific data are not available, Δh_p = 0,2 % may be used for calculation.

6.5 Heat emission from electrical generator(s)

The heat emission from air-cooled generator(s), ϕ_g, shall be calculated, in kilowatts, as follows:

$$\phi_g = P_g \left(1 - \frac{\eta}{100}\right)$$

where

P_g is the power of installed air-cooled generator(s), in kilowatts (stand-by sets shall be ignored);

η is the generator efficiency, in percentage.

NOTE — Where specific data are not available, η = 94 % may be used for calculation.

6.6 Heat emission from electrical installations

The heat emission from electrical installations, ϕ_{el}, shall be calculated, in kilowatts, in accordance with one of the following two alternative methods in descending order of preference:

a) where full details of the electrical installations are known, the heat emission shall be taken as the sum of the simultaneous heat emission; or

b) for conventional ships where full details of the electrical installations are not known, the heat emission is taken as 20 % of the rated power of the electrical apparatus and lighting that are in use at sea.

6.7 Heat emission from exhaust pipes and exhaust gas-fired boiler(s)

The heat emission from exhaust pipes and exhaust gas-fired boiler(s) may be determined from the curves in 7.3, in kilowatts per metre of pipe.

If specific figures are not available, Δt = 250 K may be used for 2-stroke engines and Δt = 320 K for 4-stroke engines.

Exhaust gas pipes and exhaust gas-fired boiler(s) situated in the casing and funnel shall not be taken into account.

If a case of exhaust gas boiler(s) placed directly below exposed casing exists, the same factor B_1 = 0,1 as in 6.3 is to be used.

6.8 Heat emission from hot tanks

The heat emission from hot tanks, ϕ_t, in kilowatts, shall be based on the sum of the hot tank surfaces contiguous with the engine room, using the values given in table 1.

Table 1 — Heat emission from hot tanks

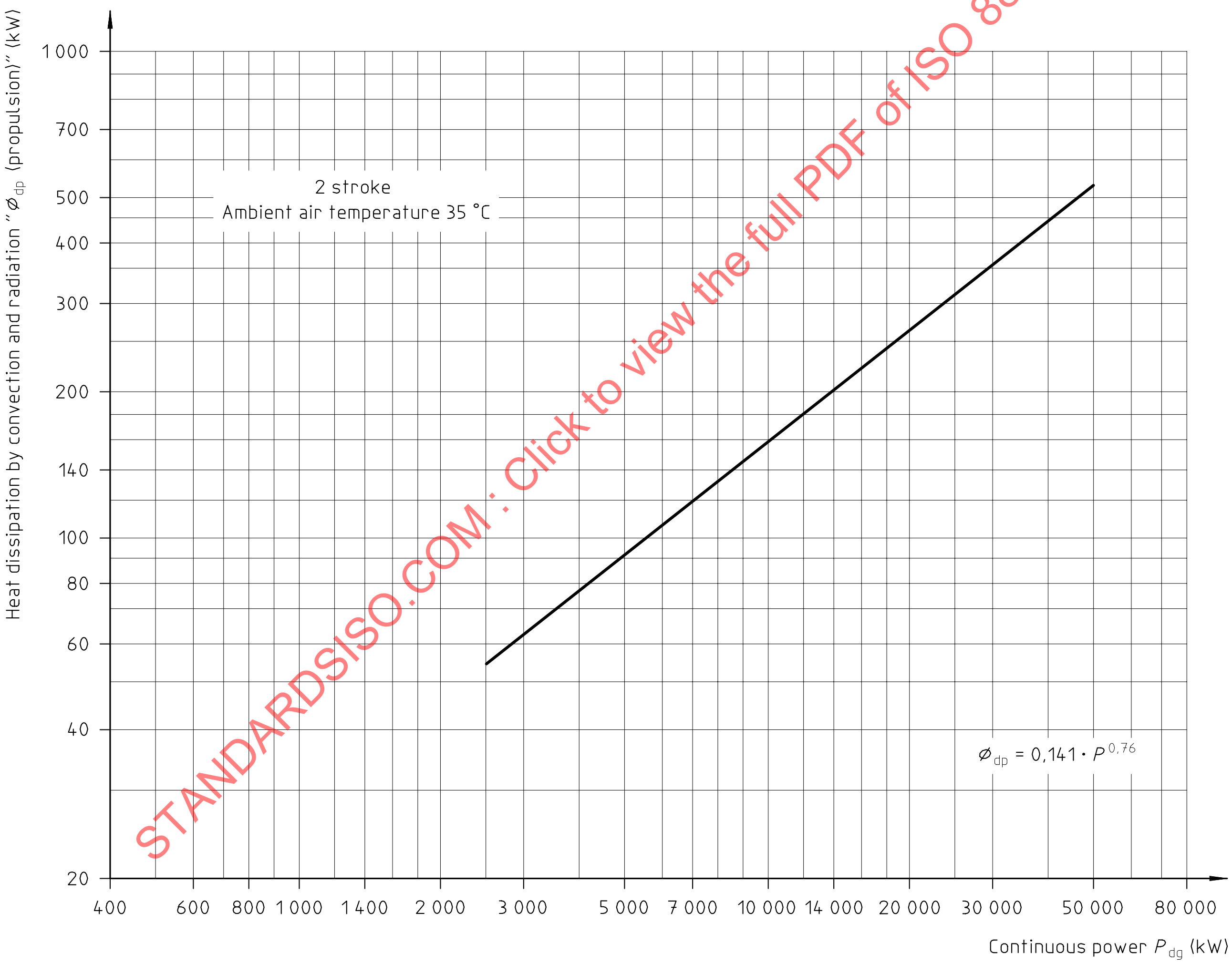
Tank surface	Heat emission, ϕ_t, in kW/m^2 at a tank temperature of				
	60 °C	70 °C	80 °C	90 °C	100 °C
Uninsulated	0,14	0,234	0,328	0,42	0,515
Insulation 30 mm	0,02	0,035	0,05	0,06	0,08
Insulation 50 mm	0,01	0,02	0,03	0,04	0,05

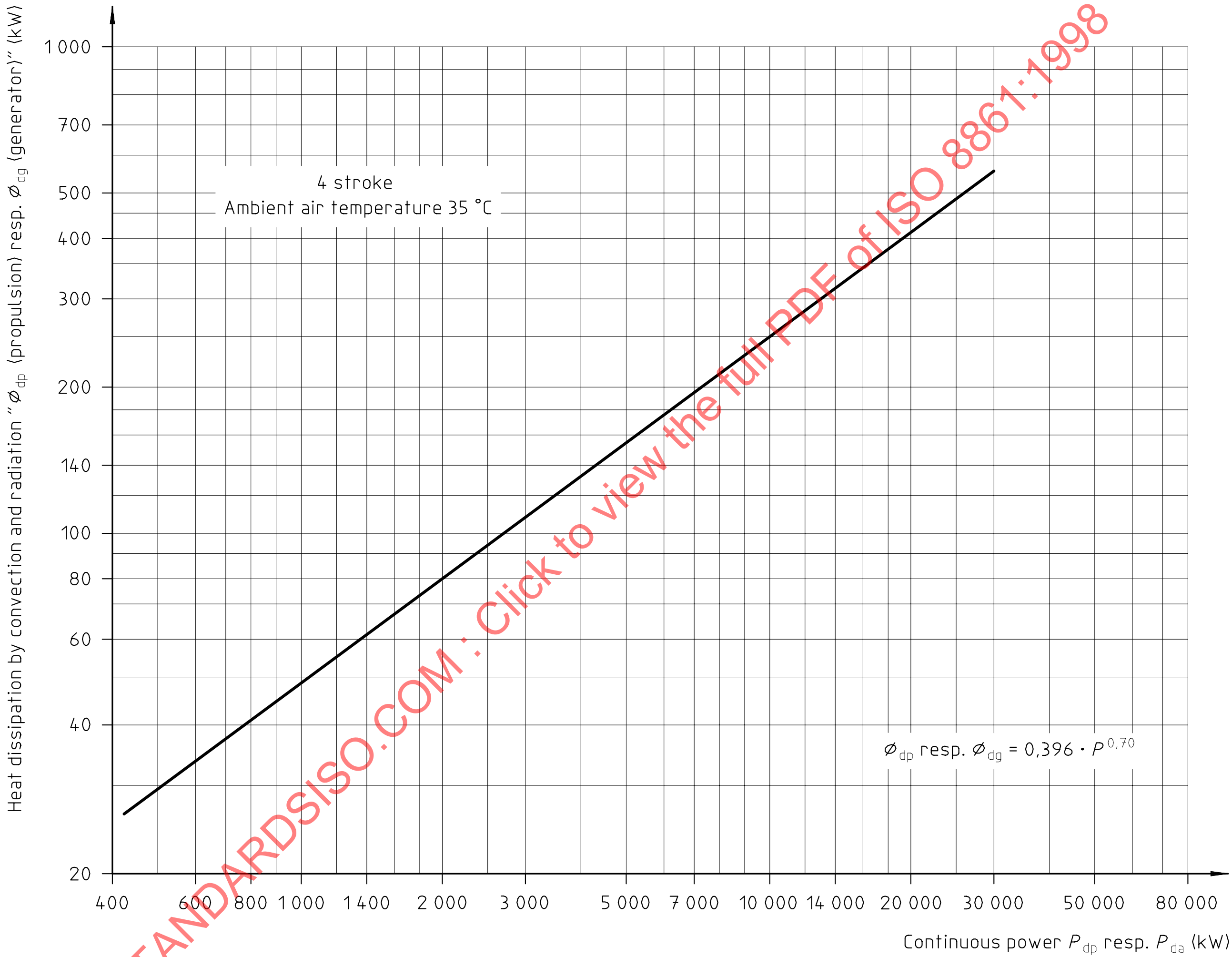
6.9 Heat emission from other components

The heat emission from other components, ϕ_o, in kilowatts, e.g. compressor(s), steam, turbine(s), reduction gear(s), separator(s), heat exchanger(s), piping and hydraulic system(s), shall be included when calculating the sum of the airflow for evacuation of heat emission.

7 Graphs

7.1 Heat loss in percentage from diesel engine based on service standard power of engine




Heat dissipation by convection and radiation "Ø dp (propulsion) resp. Ø dg (generator)" (kW)
1 000
700
500
400
300
200
140
100
80
60
40
20
4 stroke
Ambient air temperature 35 °C
Ø dp resp. Ø dg = 0,396 · P 0,70
400
600
800
1 000
1 400
2 000
3 000
5 000
7 000
10 000
14 000
20 000
30 000
50 000
80 000
Continuous power P dp resp. P da (kW)

7.2 Heat loss in percentage of maximum continuous rating of boilers (kg/s) and thermal fluid heaters (kW)