VI Additional Rules and Guidelines

3 Machinery Installations

7 Guidelines for the Design, Construction and Testing of Pumps
The following Guidelines come into force on 1 May 2013.

Alterations to the preceding Edition are marked by beams at the text margin.

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## Annex A Illustration of Principles of Pumps
Section 1 General

A Scope
The following Guidelines apply to the design, construction and testing of pumps for the handling of liquids. The application of these Guidelines covers pumps whose capacity in accordance with the GL Rules for Machinery Installations (I-1-2), Section 11, D have to be verified in the manufacturer’s works as well as pumps and motors of hydraulically operated systems in accordance with GL Rules for Machinery Installations (I-1-2), Section 14.

These Guidelines may be similarly applied to other pumps as appropriate.

B Definition
For the purpose of these Guidelines, liquid pumps include:
- rotodynamic pumps
- side channel pumps
- rotary and oscillating positive displacement pumps
- liquid ejectors

For pumps of other designs, the requirements are to be agreed on a case to case basis.

C Documents to be Submitted
In the case of pumps for handling liquid gases, dangerous chemicals and liquid foodstuffs, sectional drawings together with details relating to the proposed materials and operating conditions are to be submitted electronically via GLOBE or in paper form in triplicate to the GL Head Office for approval. GLOBE submission is the preferred option.

Approval of drawings is not normally required for other pumps.

In individual cases and depending on the design and application the Society does, however, reserve the right to call for the documentation necessary to an assessment of the pump in question.

D Prototype testing of cargo pumps used for liquefied gases

D.1 Each size and type of pump is to be approved through design assessment and prototype testing. Prototype testing is to be witnessed in the presence of a GL-Surveyor. Based on satisfactory test results GL may issue an approval certificate for respective pump type.

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1 Detailed information about GLOBE submission can be found on GL’s website www.gl-group.com/globe
In lieu of prototype testing, satisfactory in-service experience of an existing pump design approved by a recognized body submitted by the manufacturer may be considered.

D.2 Prototype testing is to include hydrostatic test of the pump body equal to 1.5x design pressure and a capacity test. For submerged electric motor driven pumps, the capacity test is to be carried out with the design medium or with a medium below the minimum working temperature. For shaft driven deep well pumps, the capacity test may be carried out with water. In addition, for shaft driven deep well pumps, a spin test to demonstrate satisfactory operation of bearing clearances, wear rings and sealing arrangements is to be carried out at the minimum design temperature. The full length of shafting is not required for the spin test, but must be of sufficient length to include at least one bearing and sealing arrangements. After completion of tests, the pump is to be opened up for examination in the presence of a GL-Surveyor.
A.1 Approved materials

The materials of the pump components shall be suitable for the proposed applications. They are to be selected with due regard to the operating conditions and the nature of the liquid to be handled. The Rules for Materials issued by GL are to be observed. These Rules apply analogously to pressurized parts attached to the pumps.

Where the working temperature \( t_{zul} \) of the liquid to be pumped is \( \leq -10 ^\circ C \), the choice of materials is subject to the requirements of GL-Rules for Steel and Iron Materials (II-1-2).

Where dangerous chemicals are to be pumped, evidence is to be supplied to GL attesting the suitability of the materials used.

A.2 Requirements on material manufacturers

Casings for pumps intended to be used for piping systems of pipe class I and II shall be manufactured by GL approved manufacturers. For the use in pipe class III piping systems an approval according to other recognized standards may be accepted.

A.3 Limits on the application of materials for pump casings

A.3.1 Cast iron with lamellar graphite (at least EN-GJL-200)

max. allowable working temperature \( t_{zul} \) \( \leq 200 ^\circ C \)

max. allowable working pressure \( p_{e,zul} \) \( \leq 16 \text{ bar} \)

Limitations:

a) for boiler water \( p_{e,zul} \) \( \leq 10 \text{ bar} \)

b) for liquid fuels, lubricating oil \( t_{zul} \) \( \leq 60 ^\circ C \)

for flammable hydraulic fluid \( p_{e,zul} \) \( \leq 7 \text{ bar} \)

Not permitted:

a) for casings of circulating pumps for heat-transfer oil

b) for casings of pumps for handling of dangerous chemicals

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1 See GL-Rules for Machinery Installations (I-1-2), Section 11, Table 11.1.
A.3.2  Nodular cast iron (Elongation $A_5$ at least 12 %)

max. allowable working temperature $t_{zul} \leq 300 \, ^\circ C$ for nodular cast iron in normal quality

max. allowable working temperature $t_{zul} \leq 350 \, ^\circ C$ for nodular cast iron in special quality according to GL Rules for Steel and Iron Materials (II-1-2), Section 5, acceptable for casings of circulating pumps for heat-transfer oil

A.3.3  Steel and cast steel for general applications

max. allowable working temperature $t_{zul} \leq 300 \, ^\circ C$

A.3.4  Cast copper alloys

max. allowable working temperature $t_{zul} \leq 200 \, ^\circ C$ for copper and aluminium brass,

max. allowable working temperature $t_{zul} \leq 300 \, ^\circ C$ for copper nickel alloys

A.3.5  Aluminium casting alloys

max. allowable working temperature $t_{zul} \leq 200 \, ^\circ C$ with the approval of the GL.

A.3.6  Plastics

The use of plastics requires the approval of GL in the individual case of application.

A.4  Casing repairs

Casting defects in pump casings may be repaired only by recognized methods. The GL-Surveyor is to be notified prior to the execution of the repair.

B  Protection Against Excessive Pressure

B.1  Rotodynamic pumps must be so designed that they can be operated for a short time without damage even with the discharge line closed.

B.2  Positive displacement pumps must be protected against excessive pressure increases in the pump casing by fitting relief valves which cannot be adjusted to the closed position.

B.3  Pumps which do not clearly conform to one of these two designs must comply with requirement B.1 or B.2.

C  Rated Output of Prime Mover

C.1  General requirements

The rated output of the prime mover is to be determined in such a way as to ensure the reliable operation of the pump under all anticipated operating conditions. It is required to be compatible with the mode of operation, the characteristic curve of the pump and with the properties of the liquid to be pumped.

C.2  Prime movers for rotodynamic pumps

By the way of a guide, the following values can, for example, normally be regarded as adequate in the case of rotodynamic pumps intended for operation in closed piping systems, e.g. fresh cooling water systems, brine systems, thermal oil systems:
Prime mover for pumps intended for operation in open piping systems, e.g. fire and emergency fire systems, ballast and bilge systems shall be rated for the entire capacity range of the pump. Unrestricted operation is to be ensured including direct (non throttled) discharge over board at maximum inlet head (max. draught). The rated output of the prime mover shall include a reserve power of not less than 10 %.

C.3 Prime movers for positive displacement pumps
Prime movers of positive displacement pumps shall be rated for short circuit operation at maximum viscosity, i.e. the total flow is returned to the suction side via the relief valve.

D Branches, Connections
As far as possible, inlet and outlet branches shall be designed for the same rated pressure. Pipe connections are to be executed in such a manner that no unpermissible forces and moments are exerted on the pump.

E Circulating Pumps for Heat-Transfer Oil
The shaft sealing of circulating pumps for heat-transfer oil must be so designed that oil leakage cannot occur in an unacceptable manner and unacceptable leakage rate. For shaft seals and/or bearings fitted with a cooling system the circulation flow is to be monitored.

F Emergency Fire Pumps
Emergency fire pumps shall be of self-priming type or be equipped with additional suction aid. For emergency fire pumps installed above the water line in light condition of the ship, the \( NPSH^2 \) of the pump \( (NPSH_{\text{req}}) \) should be about 1 m lower than the \( NPSH \) value of the plant \( (NPSH_a) \). Details for determining \( NPSH_a \) are given in Fig. 2.1.

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**Table:**

<table>
<thead>
<tr>
<th>Rated power of pump ( P_N ) [kW]</th>
<th>Rated power of prime mover ( P_M ) [kW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 10</td>
<td>&gt; 1,2 ( P_N )</td>
</tr>
<tr>
<td>up to 50</td>
<td>1,2 – 1,1 ( P_N )</td>
</tr>
<tr>
<td>over 50</td>
<td>1,1 ( P_N )</td>
</tr>
</tbody>
</table>
Fig. 2.1 Calculation of NPSHₐ for emergency fire pumps which are installed above the water line in light condition

\[
\text{NPSH}_a = \frac{p_b - p_D}{\rho \cdot g} - Z_c - H_{VS} \quad [m]
\]

- NPSHₐ  [m] net positive suction head available
- H₉₅ [m] loss of head in the suction pipe
- Zₑ [m] distance between water line in light condition and center line of the impeller
- \( r = 1025 \) [kg/m³] density of seawater
- \( p_b = 101300 \) [N/m²] atmospheric pressure
- \( p_D = 4750 \) [N/m²] vapour pressure of seawater at \( t = 32 \) °C
Section 3 Testing

A Testing of Materials

A.1 The following are subject to material testing and certification in accordance with GL Rules:
- casings of boiler water circulating pumps with a permitted working pressure of $p_{e,zul} \geq 10$ bar
- casings of pumps for handling liquids with a working temperature of $t_{zul} \leq -10$ °C
- casings of pumps for handling dangerous chemicals

A.2 For all other pumps, the casing materials may be attested by a test report 2.2 according to EN 10204. The same procedure is also to be applied to the materials used for rotating components.

A.3 Type and scope of non-destructive material tests are to be agreed between the pump manufacturer and the foundry appropriate to the application requirements, for example, in case of pumps handling chemicals or liquid gases.

B Pressure Testing

B.1 All pump components exposed to internal pressure (casing, cover, seal plate) are to be subjected to a hydrostatic pressure test.

The following test pressure $p_p$ at least is to be applied:

$$p_p : 1.5 \times p_{e,zul} \text{ where } p_{e,zul} \leq 200 \text{ bar}$$

subject to a minimum of $p_p = 4$ bar

$$p_p : p_{e,zul} + 100 \text{ bar where } p_{e,zul} > 200 \text{ bar}$$

$$p_{e,zul} : \text{maximum allowable working pressure}$$

B.1.1 In the case of rotodynamic pumps, the maximum allowable working pressure $p_{e,zul}$ is equal to the sum of the pressure in the suction branch and the maximum pressure difference according to the pump characteristic.

B.1.2 In case of positive displacement pumps, the maximum allowable working pressure $p_{e,zul}$ is equal to the pressure which occurs on the discharge side when the total flow is returned to the suction side via the relief valve. The maximum pressure at the suction branch shall be considered.

B.2 For the purpose of hydrostatic pressure testing, pump casings shall not be painted on their internal or external surfaces.
C Performance Testing

C.1 The following pumps are subject to final inspection and to hydraulic performance testing in the manufacturer's works under the supervision of a GL-Surveyor:

- bilge pumps / bilge ejectors
- ballast pumps
- seawater cooling pumps
- fresh water cooling pumps
- cooling pumps for fuel injection valves
- fire pumps including pumps serving fixed fire extinguishing systems, e.g. sprinkler pumps
- emergency fire pumps
- pumps serving water spraying systems dedicated to cooling purposes (drencher pumps)
- condensate pumps
- boiler feedwater pumps
- boiler water circulating pumps
- lubricating oil pumps
- fuel oil booster and transfer pumps
- circulating pumps for heat-transfer oil
- brine pumps
- refrigerant circulating pumps
- cargo pumps
- hydraulic pumps for controllable pitch propellers

Other hydraulic pumps/hydraulic motors, see GL Rules for Machinery Installations (I-1-2), Section 14

C.2 The following contractually agreed operating data are to be verified during the performance test:

Volume rate of flow $Q$ [m³/h]
Delivery head $H$ [m]
Pump power input $P$ [kW]
Speed of rotation $n$ [min⁻¹]

C.3 As a standard procedure the hydraulic performance test shall be performed on manufacturer's test bench. The procedure followed shall be based on recognized national or international Standards and Regulations, such as:

- DIN EN ISO 9906 – Rotodynamic pumps – Hydraulic performance acceptance test grade 2
- VDMA 24 284 – Testing of positive displacement pumps – General regulations for testing

If the contract provides for a performance test in accordance with one of the aforementioned standards or a comparable regulation the pump manufacturer is bound to hold the said standard available for consultation during the performance test.

C.4 If the performance test is conducted without the corresponding prime mover but with a test bench motor, deviations from the nominal speed of rotation $n_N$ may result which can be tolerated within specific limits. In case of rotodynamic pumps, the speed of rotation during testing shall be in line with ISO 9906. Accordingly, the speed of rotation during testing shall be within the range 50 % and 120 % of the

\[ n = \frac{Q}{\eta} \]

\[ P = \frac{1}{\eta} \]

\[ H = \frac{Q^2}{n^2} \]

\[ n = \frac{P}{Q \cdot \eta} \]

1 The volume rate of flow is defined as the usable volume rate which is delivered by the pump through its outlet cross-section (pressure socket).
specification speed. In order to translate the performance data $Q$, $H$ and $P$ measured at test speed $n$ to the corresponding values for the specified speed $n_N$, the following equations may be applied:

$$Q_N = Q \left( \frac{n_N}{n} \right)^2; \quad H_N = H \left( \frac{n_N}{n} \right)^3; \quad P_N = P \left( \frac{n_N}{n} \right)^3$$

C.5 For positive displacement pumps, the permissible deviations call for special agreement depending on the design involved.

C.6 Conversion of the measured power input $P$ to the nominal power input $P_N$ is also required where the power input is measured with a liquid which differs as regards density and/or viscosity from the liquid specified in the contract.

C.7 Where the contract calls for verification of the NPSH value, an approximation formula is to be agreed between customer and supplier to enable the conversion to be made if the test speed differs from the nominal speed.

C.8 Where pumps subject to mandatory testing are hydraulically driven, the corresponding hydraulic motors and hydraulic pumps are to undergo a performance test, unless the pump is performance-tested in conjunction with the entire unit.

C.9 In case of submerged electric driven cargo pumps intended for liquefied gases the capacity test is to be carried out with the design medium or with a medium below minimum working temperature. For shaft driven deep well pumps the capacity test may be carried out with water.

D Other Tests

D.1 On positive displacement pumps the setting and correct dimensioning of the relief valve is to be checked. Generally, the set pressure, the opening pressure and the reseating pressure shall be measured and documented. Where a positive displacement pump is supplied without a relief valve, this point is to be noted in the Test Certificate.

D.2 With self-priming rotodynamic pumps as well as for rotodynamic pumps with attached or built-in suction aid, the functioning of the air intake stage is to be included within the scope of performance test.

D.3 During the performance test, the pump is to be checked for smooth running and bearing temperature.

D.4 Where the performance test is carried out on the entire unit comprising the pump, coupling, prime mover and common baseplate, the alignment of the unit is to be checked. The fact that the test has been performed on the entire unit is to be noted in the Test Certificate.

D.5 In case of performance testing of bilge ejectors the pressures shall be within $\pm 3\%$ of the nominal data. The resulting flow at the suction side may not deviate by more than $–5\%$ compared to the data sheet values stated by the manufacturer. Higher volume rate of flows are permitted.

In case of bilge ejectors the performance test of each individual pump may be replaced by type test procedure of respective pump type series agreed with GL. In these cases proof of performance of the individual pump may then be limited to a comparison of dimensions relevant to pump performance with those from the type test.

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2 The effect of viscosity on the characteristic of pumps is shown in Figure 3.1.

3 The assessment may be based on VDI Regulation 2056 "Criteria for the assessment of mechanical vibration in machines" or on a comparable standard.
E  Test Documents

E.1 The documents required for the various tests shall be supplied by the pump manufacturer to the Surveyor in good time and at the latest at the time of carrying out the tests.

E.2 A GL Test Certificate is to be issued showing the results of the tests. Where the extent of the tests goes beyond that specified by GL, the GL Test Certificate may be supplemented by the pump manufacturer’s own test report.

![Diagram of pump characteristic](image)

**Fig. 3.1** Effect of viscosity \( \nu \) on pump characteristic
Annex A  Illustration of Principles of Pumps

Note
The following illustrations of the principles of pumps together with the appropriate terminology have been taken from volume 1 of the EUROPUMP Technical Dictionary with the agreement of the European Committee of Pump Manufacturers. In the context of the present Regulations, it is hoped that this information compiled by the European pump industry will contribute to the clear identification of pump types.

Fig. A.1  Illustrations of the principles of rotodynamic pumps and side channel pump
Fig. A.2 Illustrations of principles of positive-rotary pumps
Annex A  Illustration of Principles of Pumps

In line piston pump  Axial piston pump

Radial piston pump  Ram pump

Bucket pump (double acting)  Rocking pindle piston pump

Diaphragm pump  Double acting semi rotary pump

Fig. A.3  Illustrations of the principles of reciprocating pumps
Fig. A.4  Illustrations of the principles of other pumps