

NORSOK STANDARD

COMMON REQUIREMENTS
MECHANICAL EQUIPMENT

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Please note that whilst every effort has been made to ensure the accuracy of the NORSOK standards neither OLF nor TBL or any of their members will assume liability for any use thereof.

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1 FOREWORD

NORSOK (The competitive standing of the Norwegian offshore sector) is the industry initiative to add value, reduce cost and lead time and remove unnecessary activities in offshore field developments and operations.

The NORSOK standards are developed by the Norwegian petroleum industry as a part of the NORSOK initiative and are jointly issued by OLF (The Norwegian Oil Industry Association) and TBL (Federation of Norwegian Engineering Industries). NORSOK standards are administered by NTS (Norwegian Technology Standards Institution).

The purpose of this industry standard is to replace the individual oil company specifications for use in existing and future petroleum industry developments, subject to the individual company's review and application.

The NORSOK standards make extensive references to international standards. Where relevant, the contents of this standard will be used to provide input to the international standardisation process. Subject to implementation into international standards, this NORSOK standard will be withdrawn.

2 SCOPE

This standard describes technical requirements for the design, manufacturing, assembling, product inspection, installation and testing of mechanical equipment, except lifting equipment.

The requirements of this standard and the relevant data sheets of Annex A are covering the mechanical requirements of the following equipment categories:

Pumps, compressors, gas turbines, reciprocating combustion engines, transmissions, expanders, steam turbines, lubrication and seal oil systems, baseplates, centrifuges, cyclones, pressure retaining equipment (incl. heat exchangers etc.) and atmospheric tanks.

The main design code or standard shall be stated on the relevant data sheets.

An API-standard shall only be included if it is deemed necessary due to the critical nature of the equipment or if necessary for the definition of the design, ref. table 5.1.

Codes and standards which constitute part of Purchaser's Standard are referred to under clause 3 below.

3 NORMATIVE REFERENCES

Alternative standards may be used provided if can be shown that they are equivalent.

General References

ANSI B1.020	Pipe Threads.
ANSI B16.5	Steel Pipe Flanges and Flanged Fittings.
ANSI B31.3	Petroleum Refinery Piping.

INSTA 121	Acoustics - Determination of Sound Power Level of Noise Sources Using Sound Intensity Measurement, Scanning Method for Use in Situ.
ISO 262	General Purpose Metric Screw Threads.
ISO 1940	Mechanical Vibration - Balance Quality Requirements of Rigid Rotors.
ISO 9614 - 2	Acoustics - Determination of Sound Power Level of Noise Sources Using Sound Intensity, Part 2: Measurement by Scanning.
API 670	Non-contacting Vibration and Axial Position Monitoring System.
API 678	Accelerometer Based Vibration Monitoring System.

Pumps

NFPA 20	Centrifugal Fire Pumps.
API 610	Centrifugal Pumps for General Refinery Service.

Compressors

API 617	Centrifugal Compressors for General Refinery Service, 5th edition, April 1988. (Replace with ISO 10439 in development)
ASME PTC 10	Power Test Code - Compressors and Exhausters.
NEMA SM23	Steam Turbines for mechanical drive service.

Gas Turbines

API 616	Gas Turbines for Refinery Services.
ASME PTC 22	Performance Test Code - Gas Turbine Power Plants.
ISO 1363	Package Gas Turbines (in development).

Reciprocating Combustion Engines

ISO 2954	Mechanical Vibration of Rotating and Reciprocating Machines.
ISO 3046	Reciprocating Internal Combustion Engines - Performance.
ISO 3945	Mechanical Vibration of Large Rotating Machines.
DnV	Rules for Classification of Steel Ships.

Transmissions

API 613	Special Purpose Gear Units for Refinery Service (Replace with ISO 13711 in development).
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Expanders

API 617	Centrifugal Compressors for General Refinery Service (Replace with ISO 10439 in development).
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Steam Turbines

IEC	Publication No.45.
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ISO 10437 Special Purpose Steam Turbines for Refinery Services.

Lubrication and Seal Oil Systems

NAS 1638 National Aerospace Standard. Cleanliness required of parts used in hydraulic systems.
ISO 4406 Hydraulic fluid power Fluids, Method for coding of contamination by solid particles.
API 614 Lubrication, Shaft Sealing and Control - Oil Systems for Special Purpose Applications.

Baseplates

NS 3472 Structural Steel - Design Rules.

Pressure Retaining Equipment

TBK 1-2 Norwegian Pressure Vessel Code.
BS 5500 Unfired Fusion Welded Pressure Vessel Code.
ASME VIII Boiler and Pressure Vessel Code.
TEMA Standards of Tubular Exchanger Manufacturers Association.
DIN 1942 Abnahmeversuche an Dampferzeugern.

Norwegian Boiler Regulations

TRD 611 Speisewasser und Kesselwasser von Dampferzeugern der Gruppe IV.

Atmospheric Tanks

NS 3472 Structural Steel - Design Rules.

As per Pressure Retaining Equipment.

4 DEFINITIONS AND ABBREVIATIONS

4.1 Definitions

Shall Shall is an absolute requirement which shall be followed strictly in order to conform with the standard.
Should Should is a recommendation. Alternative solutions having the same functionality and quality are acceptable.
May May indicates a course of action that is permissible within the limits of the standard (a permission).
Can Can-requirements are conditional and indicates a possibility open to the user of the standard.

4.2 Abbreviations

ACM/H	Actual Cubic Meter per Hour
CCR	Central Control Room
DN	Nominal Diameter
FAT	Factory Acceptance Test
INSTA	Inter Nordic Standardisation Association
LCR	Local Control Room
MCR	Maximum Continuous Rating
NAS	National Aerospace Standard
NPSH	Net Positive Suction Head
NPSHA	Net Positive Suction Head Available
NPSHR	Net Positive Suction Head Required
NS	Norwegian Standard
PL	Peak Load
PN	Nominal Pressure
PO	Purchase Order
PSV	Pressure Safety Valve
RMS	Root Mean Square Value
TBK	Norwegian Pressure Vessel Committee
TRD	Technische Regeln vur Dampfkessel
VGB	German Boiler Association

5 GUIDELINES FOR SELECTION OF EQUIPMENT IN SYSTEMS

Equipment selection shall be done in accordance with table 5.1. The boxed numbers are referring to clauses in this standard.

Equipment application in cases where the table is empty shall be done in accordance with data sheets and clause 6.1.

Deviations from the table shall require project acceptance.

Vertical in-line pumps or similar shall be the preferred selection for all sizes of dry mounted motor driven pumps due to lower total cost. Less cost is associated with piping design, piping stress calculations, piping alignment and equipment alignment.

Submerged pumps shall be selected in preference to line shaft and sump pumps.

There shall be no principal preference to aero-derivative over industrial gas turbines, suitability shall determine.

Table 5.1 Equipment Selection Matrix

	Pumps	Compressors	Gas Turbines	Combustion Engines	Transmissions	Expanders	Steam Turbines	Lube & Seal Oil Systems	Pressure Vessels	Heat Exchangers	Exhaust Boilers and Heat Recovery Units
Oil Processing	6.2.2	6.3	6.4		6.6			6.9.2	6.11.1	6.11.3	
Gas Processing	6.2.1	6.3	6.4		6.6	6.7	6.8	6.9.2	6.11.1	6.11.4	
Well Stream	6.2.2				6.6	6.7		6.9.1		6.11.2	
Oil Export	6.2.2		6.4	6.5.2			6.8	6.9.1			
Gas Export		6.3	6.4		6.6		6.8	6.9.2	6.11.1	6.11.4	
Cooling Seawater	6.2.1										
Cooling Medium	6.2.1								6.11.1	6.11.3	
Heating Medium	6.2.2								6.11.1		6.11.5
Steam/Condensate	6.2.1							6.9.1	6.11.1	6.11.2	6.11.6
Chemical Injection	6.2.1										
Flare/Vent	6.2.1								6.11.1		
Produced Water	6.2.1										
Fuel Gas		6.3								6.11.4	
Seawater Supply	6.2.2										
Ballasting	6.2.1										
Fresh Water	6.2.1										
Hot water	6.2.1									6.11.3	

	Pumps	Compressors	Gas Turbines	Combustion Engines	Transmissions	Expanders	Steam Turbines	Lube & Seal Oil Systems	Pressure Vessels	Heat Exchangers	Exhaust Boilers and Heat Recovery Units
Drain	6.2.1										
Diesel	6.2.1										
Pressurised Air					6.6				6.11.1		
Inert Gas					6.6				6.11.1		
Hydraulic Power									6.11.1		
Glycol	6.2.1										
Fire Water	6.2.1		6.4	6.5.2	6.6						
Main Power			6.4	6.5.1	6.6		6.8	6.9.2			
Essential Power	6.2.1		6.4	6.5.2	6.6		6.8	6.9.1			
Emergency Power	6.2.1		6.4	6.5.2				6.9.1			

6 TECHNICAL REQUIREMENTS

6.1 General

6.1.1 *Engineering basis*

The application of voluntary paragraphs shall be settled.

All equipment shall be designed for ease of installation and maintenance. Special tools and equipment shall be supplied.

6.1.2 *Dynamic design*

Balance quality for all rotating equipment shall be stated in accordance with ISO 1940.

For equipment with vibration detection instrumentation, the measurements shall be verified on the equipment.

6.1.3 *Lay-out, piping and alignment*

Shaft alignment tolerances shall be determined and specified, based on the conditions for installation.

All equipment mounted on baseplates and requiring alignment to fine tolerances shall be designed for application of temporary alignment measuring system, preferably laser optical.

Hatches, doors and manways shall be provided as required for repair, inspection, maintenance or installation.

Equipment with walk-in enclosures shall have windows for visual control of conditions inside.

General piping design shall be in accordance with ASME B31.3.

All packages including a baseplate shall have all flange connections at the edge of the base. Piping terminations for each service shall have single inlet and outlet flange connections.

Steel pipe flanges and flanges fittings design shall be in accordance with ANSI B16.5.

Pipe threads shall be in accordance with ANSI B1.020.

Liquid containing systems shall be completely drainable in all parts without dismantling.

Drains shall be provided on all casings.

Drain lines shall be brought out to the edge of the base plate and individually valved.

Vent connections shall be provided with valves.

Valves shall be grouped and accessible within reach from the operating floor level.

Drain points shall have a second barrier against leakage or accidental emptying.

Systems and equipment shall be designed without pockets to avoid foreign matter accumulation.

Traps, strainers or filters shall be used to capture foreign matter detrimental to the equipment.

6.1.4 *Mechanical design*

Systems or equipment which are dependent on liquid supply at emergency or other run-down situations shall be provided with emergency supply for the necessary period.

Flow and rotation direction shall be permanently marked.

Renewable sleeves under seals shall be removable on site without the application of heat.

Material for external bolting of 10mm and smaller shall be corrosion resistant steel. Larger bolting shall as a minimum be hot dip galvanised low alloy steel. Submerged bolting shall be compatible with the base metal. Bolts shall be in accordance with ISO 262.

All equipment shall have a material handling procedure. When manhandling cannot be expected, handling and lifting devices shall be provided or clearly defined.

Couplings shall not contain wear parts and shall use forged steel. Dampening couplings can be differently designed.

All rotating couplings shall be shielded by structurally strong coupling guards. Non-sparking guard is required in classified zones 0, 1 and 2.

Limitation of the noise emission from the equipment shall be specified.

6.1.5 *Nozzle loads*

Table 6.1 below, gives forces and moments induced from package external pipework, which shall be minimum allowance in the calculations.

Forces and moments are acting at the nozzle to shell junction for tanks and at skid edge for piping nozzles. The table does not apply to equipment nozzles within package units interconnected to each other with Supplier's piping, nor is it applicable to pressure vessels.

Table 6.1 Nozzle loads from connected piping

Nozzle Size	Resultant Force, N			Resultant Moment, NM		
	F _x	F _y	F _z	M _x	M _y	M _z
2"	500	900	700	300	200	200
3"	950	1700	1100	700	350	350
4"	1300	2500	1800	1100	540	540
6"	1900	3350	3200	2300	1000	1000
8"	2200	5700	5300	3500	1400	1400
10"	2500	7400	6600	5200	1800	1800
12"	2700	9000	8000	6400	2100	2100
14"	2800	11000	10000	7800	2300	2300

x = axial, y = up, z = side

6.1.6 Testing

Hydrocarbon gas containing equipment shall be tested with gas for leakages.

All equipment shall be subjected to FAT under realistic conditions according to accepted procedure.

All registrations necessary to demonstrate adherence to requirements or needed as reference for maintenance/surveillance shall be electronically stored and be available as print-out or curves.

All noise tests shall be performed in accordance with listed standard INSTA 121 and ISO 9614-2.

Changes or repairs as a result of failed tests require retesting if the performance or function may be affected.

A complete performance test dossier shall be produced immediately after acceptance.

6.1.7 Cleaning and preservation

The equipment shall be delivered fully cleaned and flushed for immediate service.

The equipment shall be properly preserved for transport and storage.

6.2 Centrifugal pumps

6.2.1 Standard requirements

Basic design

All shaft seals on pumps shall be mechanical.

The NPSHR shall be at least 1.0m less than the NPSH available, for boiler feed pumps at least 3m less. Correction factors for hydrocarbons are not allowed.

Onset of cavitation shall be defined as three (3.0) percent head drop (first-stage head on multistage pumps) from the horizontal line drawn through the non-cavitating points derived from the head/NPSH plot obtained by holding speed and flow constant, while reducing the suction pressure.

The region of uncertainty is defined as +5.0% of the NPSHR at the point of incipience and shall be added to the measured NPSHR to define the contract NPSHR value.

The whole pump casing shall have a pressure rating allowing it to be tested at the hydrostatic test pressure of the discharge side by mounting blinds to the suction and discharge nozzles.

The best efficiency point for the pump shall be to the right of the rated point on the head capacity curve.

Fire water pumps shall be designed in accordance with NFPA 20.

Critical speeds

If the first lateral or torsional critical speed of the shaft system for Multi-stage Pumps above 500kW when coupled to the driver, lies below the minimum operating speed of the pump, vibration calculations are required.

Drivers

Drivers shall allow full testing with water.

The nominal motor power rating (kW) shall be selected in accordance with the requirements in API 610.

Alignment

Minimum twice the forces and moments in API 610, Table 2 at maximum deck deflection shall apply, but the design's additional capability shall be stated.

6.2.2 Centrifugal Pumps to API 610

Piping

Rating	PN	API-Pumps
150	20	2 x API 610
300	50	4 x API 610
600	100	6 x API 610
900	150	8 x API 610
1500	250	10 x API 610

Vertical pump main nozzles shall withstand a multiple as defined in the above table of the standard forces and moments as defined in API 610, table 2 under continuous operation.

Hydrocarbon duty pumps shall have direct casing vent and drain connections.

Vibration and balance

Vibration limits shall apply to horizontal and vertical pumps. These limits shall cover rotor vibration during shop tests at rated speed from minimum flow to 110% rated capacity.

6.3 Centrifugal compressors

The following consist of amendments, additions or other changes to API standard 617 for Centrifugal compressors. References given under each subheading below are to API 617.

General**2.1.3 (Addition)**

For the purpose of performance calculation it shall be assumed that for any given process case specified in the data sheets, a condition of flow recycling exists if the discharge volume flow from the operating point to the surge line at constant speed becomes less than 5% of the design capacity.

At the specified operating point in the data sheets the calculated pressure rise to surge shall not exceed 15%, but not be lower than 7.5%. The turn down range shall be 35% minimum at rated speed.

External forces and moments**2.5.1. (Addition)**

Each nozzle shall withstand 4 x NEMA SM23 forces and moments within the alignment tolerances.

Rotating elements**2.6.12 (Substitution, 1st sentence)**

The thrust collar shall be hydraulically fitted and replaceable.

2.6.15 (Addition)

A locally mounted pressure gauge (with valve bleeder) shall be supplied to indicate balancing drum pressure.

2.6.16 (Addition)

For compressor with a rated discharge pressure of 100 barg or above, a pressure gauge with valve bleeder mounted directly on the casing with a flanged or studed boss connection to indicate balancing drum pressure shall be included.

Bearings and bearing housings**2.7.1.2 (Addition)**

Each radial bearing shall be fitted with two temperature sensors, one spare decoupled. Details of installation shall be as per API Standards 670 and 678.

2.7.3.3 (Substitution)

Thrust bearings shall be sized for continuous operation and thrust calculations shall take into account the thrust imposed by the loss of balance piston labyrinths.

2.7.3.7 (Addition)

For compressors with discharge pressures greater than 200 barg (20 MPag), thrust bearings shall be selected at no more than one third of the manufacturer's rating.

All thrust bearings shall be provided with four bearing metal temperature sensing elements, two located on the pads on the active side and two on the pads on the inactive side.

Shaft seals

2.8.3.6 (New paragraph)

The standard sealing method is to use dry gas shaft seals. The gas seals shall be designed as a replaceable cartridge.

2.8.4 (Addition)

The maximum amount of seal oil leakage to the gas side of the seal shall be specified and verified in the FAT.

Dynamics

2.9.3.1 (Addition)

The critical speed transition behaviour shall be recorded on run-up and on deceleration at the beginning and at the end (after the overspeed) of the mechanical test run. The rate of change of speed when passing through the critical speed shall be uniform and about 500 RPM/minute.

2.9.4.5 (Addition)

Torsional vibration analysis shall be performed for the complete coupled train also for turbine driven units.

2.9.5.2 (Substitution)

The maximum permissible residual specific unbalance value of the rotor during the shop tests of the assembled machine shall be determined by the balance quality grade G1 as specified in ISO 1940/1.

2.9.5.3 (Addition)

After completion of the final balancing, all major elements of the assembled rotor shall be match marked.

Drivers

3.1.3 (Addition)

Driver torque capabilities shall exceed compressor torque requirements by a minimum of 10%. For el-motors, torque requirements must be met at 80% voltage.

Controls and instrumentation

3.4.4 (Deletion)

3.4.5 (Deletion)

3.4.6 (Deletion)

Optional tests

4.3.6.1.1 (Substitution)

The compressor shall be performance tested in accordance with ASME Power Test Code PTC 10, latest addition, "Compressors and Exhausters", according to the class specified on the data sheets.

A minimum of five points including surge and overload shall be plotted at 100% test speed. For variable speed units, four additional points shall be plotted. These shall be at 85% of the test speed and surge points at 75%, 95% and 105% of the test speed.

For the purpose of defining the polytrophic efficiency on a flange to flange basis, the power losses due to internal gas recirculations shall be taken into account.

For compressors above 200 bars full load test at full density shall be offered.

4.3.6.2 (Addition)

A mechanical string test shall be offered.

6.4 Gas turbines

The following items consist of amendments, additions or other changes to API Standard 616. References given under each subheading below are to API 616.

Basic design

2.1.16 (Addition)

The guaranteed rated power shall be as defined and subject to zero negative tolerance when operated at rated firing temperature (subject to a maximum tolerance of +2.5%) and rated speed (subject to a measuring tolerance of $\pm 0.2\%$).

The guaranteed heat rate shall be the heat rate at rated power or at rated temperature +2.5%, whichever gives the greater value.

2.1.20 (Addition)

The gas turbine shall be guaranteed not to exceed a specified power/efficiency degradation at 8000 and 24000 operating hours before major overhaul, and at 24000 operating hours after a major overhaul program. The Supplier shall specify these guaranteed power and efficiency degradation figures in the quotation. Supplier shall also specify the effect of fuel type on the guaranteed figures.

Combustors and fuel nozzles

2.3.7 (New)

Turbines with only conventional combustors available shall be prepared for change out to dry low NO_x types at a later stage.

Controls and instrumentation**3.4.2.1 (Substitution)**

The starting sequence control system shall be fully automatic. Both manual and automatic starting systems shall be supplied. The control system shall visually display the progress of the starting sequence, including the running state of motor driven auxiliaries.

3.4.3.5 (Addition)

Operation and shut-down protection shall be maintained during a break in A.C. power on changeover from emergency to main supply and vice versa.

3.4.3.6 (New)

Gas turbine control shall not be affected by changeovers between hydraulic pumps or by gas turbine operating transients.

Air inlet**3.5.5.9 (New)**

The air inlet system shall include an anti-icing system upstream of the moisture separator and air filtration.

The inlet air anti-icing system shall be manually actuated.

3.5.6.1 (New)

The inlet filter shall be designed for minimum pressure loss and optimum energy conservation.

Weatherproofing (enclosure)**3.6.2.1 (Addition)**

The gas turbine should be installed in an enclosure having inspection windows with blinds, main and emergency lights and thermostatically controlled anti-condensation heaters. Equipment needing inspection and/or maintenance during normal operation shall be installed outside the enclosure.

3.6.2.2 (Addition)

The enclosure shall be of corrosion resistant and approved fire resistant material. Noise insulation shall be of fibreglass or equivalent non-flammable sound absorption material. Insulation shall be designed to avoid collection of flammable fluids. The access doors shall be lockable from the outside only and overridden by a quick release bar on the inside. Doors shall be equipped with micro-switches to give closed or open indication signals.

Fire protection**3.6.3.1 (New)**

A suitable fire prevention and protection system compatible with the existing surrounding system shall be provided. This shall include heat, flame and gas detection and fire extinguishing facilities.

The following protection and shut-down functions shall be provided:

- Detection of a low level gas concentration in the ventilation air inlet to the gas turbine enclosure shall cause an alarm.
- Confirmed detection of high gas concentration in the ventilation air inlet shall cause an alarm and shall shut down the affected gas turbine unit. Also the ventilation air inlet to the enclosure shall be closed.
- Detection of a low gas concentration in the ventilation air outlet shall cause an alarm and shall on dual fuel machines initiate changeover to diesel fuel.
- Confirmed detection of a high gas concentration in the ventilation air outlet or combustion air inlet, or in the enclosure shall cause an alarm, shut down the affected unit, close the ventilation inlet and activate the fire extinguisher.
- Detection of heat or flame in the gas turbine enclosure or ventilation air ducts shall cause an alarm, shut down the affected gas turbine unit, close the ventilation air inlet and outlet and activate the fire extinguisher.
- Detection of heat or flame in the combustion air inlet shall shut down the gas turbine.

3.6.3.2 (New)

Enclosures for all turbine drivers located in safe area shall have a ventilation system under negative pressure. There shall be two full capacity motor driven fans with dampers to prevent back-flow.

3.6.3.3 (New)

A failure of the fan maintaining flow through the turbine enclosure ventilation system shall cause the other fan to start automatically. Automatic or manually initiated changeover shall take place without causing turbine trip.

3.6.3.4 (New)

The turbine enclosure ventilation system shall be equipped with three independent devices checking the adequacy of ventilation flow through the system. Turbine shut-down shall occur as a result of two out of three redundancy.

Fuel system

3.7.1.7 (Addition)

Manual changeover from gas to liquid fuel shall also be possible by manual initiation in the Local control room, with automatic sequencing and control.

Change over from liquid to gas fuel shall be only by manual initiation in the Local control room, with automatic sequencing and control.

3.7.1.8 (New)

Dual fuel gas turbines shall be arranged to switch the fuel control system automatically from gas to liquid fuel when sensing fuel gas pressure falling below set limit and with no more than 1% speed reduction by change-over.

Manual changeover from gas to liquid fuel shall also be possible with automatic sequencing and control.

3.7.1.9 (New)

The fuel gas double block and intermediate bleed-off (vent) valve shall be located upstream of the gas fuel flow control valve. All valving shall be as close to the gas turbine as practically possible.

Piping shall be installed to automatically drain off liquid fuel from inside the gas turbine after a false start. A flanged connection of DN 25 minimum shall be installed at the skid boundary. A drain box shall be provided to keep the connection open at all times.

3.7.1.10 (New)

A purge cycle shall be included where the fuel line between the fuel gas scrubber and the turbine is purged by fuel gas vented to a flare system prior to cold start of the turbine and prior to changeover from liquid fuel to gas fuel.

Testing and inspection**4.3.3.3.5 (Addition)**

The recording of an unfiltered signal shall be made with a digital tape recorder and shall cover the frequency range from zero up to twice maximum vane passing frequency or 10kHz as applicable.

In addition, vibration signature tape recording and spectrum analysis during start-up and coast-down, shall be done.

4.3.4.1 (Substitution)

Performance test shall be performed according to ASME Power Test Code PTC 22.

4.3.4.7 (Include)

Inspection of hub/shaft fit for hydraulically mounted couplings shall be performed.

4.3.4.8 (Include)

Governor response and emergency overspeed trip system tests shall be performed.

4.3.4.8.2 (New)

Two overspeed trips from each speed pick-up on the power turbine shall be performed.

Preparation for shipment**4.4.4.6 (Addition)**

Borescope examination of blades, nozzles and combustion areas shall be done after testing.

6.5 Combustion engines**6.5.1 *Standard requirements*****Type approval**

The engine shall have a relevant type approval.

Engine rating

Ratings shall be given according to ISO standard No. 3046 or an equivalent standard.

Vibration

The measurement and evaluation of vibration severity shall be in accordance with ISO 2372 and ISO 2373.

Crankshaft dynamics

The crankshaft shall specifically comply with DnV "Rules for classification of steel ships".

Torsional stresses and deflections

The torsional natural frequencies of the engine and driven system including ancillary drives shall not be closer than 10% to any specified running speed including variation. Constant speed applications shall be considered to have a speed range within plus or minus 10% of stated running speed.

Engine starting

The engine shall be capable of starting when coupled to the driven machine. Starting devices shall have enclosed rotating parts.

Engine cooling system

Jacket water and sea water cooling system shall be completely separate. Direct sea water cooling of engine components is not permitted.

The jacket cooling water circulation pump shall be engine driven. The system shall be thermostatically controlled with a full bypass temperature control valve.

Engine lubricant system

A thermostatically controlled bypass shall be installed.

The oil filters shall be of the full flow cartridge type with continuous flow transfer valves and differential pressure gauge.

Exhaust system

The surface temperature shall not exceed 200°C. Water shielding is preferred for the exhaust manifold and turbocharger. If insulation is used, the metal jacket shall be completely water tight.

The engine shall be supplied with exhaust silencer(s) with spark arrestor.

Safety devices

Minimum requirements for safety devices:

- Crankcase safety valves according to DnV.
- Automatic inlet air shut-off valve.
- Guards to protect personnel from bodily contact with hot surfaces and moving parts.
- Overspeed trip driven directly by the engine.

Instrumentation

The minimum instrumentation to be supplied is listed below.

Function	Indication	Alarm	Trip
Start and stop push buttons			
Hours run counter	x		
Engine overspeed	x	x	x 1)
Coolant temperature	x	x	x
Coolant pressure	x		
Coolant level	x	x	x
Charge air pressure	x		
Exh. Temp. engines < 600 kW (each bank)	x		
Exh. Temp., engines > 600 kW(each cylinder)	x		
Lubricating oil temperature	x	x	
Lubricating oil pressure	x	x	x 1)
Fuel leakage	x	x	
Governor battery voltage	x	x	

Note 1 Engines for emergency power generators and fire pumps shall only have these two trip initiators.

Auxiliary piping

Flexible joints shall be provided for all piping connections to and from the skid mounted equipment.

Hydrostatic tests

Hydrostatic tests shall be done for engine parts and engine accessories according to DnV rules.

Mechanical running test

A mechanical running test shall be conducted to control the mechanical function of the engine and accessories, governor system, control and safety device, etc. The system tests shall include but not be restricted to the following:

- Speed governor and any speed-regulating devices shall be tested according to ISO 3046 - 4 and the specified governor class.

- The adjustable governor response speed range and the sensitivity and linearity of relationship between the speed and control signals shall be documented as tested.

Performance test

The engine including all auxiliaries and control panels shall be subject to a full load performance test in accordance with ISO 3046 or an equal standard.

Noise test

The exhaust noise level shall be measured separately.

6.5.2 Diesel engines**Engine starting**

Engines for emergency power generators or fire pumps:

- Shall be capable of carrying its full rated load within 20 seconds after cranking is initiated.
- The starting system shall be based on NFPA 20. If air starting is used, the capacity of the air supply vessels shall be sufficient for 12 cranking cycles.

Engine fuel system

Filters shall be of the duplex type with automatic changeover. A differential pressure gauge shall be installed across the filter.

The fuel piping between the fuel pump and the injectors shall be double-walled, and equipped with instruments for detection of leaks.

Auxiliary piping

High pressure fuel oil piping to the fuel injectors is to be double walled and secured to prevent fuel oil or fuel oil mist from reaching a source of ignition on the engine or its surroundings. These pipes shall be equipped with leakage detection. When pressure pulsations can be expected in the return piping, shielding of this piping shall be provided.

Material certificates

Material certificates for engine parts for emergency power generator and fire pump engines shall be available according to relevant classification.

6.6 Transmissions

The following items consist of amendments, additions or other changes to API Standard 613 for Gear units. References given under each subheading below are to API 613.

General

2.1.3.13 (New)

Machined surfaces shall be provided near the input and output shaft bearing housings for mounting of optical alignment instruments.

Basic design

2.2.1 (Addition)

Gears located next to the driver shall be rated for the potential maximum power of the driver, plus the potential maximum power of any helper-driver transmitting power through the gear unit during operation.

A gear located between items of driven equipment shall be rated for 110% of the maximum torque required by the driven equipment, including the applicable service factor.

Casings

2.3.1.17 (New)

Casings shall be fitted with temporary jacking screws to facilitate vertical alignment.

Casing connections

2.4.1.3 (Addition)

Inert gas purge connection, suitably plugged, shall be provided.

Gear design

2.5.1.3 (Delete)

2.5.1.4 (Addition)

The design of the gears shall be such that it is not necessary to plate teeth to prevent scuffing during initial operation.

2.5.1.6 (Substitution first sentence)

Hunting tooth combinations are only required for non surface hardened gears.

2.5.1.8 (New)

The free end of the high speed shaft shall have a suitable arrangement which can be used to turn the shafts manually after removing the bearing end cover.

Bearings

2.7.3. (Addition)

The thrust collar which revolves with the shaft shall be replaceable.

2.7.4.2 (Addition)

Shaft oil seals shall be easily accessible for removal and re-installation without removing couplings.

Controls and instrumentation

3.4.2.1.3 (Addition)

Measurement of combined oil temperatures from more than one bearing (i.e., from radial and thrust bearings) shall be avoided wherever possible.

3.4.2. (New)

Wiring with particular attention to vibration and temperature measurements shall be arranged to facilitate removal of the casing top.

6.7 Expanders

In the lack of an appropriate recognised standard for gas and well stream expanders the API standard 617 shall be used.

The following items consist of amendments, additions or other changes to API standard 617, reference to API 617 is given under each subheading below.

Scope

1.1 (Deletion)

Definition of terms

1.4 (Addition)

Expander normal operating point is the point at which the usual process operation is expected.

Design point is the point of operating duty which provides optimum isentropic efficiency from the expander. The design point shall be so selected to:

1. Achieve best possible efficiency at normal operating duty with design feed analysis at expander inlet.
2. Ensure acceptable efficiency at maximum flow rates.

Inlet guide vanes

2.3.1 (Substitution)

Expander inlet guide vanes shall be adjustable and suitable for operation at all the specified operating, start-up, shut-down, trip-out and transient conditions.

2.3.2 (Substitution)

The expander guide vanes shall be designed to minimise mechanical wear, vapour/liquid erosion and losses over the operating life of the machine.

2.3.3 (Substitution)

The guide vanes control system shall be capable of both remote and local adjustment.

2.3.4 (Substitution)

The adjustable guide vane positions shall be locally indicated by a pointer over a scale marked in 5 percent of area divisions from fully closed to maximum.

2.3.5 (Substitution)

Inlet guide vanes with adjustment mechanism should optionally be proposed for the compressor if a significant improvement in expander efficiency could be achieved by speed adjustment of the machine at the specified off-normal duties.

Bearings

2.7.1.2 (Addition)

When using magnetic bearing system, radial bearing rating shall not exceed 25% of manufacturer's rating.

2.7.3.3 (Addition)

For turbo-expander with inlet pressures greater than 200 barg, thrust bearings shall be selected at no more than one third of the manufacturer's rating.

The thrust bearings shall be provided with two bearing metal temperature sensing elements for each bearing side. High-temperature alarm with adjustable set point shall be included.

Shaft seals

2.8.6 (Addition)

The seal gas system shall be design to avoid excessive pressure build-up in the unit's casing.

Drivers

3.1.1 (Deletion)

3.1.8 (Deletion)

Controls and instrumentation

3.4.4 (Deletion)

3.4.5 (Deletion)

3.4.5.5 (Addition)

1. Lube oil pump running confirmation:

To indicate that the stand-by pump circuit is functional and ready for starting.

To indicate that the stand-by pump is running.

2. "Ready to start" confirmation:

Confirmation shall be provided on the panel/monitor to indicate when various required levels have been reached in the seal/lubrication system, etc. to allow safe starting of the machine without mechanical damage.

3.4.6 (Deletion)

Testing

4.3.3 (Substitution of first paragraph only)

Each expander and compressor's impeller wheels (and any spare units) shall be subject to an overspeed test of 115 percent of maximum continuous speed for a minimum test duration of one minute.

4.3.4.2 (Addition)

Employing an external compressed air facility, operate the turbo-expander unit in the following sequence as described for the mechanical running test.

Optional tests

4.3.6 (Addition)

Performance tests:

Performance tests for evaluating both expander and compressor performance shall be carried out at the manufacturer's works prior to delivery. These tests shall simulate the individual operating cases as defined on the data sheets and in particular the "normal operating point" (guaranteed performance).

Suppliers data

5.1.c (Addition)

Performance curves for each operating case listed on the data sheet shall be included in the proposals.

The performance curves for the expander shall take the form of polytrophic efficiency plotted against the ratio of expander impeller tangential tip speed (U) divided by the ideal spouting velocity for the expansion (C_o). The U/C_o ratios for all operating cases specified on the data sheets and their individual operating speeds shall be shown.

6.8 Steam turbines

The following items consist of amendments, additions or other changes to API standard 612. References under each subheading below are to API 612.

General

2.1.3.8 (Addition)

The rated load shall be at least 110% of the maximum operating load at any of the specified operating conditions. The speed at rated load is the normal speed.

Pressure casings

2.2.1 (Substitution)

All pressure parts of the turbine shall be suitable for continuous operation at the maximum specified steam conditions. The behaviour of the turbine casing, where subjected to swings in temperature or pressure, shall be in accordance with the requirements of IEC - publication No 45, latest edition.

2.2.9 (Addition)

For continuous drainage, steam traps shall be provided.

Dynamics

2.8.5.2 (Addition)

Drum type rotors (stiff shafts) can be dynamically balanced, after final assembly of the rotors by "high speed" balancing close to the critical speed N_{cn} .

2.8.5.8 (New)

The rotor and turbine design shall include provisions to facilitate field balancing.

Bearings and bearing housing

2.9.1 (Addition)

Active magnetic bearings can be accepted.

2.9.3.4 (Addition)

One key-phazor probe shall be furnished per shaft.

Accessories

3.4.6.1.2 (Addition)

Limit switches shall be furnished on each trip valve to indicate "open" or "closed" position of it.

Insulation and jacketing

3.7.1 (Addition)

The insulation shall be reusable.

6.9 Lube and seal oil systems**6.9.1 Standard requirements**

The lube and seal oil system shall be cleaned and flushed in accordance with the requirements in NAS 1638 and ISO 4406.

The lube oil system shall be arranged with sample testing facilities for the oil at the following locations:

- In storage tank.
- Downstream of filters.
- In return line from the equipment.

The sampling facilities shall be arranged so that the samples can be taken during operation of the unit.

Baseplates shall be suitable for column mounting, multipoint three point bolt down support.

An electric heating device shall be provided for heating of the oil prior to start-up. Electric immersion heaters shall be corrosion resistant.

Connections for oil conditioner with pipe loop shall be provided.

Drain lines shall be provided with valves and blind flanges at the lowest point on the oil pump inlet and outlet.

Oil vent pipes shall be routed back to the reservoir. A flanged vent valve shall be provided at the highest point on the cooling medium side of the coolers with vent pipe routed to an open drain line.

Vent and drain nozzles shall be provided with valves and blind flanges.

6.9.2 *Lubrication and seal oil system to API 614*

The following items consist of amendments, additions or other changes to API standard 614. References given under each subheading below are to API 614.

Basic design

2.1.19 (New)

Where a gas compressor shares a common lube-oil system with a (or part of a) gas turbine, oil returns from driven equipment and driver shall be separated from each other in separate sections of the lube-oil reservoir. Each section shall have its own vent connection.

Oil reservoirs

2.3.6.h (New)

Provisions shall be made to prevent oil from flowing into the gas turbine via the lube oil reservoir in case of compressor and gas turbine driver having common lube oil system.

Filters

2.7.1 (Addition)

Individual transfer valves independently serving each cooler and filter set, are required.

Degassing drum

2.12.1 (Addition)

Seal-oil degassing facilities shall be provided when the compressor duty will contaminate the oil.

3.5.7 (Deletion)

3.5.8 (Deletion)

6.10 Baseplates

Design requirements

The baseplate shall be designed in accordance with NS3472.

The lifting lugs shall be designed for a load calculated assuming that only two diagonally opposite lifting lugs are carrying the full load. The design and manufacture of the lifting lugs shall be certified.

The base plate and equipment supports shall also be designed to sustain loads resulting from the supported equipment during ocean-going transportation.

The provision of all appurtenances required to tie-down the baseplate with all supported equipment during transportation shall be specified. When an ocean going vessel is used, the baseplate shall be provided with suitable attachments for securing directly to the vessel deck.

Lay-out and functional requirements

The baseplate shall be fitted with a steel plate top sheet continuously welded to the framework where fluid leakages may occur and shall be selfdraining.

Earthing studs shall be provided on the baseplate.

When multipoint mounting is specified, the base plate shall be provided with foundation pads at least 20mm thick for anchoring to the foundation framework.

Unless otherwise specified, the bottom of the baseplate between structural members shall be open. Closed pedestal supports or closed volumes are not permitted. All surfaces shall be accessible for proper sandblasting and painting including the underside.

All joints shall be designed as continuously welded.

The height of mounting pads and/or support pedestals shall be such that a minimum vertical clearance of 50mm is available underneath all mounted equipment and piping including under the drain line flanges at the edges of the baseplate.

The driver mounting pads shall be machined to corresponding center height allowing the driver to be mounted with a shim pack of minimum 3mm and maximum 6mm. Final machining shall take place after heat treatment.

Installation requirements

All base plates shall be designed to be skidded in two orthogonal directions in the horizontal plane. Lugs/reinforcement shall be located at suitable points around the baseplate to enable easy application of an appropriate motive force.

Where necessary, provisions shall be made for the levelling of base plate mounted equipment and this shall be accomplished by the suitable location of jacking points. After jacking, appropriate shim plates shall be located at the support points.

When applicable, consideration shall be given to access with sufficient space for the bolting of the base plate to the deck foundations. Fixation shall be designed for the most critical of the loading conditions.

All shims shall provide full foot support. Shims shall be made of stainless steel, pre-cut and deburred.

6.11 Pressure retaining equipment**6.11.1 Standard requirements****General**

Pressure retaining equipment shall be designed in accordance with one of the following codes:

TBK 1-2, BS 5500, ASME VIII

Design loadings

The equipment shall be designed taking account of all relevant loads listed in codes and data sheets, and include the effect of field hydrostatic tests, wind, explosion blast pressure, acceleration, connected piping, transportation and installation.

Lifting lugs shall be designed with a safety factor of 2.

Design pressure

Pressure retaining parts shall be designed for a pressure at least 8% or minimum 3.5 bar above maximum operating pressure.

Equipment operating at less than atmospheric pressure shall be designed for full vacuum.

Differential pressure shall not be used as design basis for multicompartment equipment.

Design temperature

Upper and lower design temperatures shall cover all normal-, testing- and emergency conditions.

Design temperature shall be 10°C above maximum operating temperature, but for compressor installations, the actual operating conditions shall be taken into consideration.

Lower design temperature shall be 5°C below minimum operating temperature.

Nozzles and openings

Nozzles welded to pressure retaining equipment shall as a minimum be 50mm nominal diameter for its own structural strength.

Minimum standoff is 150mm measured from nozzle face to equipment or insulation surface.

Reinforcement of openings in equipment designed for more than 200 bar or with wall thickness above 40mm shall be by integrally reinforced nozzle necks or locally increased wall thickness. Hence, doubling plates are not allowed.

Full penetration welds shall be applied between vessel and pipe connected nozzles with nominal diameter larger than three times the shell thickness.

All pipe connected nozzles shall be designed for the following piping loads applied at the nozzle/shell interface: (Stresses shall be calculated according to BS 5500)

$$M = 4x(DN-25)^{1.4} + 2x10^{-5} x PNx(DN)^{2.7} [Nm]$$

$$F = 7.5x(DN)^{1.2} + 0.1xPNx(DN)^{1.2} [N]$$

PN in bar and DN in millimetres.

Miscellaneous requirements

Manholes shall have a nominal diameter of 600mm.

Hand holes shall have a minimum nominal diameter of 200mm.

The vessel shall be provided with all necessary attachment brackets for insulation and for installation of access platforms and ladders.

All attachment welds shall be continuous.

Internal piping shall be flanged inside the vessel.

All connections shall be flanged and readily accessible. There shall be no connections inside vessel skirts or equipment foundations.

Skirts shall have top and bottom vent openings and access opening allowing easy inspection of vessel.

Corrosion allowance shall be added to all medium exposed surfaces. Removable internals can have corrosion allowance added to one side only.

Fabrication

Welder and welding operators shall be certified according to a recognised certification scheme.

All welding shall be performed according to qualified welding procedures

All NDT operators shall be certified according to a recognised certification scheme

6.11.2 *Shell and tube type heat exchangers*

General

TEMA Class R shall apply for all hydrocarbon service. Class C may be selected for utility service.

Vibration analysis shall be carried out. Tube support plates shall be considered.

Mechanical design

The internals shall be equipped with necessary provisions for separate and easy dismantling and removal.

Square tube arrangement is required on removable bundles where shell side fluid fouling resistance is $0.00035 \text{ m}^2\text{°C/W}$ or more.

Internal welds of shells for heat exchangers with removable bundles shall be finished flush with the inner contour for ease of tube bundle insertion and withdrawal.

6.11.3 *Plate type heat exchangers*

General requirements

All relevant pressure retaining parts shall be designed, fabricated and tested in accordance with the pressure vessel code.

Thermal design

The design shall account for expected fouling. The heat transfer area shall be at least 20% above theoretical requirement for clean condition.

Mechanical design

The design pressure shall be at least 10%, minimum 0.7 bar above maximum operating pressure.

The cover plate shall be movable without the assistance of mechanical equipment. The frame and bolting shall be designed to allow for future installation of additional plates.

Plate gaskets shall be arranged so that a gasket leak cannot result in mixing of the fluids for example by use of double gaskets with a vent opening between.

The plates shall be marked to facilitate correct reassembly.

6.11.4 *Matrix type heat exchangers (bonded plates)*

Thermal design

Additional heat transfer area is required due to fouling. This area must result in a true corresponding percentage increase in thermal performance. The additional heat transfer area shall be as follows:

For cooling water services :	20%
For fouling services such as natural gas and crude oil cooling etc. :	25%

The exchanger shall be oversized by 10% in addition to above.

Pressure testing

A hydrostatic test shall be performed on each side independently as well as together. The heat exchanger shall be checked for leakage at the end of each test sequence.

A helium leak test shall be carried out on each side after hydrostatic testing.

The leak test pressure shall be either at 25% of the design pressure or 800 kPag, whichever is lower.

The leak test procedure shall be sensitive to helium leaks exceeding 2×10^{-4} cc/s.

No detectable leakage shall be permitted.

6.11.5 *Waste heat recovery units*

General

The Waste heat recovery unit shall be skid mounted and supplied as a package unit including necessary expansion bellows for connection to fixed duct and pipe.

Headers and coils shall be designed as pressure vessels.

Thermal design

Maximum and minimum heat output at the specified maximum and minimum gas flow conditions shall be given.

The temperature margin against thermal decomposition of any component of the heating medium mixture in the critical part of the coil shall be documented.

The temperature of the metal at the coldest section of the tubes shall be at least 10°C higher than the condensing temperature of the corrosive compounds contained within the exhaust gases.

The tube and fin-tip metal design temperature shall be 25°C higher than the highest expected normal operating temperature. This must take into account the maximum occurring local metal temperature affected by internal fouling and heating medium and gas flow imbalances.

Coil

The coil shall be equipped with a manual blowdown and vent facility.

Headers

The WHRU shall have external header boxes or header pipes which shall be supported independently of the tubes. Each header shall be equipped to enable inspection of the tubes during major shutdowns.

Provision shall be made to facilitate the removal and reinstallation of tubes. A description of tube removal and replacement procedures shall be furnished.

Duct design

Provision shall be made for duct drainage in connection with water washing and in the event of firewater entering the ducts with a hopper arrangement. All sections shall be joined using flanged and bolted connections.

If the design of the Waste heat recovery unit is such that this design pressure may be exceeded due to maloperation, a pressure release device shall be included in the design to prevent overpressurizing the exhaust ductwork.

6.11.6 Exhaust steam boilers

Boiler surveillance category

The requirements to the boiler operation mode is specified in Norwegian boiler regulations, section 8. The boiler shall be designed, equipped and operated to the surveillance category "Indirect surveillance".

General boiler design

The boiler shall be designed for at least two years of continuous service and shall be capable of sustained operation at MCR between mandatory inspections. Required design life shall be stated on data sheet.

Feed water, boiler water and steam quality

Feed water and boiler water quality shall meet the requirements given in the German standard TRD 611.

The steam quality shall be to the German boiler association - VGB - recommendations as a minimum.

Noise Level

The noise levels shall apply at all operating conditions up to MCR.

Boiler design criteria

Boiler circulation shall be based upon the following parameters:

- Furnace tubes inlet water velocity shall be 1.0m/s minimum.
- Boiler bank tubes inlet water velocity shall be 0.5m/s minimum.

The boiler gas side shall be designed for 5000Pa overpressure, minimum.

The boiler shall be suitable for chemical cleaning prior to commissioning or after long lay up. Inspection nozzles shall be provided at various locations to facilitate connection to chemical cleaning system as well as to provide means for inspection after chemical cleaning.

Furnace design

The heat release in the furnace shall not exceed 800 KW/m³ at any condition.

The number and position of the peep holes shall enable control of all important parts of the furnace.

Steam drum

The steam drum water volume at the low-level alarm point shall accommodate the water shrinkage resulting from a decrease in load of 25% of MCR occurring in one minute and with system pressure increased to the safety valve setting pressure without actuating the low-level trip.

Minimum drum hold-up capacity shall be two minutes at MCR and shall be based on volume between low level alarm and lowest visible level.

Vortex breakers shall be fitted to downcomers, nominal bore 150mm and above.

The steam drum shall be furnished with steam drying equipment.

The moisture carry-over shall not be more than 0.02% during normal operations and 0.2% during upset conditions.

Thermal sleeve nozzle arrangement with waterfilled sleeve shall not be accepted.

Drum longitudinal weld seam(s) shall be located in the steam area.

Gas and air ducting

Safety release hatch(es) shall be arranged in the ducting system to prevent overpressure by damper failure.

Each part of duct shall be provided with access doors, 600mm square, to allow access to any section of the duct.

Ducts shall be furnished with arrangement allowing washing/firewater drain. Drain size shall be 100mm minimum.

Dampers

The dampers shall be designed to fail open on loss of power, air supply or linkage failure.

Requirements for piping

By-pass lines with shut-off valves shall be provided at control valves, flow meter etc.

All pressure safety valves shall have flanged connections.

Flanged pipe connections shall be limited to a minimum for high pressure steam and water systems. Control valves shall be flanged.

Boiler start-up steam vent shall be arranged:

- Branch-off valve, manual operated gate.
- Remote controlled, motor operated valve with by-pass arrangement.
- Discharge silencer.

Individual steam/water sample coolers including the required sample/cooling water piping shall be arranged.

Hydrostatic test

The complete steam boiler including economiser and superheater with interconnecting piping shall be hydrotested.

Pre-start-up tests

Following completion of erection, a cold test of boiler, equipment, control and safeguard systems including pressure safety valves shall be performed.

Performance and acceptance tests

After at least 48 hours of satisfactory operation at MCR, performance and acceptance tests shall be run and include at least:

- 8 h operation at normal boiler load.
- 8 h operation at minimum continuous boiler load.

A boiler efficiency test shall be performed during MCR operation.

Boiler efficiency test shall be carried out according to DIN 1942, indirect method.

Boiler tests

Boiler and control system response to load variations shall be recorded and compared to guarantee data.

Remote control shall be tested.

Boiler plant emission tests

Test measurements shall be performed of the boiler plant emissions.

Service and maintenance requirements

The Supplier shall recommend suitable equipment and related boiler facilities for cleaning the gas side of the steam boiler, economiser and fuel gas ducting.

6.12 Atmospheric tanks**General**

Atmospheric tanks shall be designed in accordance with NS 3472.

All relevant requirements listed under 6.11.1 Standard Requirements shall apply.

Loads

The following additional loads shall be accounted for in the design:

- 1000 N/m² vertically on top surface plus.
- 250Pa external or 750Pa internal pressure.

Deflection

Deflections calculated for the worst combination of operating condition loads, using load coefficient 1.0, shall be less than:

- 1/300 of span of stiffeners.
- 1/150 of shortest width of flat plates.

Stiffening shall be by external stiffeners continuously welded on both sides. Internal stays shall not be used.

The tank bottom shall have a slope of at least 1/50 towards the drain connection.

Openings

All openings shall be reinforced by addition of cross sectional area equivalent to the area removed.

ANNEX A MECHANICAL EQUIPMENT DATA SHEETS (NORMATIVE)

RDS-001	Rev. 1, Dec. 1994	Centrifugal pump
RDS-002	Rev. 1, Dec. 1994	Rotary pump
RDS-003	Rev. 1, Dec. 1994	Reciprocating pump
RDS-004	Rev. 1, Dec. 1994	Controlled volume pump
RDS-005	Rev. 1, Dec. 1994	Centrifugal compressor
RDS-006	Rev. 2, April 1996	Positive displacement rotary compressor
RDS-007	Rev. 1, Dec. 1994	Combustion gas turbine
RDS-008	Rev. 1, Dec. 1994	Diesel engine
RDS-009	Rev. 1, Dec. 1994	Gear (standard type)
RDS-010	Rev. 1, Dec. 1994	Special purpose gear
RDS-011	Rev. 1, Dec. 1994	Coupling
RDS-012	Rev. 2, April 1996	Oil system
RDS-013	Rev. 1, April 1996	Hydraulic power pack
RDS-014	Rev. 1, Dec. 1994	Centrifugal separator
RDS-015	Rev. 1, Dec. 1994	Cyclone (standard type)
RDS-016	Rev. 1, Dec. 1994	Cyclone (treatment of produced water)
RDS-017	Rev. 1, Dec. 1994	Pressure vessel
RDS-018	Rev. 1, Dec. 1994	Shell and tube heat exchanger (standard type)
RDS-019	Rev. 1, Dec. 1994	Shell and tube heat exchanger
RDS-020	Rev. 1, Dec. 1994	Plate heat exchanger (standard type)
RDS-021	Rev. 1, Dec. 1994	Air cooled heat exchanger
RDS-022	Rev. 1, Dec. 1994	Waste heat recovery unit
RDS-023	Rev. 1, Dec. 1994	Atmospheric tank
RDS-024	Rev. 1, April 1996	Vacuum pump package
RDS-025	Rev. 1, April 1996	Hydraulic motor
RDS-026	Rev. 1, April 1996	Centrifuge (standard type)
RDS-027	Rev. 1, April 1996	Filter
RDS-028	Rev. 1, April 1996	Fresh water maker
RDS-029	Rev. 1, April 1996	Reverse osmosis membrane
RDS-030	Rev. 1, April 1996	Reciprocating compressor

Note

The data sheets can be subject to changes both in the selection and content as part of this Annex without affecting the revision status of the standard.