TECHNICAL SPECIFICATION

SPECIAL-PURPOSE STEAM TURBINES
(AMENDMENTS/SUPPLEMENTS TO API 612)

DEP 31.29.60.31-Gen.

December 1998
(DEP Circular 30/99 has been incorporated)

DESIGN AND ENGINEERING PRACTICE

PREFACE

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The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

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PART I INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for special purpose steam turbines.

This DEP is a revision of the DEP of the same number dated December 1983.

This DEP is based on API 612, fourth edition, June 1995. Part III of this DEP amends, supplements and deletes various clauses and paragraphs of API 612.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP/SIEP the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers nominated by them (i.e. the distribution code is "F", as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants and in exploration and production facilities.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP, which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, installation, and commissioning or management of a project or operation of a facility. The Principal may sometimes undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier/Vendor** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorised to act for the Principal.

The word **Shall** indicates a requirement.

The word **Should** indicates a recommendation.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (Part IV).

PART II GENERAL INFORMATION

Part III of this DEP is written as amendments and supplements to API 612, Fourth Edition, June 1995. Wherever reference is made to API 612, it shall be understood to mean API 612 as amended/supplemented by this DEP.

For ease of reference, the clause numbering of API 612 has been used throughout Part III of this DEP. Clauses in API 612 which are not mentioned in this DEP shall remain valid as written. A bullet (•) in the margin against certain clauses in API 612 indicates that a decision by the Principal is required. These decisions shall be indicated directly on the relevant data/requisition sheet when provisions are made for them; otherwise they shall be indicated on the data/requisition sheet(s) under the heading 'Additional Requirements' or stated in the purchase order.

PART III AMENDMENTS/SUPPLEMENTS TO API 612

SECTION 1 GENERAL

1.1 SCOPE

1.1.2.1 Replace the last sentence by:

Requirements for general-purpose steam turbines are defined in API 611 as amended/supplemented by DEP 31.29.60.30-Gen.

1.3 CONFLICTING REQUIREMENTS

Replace this clause by:

In the case of conflict between documents relating to the inquiry or order, the following hierarchy of documents shall apply:

- upper level : purchase order and variations thereto
- second level : data/requisition sheets and drawings
- third level : this DEP.

1.5 REFERENCED PUBLICATIONS

Add to this clause:

Standards referred to in this DEP are listed in Part IV.

SECTION 2 BASIC DESIGN

2.1 GENERAL

2.1.1 Add to this clause:

Turbine ratings shall not exceed the limits of the vendor's design, but shall be well within the range of the manufacturer's actual experience. Only equipment, which has proven its reliability in service, is acceptable.

2.1.4 Add to item g.:

The vendor shall specify the limits of variation from rated steam conditions, which the turbine can accept.

2.1.6 Replace the second sentence by:

After installation, the performance of the combined units shall be the responsibility of the vendor who has been nominated as being responsible for the complete unit.

2.1.9 Add to this clause:

(a) All left-handed threads shall be clearly marked.

(b) Any maintenance item heavier than 20 kg shall be provided with lifting lugs or similar dedicated fixed lifting point(s). Screw-in eyebolts are only acceptable for bearing housing covers and for internal components where other lifting arrangements are impractical. Holes for eyebolts shall be permanently marked with the correct bolt size to be used. If this marking is impractical, bolt size information should be clearly indicated in the instruction manual.

2.1.10 Replace “minimise” by “prevent”.

2.1.12 Replace this clause by:

2.1.12 Noise Control

2.1.12.1 General

The Contractor shall comply with DEP 31.10.00.31-Gen. and thereby communicate to the Vendor the specified equipment noise limitations by using data sheet DEP 31.10.00.94-Gen., which forms part of the requisition. The Vendor is responsible for assuring that these equipment noise limitations have been specified.

2.1.12.2 Information to be submitted with the Tender

The Vendor shall submit guaranteed sound power levels and sound pressure levels of the equipment, together with any other relevant information as requested in the data sheet, DEP 31.10.00.94-Gen. The Vendor shall indicate what special silencing measures, if any, are proposed in order to meet the specified levels.

If noise enclosures are supplied, the full access to the equipment for maintenance purposes shall be ensured by means of an appropriate design (2.1.9).

2.1.13 Replace this clause by:

Motors, electrical components and electrical installations shall be in accordance with DEP 33.64.10.10-Gen.

2.1.15 Add to this clause:

Throughout the service life specified in (2.1.1), spare parts for all components of the unit shall be available for purchase and all manufacturing drawings shall be retained.

2.1.16 Add new clause:

The Vendor shall list in his proposal all detailed design and material changes that have been introduced in the selected turbine design in similar machines in the last 5 years or which have not acquired at least 16 000 hours in operation. Although continuous developments by the manufacturer in his product line are recognised, these changes are subject to the Principal's approval. At the discretion of the Principal alternative designs may be requested, if the manufacturer fails to provide evidence of proven reliability.

2.1.17 Add new clause:

In the event of any design or manufacturing error, faulty material or damage relating to any turbine part, the component in question shall be replaced unless otherwise agreed by the Principal. Any proposal to recover the component rather than replace it, and the method of repair, shall be submitted to the Principal to obtain approval. Additional tests or calculations may be required to prove (a) the effectiveness of the repair, and (b) that there will be no detrimental effect on the serviceability of the component. At the discretion of the Principal a temporary repair or recovery may be accepted subject to a later replacement of the complete component or assembly by the Vendor.

2.2 PRESSURE CASINGS

2.2.5 Add to this clause:

Steam turbines with inlet pressures above 50 bar (ga) shall be equipped with pressure relief grooves at the splitline to minimise steam leakage.

Re-torquing splitline bolting when hot is not acceptable as a means of achieving a seal tight joint.

2.2.8 Add to this clause:

If the steam chest is not an integral part of the casing it shall be dowelled with cylindrical dowels.

2.2.9 Add to this clause:

Inter-stage water passage holes in the wet region of a condensing turbine shall be stainless steel lined.

2.2.12.4 Add to this clause:

Bolting at casing joints and main process connections shall be designed to be tensioned by an approved hydraulic tensioning method and sufficient space shall be provided to facilitate the use of such equipment.

Internal splitline bolts shall not be used.

2.3 CASING APPURTANCES

2.3.2 Replace last sentence by:

Nozzles or blading shall be welded to the diaphragms.

2.3.3 Add new clause:

Diaphragm anti-rotation devices shall be mounted at the split joint.

2.3.4 Add new clause:

Diaphragm seats in the wet region of the flowpath shall be made from erosion resistant materials or shall have replaceable inserts.

2.4 CASING CONNECTIONS

2.4.3 Replace this clause by:

All casing openings for pipe connections shall be not less than DN 20 (3/4 in. NPS) and shall be flanged, machined and studded, or welded. Threaded connections shall not be used. Where flanged or machined and studded openings are impractical on weldable casings, openings of DN 25 or larger shall be full penetration butt weld connections, not socket weld connections.

Exceptions allowed by clause 2.4.3.1 through 2.4.3.7 shall be subject to the approval of the Principal. Openings of less than DN 25 may be reinforced boss connections of the "weldolet" type, using only full penetration butt welds.

2.4.6.6 Replace this clause by:

The finish of all steel flanges and nozzles shall conform to ASME B16.5.

2.4.9 Replace this clause by:

Pipe-flange gaskets shall be in accordance with the specified piping class.

2.6 ROTATING ELEMENTS

2.6.1 ROTORS

2.6.1.1 Replace this clause by:

Rotors shall be of integrally forged construction.

2.6.2 SHAFTS

2.6.2.5 Add to this clause:

Shafts shall have an integral coupling hub.

2.6.2.7 Add new clause:

Each rotor shall undergo a heat stabilty test in accordance with ASTM A 472 or SEP 1950.

2.6.3 BLADING

2.6.3.1 Replace the penultimate sentence by:

Copies of Cambell and Goodman diagrams shall be provided to the purchaser.

2.6.3.2 Replace first sentence by:

All blades shall be mechanically suitable for operation (including transient conditions) over the specified speed range and steam conditions.

2.7 SHAFT SEALS

2.7.1 Replace this clause by:

Outer glands shall be sealed with replaceable labyrinth seals. Stepped labyrinth rings mounted on the rotor are not acceptable. If stepped labyrinths are applied they shall be integrally machined.

2.7.2 Delete this clause.

2.7.4 Replace the first sentence by:

Glands operating below atmospheric pressure shall be designed for admission of dry steam to seal against air leakage.

2.7.5 Replace this clause by:

The Vendor shall furnish a separate vacuum device for mounting and connecting to the glands to reduce external steam leakage if he considers this necessary to prevent contamination of the bearing oil and to reduce the external leakage.

2.8 DYNAMICS

2.8.1.4 Add to this clause:

The critical speed and separation margin values resulting from the most unfavourable combination of the parameters under 2.8.2.2 shall be used to verify compliance with the criteria in 2.8.2.5 and further.

2.8.1.6 Delete from this clause:

"Unless the resonances are critically damped".

2.8.2 LATERAL ANALYSIS

2.8.2.5 Replace this clause by:

The damped unbalance response analysis shall indicate that the machine in the unbalanced condition described in 2.8.2.4 item b will meet the following acceptance criteria (see Figure 1):

a. If the amplification factor is less than 2.5 the response is considered critically damped and no separation margin is required.
b. If the amplification factor is between 2.5 and 4.01, the separation margin from all lateral modes shall be at least:
   - 20% over the maximum continuous speed.
   - 10% below the minimum operating speed.

In sub c) and sub d) of this clause, replace “3.55” by “4.00”

2.8.2.8 Add new clause:

The Vendor shall carry out a rotor stability analysis. This shall be made at rated speed for constant speed machines and over the speed range from minimum to maximum continuous for variable speed machines. The analysis shall take into consideration de-stabilising effects such as aerodynamic interactions and close clearance labyrinths.

The results shall be provided as plots showing the following:

- for stiff supports, calculated log decrement as a function of rotor speed versus de-stabilising effects of labyrinths with minimum clearances and twice the maximum clearances;
- for soft supports, calculated log decrement as a function of rotor speed versus de-stabilising effects of labyrinths with minimum clearances and twice the maximum clearances;

Results shall also be presented in a table showing the damped natural frequencies for all cases; predominant sources of instability shall be clearly indicated.

The calculated log decrement shall have a minimum positive value of 0.2. On variable speed machines this shall be over the speed range from minimum to maximum continuous speed.

2.8.4 TORSIONAL ANALYSIS

2.8.4.4 In last sentence, delete “mutual” and “purchaser and the”

2.8.4.5 Add to this clause:

The Vendor shall submit his procedures for carrying out stress analyses and the corresponding acceptance criteria to the purchaser for approval by the Principal.

2.8.5 VIBRATION AND BALANCING

2.8.5.2 Replace second sentence by:

This shall be accomplished after the addition of no more than two individually balanced major components.

2.8.5.4 Replace this clause by:

High speed balancing is not required for rotors that have their operating speed range below the first rotor bending critical speed.

Unless otherwise approved by the principal, rotors, operating above the first rotor bending critical speed, shall be balanced at high speed in accordance with the following procedure:

High speed balancing:

- After initial low speed balancing each complete assembled rotor shall be run at 114 % of maximum continuous speed in order to promote a proper settling of the turbine blading.
- After this run the rotor shall be balanced at low speed (below 1000 r/min) to a balance quality according ISO 1940, grade G1.
- Subsequently, the rotor shall be balanced at maximum continuous speed or higher to a balance quality according ISO 1940, grade G1. In addition, the relative shaft displacement at the location of the bearings shall not exceed the limits of 2.8.5.5. High speed balancing shall be done with bearings that are similar to the contract bearings. The stiffness of the bearing supports of the high speed-balancing machine shall be as close as practical to the actual calculated stiffness of the turbine bearing supports.
- After the high speed balancing the residual unbalance of the rotor shall be verified at low speed. It shall be within the limits of ISO 1940, grade G 2.5. If the rotor exceeds this limit and corrections are made, the high speed balancing and low speed balance verification shall be repeated.

  Rotors that are balanced in accordance with above procedure are exempted from the residual unbalance requirements of 2.8.5.2.

  If the manufacturer considers alternative and/or additional balancing procedures necessary in order to comply with 2.8.5.5 during the mechanical running test, he shall submit a proposal for approval by the Principal.

2.8.5.5 Add to this clause:

When passing critical speeds the overall unfiltered peak-to-peak amplitude of vibration shall not exceed 150 % of the above limit.

The maximum allowable casing or bearing housing vibration in any plane shall not exceed a value of 3 mm/s RMS.

2.8.5.8 Change “Equation 6” to “paragraph 2.8.5.5”

2.9 BEARINGS AND BEARING HOUSINGS

Add new section:

2.9.0 GENERAL

2.9.0.1 Add new clause:

Radial bearings and thrust bearings shall be fitted with bearing-metal temperature sensors

installed in accordance with API 670.

Platinum (100 Ohm, three-wire) RTDs shall be used for bearing metal temperature detection arranged as follows:

- radial bearings shall have two RTDs within the expected load zone
- thrust bearings shall have five RTDs, three on the active side and two on the inactive side. RTD's shall be located in the highest loaded part of the pad.

In case of tilting pad bearings each RTD shall be installed in a separate bearing pad.

For monitoring, a minimum one RTD of each radial bearing, two RTD's of the active thrust and one of the inactive side of the thrust bearing shall be connected to the operator display in the main control room and provided with an alarm function.

2.9.0.2 Add new clause:

Bearing metal temperatures shall not exceed 110 deg. C under any load conditions and at the maximum specified ambient or cooling water temperature.

2.9.0.3 Add new clause:

Damper type bearings shall not be used.

2.9.0.4 Add new clause:

Spherical seat tilting pad bearings may be used only with the approval of the Principal.

2.9.1.1 Add to clause:

Bearings shall be suitable for operating at barring speed without damaging the babbit lining.

2.9.2 THRUST BEARINGS

2.9.2.2 Add new item:

f. Transient effects on start up and shut down

2.9.2.6 Add to this clause:

If requested by the Principal, the manufacturer shall provide all details of the rotor thrust balance calculations and the associated specific thrust bearing loading.

2.9.3 BEARING HOUSINGS

2.9.3.2 Add to clause:

Provision shall be made for connecting an air buffer to the steam side labyrinth.

2.9.3.5 Replace this clause by:

Each bearing housing shall be provided with two radial vibration displacement type probes, at each thrust bearing three axial position displacement probes shall be installed and a key phasor. Probes and their installation shall be as specified in API 670 (see 3.4.8).

2.10 LUBRICATION AND CONTROL OIL SYSTEM

2.10.1 Add to this clause:

Every effort shall be made to select the same oil type and viscosity grade for the complete machine train.

2.10.4 Replace this clause by:

Lubricating oil and seal oil systems shall comply with DEP 31.29.60.32-Gen.

2.10.6 Add to this clause:

Extension lines shall be shielded from heat.

2.11 MATERIALS

2.11.1 GENERAL

2.11.1.1 Replace this clause by:

Materials of construction shall be as specified in the data/requisition sheets. The Vendor may offer alternative materials if based on his experience these would be a better selection. Acceptance of these alternative materials is subject to the written approval of the Principal.

The Vendor shall advise all parts that are designed on other criteria than ultimate stress, with criteria listed.

2.11.1.12 Replace this clause by:

All pressure containing parts shall be of steel. Alloy steels shall be used for maximum steam temperatures exceeding 410 °C (775 °F).

2.11.1.13 Add to this clause:

Rotating blading shall be forged. Alternative designs are subject to Principal approval.

2.11.2 CASTINGS

2.11.2.3 Replace this clause by:

The repair of leaks and defects in pressure-containing castings by peening or burning-in, or by impregnation with plastics or cement compounds is prohibited.

Repair by welding or by plugging shall be undertaken only when permitted by the material specification, and then only in accordance with the procedures detailed below.

Repair by welding:

Weldable grades of steel castings may be repaired by welding subject to the following criteria:

1. Approval by the Principal shall be obtained before any major* weld repair is carried out.

   Refer to definition included after item 6.

2. All repairs shall meet the inspection requirements and acceptance standards for the original material.

3. For steel castings, the repair welding procedure and the repair welder's qualifications shall both be in accordance with ASTM A 488.

   Repair procedures are subject to approval by the Principal.

4. The total quantity of weld metal deposited shall be less than 10% of the mass of the casting.

5. After weld repair, castings shall be suitably heat-treated if this is specified in the relevant material specification.

   A major* weld repair shall always be followed by a suitable heat treatment.

6. Details of all major weld repairs, and of the heat treatment where applicable, shall be recorded and reported to the Principal. Details of the repair, including a drawing identifying the location, shall be included in the manufacturers data report.

   * The definition of a major weld repair is to be taken as either a removal of more than 50% of the wall thickness, or a length of more than 150 mm. in one or more directions, or a total surface area of all repairs exceeding 10% of the total casting surface area.

Repair by plugging:

Grey cast iron or nodular cast iron may be repaired by plugging within the limits specified in ASTM A 278, ASTM A 536 or ASTM A 395, respectively. The drilled holes for plugs shall be carefully examined by dye penetrant to ensure removal of all defective material. All necessary repairs not covered by ASTM shall be subject to approval by the Principal.

Details of all repairs shall be recorded and reported to the Principal, who shall be informed of the need for plugging before any repair is carried out.

2.11.3 WELDING

2.11.3.2 Add to this clause:

The Vendor shall be responsible for the review of all repairs and repair welds to ensure that they are properly heat-treated and non-destructively examined for soundness and compliance with applicable qualified procedures, and that they meet the acceptance standards for the original material.

2.11.3.5.1 Replace this clause by:

100 percent radiography inspection of welds shall be applied where possible. Magnetic particle inspection or liquid penetrant inspection of welds shall be used where radiography is not possible.

2.12 NAMEPLATES

2.12.3 Add to this clause:

l. Year of manufacture.

2.12.4 Replace this clause by:

Unless otherwise specified the text on the nameplates shall be in the English language and the data shall be in SI units.

SECTION 3 ACCESSORIES

3.1 COUPLINGS AND GUARDS

3.1.1 Add to this clause:

Unless otherwise specified or approved by the principal, non-lubricated spacer type membrane or disc couplings shall be used.

3.2 MOUNTING PLATES

3.2.1.1 Replace this clause by:

The turbine and driven equipment shall be mounted on the same baseplate, unless this is impractical, in which case the manufacturer shall seek the approval of the Principal to use separate baseplates (which shall be able to be bolted together to facilitate field erection and alignment).

3.2.2 BASEPLATES

3.2.2.1 Add to first paragraph of this clause:

The baseplate shall be constructed with longitudinal steel beams and full support cross members. Cross members shall be located underneath the support plane of the turbine and all turbine-driven equipment. All butt welds shall be full penetration welds.

3.2.2.4 Add to this clause:

When lifting the baseplate complete with all equipment mounted, beam deflection shall not exceed L/1200, where "L" is the total length of the beam in millimetres.

3.3 GEAR UNITS

Replace clause by:

Gear units shall conform to the requirements of DEP 31.29.00.32-Gen.

3.4 CONTROLS AND INSTRUMENTATION

3.4.1 General

3.4.1.1 Replace this clause by:

Amended per Circular 30/99

Instrumentation and connections for instruments shall be in accordance with DEP 32.31.09.31-Gen and DEP 32.31.00.32-Gen.

3.4.1.3 Add new clause:

Controls and instrumentation shall be designed and manufactured for use in the area classification specified by the purchaser and shall comply with any local codes and regulations.

3.4.1.4 Add new clause:

All conduit, armoured cable and supports shall be designed and installed so that it can easily be removed without damage and shall be located so that it does not hamper removal of noisehoods, lagging, bearings, seals, or other equipment internals.

3.4.2 Overspeed shutdown system

3.4.2.1 Replace “127%” by “120%”.

3.4.2.2 ELECTRONIC OVERSPEED CIRCUIT

3.4.2.2.2 Delete from the first sentence “When specified”

3.4.2.4.2 Delete “surfaces” from item a).

Add to item h):

Design shall be such that it is not possible to fully close the trip valve during testing.

3.4.3 GOVERNING SYSTEM

3.4.3.8 Replace “governor” by “governing system”

3.4.3.12 Replace this clause by:

The level of redundancy and fault tolerance shall be as required to meet the five year uninterrupted service expectation (API 612, clause 2.1.1).

3.4.3.14 Add new clause:

To avoid damage to valves and valve regulating mechanisms, the design of the valves and valve stem shall be such, that valve flutter or flow induced valve vibration does not occur over the entire control region. Forces acting on the valves or valve bar due to the steam velocity in the steam chest shall not in anyway prevent or hamper free valve travel. Since above can not normally be tested at the test stand, the vendor shall provide references of similar designs at comparable operating conditions in the quotation stage.

3.4.3.15 Add new clause:

Mounting of valve seats in steam chests shall be such that the seats will not dislodge due to thermal transient gradients. Apart from seal welds, no other welding shall be used to fit seats into the steam chest.

Each valve shall be numbered on the valve and on an exposed area of the corresponding bonnet. Valve opening shall reflect the same numbering.

3.4.5 INSTRUMENTATION

3.4.5.2.1 Delete the words "or gas filled". Add the words "stem diameter shall be 6 mm".

3.4.5.3 Delete "300" and replace by "316L"

Add " These shall be in accordance with Standard Drawing S 38.103"

3.4.5.7.3 Add new clause:

Sentinel valves shall not be used.

3.4.6 ALARMS AND SHUTDOWNS

3.4.6.1.2 Replace clause by:

Electrical switches for alarms or trips shall open to trip (i.e. fail-safe). Solenoids for trips shall be de-energised to trip (i.e. fail-safe).

3.4.6.1.5 Replace clause by:

The turbine vendor shall advise the purchaser of any alarms and/or shutdowns considered essential to safeguard the turbine.

3.4.6.1.6 Add new clause:

The purchaser will specify the alarms and shutdowns required for safeguarding the turbine, which as a minimum shall include the following:

Alarms:

Overspeed shutdown system fault.

Failure of one governor speed sensor.

Low lube oil pressure.

High exhaust pressure.

High radial vibration.

Axial displacement.

High bearing temperature.

Low control oil pressure.

Low/high extraction pressure (if applicable).

Low steam inlet temperature.

Low steam inlet pressure.

High first stage steam pressure.

Turning gear not engaged. (if applicable).

Shutdowns:

Overspeed.

Failure of all governor speed sensors.

Very low lube oil pressure.

High axial displacement (2 out of 3).

High condensate level.

High differential steam pressure (if applicable).

3.4.7 ELECTRICAL SYSTEMS

3.4.7.1 Delete last two sentences.

3.4.7.2 Replace this clause by:

Electrical components and electrical installations shall be in accordance with Electrical Engineering Guidelines DEP 33.64.10.10-Gen.

3.4.7.3 Delete “wiring" and replace by "wiring or cabling".

Add to this clause:

Instrument and power wiring or cabling, with the exception of power supply to electric motors, shall be connected to terminal strips installed in terminal boxes. Instrument signals and wiring or cabling with different voltages shall be connected to separate terminal boxes. The terminal boxes shall be mounted in one central location on the base plate. The location of the terminal boxes shall be shown on the layout drawing.

3.4.7.4 Delete second sentence.

3.4.7.6 Add to the beginning of this clause:

The Purchaser shall specify whether cabling or wiring in metal conduits shall be used.

a. When cabling is specified the following shall apply:

   Cables shall be of the metal armoured or braided type. They shall be installed on cable trays properly supported to minimise vibration and be segregated such as to prevent interference between voltage levels.

b. When metal conduits are specified the following shall apply.

3.4.7.7 Delete this clause

3.4.8 VIBRATION, POSITION AND BEARING TEMPERATURE DETECTORS

3.4.8.1 Replace this clause by:

As specified on the data requisition sheets, non-contacting vibration and axial position transducers shall be supplied, installed and calibrated in accordance with API 670 as amended/supplemented by DEP 32.31.09.31-Gen.

3.4.8.2 Add to this clause:

"as amended/supplemented by DEP 32.31.09.31-Gen."

3.4.8.4 Add to this clause:

"as amended/supplemented by DEP 32.31.09.31-Gen."

3.4.8.5 Add new clause:

All wire entries into the bearing housings shall be provided with proper sealing against leakage.

3.6 PIPING AND APPURTENANCES

3.6.1 General

3.6.1.1 Add to this clause:

"and DEP 31.38.01.31-Gen."

3.7 INSULATION AND JACKETING

3.7.1 Delete “When specified or required by the vendor” from first sentence.

Add to this clause:

Insulation shall not contain asbestos.

3.7.3 Add new clause:

Jackets and insulation shall be designed to cause no obstruction to operational activities and be readily removable for maintenance.

3.9 TURNING GEAR

3.9.3 Add to this clause:

If an electric motor drive for the turning gear is selected, the electric motor shall comply with DEP 33.66.05.31-Gen.

Turning gear shall include a facility for manual barring in the event of turning gear drive failure.

3.10 CONDENSING TURBINE EXHAUST

3.10.1 Connection

The connection between turbine and condenser shall be designed so that it can be removed and replaced without the need for dismantling the turbine casing.

3.10.2 Inspection openings

Adequate inspection openings shall be provided in the exhaust for inspection and access.

3.10.3 Air ejectors

For steam-driven air ejectors, the ejector nozzles shall be of 13% Cr-type stainless steel and protected against clogging by 32 mesh basket-type steam strainers. The ejector equipment shall be complete with all interconnecting piping, including valves, traps, etc., and with connections for pressure gauges required for proper operation. Ejector equipment shall be fully spared.

3.10.4 Extraction pumps

Two condensate extraction pumps shall be installed, one for normal operation and one for stand-by duty. Unless otherwise specified, the pumps shall be electric-motor-driven.

Each pump shall be capable of handling the maximum flow of condensate plus 20%, and shall be provided with a minimum flow protection. Both pumps shall be centrifugal-type and shall comply with API 610 as amended/supplemented by DEP 31.29.02.30-Gen.

The Vendor shall specify the minimum required vertical distance between the suction nozzle of the pump and the normal working level in the condenser hot well or water box.

3.10.5 Relief valve and alarm

A water-sealed atmospheric relief valve shall be provided, and sized for full steam flow at 0.2 bar (ga) backpressure.

The condenser shall be capable of withstanding this pressure for prolonged periods. The Vendor shall provide a connection for a pressure transmitter to activate an alarm under high-pressure conditions.

3.10.6 Condensate sump

The main condenser condensate sump or hot well shall be sized to provide a three-minute hold-up at maximum flow rate, and shall be provided with suitable level glasses and connections for level controller, condensate outlet, drains and high/low-level alarms and trips.

3.10.7 Off-design vacuum conditions

For air condensors the variation in condenser air temperature and its impact to possible variation in the turbine's performance and integrity arising from significantly off-design vacuum conditions shall be analysed and suitably allowed for.

SECTION 4 INSPECTION, TESTING AND PREPARATION FOR SHIPMENT

4.1 GENERAL

4.1.3 Replace “sufficient notice” by “not less than 5 working days”

4.1.6 Delete “ When specified,”

4.1.8 Add new clause:

The scope of Principal’s shop inspection shall be confirmed prior to manufacture. It may include, but need not be limited to, the following:

- a check (against outline drawings which have been approved by the purchaser) of all main dimensions, base plate dimensions, location of foundation bolt holes, size/position/rating of flanges and coupling guard arrangement;
- an inspection of flange face finish;
- a verification that the Vendor has performed the specified inspections and tests with satisfactory results;
- a verification of the required material certificates and (to the extent specified) their traceability to the respective components;
- a check of casing wall thickness;
- measurement of the running clearances;
- a visual check for good workmanship and finish of internals
- verification of taper fits with matched plug and ring set.

4.2 INSPECTION

4.2.1.1 Replace the first sentence of this clause by:

The Vendor shall keep the data listed below available for examination by the Principal or his representative upon request. The data shall be kept for at least 10 years and shall thereafter be offered to the Principal.

Add new items:

f. Fully identified records of all heat treatment whether performed in the normal course of manufacture or as part of a repair procedure.

g. Details of all major repairs (ref. Paragraph 2.11.2.3).

4.2.2 Replace this Section by:

4.2.2 MATERIAL INSPECTION

4.2.2.1 The material inspection requirements are summarised in the following table; the procedures and acceptance criteria are given in the subsequent paragraphs.

COMPONENT	REQUIRED MATERIAL INSPECTION
Turbine casing - cast	RT (or UT per 4.2.2.3), and MT or PT and VI
Turbine casing - fabricated	UT, and MT or PT and VI
Turbine fabrication	
-full penetration welds	RT or UT, and MT or PT
-fillet welds	MT or PT
Diaphragms, guide channels	MT or PT, and VI
Labyrinths	VI
Shaft	UT, and MT or PT and VI
Bearing housing, bearings	VI and PT
Auxiliary piping	See DEP 31.38.01.31-Gen.

NOTE 1: VI = Visual Inspection

MT = Magnetic Particle Examination

PT = Liquid Penetrant Examination

RT = Radiographic Examination

UT = Ultrasonic Examination

NOTE 2: "Casing" includes all items of the pressure boundary of the finished turbine casing (e.g. the casing itself and other parts such as nozzles, flanges, end head, closure plates, shear rings, etc).

NOTE 3: Timing of inspection

- VI/MT/PT shall be performed after final heat treatment in the final machined condition
- RT/UT of castings shall be performed after final heat treatment but need not be in the final machined condition provided that the thickness is within 90 percent of the final thickness (that is, no more than 10 percent further reduction in thickness allowed). In any case the radiographic sensitivity indicator (e.g. penetrameter) shall be selected based on the actual thickness.
- RT of welds and UT of fabricated material and welds shall be performed after final heat treatment.

  UT of wrought material shall be performed prior to any machining operations (e.g. for keyways, drilled holes etc.) which may interfere with the UT examination.

NOTE 4: PT examination shall only be used where MT is not feasible (see paragraph 4.2.2.5).

4.2.2.2 Radiographic Examination (RT)

4.2.2.2.1 RT of castings shall be performed in accordance with ASME VIII, Division 1, Appendix 7. Critical sections of each casting shall be fully radiographed; where such sections cannot be radiographed and/or for wall thickness above 50 mm, UT shall be used (also in accordance with ASME VIII, Division 1, Appendix 7). The Vendor shall submit details of the critical sections proposed to receive RT/UT, for the Purchaser's approval.

4.2.2.2.2 RT of welds shall be in accordance with ASME VIII, Division 1, UW-51. Coverage shall be 100 percent.

4.2.2.3 Ultrasonic Examination (UT)

4.2.2.3.1 UT of welds shall be in accordance with ASME VIII, Division 1, Appendix 12. Coverage shall be 100 percent. UT of welds shall be performed for weld thickness over 30 mm.

4.2.2.3.2 UT of fabricated material shall be in accordance with ASME V, Article 5. The acceptance criteria shall be as follows:

a) Austenitic forgings

Referring to ASTM A 745:

- QL-1 for straight beam with thickness t = 0 to 75 mm

- QL-2 for straight beam with thickness t = 76 to 200 mm or
- QA-2 for angle beam, all thicknesses.

b) Non-austenitic forgings

Referring to ASTM A 388:

- For straight beam examination, back reflection method, no areas shall have a loss of 95 percent or more of the reference back reflection.
- For straight beam examination, reference block method, there shall be no indications equal to or larger than the indication received from the reference block constructed with the following flat bottomed holes:

1.5 mm for t = 0 to 37 mm

3 mm for t = 38 to 150 mm

6 mm for t = 151 mm and greater.

- For angle beam examination, there shall be no indications equal to or larger than the indication received from the reference notch or amplitude reference line.

c) Plate material

Acceptance criteria in accordance with ASME II, SA-435 or SA-577, depending on the material.

After fabrication UT inspection shall be in accordance with ASTM A 577.

d) Tubular material

Acceptance criteria in accordance with ASTM E 213, in which the calibration notch shall take the following form:

- shape shall be rectangular
- depth shall be maximum 5 percent of the nominal wall thickness
- length shall be 25 +/-5 mm
- width shall be no greater than twice the depth.

4.2.2.4 Magnetic Particle Examination (MT)

MT of castings shall be performed in accordance with ASME VIII, Division 1, Appendix 7.

MT of welds and wrought material shall be performed in accordance with ASME VIII, Division 1, Appendix 6. All surfaces shall be examined.

4.2.2.5 Liquid Penetrant Examination (PT)

PT shall only be performed when specified MT is not possible; in which case it shall be done in accordance with ASME VIII, Division 1, Appendix 7 for castings or Appendix 8 for welds and wrought material (all surfaces to be examined).

4.2.2.6 Visual Inspection (VI)

VI shall be performed in accordance with ASME V, Article 9. All surfaces shall be inspected. Acceptance criteria for pressure-containing steel castings shall be in accordance with MSS SP-55. Acceptance criteria for other parts shall be in accordance with the material specification and the Vendor's documented procedures.

Add new Section:

4.2.4 MATERIAL INSPECTION CERTIFICATES

The Vendor shall furnish material inspection certificates in accordance with ISO 10474, of the type as specified in the table below.

CERTIFICATION OF MATERIALS BY TURBINE PART

COMPONENT	ISO 10474 CERTIFICATE TYPE
Pressure containing parts (casing, end head and main process nozzles)	3.1.B (see NOTE)
Rotor and buckets	3.1.B (see NOTE)
Internals - Nozzle ring, bolting, -diaphragms-guides blades, valves , valve seats, valve stems	3.1.B
Main bolting and nuts	3.1.B
All other process and auxiliary piping, flanges and connections	3.1.B

NOTE: Positive alloy material identification (PAMI) shall be applied at the time of assembly for pressure containing parts, rotor shafts and disks and blades, which are made of low-alloy steel, high-alloy martensitic steel, ferritic or austenic stainless steels or nickel alloys. This shall be used to positively identify that the materials have the specified alloy composition. The method and procedures are subject to approval by the Principal.

Add new section:

4.2.5 MARKING

Marking is required for all pressure casings. Parts with a wall thickness in excess of 5 mm, except those items manufactured from austenitic stainless steel or from nickel alloys, shall be legibly marked by hard-die stamping on to a painted background at a place clearly visible later. Pipes should be marked at a point approximately 250 mm from one end.

Only low-stress stamps (dot-type or round-nosed with a minimum radius of 0.25 mm) shall be used for hard-die stamping.

For items manufactured from austenitic stainless steel or nickel alloys, and for items with a wall thickness of 5 mm or less, the marking shall be applied by stencil using a water-insoluble ink which contains no injurious substances such as metallic pigments, sulfur, sulfides or chlorides which could attack or harmfully affect the material.

The stamping/marking shall include:

- material manufacturer's symbol and, where applicable, the independent inspector's symbol; these symbols shall be identical to the symbols on the material certificate
- material identification
- heat, charge or batch number to relate to the material certificate
- heat treatment symbol or code, where applicable
- non-destructive testing symbol or code, where applicable
- size and schedule, where applicable
- hydrostatic test pressure, where applicable.

NOTE: Where the size of the item does not permit complete marking, the above identification marks may be substituted by a unique code which is fully traceable to the material certificate for the item.

4.3 TESTING

4.3.2 HYDROSTATIC TEST

4.3.2.1 Add to this clause:

Hydrostatic testing shall only be done after final machining of the subject component.

4.3.2.4 Replace "50 parts per million" by "10 mg/kg".

Insert new Section:

4.3.3.0 ROTOR OVERSPEED TEST

4.3.3.0.1 Each rotor shall be subjected to an overspeed test at at least 115% of maximum continuous speed for a duration of at least three minutes. After the overspeed test, the rotor shall be magnetic particle examined (the acceptance criterion being zero linear indications). The rotor shall then be balance checked at maximum continous speed; if the acceptance limits are exceeded, then the rotor shall be rebalanced.

4.3.3 MECHANICAL RUNNING TEST

4.3.3.2.7 Replace this clause by:

During this 4 hour test, the lubricating oil temperature shall be held for at least 30 minutes at the value corresponding to the maximum allowable viscosity, and for 30 minutes at the value corresponding to the minimum allowable viscosity. At minimum and maximum viscosity, and at the viscosity corresponding to the normal operating oil temperature, shaft vibration shall be measured and vibration frequency analysed to check for instabilities. Oil pressures and temperatures and bearing temperatures shall be measured throughout the test. Prior to testing, the Vendor and the Principal shall agree upon the acceptance criteria.

4.3.3.3.2 Add to this clause:

There shall be no sub-synchronous vibration at a frequency coinciding with a rotor critical speed.

4.3.3.3.5 Replace this clause by:

Recordings shall be made of all real time vibration data for later retrieval and analysis.

4.3.3.3.6 Delete the words “when specified, the tape”

4.3.3.4.3 Add to this clause:

Subject to the approval of the Principal, spare rotors for turbines may be exempted from the mechanical running test, provided the following conditions are met :

- Both main and spare rotors have been balanced at high speed in accordance with the requirements of 2.8.5.4.
- The main rotor has successfully completed the mechanical running test.

4.3.3.4.4 Add new clause:

The determination of lateral critical speeds shall be recorded on start-up and coast down with the slow roll (300 to 600 r/min) total run- out (electrical and mechanical) subtracted by vectorial compensation. This recorded shaft relative data shall include speed, peak-to-peak displacement and phase.

4.3.3.4.5 Add new clause:

If (any of) the critical speed(s) verified fall(s) within the specified operating speed range, or fails to meet the separation margin requirement (see paragraph 2.8.2.5 of API 612), rotor

insensitivity shall be demonstrated.

4.3.4 OPTIONAL TESTS AND INSPECTIONS

4.3.4.7 Change first part of sentence to “After the complete unit test,”

4.4 PREPARATION FOR SHIPMENT

4.4.1 Replace "6 months" by "18 months".

Add to this clause:

The equipment shall be shipped in the minimum possible number of baseplate sections.

4.4.3.10 Replace this clause by:

When a spare rotor is ordered it shall be crated in a metal container which is suitable for transportation and storage. The crating and storage shall be suitable for 10 years outdoor storage in the vertical position. The container shall be equipped for pressurized nitrogen blanketing.

4.4.3.11 Add to this clause:

Exposed shaft ends shall be protected against physical damage.

4.4.3.12 Add new clause:

Where vapour-phase inhibitor (VPI) or silica gel crystals in bags are installed in large cavities, either for inhibiting corrosion or absorbing moisture respectively, they must be in an accessible area for easy removal. The bags shall be attached with stainless steel wire and their locations indicated with corrosion resistant tags also fixed with stainless steel wire.

PART IV REFERENCES

In this DEP, reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto

Amended per Circular 30/99

SHELL STANDARDS

Index to DEPs and Standard Specifications	DEP 00.00.05.05-Gen.
Noise control	DEP 31.10.00.31-Gen.
Data/requisition sheet for equipment noise limitation	DEP 31.10.00.94-Gen.
Shell-and-tube heat exchangers (amendments/supplements to TEMA)	DEP 31.21.01.30-Gen.
Selected construction materials for shell-and-tube heat exchangers	DEP 31.21.01.31-Gen.
Centrifugal pumps (amendments/supplements to API 610)	DEP 31.29.02.30-Gen
Lubrication, shaft-sealing and control oil systems for special-purpose application (amendments/supplements to API 614)	DEP 31.29.60.32-Gen
Data/requisition sheet for special-purpose steam turbines	DEP 31.29.61.93-Gen.
Instruments for measurement control	DEP 32.31.00.32-Gen.
Instrumentation for equipment packages	DEP 32.31.09.31-Gen.
Electrical engineering guidelines	DEP 33.64.10.10-Gen.
Electric motors	DEP 33.66.05.31-Gen.

AMERICAN STANDARDS

General purpose steam turbines	API 611
Centrifugal pumps for general refinery services	API 610
Special-purpose steam turbines for refinery services	API 612, Fourth Edition, June 1995
Non contacting vibration and axial position monitoring systems	API 670

Issued by:
American Petroleum Institute,
Publications and Distribution Section,
2101 L Street Northwest,
Washington, DC 20037, USA

Pipe flanges and flanged fittings	ASME B16.5
ASME Boiler and Pressure Vessel Code	
- Material specifications	ASME II
- Unfired pressure vessels	ASME VIII
- Non-destructive examination	ASME V

Issued by:
American Society of Mechanical Engineers
345 East 47th Street
New York NY 10017
USA

Gray iron castings for pressure- containing parts for	ASTM A 278

temperatures up to 650 °F (345 °C)	
Ultrasonic examination of heavy steel forgings	ASTM A 388
Specification for ferrite ductile iron pressure retaining castings for use at elevated temperatures	ASTM A 395
Tests for heat stability of steam turbine shafts and rotors	ASTM A 472
Qualification of procedures and personnel for the welding of steel castings	ASTM A 488
Ductile iron castings	ASTM A 536
Ultrasonic angle-beam examination of steel plates	ASTM A 577
Ultrasonic examination of austenitic steel forgings	ASTM A 745
Ultrasonic examination of metal pipe and tubing	ASTM E 213

Issued by
American Society for Testing and Materials
1916 Race St.
Philadelphia
Pa. 19103
USA

Quality standard for steel castings - visual method	MSS SP-55

Issued by
Manufacturers Standardization Society
5203 Leesburg Pike, Suite 502
Falls Church, Virginia 22041
USA

GERMAN STANDARDS

Stahl Eisen Prüfblätter, Warmrundlaufprüfung an Turbinenwellen	SEP 1950

Issued by:
Verlag Stahleisen GmbH,
Postfach 10 51 64
40042 Düsseldorf
Germany

INTERNATIONAL STANDARDS

Balance quality requirements for rigid rotors	ISO 1940
Steel and steel products - inspection documents	ISO 10474

Issued by:
International Organization for Standardization
Case Postal 56
CH-1211 Geneva 20
Switzerland

Copies can also be obtained from national standards organizations.