

MANUAL

# **STEAM TURBINES - SELECTION, TESTING AND INSTALLATION**

DEP 31.29.60.10-Gen.

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**DESIGN AND ENGINEERING PRACTICE**

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP



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## 1. INTRODUCTION

### 1.1 SCOPE

This DEP specifies requirements and gives recommendations for the type selection, testing and installation of steam turbines.

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

### 1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this DEP is confined to companies forming part of or managed by the Royal Dutch/Shell Group, and to Contractors and Manufacturers/Suppliers 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, where applicable, in exploration and production facilities and supply/marketing installations.

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, 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

#### 1.3.1 General definitions

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

The **Manufacturer/Supplier/Vendor** is the party which manufactures or supplies the turbine and provides associated back-up services to perform the duties specified by the Contractor.

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

The **Purchaser** is the party which buys the turbine and its auxiliaries for its own use or as agent for the owner. The Purchaser may be either the Principal or the Contractor.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

#### 1.3.2 Specific definitions

**Continuous service:** A service in which it is not expected that the turbine will have to be stopped/started during normal plant operation.

**Intermittent service:** A service in which it is expected that the turbine will be started/stopped at unspecified intervals, e.g.:

- automatic starts and stops at intervals by process operated controls;
- manual starts and stops at intervals by manual control for batch processes.

NOTE      The above two definitions are independent of the requirements for a service life of 20 years and for at least 3 years of uninterrupted operation, as specified by DEP 31.29.60.30-Gen. and DEP 31.29.60.31-Gen.

#### 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 by this DEP are listed in (10).

## **2. RESPONSIBILITIES**

Where steam turbines are coupled to compressors, the compressor vendor shall be responsible for coordinating the turbine with the compressor. The turbine vendor shall in that case offer all assistance necessary to the coordinating vendor.

In all other cases of steam turbine drive, such as generators and pumps, the turbine vendor shall be made responsible for the coordination of the whole unit, including lubrication and control oil systems, and the vendor of the driven equipment shall offer all assistance necessary.

### 3. TYPE SELECTION

#### 3.1 GENERAL

Steam turbines are divided into two categories according to their size and usage:

- General-purpose steam turbines, and
- Special-purpose steam turbines.

Independently of the above two categories, steam turbines can be classified on the basis of their working principles, i.e. impulse turbines and reaction turbines

#### 3.2 GENERAL-PURPOSE STEAM TURBINES

These turbines can be horizontal or vertical and are used to drive equipment that is usually spared or is in non-critical service. Examples are drivers for spared pumps and compressors and drivers for fans and small generators.

These turbines are intended for applications where inlet steam conditions will not exceed 42 bar absolute pressure or 400 °C steam inlet temperature, or both, and where the speed will not exceed 6 000 r/min.

However, to achieve better efficiencies, or if the speed of the driven equipment is relatively low, the use of integrally geared steam turbines may be considered; in which case the speed of the turbine rotor may exceed 6 000 r/min.

General-purpose steam turbines shall comply with DEP 31.29.60.30-Gen.

#### 3.3 SPECIAL-PURPOSE STEAM TURBINES

These are horizontal turbines and are used to drive equipment that is usually not spared or is in critical service. Examples are drivers for centrifugal compressors or generators.

The use of these turbines is not limited by steam conditions or speed.

Special-purpose steam turbines shall comply with DEP 31.29.60.31-Gen.

#### 3.4 IMPULSE TURBINES VERSUS REACTION TURBINES

Independently of the above two categories, steam turbines can be classified on the basis of their working principles:

- **Impulse turbines (action turbines)**  
where steam expansion occurs only in the nozzles and / or in the stationary blades, not in the rotating blades.
- **Reaction turbines**  
where steam expansion occurs in both the stationary and the rotating blades.

With an impulse turbine, close clearances at the rotating blade tips are not essential. Interstage labyrinths over the diaphragms and shaft seal labyrinths have relatively small diameters, so the leakage losses are correspondingly small even with larger clearances. This makes an impulse turbine specifically suitable for quick starting from relatively cold stand-by conditions.

An impulse turbine is also preferred wherever rapid changes in steam and/or load conditions can be expected.

#### 3.5 SELECTION

The advantages and disadvantages of each type shall be evaluated for each application. Special attention shall be given to capital expenditure, operational aspects, maintenance aspects and life-cycle costs. Every effort should be made, consistent with sound engineering practice, to minimize the spares inventory by rationalizing the variety of makes and types of turbine drivers selected for any particular project.

In selecting equipment care should be taken to ensure that prospective Vendors do not exceed the ratings of their designs.

Selected equipment shall, in all respects, be within the range of the Vendor's proven experience, and shall not involve the use of any prototype components without the approval of the Principal.

#### 4. INSTALLATION

Installation shall be done in compliance with DEP 31.29.00.10-Gen.

In deciding upon the exact location of a turbine (and its driven equipment), due consideration shall be given to maintenance and process operation requirements.

Whether or not hoisting facilities and weather protection are to be provided shall be decided in co-operation with the Principal. DEP 31.25.00.10-Gen. should be used for guidance.

The layout of a turbine and its driven equipment and auxiliary equipment shall allow safe access for operations and maintenance. There shall be no unguarded floor openings around turbines. Adequate clear space and, where applicable, permanent steps and platforms shall be provided.

For major overhauls entailing the dismantling of the turbine and its driven equipment and auxiliaries, sufficient clear floor space shall be provided around the unit for laying out the dismantled parts for inspection and for carrying out the necessary repairs in a safe and practical manner. For adjacent turbines, sufficient clear floor space shall be provided between the turbines (and their driven equipment) to enable major overhauls to be carried out on all units simultaneously.

All special lifting equipment and special tools required for turbine maintenance shall be listed and provided in a metal box by the Vendor.

Steam inlet and exhaust lines shall be designed and installed in such a way that the forces and moments acting on the nozzles of the turbine do not exceed the allowable loadings specified by the Vendor.

Turbine nozzles shall be free to move whenever the turbine is heated up or cooled down. There shall be no fixed pipe supports close to the turbine and there shall be ample room left for pipe expansion between the turbine and the nearest fixed pipe supports.

The layout of piping around the turbine shall have the approval of the turbine Vendor.

To enable checks to be made on the performance of the turbine whilst it is on-stream, suitable instrument connections (flow, temperature and pressure) shall be installed in the steam inlet and exhaust lines, first wheel chamber and, where applicable, in the condensate lines.

An isolating main steam stop valve shall be provided in addition to the trip/throttle valve delivered with the unit.

A check valve shall be provided in the exhaust lines of backpressure or extraction turbines. These valves shall be located as close as possible to the turbine.

A warm-up line shall be installed to heat up the inlet steam line as close as possible to the steam inlet valve.

All areas of the turbine where the external surface temperature during normal operation is likely to exceed 70 °C shall be protected or insulated. Preshaped shells which are easily removable and replaceable for maintenance should be used.

Insulation shall be free of asbestos and hazardous ceramic man-made fibres.

Steam inlet strainers shall be provided to safeguard the turbine from extraneous solid materials getting into the machine.

The turbine foundation shall be shielded against radiant heat at points adjacent to hot areas of the machine and piping since the foundations can be thrown appreciably out of line by such hot spots, and concrete can suffer a permanent deformation over time. Considerable heat may be conducted from the casing through the supports and sole plates to the concrete. In such cases, water-cooled sole plates should be considered.

Turbine casing foundation bolting shall allow for free expansion of the turbine whenever the turbine is heated up or cooled down.

## **5. NOISE LEVELS**

### **5.1 LIMITS**

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

### **5.2 INFORMATION TO BE SUBMITTED WITH THE TENDER**

The Vendor shall submit guaranteed sound power levels and sound pressure levels (including octave band spectrum) of the equipment together with any 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.

### **5.3 GENERAL**

Noise control measures shall cause no hindrance to operations nor any obstruction to routine maintenance activities.

All definitions, notations, measuring equipment, measuring procedures, test reporting, calculation methods and calculation procedures shall be in accordance with EEMUA 140.

## **6. MATERIALS**

### **6.1 GENERAL**

Materials for the main component parts of the turbine shall be specified, as far as practicable, in the data/requisition sheet. These materials shall be selected in accordance with DEP 30.10.02.11-Gen.

Special consideration shall be given to the selection materials for the steam conditions specified. Under wet steam regimes, corrosion resistance and condensate withdrawal shall be evaluated.

### **6.2 MATERIALS CERTIFICATION**

The Vendor shall confirm by means of appropriate certificates that the chemical composition and mechanical properties of the materials of construction used in the manufacture of the pressure-containing parts and all the main components of the turbine are in accordance with the specifications for those materials.

The minimum requirements for materials certification for each type of steam turbine are given in DEP 31.29.60.30-Gen. and DEP 31.29.60.31-Gen.

## **7. INSPECTION**

### **7.1 GENERAL-PURPOSE STEAM TURBINES**

Inspection shall be in accordance with DEP 31.29.60.30-Gen.

NOTE DEP 31.29.60.30-Gen. specifies the methods to be applied if non-destructive examination is specified, but leaves it up to the Principal to specify whether such examinations are required. In making this decision, the Principal should recognise that general purpose steam turbines are often assembled from standard components and in most cases it is neither practical nor necessary to specify additional examinations to those already applied by the Vendor's standard. The Principal should make this decision based on the actual situation, e.g. it may be necessary to specify certain non-destructive examination if a casting is to be supplied by a foundry with which the Vendor has limited experience.

### **7.2 SPECIAL-PURPOSE STEAM TURBINES**

Inspection shall be in accordance with DEP 31.29.60.31-Gen.

## **8. GENERAL-PURPOSE STEAM TURBINES**

### **8.1 GENERAL**

General-purpose steam turbines shall comply with the requirements of DEP 31.29.60.30-Gen. The operating requirements and conditions, and the necessary data for the turbine shall be specified in data/requisition sheet DEP 31.29.61.95-Gen. The data/requisition sheet(s) shall be filled in properly in order to give the Vendor all the necessary information on which to base his tender.

NOTE The terms "continuous service" and "intermittent service" as used in the data/requisition sheet are defined in (1.3.2).

The Vendor shall complete these data/requisition sheets for the evaluation of his tender by the Principal. When drawing up the requirements, special attention shall be given to off-design conditions which may occur during the sequences of starting up or shutting down the turbine and the driven equipment.

### **8.2 VIBRATION**

Provision shall be made for installing vibration pick-ups to permit on-stream checks of vibration levels using portable or permanently installed vibration monitoring systems.

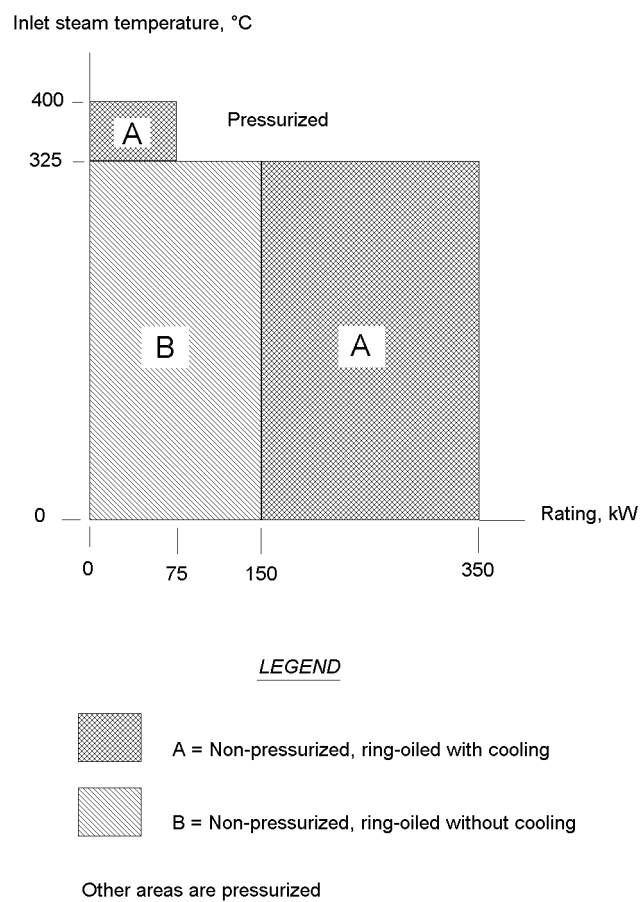
### **8.3 LUBRICATION**

The lubrication may be pressurized, non-pressurized (ring-oiled) with cooling, or non-pressurized (ring-oiled) without cooling. For non-pressurized (ring-oiled) systems with water cooling circuits which tend to foul and so require regular cleaning, circulation of the oil through an external cleanable water cooler with a shaft-driven oil pump shall be considered.

In addition to the Vendor's recommendations, the following guidelines shall be followed when making the selection.

- For turbines with rated speeds above 3600 r/min, pressurized lubrication should be specified.
- For turbines with speeds of 3600 r/min and below, the choice of lubrication system depends mainly on the inlet steam temperature and the developed power, as indicated in Figure 1.

**Figure 1 Selection of lubrication system for turbines with speeds of 3600 r/min and less**



## **9. SPECIAL-PURPOSE STEAM TURBINES**

### **9.1 GENERAL**

Special-purpose steam turbines shall comply with DEP 31.29.60.31-Gen. The operating requirements and conditions, and the necessary data for the turbine shall be specified in data/requisition sheet DEP 31.29.61.93-Gen. The data/requisition sheet(s) shall be filled in properly in order to give the Vendor all the necessary information on which to base his tender. The Vendor shall complete these data/requisition sheets for the evaluation of his tender by the Principal. When drawing up the requirements, special attention shall be given to off-design conditions which may occur during the sequences of starting up or shutting down the turbine and the driven equipment.

If condensing equipment is required, condensers, if water-cooled, shall be in accordance with DEP 31.21.01.30-Gen. If air-cooled condensers are required, they shall comply with DEP 31.21.70.31-Gen. Roof-type air-cooled condensers may be specified.

Condensate pumps shall comply with DEP 31.29.02.30-Gen.

### **9.2 ACCESSORIES**

#### **9.2.1 Couplings**

The coupling between the turbine driver and the driven equipment shall be supplied by the Vendor responsible for coordinating the turbine with the driven equipment.

A dry type of coupling should be used in preference to a gear type of coupling.

#### **9.2.2 Gear units**

Gear transmissions should be avoided wherever possible.

#### **9.2.3 Governor**

Mechanical/hydraulic governors driven by a helical gear or worm drive shall not be selected. Instead, an electrical/hydraulic governor shall be specified.

#### **9.2.4 Oil systems**

If the turbine is driving a centrifugal compressor handling gases which contain components that could degrade the lube oil, the turbine control oil and the lubricating oil for the turbine and compressor shall be separated from the compressor seal oil to avoid their contamination. In such cases, a combined turbine control oil and lubricating oil system with a separate seal oil system shall be specified.

#### **9.2.5 Turning gear**

A turning gear shall be specified particularly if there is a requirement to re-start quickly within 8 hours of shutdown or if there is a risk of rotor sag during cooldown or standstill.

#### **9.2.6 Testing**

A complete unit test shall be specified for turbine-driven units if such a combined set has not been tested before.

If several identical units are ordered, a complete unit test of the first set only should be specified.

## 10. 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.

### SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Requisitioning binder	DEP 30.10.01.10-Gen.
Metallic materials - Selected standards	DEP 30.10.02.11-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 - Design, engineering and fabrication	DEP 31.21.01.30-Gen.
Air-cooled heat exchange equipment - Design, engineering and fabrication	DEP 31.21.70.31-Gen.
Guide for the selection of hoisting facilities and weather protection for rotating equipment	DEP 31.25.00.10-Gen.
Installation of rotating equipment	DEP 31.29.00.10-Gen.
Centrifugal pumps	DEP 31.29.02.30-Gen.
General-purpose steam turbines	DEP 31.29.60.30-Gen.
Special-purpose steam turbines	DEP 31.29.60.31-Gen.
* Data/requisition sheet for special-purpose steam turbines	DEP 31.29.61.93-Gen.
* Data/requisition sheet for general-purpose steam turbines	DEP 31.29.61.95-Gen.

\* NOTE Data/requisition sheets are contained in the Requisitioning binder DEP 30.10.01.10-Gen.

### BRITISH STANDARDS

Noise procedure specification	EEMUA 140
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