

STEAM TURBINES**JGS 210-120-1-30E**

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1. SCOPE

- (1) This standard practice provides the guideline for preparing general & special purpose steam turbine data sheets and the P&I Diagram around the steam turbines outside vendor's battery limit in refineries, petrochemical and similar plants.
- (2) Specific instructions given in the Project Specifications take precedence over the requirements given in this standard practice.

2. WORK PROCEDURE**2.1 Input Data****2.1.1 Source of the Data**

The data to prepare the steam turbine data sheets will be obtained from, but not limited to, the following documents.

- (1) Basic Engineering Design Data (BEDD)
- (2) Onsite and Offsite utility summary
- (3) Plant over-all steam balance
- (4) P&ID around the turbine from vendor

2.1.2 Required Data for Preparing the Data Sheets

- (1) The data for preparing the data sheets are extracted and/or selected from the documents shown in para 2.1.1.
- (2) The P&ID within vendor's battery limit will be supplied by vendor.

2.2 Preparation of the Steam Turbine Data Sheet**2.2.1 Input to the Steam Turbine Data Sheet**

Following data sheets that are mainly applied for power generation steam turbine should be referred to in preparing the data sheets.

Utility conditions are referred to BEDD.

- | | | |
|---------------------|---|---|
| (a) JGC FORM 1836 | : | DATA SHEET (GENERAL-PURPOSE STEAM TURBINE) |
| (b) JGC FORM 1787-1 | : | DATA SHEET (SPECIAL PURPOSE STEAM TURBINES) |
| (c) JGC FORM 1787-4 | : | DATA SHEET (SPECIAL PURPOSE STEAM TURBINES) |

(1) Type of steam turbine

The type of turbine should be determined by steam balance study including critical driver ^(*) selection for the plant. Generally, the steam and power balance study will be conducted by a utility engineer ^(*). The following types of the turbine will be considered. (Refer to Table 2.2.1a and Fig. 2.2.1.)

- Condensing turbine
- Back pressure turbine
- Extraction/condensing turbine
- Extraction/back pressure turbine
- Mixed pressure turbine

^(*) Essential driver for continuous operation in an emergency, e.g. power failure.

^(*) Utility engineer refers to the person who prepares on-site and off-site utility summaries, steam and power balance study, driver selection.

(2) Required Output

Required outputs under rated, normal, and reduced operating cases, if necessary, are specified.

(3) Rotational Speed

It is not necessary to specify the speed of the turbine for mechanical drive, e.g. pump, and compressor, unless speed of the driven equipment is known.

If the speed or speed range of driven equipment is already known, the speed is specified for necessary operating cases (or operating range).

For power generation purposes, following speeds are specified:

- for 50 Hz generator = 3,000 rpm
- for 60 Hz generator = 3,600 rpm

For better turbine efficiency, speed reduction gear for higher speed will be provided. Application of gear should be consulted with rotary machinery engineer.

(4) Steam Conditions

In accordance with the BEDD the inlet & outlet steam conditions are specified.

The inlet & outlet steam conditions are not at each steam header, but at the turbine inlet & outlet nozzles, respectively. If specific outlet, i.e. extraction or exhaust, steam temperature (or temperature range) is required, the temperature is specified for necessary operating cases (or operating range).

(5) Extraction/Admission Flow

Based on the steam & power balance study, the steam flow rates are specified for each operating case.

(6) Inlet Steam Flow

If pre-determined value of turbine inlet steam flow is required, it is necessary to specify the flow rate with the steam conditions.

(7) Steam Rate

If pre-determined value of turbine steam rate is required, it is necessary to specify the steam rate with the steam conditions.

(8) Total Efficiency

If pre-determined value of turbine efficiency is required, it is necessary to specify the efficiency value with the steam conditions.

(9) Other Utility Data

Following utilities conditions are specified in accordance with the BEDD:

- Supplied pressure and temperature of cooling water (for mechanical cooling purposes) with fouling factor, allowable pressure drop & temperature increase.
- Auxiliary steam for steam seal, ejector, etc.
- Electric power

(10) Turbine Condenser & Ejectors Data

Following input data are required for vendor quotation or design if the condenser and associated equipment are supplied by the turbine manufacturer.

(a) Water-cooled Surface Condenser:

Data sheets attached (A1) are used unless otherwise specified. Process data required are marked with *(an asterisk) in the data sheets. The data should be based on HEI principally except when HTRI is required by client.

- Type : Divided water box type, i.e. 2 water boxes, is specified unless shut-down of the turbine is allowable for placing stoppers on leaking pipes.
- Tube material : Refer to the attached Table 2.2.1b.
- Cleanliness factor : 0.85 with tube cleaning system is to be used for fresh & sea water cooling, using copper alloy tube.
0.90 with tube cleaning system is to be used for sea water cooling cooling, using titanium tube.
0.7 is to be used for fresh and sea water cooling without cleaning system.
Manufacturer's experience should be reflected in the final determination of the tube material, cleanliness factor and the cleaning system application.

- Vacuum equipment : Steam jet air ejector(s) with an inter-/after-condenser are to be used if auxiliary steam is available. If auxiliary steam is not available, vacuum pump is to be used.
- (b) Air-cooled surface Condenser:
 - Type : Roof type or flat type should be determined through assessment of available plot space for the plant.
 - Tube material : Carbon steel is to be used unless otherwise specified.
 - Air side fouling factor
 - Vacuum equipment : Steam jet air ejector(s) with an inter-/after-condenser are to be used if auxiliary steam is available.
 - Ambient conditions in accordance with the BEDD
- (c) Gland Condenser:

The following items should be specified if the data are not mentioned in BEDD.

 - Cooling fluid data:
 - * Fluid name
 - * Fluid flow rate (if already known)
 - * Fluid physical properties (density, viscosity, specific heat, thermal conductivity)
 - * Supply & return conditions with allowable pressure drop & temperature increase
 - * Mechanical design conditions
 - * Fouling factor
 - * Materials
- (d) Ejector Condenser:

The cooling fluid for ejector condenser is usually condensate, but if the cooling fluid is not condensate, the following items should be specified.

 - Cooling fluid data:
 - * Fluid name
 - * Fluid flow rate (if already known)
 - * Fluid physical properties (density, viscosity, specific heat, thermal conductivity)
 - * Supply & return conditions with allowable pressure drop & temperature increase
 - * Mechanical design conditions
 - * Fouling factor
 - * Materials

2.2.2 Equipment Related to Steam Turbine

Following equipment will be required for the steam turbine.

(1) Mechanical Equipment

- Main stop valve(s) including steam strainer(s), main control valve(s), and internal or external extraction control valve(s) if necessary.
- Speed governor
- Speed reduction gear if necessary
- Seal steam supply & regulating system ^(*)
- Gland steam exhausting system (if necessary)
- Lubricating oil system with tank, pump, cooler, filter, vapor exhauster, and conditioner (if necessary)
- Control oil system with tank, pump, cooler (if necessary)
- Turning gear (if necessary)
- Power-assisted extraction check valve(s) (if necessary)
- Surface condenser (if necessary) ^(*)
- Ejector condenser (if necessary) ^(*)
- Vacuum breaker for the surface condenser (if necessary) ^(*)
- Associated piping system

^(*) These equipments are required for condensing turbine only.

(2) Instrumentation

- Speed/load control system, with extraction pressure control (if necessary)
- Extraction steam temperature control system (if necessary)
- Alarm & trip system
- Supervisory instruments at site and local panel
- Relief valve(s) for extraction system and/or surface condenser

2.3 Output from Vendor's Design Data

Steam consumption and utilities consumption data shall be fed back to the utility engineer. In this step, capacities of utility boiler(s) and power generator(s) shall be rechecked by utility engineer from overall steam & power balance point of view.

Utility engineer may inform the change of turbine type, if necessary.

2.4 Work Steps

- (Step-1) Collecting "ON-SITE UNITS & OFF-SITE UTILITY SUMMARIES"
- (Step-2) Assuming "PLANT OVERALL UTILITY SUMMARY" including "UTILITY UNITS UTILITY SUMMARIES"
In this step, process engineer should inform utility engineer of desire to apply a steam turbine, if preferred from operational requirements^(*).
- (Step-3) Preliminary "STEAM & POWER BALANCE STUDY"^(*)
- (Step-4) Preliminary "TYPE OF DRIVER SELECTION"^(*)
- (Step-5) Preparing "STEAM TURBINE DATA SHEETS" and other "DATA SHEETS", if necessary
- (Step-6) Review of received manufacturer's "DESIGN DATA"
- (Step-7) Back to Step-2 for consolidation^(*)
- (Step-8) Preparing P&ID around the steam turbine if necessary

^(*) This work would be conducted in cooperation with utility engineers.

2.5 Check Items on Vendor's Data

Following items should be checked for the overall steam & power balance study at the step-7 when the vendor's data are available.

- (1) Process & utilities conditions
- (2) Steam rate or steam consumption at rated, normal, and reduced operating cases are specified based on normal steam conditions
- (3) Utilities consumption
- (4) Extraction and/or exhaust steam temperature

2.6 Quick Calculation of Steam Consumption

APPENDIX 2 (Fig. A2-1 and Fig. A2-2) is prepared to be used for preliminary calculation (that is based on actual data). The efficiency of steam turbines (η_{th}) differ according to type, stage number, inlet and outlet steam pressure etc. Therefore, if rigorous estimation is needed, the estimation should be done by using η_{th} from vendor's data.

Application of the following procedures should be restricted into preliminary estimation such as feasibility study. The large scale, back pressure steam turbine type is hardly used, so that can be disregarded.

2.6.1 Small back pressure turbine below 1000 kW

For small back pressure steam turbine of required output below 1,000 BHP (Braking Horse Power), Fig. 2.6.1a is applicable for estimation of the steam turbine overall efficiency (e_t). For the estimation of efficiency, revolution speed of the turbine and live steam pressure should be known. Fig. 2.6.1b and Fig. 2.6.1c show the relation between efficiency and BPH for revolution speed 3000rpm and 3600rpm, respectively. If the live pressure is between 20 and 40 kg/cm²G, it may be estimated by means of interpolation. However, these data should be updated from time to time with data accumulation.

Estimation of steam consumption is calculated using the following equation.

$$Go = \{860 / (Had \times e_t)\} \times BHP \quad (\text{kg/h})$$

Where

Go	:	Steam consumption	(kg/h)
Had	:	Adiabatic enthalphy drop ^{*1)}	(kcal/kg)
e_t	:	Turbine overall efficiency	(-)
BHP	:	Braking horse power of driven equipment	(kW)

^{*1)} from Mollier Chart for Steam

Fig. 2.6.1a General Purpose Turbine Overall Efficiency (3,000 - 3,6000 RPM)

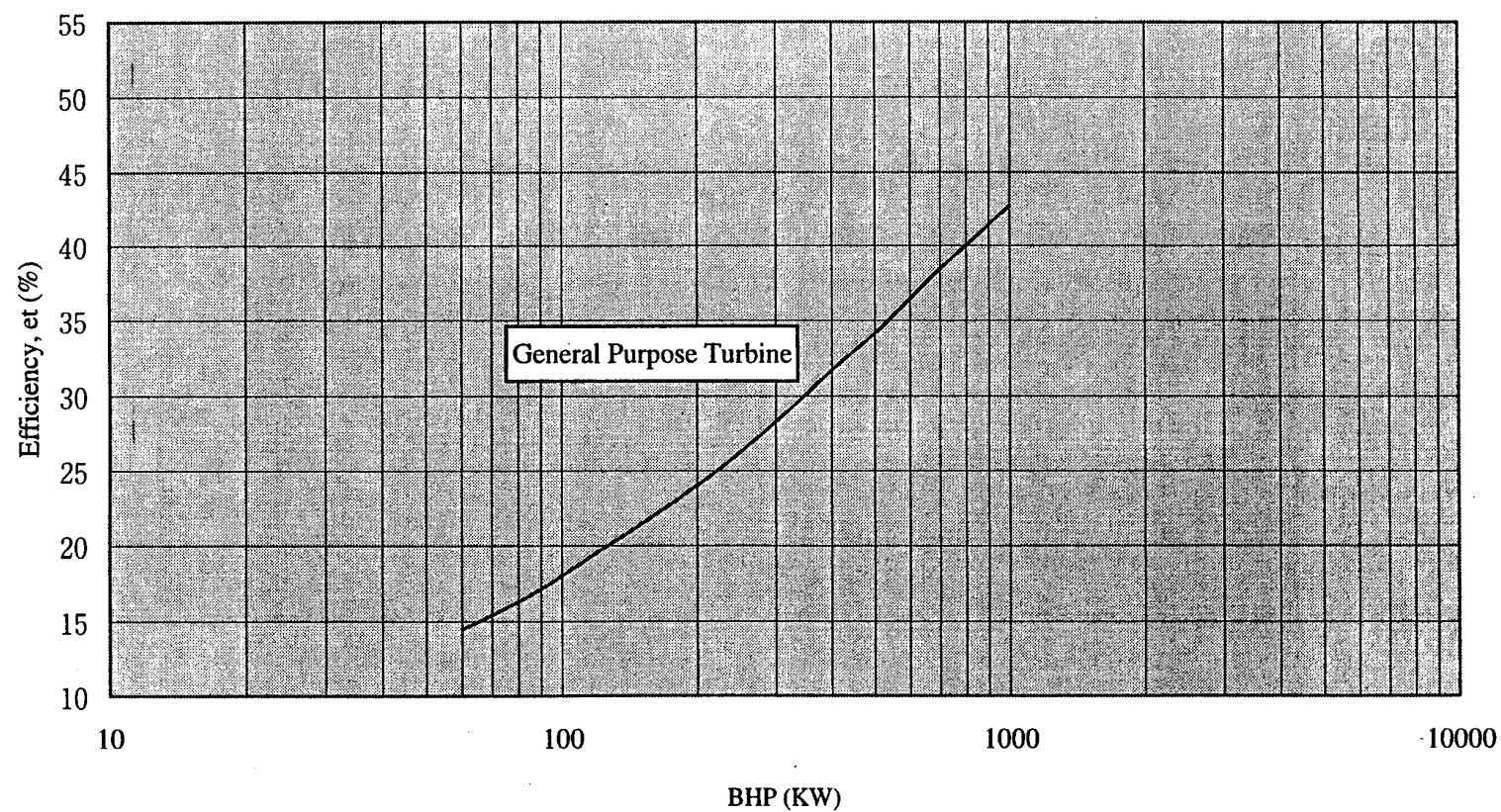


Fig. 2.6.1b General Purpose Turbine Overall Efficiency (3,000 RPM)

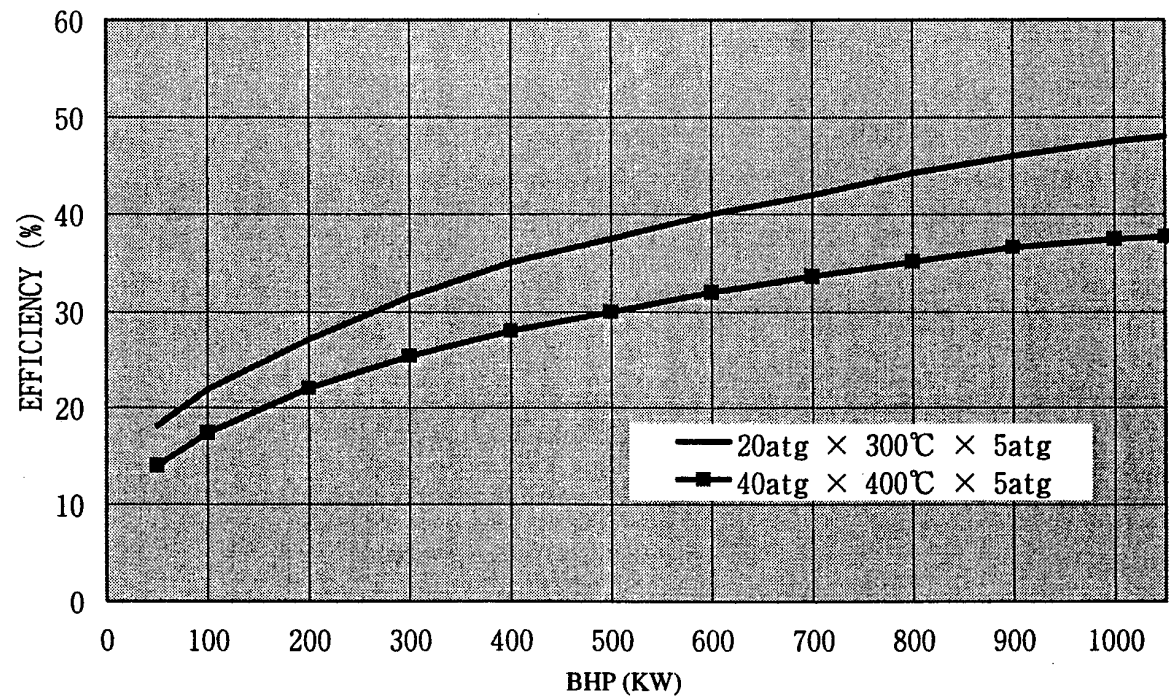


Fig. 2.6.1c General Purpose Turbine Overall Efficiency (3,600 RPM)

