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SAMSUNG ENGINEERING CO., LTD.

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1. SCOPE

This manual is intended to give general precautions to be taken in steam turbine selection and to discuss the calculation of steam consumptions.

2. FORMAT

The following forms should be used for steam turbines: C-6330-119A4

Special purpose steam turbines : C-6330-119A4

3. PRECAUTIONS TO BE TAKEN IN STEAM TURBINE SELECTION

In cases where steam turbines are to be used as drivers, their selection must be made with consideration given to their economics, operational stability, and ease of operation and maintenance. The precautions to be taken in selection are as summarized below.

3.1 Superiority over Electric Motors

- (1) Since the motor is held in the steam, good explosion proofness will be provided.
- (2) The design speed and operating speed can be decided at a desired value.
- (3) Overload characteristics are good : even if steam turbines are overloaded, they can continue operating without developing any trouble in many cases though their speeds will decrease.
- (4) Steam turbines require no special cooling even at a large output and their sound level is low.

3.2 Inferiority to Electric Motors

(1) Speed increase and rotation direction

Should the governor and overspeed trip fail, the speed will increase if the load decreases. In such a case, the turbine may be damaged.
The direction of rotation cannot be changed.

(2) Warming-up

High temperature steam turbines and large capacity turbines require warming-up prior to start, to avoid thermal shocks, thermal stresses and vibration due to uneven heating.

(3) Operation and maintenance

Operation and maintenance of steam turbines are complicated, compared with those of electric motors.

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3.3 Problems Associated with Inlet Steam Conditions

In a case of high pressure steam application for small capacity turbine, small volume flow design can be used.

The losses of leakage and fluid dynamic friction around stage may be great. Consequently, overall efficiency of turbine goes down.

(1) Turbine efficiency

Efficiency is high if the steam inlet pressure is low and the steam temperature is high.

(2) Number of stages

The number of stage must be suitable for so called heat drop originated be turn inlet and exhaust steam conditions. Insufficient number of stage lead to exhaust pressure rise due to insufficient expansion of steam in the turbine blading.

The number of stages affects the price of the turbine.

High efficiency cannot be obtained if the number of stages is not proportional to the steam inlet pressure.

Inversely speaking, if a lower inlet pressure is used, the turbine can be designed for a smaller number of stages and for higher efficiency.

(3) Turbine size

Turbine size shall be determined with steam conditions of inlet and exhaust, required shaft horse power, blade design practice (impulse or reaction), number of reheat and number of extraction.

Turbines can be designed for a small size if the inlet pressure is high, but if the steam pressure is high, as a large number of stages must be used, the turbines cannot be designed to be of a small size.

(4) Materials

The materials for moving parts should have good characteristics such as high allowable stress, corrosion resistance, damping effect and creep resistance.

Ordinary materials can be used for temperatures up to 400 – 420°C

If the temperature exceeds 420°C one-grade higher materials must be used.

Further, if the temperature exceeds 485°C, the material must be upgraded again.

In cases where saturated steam application on last stage of condensing turbine, special attention and protection for drain attack shall be required.

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3.4 Determination of Speed

Generally, the higher the speed is, the higher the turbine efficiency is.

At the same time, the size and weight can be reduced accordingly.

Hence, it is desirable that the speeds of driven equipment (for instance, pumps and compressors) should be increased for direct connection to the drivers (steam turbines) without using speed reducers.

3.5 Review of Critical Speed

Rotating shafts become dynamically unstable with large lateral amplitudes at certain speeds which are called critical speeds.

Critical speed due to lateral and torsional vibration will occur in drivers and driven equipment connected to each other.

Hence, at the design stage, all matters involved must be reviewed and discussed with the turbine vendor and driven equipment vendor.

3.6 Review Of Couplings

The primary purpose of couplings is to transmit the power, but coupling selection must be made with consideration given to the following points:

- (1) Dynamic balance can be well maintained independent from the rotating assemblies.
- (2) Selection should not be made from among those couplings which are of such weight or construction that the critical speeds will vary owing to the weight and overhang distance from the bearing.
- (3) The couplings and spacers should be dynamically balanced to a tolerance suitable for the maximum continuous speed.
- (4) Couplings should be of construction which can absorb dimensional variations in the axial direction and will not cause any excessive thrust loads.

This thrust load must be advised by the driven equipment vendor and the capacity of the thrust bearing must be taken into consideration.

- (5) Selection should be made from among those which are of such construction that vibration transmission is small.

- (6) Selection should be made from among those whose characteristics are known with respect to torsional vibration.

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4. SPECIAL REQUIREMENTS FOR STEAM TURBINES TO BE USED IN PROCESS

Basically, the requirements for steam turbines to be used in process operation are no different from those for general services, but the following points should be considered in selection.

- (1) Since it is highly probable that shut-down will result from turbine failure, not only reliability is high but also inspection and maintenance must be easy.
- (2) Because of the nature of the plant, turbines for process operation must be capable of conducting one to two year continuous operation.
- (3) In cases where steam turbines are to be used as stand-by, consideration must be provided for corrosion prevention during stand-by periods.
- (4) Steam turbines for use as stand-by must be provided with sufficient considerations for emergency quick start.
- (5) In most cases, steam turbines are located outdoors. Sufficient considerations must be provided against rainfall and dust.

Requirements for steam turbines for process services are indicated in the following API standards:

API-611 General-purpose steam turbines for refinery services.

API-612 Special-purpose steam turbines for refinery services.

API-613 Special-purpose gear units for refinery services

API-614 Lubrication, shaft-sealing and control oil systems for special purpose applications

5. APPLICATIONS OF STEAM TURBINES

Steam turbines in process services are intended for various purposes.

Their applications can be classified as shown below.

- (1) Driving of centrifugal compressors
 - Output 500 – 20000 kW
 - Speed 5000 – 15000 rpm
- (2) Driving of pumps, fans, blowers, reciprocating pumps and reciprocating compressors
 - Output Generally under 3000 kW
 - Speed Generally under 3600 rpm in many cases

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6. CLASSIFICATION OF TURBINES

Steam turbines can be classified, depending on whether exhaust steam from the turbines is re-used or condensed in surface condensers as follows:

(1) Back pressure turbines

Exhaust steam is passed to the steam header for re-use in the case of this type.

Since no surface condenser is used, the outlet pressure (or exhaust pressure) is 0 – 20 kg/cm²G in usual cases.

(2) Condensing turbines

Unlike back pressure turbines, condensing turbines are designed to convert the energy of inlet steam into mechanical power to a possible extent.

Hence, the outlet pressure is held low (0.05 – 0.2 kg/cm²A in usual cases) by using condensers or ejectors to expand steam to the low pressure and the steam is passed to the surface condenser in which it is recovered as condensate.

Usually, it is determined chiefly from the overall steam balance in the plant, which should be used, back pressure turbines or condensing turbines.

7. REQUIRED INFORMATION

(1) Specifications of driven equipment brake horsepower and speed (rpm)

(2) Steam consumptions

Pressure and temperature of inlet steam and pressure of exhaust steam.

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8. ENTRIES IN DATA SHEET

Form No. C-6330-119A4 should be filled by the following procedure.

(1) Steam conditions

The steam conditions at the tie-in point with the steam turbine shall be entered in the data sheet : it must be noted that the steam conditions are those at the inlet throttle valve.

(2) Safety/relief valve (API St*d 611, 7d)

This safety/relief valve is intended to protect the casing discharge side.

The following set pressures shall be maximum and the relief rate shall be equal to the full relief of the inlet throttle valve.

Manufacturer's Exhaust Casing Pressure Class		Maximum Sentinel Warning Valve Setting	
kg/cm ² G	psig	kg/cm ² G	psig
Condensing		0.35	5
0 – 3.5	0 – 50	3.87	55
3.6 – 5.3	51 – 75	6	85
5.35 – 10.6	76 – 150	11.6	165
10.6 – 17.6	151 – 250	19.4	275
17.6 – 21.1	251 – 300	23.2	330

(3) Allowance (API St'd 611 4.d)

When the specific gravity of the liquid being pumped or the molecular weight of the gas being compressed decreases, the pump or compressor must operate at a higher rate.

To meet this, the steam turbine must be rated for at least over 105%.

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9. STEAM CONSUMPTION

Accurate steam consumptions, when required, must be obtained from the vendor.
steam consumptions are calculated by means of curves.

Overall efficiency curves have been prepared based on actual data collected.

Though conservative, overall efficiencies can be estimated from the curve, which can be used as a basis for determination of boiler capacities.

The curves should be improved from time to time with data accumulation.

(1) General-purpose turbines smaller than 1,000 HP are of noncondensing type in usual cases and each manufacturer has only three to four standard frames.

Efficiencies largely depend on the relationships between the steam velocities and impeller peripheral velocities and as they are steep, little can it be expected that any of the few frames are optimum for a given service.

Such efficiency charts as for pump efficiencies which are continuous without being limited by frames are not yet available in the case of small turbines.

For this reason, SECL data have been plotted and average values taken as overall efficiencies as shown in Fig. 9-1 for general purpose turbines.

(2) Since special-purpose turbines larger than 1,000 HP are made to order, they can be designed to be of optimum without being limited by the frames provided.

Hence, their overall efficiencies plotted form a steady curve as shown in Fig. 9-1 for condensing turbines.

(3) Since the curves in Fig. 9-1 are overall efficiencies, the steam consumption can be calculated from the difference between the enthalpy of the inlet steam and the enthalpy of the outlet steam ($i_1 - i_2$) as follows:

$$SC = \frac{642}{i_1 - i_2} \times BHP \times \frac{100}{EFF} \quad (\text{Metric unit})$$

$$SC = \frac{2545}{i_1 - i_2} \times BHP \times \frac{100}{EFF} \quad (\text{British unit})$$

Where,

SC : Steam consumption (kg/hr) (lb/hr)

i_1 : Enthalpy of inlet steam (kcal/kg) (Btu/lb)

i_2 : Enthalpy of steam at exhaust pressure (in entropy equal to that of i_1)
(kcal/kg) (Btu/lb)

BHP : Brake horsepower (hp)

EFF : Overall efficiency plotted from the brake horsepower in Fig. 9-1(%)

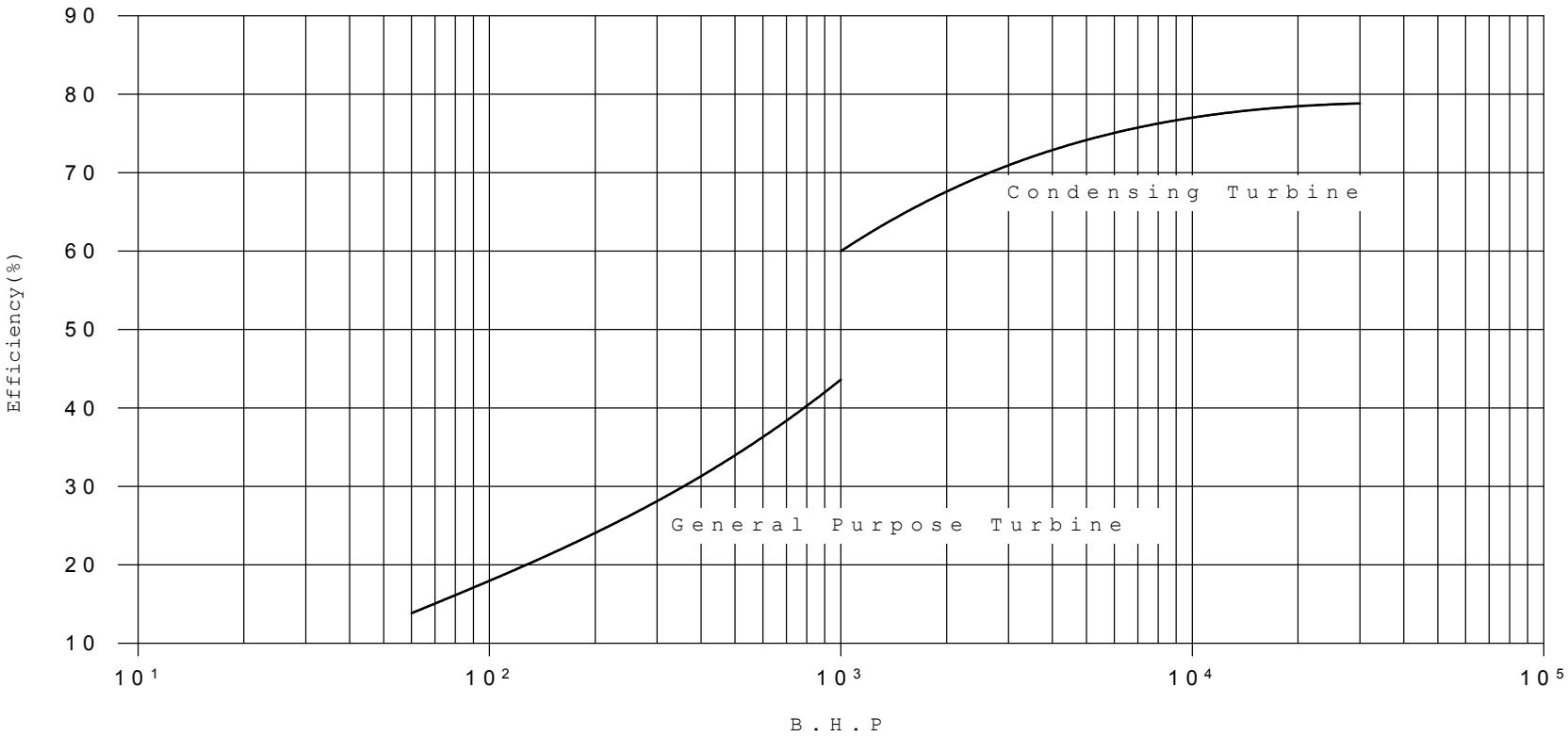
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10. ENTRIES IN P&I DIAGRAM

(1) Automatic start

In cases where automatic start is required, the control shown in Fig. 10-1 is used in usual cases.

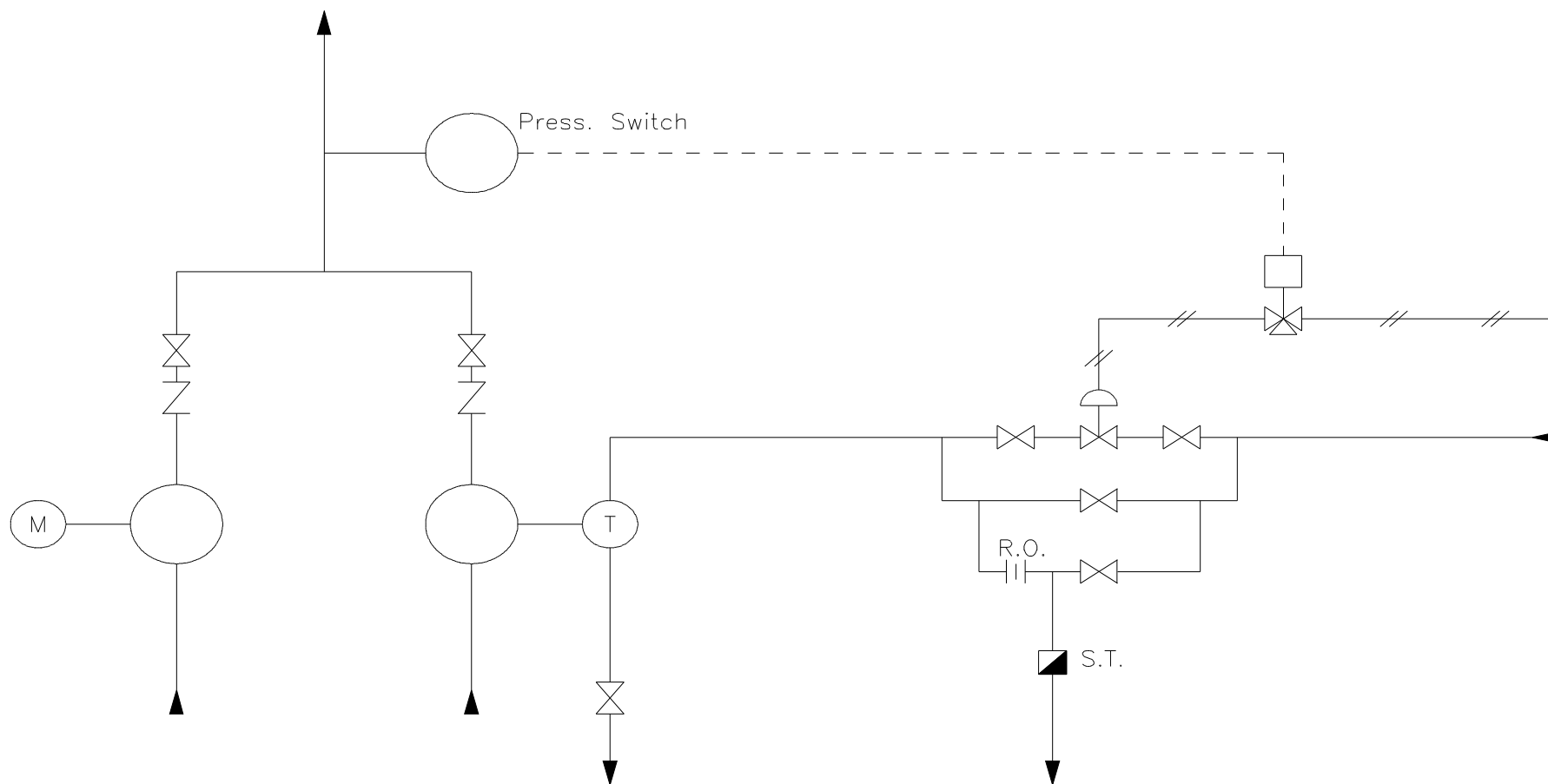
Fig. 9-1. Turbine Overall Efficiency (3000 - 3600 RPM)



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Fig. 10-1 Auto Start of Steam Turbine



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