Limits and Settings
Supervisory Instruments
The following are the alarm and trip settings for the appropriate supervisory instruments:

1. Rotor Eccentricity Recorder
   With the rotor on turning gear, the rotor truth dial indicator mounted at any bearing oil ring should indicate a measurement of not over 0.001 inch double amplitude.
   At shaft speeds up to 600 rpm the alarm point for shaft eccentricity is 0.003 inch double amplitude. At about 600 rpm the recorders are automatically switched from eccentricity to vibration. This applies to either 1800-rpm or 3600-rpm units.

2. Rotor Vibration Recorder
   The following vibration limits will prevail, measured in mils, double amplitude:
   
<table>
<thead>
<tr>
<th>rpm</th>
<th>1800 rpm</th>
<th>3600 rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfactory</td>
<td>4.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Alarm</td>
<td>7.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Trip or other suitable action</td>
<td>14.00</td>
<td>10.00</td>
</tr>
</tbody>
</table>

   1 Rebalancing is indicated if vibration is continuous and of the unbalanced type. Under special conditions, turbine may be run at higher vibration levels for short periods of time under close supervision.
   2 Other suitable action may be load change, speed change, etc., according to specific conditions.

3. Rotor Position Recorder
   Based on a nominal thrust bearing clearance of 0.005 inch and a maximum expected thrust bearing load of 600 psi, an alarm limit of 0.035 inch from the center of the thrust cage clearance (in either direction) should be used. The trip setting is 0.04 inch.

4. Casing Expansion Recorder
   There are no “Alarm” and “Trip” features on this supervisory instrument.

5. Differential Casing and Rotor Expansion Recorder
   The alarm and trip settings vary with turbine unit configuration. Specific values will be developed prior to each turbine start-up and indicated in the Turbine Instruction Book.

Bearings
1. Metal Temperatures
   The alarm and trip limits for bearing babbitt temperatures depend on the type of bearing.
   For viscosity-pump journal bearings on 1800-rpm units, a bearing babbitt temperature of up to 185 F is considered normal. The alarm should be set at 210 F, and the trip at 225 F.
   For the same type of bearing on 3600-rpm units, a temperature of up to 195 F is considered normal. The alarm should be set at 225 F, and the trip at 235 F. These temperatures are for a thermocouple on the axial centerline of the bearing 40 degrees against rotation from the trailing edge of the active arc.
   Tilting-pad journal bearings have the same temperature limits as the viscosity-pump journal bearings above. The thermocouple on this type of bearing is 20 degrees against rotation from the trailing edge of the pad.
   For thrust bearings, a bearing babbitt temperature of up to 185 F is considered normal. The alarm setting is 210 F, and the trip setting is 225 F. The thermocouple used to measure thrust bearing temperature is at the center of the shoe.

2. Oil Pressure
   Thrust bearings are set to signal an alarm at an oil pressure of 30 psig and to trip the turbine at 80 psig.

3. Oil Discharge Temperatures
   Do not start the motor-operated bearing oil pump if the oil temperature is less than 50 F at the oil reservoir. For turning gear operation and during the turbine rolling period, oil temperature should be a minimum of 70 F. For continuous operation, bearing oil discharge temperatures should not exceed 160 F. The alarm should be set at 170 F.

General
   Initial impulse chamber metal temperature below 250 F defines the condition when “cold starting” procedures apply.
   Cold Start – DRUM- and ONCE-THROUGH Type Boilers
   When starting, steam to the throttle valves should contain at least 100 F superheat. However, the steam temperature at the throttle valve inlets should not exceed 800 F when first admitting steam to the turbine.

   For adequate steam chest warming prior to transferring from throttle valve control to governor valve control, the temperature of the inner surface of the steam chest (measured by the inner wall deep thermocouple) should be equal to or greater than the saturation temperature corresponding to the prevailing steam pressure ahead of the throttle valves. This will prevent the formation of water when the steam chest pressure is raised as a result of transferring control to the governor valves.

   Figure 9.1 shows the relationship between pressure and temperature that must prevail at the inlet to the throttle valves if steam chest metal temperature is to reach the desired value. This curve allows for the temperature loss that occurs when steam to the turbine is throttled through the throttle valve pilot valves.

   Figure 9.1. Relationship of pressure and temperature during “cold start.”

At start-up of a warm or hot turbine unit (initial impulse chamber metal temperature over 250 F) it is recommended that the steam conditions at the throttle valve inlet be controlled so as to produce an impulse chamber steam temperature which is within a range of not more than 100 F below or more than 200 F above the initial impulse chamber metal temperature.

The damaging effect of transient operation on the rotor is dependent on the magnitude of change in steam temperature at the rotor, the rate of this change and the number of reheatings of heating and cooling cycles.

The temperature difference between the horizontal flange and the bolt of the HP and IP cylinders should not exceed 250 F for double wall turbines and 200 F for single wall turbines. These limits will not be exceeded under normal start-up if appropriate operating instructions specified in the turbine instruction book are followed.

The temperature difference between the horizontal flange inner surface, or cylinder cover inner surface, and the inner surface at the bottom of the HP and IP outer cylinders should not exceed 100 F. Alarm at 75 F; trip at 100 F. Sudden increases in the normal temperature difference indicates the presence of water in the bottom of the outer cylinder. Drains should be opened immediately.

The maximum temperature difference between deep and shallow thermocouples (if used) in throttle valves, steam chests or interceptor valves should not exceed 150 F.

If an initial steam pressure regulator is used it is usually set to cut in on decreasing throttle pressure at 90% to 95% of rated

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Power Plant Design Manual for Steam Turbines
Operation

Limits and Settings, Continued

pressure. With the regulator in service, load reduction is proportional to pressure reduction to a pre-set minimum limit of 20% to 25% load. If the throttle pressure falls below 80% of rated pressure, or if throttle or reheat temperature drops uncontrollable more than 150 F, remove load and trip the unit.

To avoid heating the turbine exhaust beyond allowable limits, apply gland sealing steam, start air removal equipment and maintain as high a vacuum as possible during the starting period. Exhaust temperature limits are as follows:

1. Turbine exhaust temperature (steam) should not exceed 175 F for continuous operation or 250 F for periods of about 15 minutes. These limits apply when the exhaust hood sprays (if provided) are cut off service.

2. Turbine exhaust temperature (steam) for unusual conditions should not exceed 250 F. For example, if steam is bypassed to the condenser before the turbine is rolled, the maximum allowable exhaust temperature is 250 F providing no problems develop. However, experience shows that under some conditions (such as cold start) heat rising from the condenser will cause a "rotor short" differential expansion condition which results in rubs between rotating and stationary parts. In the past this has usually been detected with the unit on turning gear when the rotor locked with turbine exhaust temperatures less than 200 F.©

Steam supplied at any turbine gland should contain not less than 25 degrees of superheat.

The temperature limits of steam in the LP turbine glands are 250 F minimum and 350 F maximum. The gland system desuperheater should be set at 300 F. This limit cannot be applied to the glands of high pressure (HP) turbines of nuclear units having wet steam conditions in the HP exhaust at load or to nuclear units using wet steam to seal low pressure turbine glands.©

Westinghouse recommends that the gland system spillover steam be routed to the main condenser as insignificant heat rate loss is involved. However, the purchaser may elect to route the spillover steam to the LP heater. It is the purchaser's responsibility to limit the temperature of the spillover steam when the heater is out of service, so that the temperature of the steam induced into the turbine will not be more than 100 F higher than the zone temperature at the point of induction.

The latch will disengage and place the vacuum trip in service in the range of 5 to 9 in. Hg Abs condenser pressure and the trip handle will drop to the unlatched position. With the handle in the unlatched position, the vacuum trip is set to trip the unit in the range of 8 to 12 in. Hg Abs condenser pressure. We suggest a trip setting of 8 in. Hg Abs. Should the latch fail to disengage, the trip device will operate to trip the unit at 1 psig condenser pressure.©

Maximum allowable backpressure for on-line operation is 5.5 in. Hg Abs.©

The overspeed trip will normally be set to trip the unit at 111% of rated speed. Certain types of turbines may require other overspeed trip settings.

It is recommended that minimum load for normal on-line operation be 5% of rated load.

The maximum permissible steam temperature difference between tandem low pressure turbine outer cylinders is 50 F for 1800 rpm turbines. Alarm at 40 F. Operator manual trip at 60 F is satisfactory.

The maximum permissible steam temperature difference between tandem low pressure turbine outer cylinders is 30 F for 3600 rpm turbines. Alarm at 20 F. Operator manual trip at 30 F is satisfactory.

When separate or zoned condensers are used with turbines having multiple low pressure cylinders, excessive pressure difference between condensers (or condenser zones) can cause cool fluid to flow from one condenser (or condenser zone) to the other through the low and intermediate pressure turbine cylinders after the unit trips. To prevent this potentially harmful condition from occurring we recommend the maximum pressure difference between condensers (or condenser zones) on tandem or cross-compound turbines with multiple LP cylinders be 2½ inches Hg. Alarm at 2 inches Hg. Operator manual trip at 2½ inches Hg is satisfactory.

The steam delivered through any turbine main inlet valve must be within 25 F of the steam delivered simultaneously through any other main inlet valve. The same temperature requirement applies to any hot reheat zone in the turbine. During abnormal conditions and for short periods of time (a few minutes) the temperature differences may approach 50 F maximum. During abnormal conditions, this difference may be as high as 75 F for periods of 15 minutes maximum duration provided that such occurrences are at least four hours apart.

Where the main steam inlet and hot reheat inlet connections are arranged in the same turbine casing, temperature differences between the main steam and reheat steam inlets must be controlled to optimize the design life of the apparatus. The difference between the main steam and hot reheat temperatures should not deviate from the difference at rated conditions by more than 50 F. During abnormal conditions, deviations as large as 75 F are acceptable provided the differences are limited to a reduction of the hot reheat temperature with respect to the main steam inlet temperature.

These limits, in general, are assumed to apply at operating conditions near full load. As the load reduces, it is assumed that the hot reheat temperature will be below the main steam inlet temperature, in which case, the difference may approach 150 F as the load approaches zero. Short time cyclic temperature fluctuations are to be avoided.

Allowable Steam Pressure and Temperature Variations — Fossil Units®

- Condensing Reheat Double-Flow 25-inch Last Row Blades (LRB) and larger.
- Condensing Nonreheat and Reheat Single Flow with 14-inch LRB Through Double Flow with 23-inch LRB.

The turbine rating capability, steam flow, speed regulation and pressure control are based on operation at rated steam conditions. The turbine generator unit is capable of operation under the following variations in steam pressure and temperature. These allowable variations are intended to provide for operating exigencies and it is expected that such abnormal operation will be kept to a minimum, especially the occurrence of simultaneous variations in pressures and temperatures.

Inlet Pressure

The pressure at the turbine throttle valve inlet connection shall be controlled to maintain an average operating pressure of not more than 105% of rated pressure. In maintaining this average over a 12-month operating period, the pressure shall not exceed 105% of rated pressure by more than 1% for periods of time no longer than reasonably required for control. During abnormal conditions, the peak of pressure swings at the inlet shall not exceed rated pressure by

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© Added since previous issue.

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