

## OPERATION

### (Non-Condensing Turbine)

The following procedure is recommended for starting and putting the turbine in operation. It is obvious that any such instructions can cover only the normal case and it will be recognized that under unusual circumstances, variations from this program will have to be adopted and the procedure to be followed will necessarily be determined by the best judgment of the operating engineers.

It is of utmost importance to see that the turbine cylinder and connecting pipe lines are drained properly at all times. During operation, any accumulation of water cools the adjacent metal and causes distortion which, if sufficient in magnitude, may cause blade rubs or vibrations. During shutdown periods, accumulation of water causes excessive corrosion which impairs the efficiency of the turbine.

The turbine cylinders are provided with built-in drains from each zone to the next lower pressure zone and finally to the exhaust. Orifices are provided for continuous drainage during normal operation, and hand-operated by-passes (where necessary) for use during starting and shutdown periods.

Similar drains must be provided from all connecting pipe lines. These include: Steam inlet line, exhaust line, extraction lines (drain both sides of shut-off valve) and atmospheric relief lines.

It is the duty of the operators to see that these drains function properly and to use those which are manually operated during starting and shutdown periods.

#### Starting

- 1 - Start the steam-driven auxiliary oil pump. Be sure it is under proper control of its regulator. See that ample oil pressure is established on the bearings and in the control system.
- 2 - Check the oil reservoir level gauge and see that the oil level does not fall below the minimum mark on the gauge plate.
- 3 - See that the turbine cylinder drains, the exhaust line drains and the extraction line drains are open and that the steam line is free of water.
- 4 - Open the gland steam leak-off to atmosphere or to the deaerator gland cooler (if one is used).
- 5 - See that the steam line to the exhaust pressure regulator is closed and that the atmospheric vent between the shut-off valve and the regulator is open. This makes the regulator inoperative other than to continuously call for full open governor valves, and leaves them entirely under the control of the speed governor until the regulator is put in service.
- 6 - Open wide the atmospheric exhaust valve.
- 7 - Turn on the gland water, throttling it so that only a slight amount leaks outward along the shaft.
- 8 - Open the throttle valve a sufficient amount to start the rotor immediately. Then close it and open it again just enough to keep the

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rotor rolling at 200 to 400 rpm. Listen for rubs or other unusual sounds, especially when the rotor is rolling with the steam shut off, for at this time a foreign noise can most easily be heard.

- 9 - Keep the turbine rolling at low speed (approximately 200 to 400 rpm) to allow the parts to become partly heated. Maintain this slow rolling about 20 minutes for machines up to 3000 kw capacity, and about 30 minutes for machines larger than 3000 kw.

The duration of the rolling period depends on the straightness of the rotor which, in turn, depends somewhat on the length of the previous shutdown. If the machine has been shut down long enough to become thoroughly cooled, the rotor should be straight. However, after shorter shutdowns (such as 4 to 8 hours) the machine is only partly cooled and the rotor may be distorted. In such cases, continued rolling at low speed will heat the rotor uniformly and straighten it.

- 10 - Trip the governing valves, by means of the hand trip, and see that the valves close and open again freely.
- 11 - At the end of the rolling period, bring the unit up to speed slowly, taking 10 to 15 minutes to reach full speed.

If the unit comes up to speed rough (that is, vibrates objectionably) reduce the speed and lengthen the slow rolling period.

- 12 - As the speed increases, adjust the gland water pressure to obtain proper sealing of the glands.
- 13 - Close the drains from pressure zones when it is assured that all water has been removed and condensation stopped.
- 14 - Turn on water to the oil coolers, regulating same to maintain the oil temperature leaving the coolers between 100 and 110°F. The correct criterion of oil cooler water supply is, of course, the temperature of oil leaving the bearings, which should not exceed 160°F. Turn on water to the generator air coolers.
- 15 - Open the throttle valve fully.
- 16 - In some cases, the atmospheric exhaust valve is not large enough to pass the no-load full speed steam. It is then necessary to open the exhaust valve when the turbine reaches the speed at which the turbine exhaust pressure is slightly higher than the pressure in the exhaust header.

Gradually close the atmospheric exhaust valve until the exhaust pressure equals the header pressure. As the exhaust pressure increases, the turbine temperature will increase rapidly. Therefore, this must be done gradually. Throttle the atmospheric exhaust in increments to 50 lbs., 100 lbs., and so forth, allowing the cylinder expansion and temperatures to level off fairly well at each pressure before increasing more.

When the turbine exhaust pressure equals the exhaust header pressure, simultaneously open the exhaust header valve and close the atmospheric exhaust valve.

Watch the glands carefully and, if necessary, adjust the gland water to maintain a proper seal.

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- 17 - Make sure that the governor properly controls the speed of the turbine with full inlet steam pressure and exhaust pressure.
- 18 - Synchronize the machine as quickly as possible and apply about 20% of load. Avoid operating at full speed with no load for any length of time.
- 19 - Engage exhaust regulator. (See instructions given in Regulator Leaflet.)

## Shutting Down

- 20 - Decrease the load to about 20% of full load. Except in an emergency shutdown, load should be removed gradually.
- 21 - Disengage the exhaust regulator. (See instructions given in Regulator Leaflet).
- 22 - Remove all load and quickly disconnect the generator from the line by tripping the main circuit breaker. Do not motorize the unit under any circumstances.
- 23 - Then shut down the turbine by manually tripping the overspeed trip mechanism.
- 24 - Immediately close the exhaust header valve.
- 25 - Make sure the auxiliary oil pump starts when the regulating oil pressure drops to the predetermined point. If it should fail to start, open the steam by pass around the regulator.
- 26 - Shut off the gland sealing water. Be sure the valve in this line does not leak because any water leaking onto the shaft after the rotor stops may cause distortion of the rotor.
- 27 - Open all atmospheric drains.
- 28 - Shut off the water to the oil coolers and generator air coolers.
- 29 - The auxiliary oil pump should be kept in operation until the machine becomes relatively cool. If this is not done, the heat conducted along the shaft from inside the turbine may injure the bearings.

On turbines which operate with inlet steam temperatures of 700° F. or higher:-

- (a) For shutdowns up to three hours duration, the auxiliary pump should be kept in operation throughout the shutdown period.
- (b) For longer shutdowns, the auxiliary pump should be kept operating three hours after closing the throttle valve.

## Precautions

- 30 - Avoid, at all times, passing steam through the turbine with the rotor at rest. With the throttle and governing valves closed, the drain between these valves should be open, and should be a free flow to atmosphere.

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- 31 - If the turbine has been idle for a considerable period of time, the throttle valve should be tripped, immediately after starting, to see if the tripping mechanism functions properly. This is done by unlatching by hand the overspeed trip on the front end of the turbine.
- 32 - Start the auxiliary oil pump occasionally, while the turbine is in normal operation to insure that the regulator and pump are in proper working order. This is done by slowly opening the valve in the oil drain (from the regulator diaphragm) provided for testing purposes.
- 33 - At regular intervals, depending on the operating requirements, test the overspeed trip mechanism by actually overspeeding the turbine, to make sure that it is in proper working order.
- 34 - Keep the oil system clean and free of water. It is suggested that a small quantity of oil be drained from the bottom of the reservoir after long shutdown periods, during which sediment and water will have had a chance to settle to the bottom.
- 35 - Oil leaks are unsightly and, in proximity to parts carrying hot steam, constitute a fire hazard. All such leaks should be corrected immediately.
- 36 - Keep all external parts of the unit clean to prevent the accumulation of dust or other foreign matter. Cleanliness, prompt attention to oil and steam leaks and general good housekeeping tend to insure satisfactory operation.
- 37 - A complete record of all pressures and temperatures should be kept and any deviation from normal operation immediately investigated. This applies especially to any variation in steam pressure distribution through the turbine for a given load.