

OPERATION

(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 procedures 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 vibration. 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, and atmospheric relief line. On condensing machines, all drains (except from the high-pressure steam inlet) should connect to the condenser or a vacuum trap because when starting or operating at light load, vacuum may exist in the entire cylinder.

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, and the gland leak offs are open and that the steam line is free of water.
- 4 - Establish water circulation through the condenser.
- 5 - Start the condensate pump. (Maintain water in pump suction either by re-circulation or intermittent operation).
- 6 - Turn on the gland water, throttling it so that only a slight amount leaks outward along the shaft.
- 7 - Start the second-stage air ejector (or the priming ejector if one is used.)
- 8 - As soon as the vacuum rises to 20 inches (or as high as the second-stage ejector or priming ejector will raise the vacuum if less than 20 inches) open the throttle valve a sufficient amount to start the rotor immediately. Then close it and open it again just enough to keep the 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.

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- 9 - Keep the turbine rolling at low speed (approximately 200 to 400 rpm) with the vacuum not over 20 inches, 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. During this same time, allow the vacuum to increase gradually so as to obtain full vacuum when the turbine reaches 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 - Shut off the priming ejector (if one is used). When the maximum vacuum that can be obtained with the second stage ejector is reached, start the first stage ejector.
- 14 - Close the drains from pressure zones when it is assured that all water has been removed and condensation stopped.
- 15 - 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.
- 16 - Open throttle valve fully.
- 17 - Make sure that the governor properly controls the speed of the turbine with full steam pressure and full vacuum.
- 18 - Synchronize the machine as quickly as possible and apply about 20% of load. Avoid operating at full speed and full vacuum with no load for any length of time, in order to avoid excessive heating of the low pressure section of the turbine.

Shutting Down

- 19 - Decrease the load to about 20% of full load. Except in an emergency shutdown, load should be removed gradually.
- 20 - 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.

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- 21 - Then shut down the turbine by manually tripping the overspeed trip mechanism.
- 22 - Shut off air ejectors.
- 23 - After the turbine rotor speed has decreased to about one-half of normal open the vacuum breaker if one is used.
- 24 - 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.
- 25 - Shut down the condensate pump.
- 26 - Shut off the gland sealing water when the vacuum has disappeared. 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 - Shut down the circulating pump.
- 30 - 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

- 31 - 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 provide a free flow to atmosphere.
- 32 - Avoid air being drawn through the glands with the rotor at rest. Therefore, do not operate the air ejectors without sealing water on the glands.
- 33 - Avoid as much as possible undue heating of the low-pressure portions of the turbine beyond what is required for operation under vacuum. This is to avoid waste of fuel and unnecessary stresses due to expansion of parts of the exhaust chamber. Therefore, apply gland sealing water, start the air pumps, or ejectors, and establish a small vacuum before starting to roll.
- 34 - If the turbine has been idle for a considerable period of time, the throttle valve should be tripped, immediately after starting,

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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.

- 35 - 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.
- 36 - 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.
- 37 - 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.
- 38 - Oil leaks are unsightly and, in proximity to parts carrying hot steam, constitute a fire hazard. All such leaks should be corrected immediately.
- 39 - 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.
- 40 - 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.