

## 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 procedure to be followed will necessarily be determined by the best judgment of the operating engineers.

In order to facilitate starting, the turning gear should be in operation and should preferably have been in service throughout the shutdown period. When the unit is taken out of service for an extended period and if the nature of the work done, or other considerations, dictate the stopping of the turning gear during that time, it is desirable that the unit shall have been on the turning gear about three or four days before rotation is stopped. In case the turning gear must be shut down shortly after turning off steam, some schedule should be adopted, if practicable, for turning the rotor through 180° at regular intervals, say once every 30 minutes. Temporary disengagement of the turning gear, involving stoppages for a few hours only, may, in case of necessity, be made after shorter periods of rolling, but it should be kept in mind that, insofar as circumstances permit, continuous turning during shutdown is the preferred and the safest procedure.

In any case, if the turning gear has been disengaged, it should be put in operation a sufficient time before admitting steam to the unit, to allow the rotor to become straight, within the limits specified in this leaflet.

### STARTING

1. Establish water circulation through the condenser.
2. Turn on the gland water, throttling it so that only a slight amount is thrown outward along the shaft.
3. Start the second stage air ejector (or the priming ejector if one is used) and establish 10 to 20 inches of vacuum.
4. 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.
5. Shut down the motor driven oil pump which has been in operation while using the turning gear.
6. Check the oil reservoir level gauge and see that the system capacity does not decrease the level below the minimum mark on each gauge plate.
7. See that the turbine drains and gland leak-offs are open and that the steam line is free of water.
8. See that the thrust bearing adjusting mechanism is in the "Start and Stop" position.
9. When a vacuum of at least 10 inches has been obtained, open the throttle valve just enough to pass sufficient steam to accelerate the rotor slightly above the speed maintained by the turning gear. When this is done, the turning gear should automatically disengage. The turning gear motor may then be shut down.

## Operation

Listen for rubs or other unusual sounds, especially when the rotors are rolling with the steam shut off, for at this time a foreign noise can most easily be heard.

When the throttle handwheel is turned in the opening direction, the governing valves should open wide. See that they open freely and are not sticking.

10. Start the condensate pump.
11. Keep the turbine rolling at low speed (approximately 100 to 400 rpm), with the vacuum not over 20 inches, for 20 to 30 minutes, to allow the parts to become partly heated, or as much longer as may be necessary until the shaft truth indicators adjacent to each gland show not more than .0005" to .001" movement. The period mentioned will be sufficient, provided the turning gear has been used as recommended in the introductory paragraphs.
12. Close the drains from pressure zones when it is assured that all water has been removed and condensation stopped.
13. Trip the governing valves, by means of the emergency hand trip, and see that the valves close and open again freely.
14. When the rotor is within the desired truth limits as shown by the indicator, bring the unit up to speed slowly, taking about 15 to 20 minutes to reach full speed. During this same time, allow the vacuum to increase gradually (but not to such an extent that will produce less than 5 lbs. pressure at the primary inlet) so as to obtain full vacuum when the turbine reaches full speed. When bringing a large turbine up to speed and before going on load, the vacuum should be regulated so as to maintain 5 lbs. to 15 lbs. pressure at the primary inlet.
15. As the speed increases, adjust the gland water supply to obtain proper sealing. 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 about 155° F. Turn on water to the generator air coolers and start the fans if separate fans are used.
16. Make sure that the governor properly controls the speed of the turbine with full steam pressure and vacuum.
17. 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.
18. After operating at 20% load for 10 to 20 minutes, load may be increased or decreased gradually. The rate of change should not exceed 2% per minute.
19. After taking on load, the turbine must be operated for some time with the rotor in the "Start and Stop" position, in order to permit the unit to become uniformly heated. The length of time required for this initial heating will depend upon several factors, principally the length of shut down and the load being carried.

## Operation

As a general rule, there are two cases to be considered: First, when the turbine has been shut down only a short time, say up to 20 hours, and, second, when there has been a shutdown of two days or more. If the load is promptly brought up to 50% or more upon starting, the rotor should remain in the "Start and Stop" position for three to five hours in the first case (short shutdown) and for six to ten hours in the second case (long shutdown). The proper period of operation in the "Start and Stop" position after periods of shutdown intermediate between those mentioned may be estimated from these limits.

20. With the bleeder heaters in operation, make sure that the condensate pump used in connection with this arrangement is started as soon as the load is put on the turbine and that the traps between different heaters are operating correctly.
21. The above is believed to be the best procedure for putting a large turbine unit on the line under normal conditions. However, in cases of emergency, it may be possible to complete the entire operation in a much shorter time without any apparent ill effect on the turbine. In such a case, particular attention should be given to the truth of the rotor as shown by the dial indicators, and the operator should listen carefully with a rod for any sign of a rub throughout the entire starting period. The extent to which the starting time is decreased should depend entirely on the emergency of the case; due consideration being given to the possibility of injury to the turbine.

## **SHUTTING DOWN**

22. Except in an emergency shutdown, load must be removed gradually, the normal rate of decrease not exceeding that specified above under "Starting", item 18.
23. When the load has been decreased to approximately 20%, move the rotor (thrust bearing adjusting mechanism) to the "Start and Stop" position.
24. When all load has been removed and the generator has been taken off the line, shut down the unit quickly by manually tripping the over-speed trip. Do not motorize the unit under any circumstances.  
  
Maintain the vacuum until the speed has dropped to the point where the gland seals break, which will be approximately three-quarters speed, and then open the vacuum breaker.
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 bypass around the regulator.
26. Shut down the air ejectors and condensate pump.
27. Shut off the gland sealing water and the cooling water to the generator air coolers.
28. Open all atmospheric drains.
29. After the rotor has stopped rolling, shut down the auxiliary oil pump.
30. Start the motor driven auxiliary oil pump to supply oil to the bearings and turning gear during the shutdown period.

## Operation

31. Engage and start the turning gear.
32. Shut off the water to the oil coolers.
33. Shut down the circulating pump.

## CAUTIONS

34. When the turbine is thoroughly heated and in normal operating conditions, no harm should result from loss of load for brief periods, with the rotor in the "Running" position. However, if, due to other station or transmission trouble, it is necessary to operate the unit at 15% load or less for 15 minutes or more, the thrust bearing adjusting mechanism should be moved to the "Start and Stop" position and restored to running position thirty minutes after resuming normal operation at extremely light loads for any considerable period of time is not recommended because of excessive heating of the LP portion of the turbine, which must be avoided.
35. 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.
36. 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.
37. 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 bring the vacuum up to at least 10 inches as soon as possible after starting to roll. The amount of vacuum is controlled at this time by the vacuum breaker.
38. 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.
39. Start the auxiliary oil pump occasionally, while the turbine is in normal operation, by manipulating its regulator and see that the regulator and pump are in proper working order.
40. At frequent intervals, perhaps once a month, depending on the operating requirements, trip the overspeed trip by means of the oil pressure testing device supplied for this purpose. Note the pressure required to trip. If this pressure is not approximately the same as that recorded at the time of installation (or the last overhaul), the mechanism should be inspected to make sure that it is in proper working order. It is, of course, necessary that at each check, the turbine be operating at exactly the same speed as on the previous occasion, in order for the pressures to indicate the condition of the trip.
41. A complete record of all pressures and temperatures should be kept, and any deviation from normal operation immediately investigated.
42. During shut down periods, the turning gear should be kept in operation except under circumstances such as described in the leaflet on "Turning Gear", for assurance of a comparatively straight rotor when it becomes necessary to start up and for assurance that the turbine can be started without a radial rub.