# HIGH PRESSURE, NON-CONDENSING TURBINE

## (Superposed Type)

## INTRODUCTION

The steam turbine, like any other high grade machine, requires, for sustained efficiency and continuity of operation, a reasonable minimum of care and attention on the part of the operator. In order that the unit may receive such care and attention, it is necessary that the operators become thoroughly familiar, not only with the mechanical structure of the several parts of the turbine, but also with their purpose and, in a general way, with the reasons why they are so designed. The following brief instructions for the care and operation of the turbine have been prepared as an aid to the attainment of this desired information and it is hoped that they may be found to be broad enough in scope for that purpose.

## GENERAL DESCRIPTION

This turbine is a single cylinder, combination impulse-reaction machine of the high pressure, non condensing type. The exact steam conditions with which it is designed to operate, the normal speed and the maximum load are given on the Title Page of the Instruction Book.

In normal operation, this machine is superposed on condensing units. That is, the high pressure turbine exhausts into a nominal pressure header (which may or may not be supplied also by nominal pressure boilers) and supplies steam to the inlet of one or more condensing machines. When operating in conjunction with the nominal pressure boilers, the high pressure turbine operates with constant exhaust pressure. If the nominal pressure boilers are not used, the high pressure turbine may operate with constant exhaust pressure, with the governor under control of an exhaust pressure regulator, or it may be operated with the condensing turbines as a cross compound unit with variable exhaust pressure on the high pressure element.

The construction of the turbine is shown in the longitudinal section photograph. (It should be noted that this illustration shows a side view below the horizontal centerline and a longitudinal section above the centerline.)

### Cylinder

The cylinder is made of cast steel (or a suitable alloy when the steam temperatures are unusually high) and is split in the horizontal centerplane to form a base and cover. Stationary blades and balance piston elements are secured in the cylinder and passages are provided for by-passing a portion of the blading for maximum steam flow when such construction is required. An important feature of this design is an annular steam belt extending around the entire cylinder at the high pressure end which equalizes the temperatures of the base and cover and thus greatly decreases the possibility of cylinder distortion. This chamber serves as the steam passage between the No. 1 inlet valve, located in the cover, and its nozzles, located in the base, and therefore is filled completely with steam as soon as the first valve opens and remains filled until this valve closes.

The method of supporting the turbine is arranged to allow the various parts to expand and contract freely without causing distortion. The cylinder is supported by four arms or lugs which are cast integrally at the top of the base, thus locating the point of support as closely as possible to the horizontal centerline. These arms rest on the bearing pedestals, which are separate pieces. Transverse keys, one attached to the bottom of each arm by a single sleeve type dowel and free to slide in its keyway cut in the pedestal, maintain the correct axial position of the cylinder with respect to the pedestals but allow free expansion in a transverse direction. Any tendency of the cylinder to rise off the pedestals is limited by a stud bolt through each arm. These bolts are placed inside the sleeve type dowels and are fitted with ample clearance under the nut and around the bolt to allow free movement of the cylinder arms in response to temperature changes. Vertical keys between the cylinder base and pedestals, placed on the vertical centerline, definitely locate the cylinder in a transverse direction, but permit free expansion and contraction vertically and transversely.

The exhaust end pedestal is anchored to the foundation seating plates by longitudinal and transverse keys and side gibs, and serves to anchor the entire unit. The inlet end pedestal is free to slide axially on its base, but is held against transverse movement by an axial key, placed on the longitudinal centerline, between it and the base. Any tendency to tilt is limited by side gibs which are fitted with ample clearance to allow free movement axially.

The base and cover of the cylinder are bolted together by large stud bolts (or studs). In order to obtain the proper stress in each of these bolts, they must be tightened sufficiently to stretch them a definite amount. The correct method to obtain this stretch is described in Supplement No. 102, Rev. 2. The cylinder joint faces are finished to make a tight joint under the standard hydrostatic and steam tests with the faces dry and metal to metal. When assembling the machine for operation, triple boiled linseed oil should be used on the joint faces. In addition, a sealing groove is provided in the joint face, into which sealing compound can be injected in case leaks develop after periods of operation.

## Rotor

The turbine rotor is machined from a solid forging of steel (or a suitable alloy for the higher temperatures) with a central inspection hole drilled through its entire length. A separate stub shaft is bolted to the inlet end to form the thrust bearing collar and to carry the oil impellers and overspeed trip. The entire rotor is finish-machined and, after being completely bladed, is given a running test at 20% overspeed and an accurate dynamic balance. The exhaust end is connected to the generator field by a rigid coupling and the main rotating element thus formed is carried in four bearings.

## Blading

The blade path includes an impulse element (either Curtis or Rateau) followed by reaction blading. The exact blade arrangement and the number of stages or rows are given on the Title Page of the Instruction Book. Throughout the blade path, the massive rotating and stationary parts are separated by relatively large clearances, and the small clearances necessary to control steam leakage are maintained by thin seal strips. These strips are made of an alloy steel with excellent wearing qualities so that contacts may occur during early operation and the strips will wear away to their necessary minimum running clearance without resulting in any damage to major parts.

## Balance Piston

The inlet end of the rotor is machined to form a single stage balance piston (or dummy) which is designed to over-balance the thrust on the blading and thus produce a thrust toward the inlet end of the machine under all operating conditions. With this arrangement, any floating of the rotor, such as is possible in case of loss of load, can occur toward the exhaust end only, thus temporarily increasing the axial running clearance by the amount of clearance in the thrust bearing, but maintaining at least the desired minimum clearance at all times.

The steam leakage past the balance piston seals is led through external pipes and is returned to the cylinder at lower pressure zones, as determined by the steam conditions and design of the machine.

The balance piston labyrinth seals are of the axial clearance type and are described in a separate leaflet. During starting and stopping periods, the rotor must be moved (by means of the thrust bearing adjusting mechanism) to the start and stop position which increases the clearance at these seals.

## Control

The control and oil system diagram shows the various parts of the control system and their relation to one another. The detail operation of each particular part is described in its respective leaflet.

Enough oil should be provided so that when the turbine is running at full speed the oil level in the reservoir, as shown by the gauge, is within the limits given on the indicator plate. Although there is a strainer in the oil system, it is desirable as a precaution to strain the oil through a fine mesh screen or cloth just before putting it into the reservoir.

The amount of water circulated through the oil cooler should be regulated to maintain the temperature of the oil leaving the cooler between 100 and 110°F. The correct criterion of oil cooler water supply is, of course, the temperature of the oil leaving the hottest bearing. This temperature will vary with different units and operating conditions. However, in general, oil return temperatures of 140 to 160°F. are considered good practice. When starting a turbine, the oil cooler water should not be turned on until the oil temperature has increased to the approximate limits given above.

## Operation and Maintenance

A recommended procedure for operating the turbine is given in a separate leaflet. While these instructions are quite specific, it is impossible to cover all details. Hence, they do not in any way relieve the operator of using sound judgment and exercising due caution.

Likewise, it is impossible to give any detailed procedure for maintenance work. It is believed that the illustrations and descriptions of the detail parts as given in the Instruction Books should enable the Maintenance Engineer to care for the apparatus properly.

On turbines which use reaction blading of the "Axial Clearance" type, there is one point which must be borne in mind and bears repetition in this book.

Before raising the cylinder cover, the rotor must be moved toward the exhaust end, beyond the start and stop position, before raising the cylinder rotor or cover. This additional clearance is absolutely necessary to avoid damaging the axial seal strips on the blading. When such additional movement is necessary, the detail instructions are given on the rotor clearance drawing.