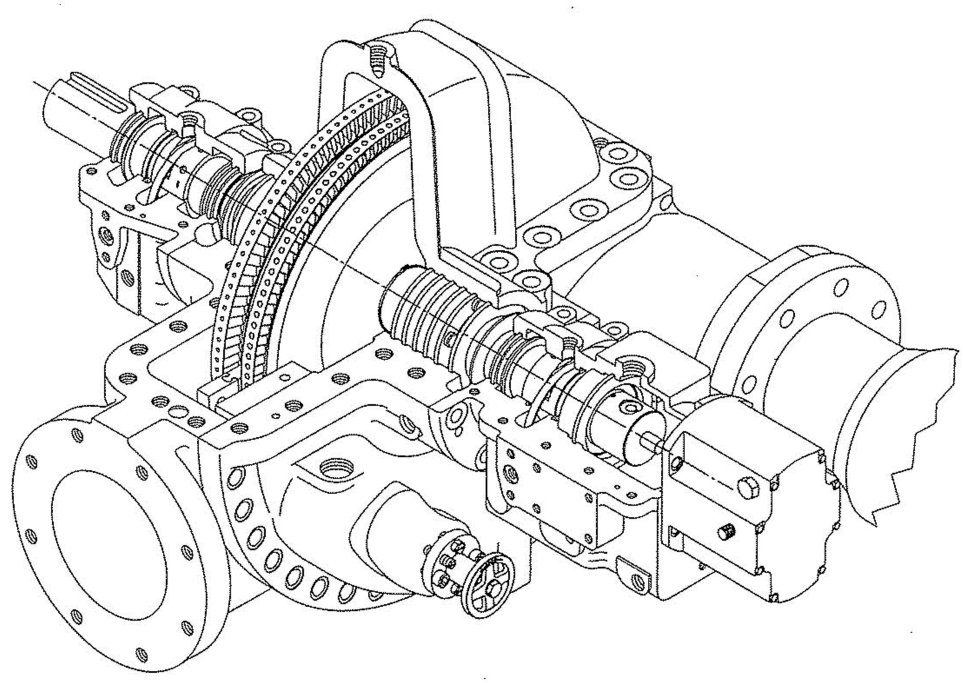
DRESSER-RAND®



Instruction Manual for Single Stage 350, 500, and 700 Frame Steam Turbines

Manual 107-A

Dresser-Rand

SST 350, SST 500, and SST 700

Single Stage Turbine

Instruction Manual

How to Use This Manual

THIS MANUAL APPLIES TO SST 350, 500, AND SST 700 SINGLE STAGE TURBINES.

This instruction manual contains installation, operation, and maintenance instructions for the Dresser-Rand Turbine identified on the Turbine Data Sheet included with this manual. It should be reviewed thoroughly by the user before attempting to install and operate the turbine, and should be kept in a location convenient to the user for ready reference during operation and maintenance.

WARNING

A complete reading of this manual by personnel in contact with the steam turbine is essential to safety. INCORRECT INSTALLATION, OPERATION, MAINTENANCE, OR PARTS REPLACEMENT CAN RESULT IN INJURY TO PERSONNEL, AND DAMAGE TO THE TURBINE, DRIVEN MACHINERY, AND PLANT.

The Instruction Manual consists of 15 sections, as listed in the table of contents. Each section is further broken down into subsections.

This is a general instruction manual, describing a standard ring oiled or pressure lubricated turbine with hydraulic or electronic governors. The description and illustrations contained herein may differ in minor details from the unit actually supplied. All general installation, operation, and maintenance procedures are applicable.

For turbines supplied with options such as forced or circulating lubrication systems, alternative speed control systems, accessories, instrumentation, speed reducers or other special configurations, refer to the appropriate accessory manuals and turbine certified drawing package included in Appendix A and Appendix B following this manual.

WARNING

Throughout this manual, it is assumed that the motive flow applied at the turbine inlet is high-pressure steam. Therefore, the word "steam" is used in reference to various aspects of turbine installation, operation, and maintenance. For some specialized applications, high-pressure gasses such as Freon, natural gas, or other vapors may provide the motive flow. In these cases, it can generally be assumed that the name of the gas in use may be used to replace the word "steam." The user of the equipment must address all hazards associated with the nature of the specific motive flow in use with the turbine. If flammable or toxic gasses are used as the motive fluid or if oil vapor could be emitted, the user/installer must pipe leak-offs and drains to a safe location. Explosive gas mixtures must not be used as the motive fluid.

The instructions contained in this manual do not attempt to cover all details, nor does it provide for every possible contingency to be met in connection with installation, operation, or maintenance of the supplied equipment.

The supplying of instructions does not imply, in any manner, that Dresser-Rand accepts liability for work carried out by a customer or contractor personnel. Liability is limited to and as stated in our Terms and Conditions of Sale.

Should further information be desired, or should particular problems arise, the matter should be referred to Dresser-Rand.

This manual is intended for use by personnel with a general knowledge of proper operation and maintenance of steam turbines. Special training or the assistance of a trained Dresser-Rand service representative is suggested for personnel with less than a general working knowledge of this type of equipment.

All inquiries regarding installation, operation, maintenance, spare parts, or service should be directed to your Dresser-Rand manufacturer's representative, or to:

Dresser-Rand
Steam Turbine Business Unit
www.dresser-rand.com
800-828-2818
585-596-3100

Refer to Section M, *Replacement Parts/Factory Service*, for information on how to request factory service or order replacement parts.

EU Compliance

The following warning and notes apply only to turbines for which compliance with European Union Directives has been specified.

NOTE

If there is a CE mark on this turbine nameplate it indicates compliance with the ATEX Directive. Machinery Directive Compliance and Machinery Directive CE marking of the turbine and driven equipment is the responsibility of the assembler or installer. See the Machinery Directive Declaration of Incorporation

WARNING

ATEX Certified turbines will have a mark –c °C X on the turbine nameplate. This indicates that the turbine casing temperature will become that of the motive fluid (steam or gas) inlet temperature, this may exceed the ignition temperature of some gasses. See the ATEX Directive Risk Assessment Summary List accompanying the ATEX Declaration of Conformance.

NOTE

Refer to the Machinery Directive – List of Residual Risks and ATEX Directive-Risk Assessment Summary List for warnings related to EU Compliance.

Additional cautions and warnings are located throughout this manual and in the Safety Precautions Section.

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Safety Precautions

This turbine has been designed to provide safe and reliable service within the designed specifications. It is a pressure containing, rotating machine; therefore, responsible and qualified personnel must exercise good judgment and proper safety practices to avoid damage to the equipment and surroundings and/or possible serious or painful injuries.

It is assumed that your company's safety department has an established safety program based on a thorough analysis of industrial hazards. Before installing, operating, or performing maintenance on the turbine, it is suggested that you review your safety program to insure that it covers the hazards arising from rotating machinery and pressure vessels.

It is important that due consideration be given to all hazards resulting from the presence of electrical power, hot oil, high pressure and temperature steam, toxic gasses, and flammable liquids and gasses. Proper installation and continued maintenance of protective guards, shutdown devices, and overpressure protection are also necessary for safe turbine operation. The turbine should never be operated by bypassing, overriding, or in any way rendering inoperative, guards, protective shutdown equipment, or other safety devices.

When internal maintenance work is in progress, it is essential that the turbine be isolated from all utilities to prevent the possibility of applying power or steam to the turbine. When performing internal turbine maintenance, always ensure that isolating valves in the steam inlet and exhaust lines are locked closed and tagged, and all drains are opened to depressurize the turbine casing and steam chest. Precautions must also be taken to prevent turbine rotation due to reverse flow through the driven machinery.

In general, you should be guided by all of the basic safety rules associated with the turbine, driven equipment, and plant process.

This manual contains four types of hazard seriousness messages. They are as follows:

DANGER: Immediate hazards that WILL result in severe personal injury or death.

WARNING: Hazards which COULD result in serious injury to the turbine operator and others, or extensive damage to the turbine, driven equipment, or the surroundings.

CAUTION: Hazards, which COULD result in damage or malfunction to the turbine or its parts, leading to subsequent downtime and expense.

NOTE: A message to clarify or simplify an operation or technique, or to avoid a common mistake.

DANGERS

DO NOT attempt to ADJUST, REPAIR, DISASSEMBLE OR MODIFY this turbine WHILE IT IS IN OPERATION, unless such action is expressly described in this instruction manual.

NEVER DISCONNECT the inlet or exhaust piping of the turbine without first CLOSING and TAGGING the ISOLATING VALVES and then OPENING DRAIN VALVES SLOWLY to relieve any pressure with the turbine. Failure to do so may expose PERSONNEL to SERIOUS INJURY if steam was to be introduced into the piping or captured in the turbine. As an added precaution, always install blank flanges on inlet and exhaust lines after removing the turbine.

DO NOT REMOVE ANY COVERS, GUARDS, GLAND HOUSINGS, DRAIN COVERS, etc. while the unit is OPERATING.

Under no circumstances should the TRIP VALVE be blocked or held open to render the trip system inoperative. Overriding the trip system, and allowing the turbine to exceed the rated (nameplate) trip speed, may result in FATAL INJURY to personnel and extensive turbine damage. In the event the trip system malfunctions, immediately SHUT DOWN the turbine and correct the cause

NEVER BLOCK OR DISABLE THE TURBINE TRIP SYSTEM OR ATTEMPT TO ADUST OR REPAIR IT WHILE THE TURBINE IS OPERATING.

DANGERS (Cont'd)

This turbine is equipped with an OVERSPEED TRIP to protect against dangerous over-speeding. It is absolutely essential that the complete trip system be MAINTAINED in such a condition that it will operate perfectly if required. It must be thoroughly INSPECTED AND TESTED WEEKLY. Inspection must include all elements of the trip system. Dresser-Rand Turbine recommends that all TESTS BE RECORDED.

Keep body parts (fingers, hands, etc.) away from shaft, couplings, linkage or other moving parts to prevent contact and possible serious injury.

NEVER WEAR NECKTIES OR LOOSE CLOTHING while in the proximity of the turbine or auxiliary equipment. These could become entangled in the shaft, coupling, linkage or other moving parts and cause serious injury.

A coupling guard must be installed at the coupling between the turbine and driven equipment.

Wear proper eye protection when working on or around the turbine.

The turbine must be grounded.

WARNINGS

Modification of, incorrect repair of, or use of non DRESSER-RAND repair parts on this turbine could result in a serious malfunction or explosion that could result in serious injury or death. Such actions will also invalidate ATEX Directive & Machinery Directive Certifications for turbines that are in compliance with those European Directives. Refer to Section M *Replacement Parts/Factory Service.*

Throughout this manual it is assumed that the motive flow applied at the turbine inlet is high-pressure steam. Therefore, the word “steam” is used in reference to various aspects of turbine installation, operation, and maintenance. For some specialized applications, high-pressure gasses such as Freon, natural gas, or other vapors may provide the motive flow. In these cases it can generally be assumed that the name of the gas in use may be used to replace the word “steam.” The user of the equipment must address all hazards associated with the nature of the specific motive fluid in use with the turbine. If flammable or toxic gasses are used as the motive fluid or oil vapor could be emitted, the user/installer must pipe leak-offs and drains to a safe location. Explosive gas mixtures must not be used as the motive fluid.

DO NOT START OR OPERATE this turbine unless the INSTALLATION has been VERIFIED TO BE CORRECT and all pre-startup SAFETY AND CONTROL FUNCTIONS have been CHECKED.

DO NOT START OR OPERATE this turbine, unless you have a COMPLETE UNDERSTANDING of the location and function of ALL COMPONENTS in the steam supply and exhaust systems, including block and relief valves, bypasses, drains, and any upstream or downstream equipment that may affect the flow of steam to or from the steam turbine.

WARNINGS

DO NOT START OR OPERATE this turbine, unless you have a complete understanding of the control system, the overspeed trip system, the drain and leak-off systems, the lubrication system, and all auxiliary mechanical, electrical, hydraulic and pneumatic systems, as well as the meaning and significance of all monitoring gages, meters, digital readouts, and warning devices.

DO NOT MAKE ANY MODIFICATIONS OR REPAIRS that are not described in this manual without consulting with and approval of an authorized Dresser-Rand company representative.

WHEN STARTING the turbine, BE PREPARED TO execute an EMERGENCY SHUTDOWN in the event of failure of the governor, overspeed control systems, linkage, or valves.

It is the USER'S RESPONSIBILITY to INSTALL A FULL-FLOW RELIEF VALVE in the exhaust line between the turbine exhaust casing and the first shut-off valve. This relief valve should be sized to relieve the FULL AMOUNT OF STEAM THAT THE TURBINE WILL PASS, in the event that the exhaust line is blocked.

VERIFICATION of proper functioning and setting of the OVERSPEED TRIP SYSTEM during initial start-up is mandatory. This should be accomplished with the turbine DISCONNECTED from the driven equipment. Turbine speed should be increased SLOWLY in a controlled manner during trip testing.

If the turbine is operated on a motive fluid other than steam due consideration must be given to safety issues that might relate to the medium used, including but not limited to the ignition, explosion or poisoning of personnel.

WARNINGS

The surface temperature of the turbine and piping will become that of the steam inlet temperature. This could exceed the ignition temperature of some gasses. Therefore if the turbine is installed where explosive gasses could be present it is the user’s responsibility to insure that this does not create a hazardous situation.

Steam quality must be DRY AND SATURATED OR SUPERHEATED. There must be provision to REMOVE MOISTURE AND CONDENSATE for the steam supply system to AVOID DAMAGING the turbine. Steam purity should meet or exceed American Boiler Manufacturers Association Guidelines.

The surface temperature of the turbine and piping will become that of the steam inlet temperature. Personnel should wear gloves and protective clothing to avoid burns.

Lighting must be provided in the installation to insure that operators can see the turbine and its controls.

Should an explosion occur in the vicinity of the turbine it is the user/installer’s responsibility to halt it immediately and/or limit the range of explosive flames and explosive pressures to a sufficient level of safety.

Shown below are turbine noise levels that were measured at three feet (1 meter), while operating at a normal load and exhausting to a positive back pressure. These noise levels are not guaranteed and are published for informational purposes only.

This noise data is based on test measurements that were taken on similar equipment being operated on the factory test stand, and have been extrapolated and/or corrected for background noise as appropriate.

WARNINGS

When the turbine is operated under actual field conditions, noise generated in or by the piping, foundation, base plate, couplings, driven equipment, background and other sources, can add significantly to the turbine noise level and to the overall noise levels in the area.

It is recommended that the equipment user assesses the noise level(s) of the completed installation and determines if additional sound attenuation and/or hearing protection for operating personnel are required.

Octave Band Frequency (HZ) - Expected Sound Pressure Levels (dB – Ref. 2 x 10-5 N/m2)									
Accoustic Insulation	**63**	**125**	**250**	**500**	**1K**	**2K**	**4K**	**8K**	**Expected Overall dBA**
YES	96	91	88	86	83	82	81	81	85
NO	97	92	90	89	87	85	84	84	88

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Section A

Introduction and General Description

THIS MANUAL APPLIES TO SINGLE STAGE 350-500-700 TURBINES.

A.1 Turbine Description

Standard Dresser-Rand SST Turbines are single-stage, impulse-type turbines with a two-row, velocity-compounded rotor and one row of stationary reversing blades between the rotating blades. The rotor is contained within a horizontally split (axially split) casing, with steam inlet and exhaust connections located in the lower half of the casing assembly.

The rotor is supported between two sleeve bearings and positioned axially by a ball thrust bearing or tilt pad thrust bearing, or it is supported between two ball bearings and positioned axially by a ball thrust bearing. Other variations of the turbine include extended inlet pressure and temperature constructions and/or a high back pressure construction.

Steam enters the turbine casing after first passing through the built-in steam strainer, the throttle valve and the overspeed trip valve. The turbine inlet casing incorporates the nozzle ring, which contains several individual steam nozzles. Some of these nozzles are controlled by hand-valves for partial load or overload conditions. Steam flowing through the nozzles expands and is directed at high velocity against the rotating blades of the first row on the turbine rotor. After passing through the first row, stationary reversing blades redirect the steam against a second row of rotating blades. The steam is then discharged into the exhaust casing and from there into the user’s exhaust piping at the exhaust system pressure.

Optionally, the turbine may be supplied with a single row rotor, in which the case stationary reversing blades are not provided.

A.2 Construction

Dresser-Rand SST Turbines are ruggedly constructed, suitable for a wide range of mechanical drive applications and comply with all basic API-611 and NEMA SM23 requirements.

The casings, valve body, shaft, wheel, blades, nozzles, valve components, and fasteners are constructed of high-grade alloy steel, stainless steel, and carbon steel, assuring a long and dependable service life.

Depending on the steam conditions, horsepower, and speed, materials used in turbine construction may vary. Always consult the turbine data sheet or nameplate on the turbine before connecting it to a steam inlet or exhaust, to ensure that the turbine is rated for the prospective conditions. Never run the turbine in excess of the maximum allowable speed, maximum inlet or exhaust pressure, maximum inlet temperature, or above the rated horsepower, as specified on the nameplate.

WARNINGS

Materials used in turbine construction (steel, stainless steel, special alloys) vary with steam conditions, speed, and power. These materials were selected according to the original rating of the turbine. NEVER attempt to RE-RATE a turbine without the assistance of a Dresser-Rand manufacturer's representative and/or the factory. MISAPPLICATION of materials COULD result in serious equipment damage and/or personal injury.

Never CONNECT the turbine to inlet or exhaust sources of UNKNOWN PRESSURE OR TEMPERATURE or to sources whose pressure or temperature EXCEED limits stated on the NAMEPLATE.

Some Dresser-Rand turbines can be re-rated for different steam conditions, powers, and speeds. Consult your Dresser-Rand manufacturer's representative or the factory for further information.

CAUTION

For turbines which will be subject to ambient temperatures of –30°C (-20°F) or less, review and comply with all requirements outlined in "Low Ambient Temperature Application of Single Stage ASTM A216-WCB Carbon Steel Pressure Casing Steam Turbines" in the "Miscellaneous" section of this instruction manual.

A.3 Main Components

Your steam turbine is a single stage impulse type machine. A cut-away view of a single stage turbine with a Woodward direct-drive speed governor is shown in Figure A-1. Following is a description of the major components that comprise the turbine.

Inlet Flange, 21. The standard SST turbine inlet flange for connection to the steam supply is part of the over-speed Venturi trip. Flange type, size and material are a function of the steam conditions and customer specifications. Refer to the certified drawings in Appendix A following this manual.

Governor, 3. The main purpose of the governor is to maintain the set turbine speed. The mechanical governors used for single stage turbines are direct acting units mechanically linked to the governor lever for control of the governor valve. Each governor is factory set to the customer's specifications for a specific speed range. The electronic governors maintain turbine speed through the use of an actuator. The actuator adjusts the governor valve in response to the signal received from the electronic governor. The Woodward PG and UG governors are gear driven. For turbines with a Woodward governor, Woodward bulletins, which describe operating characteristics and maintenance instructions, are provided in Appendix B.

Trip & Throttle Valve. A single stage turbine may include a trip and throttle valve, which is mounted between the turbine casing and the inlet steam line. It normally houses both a throttle valve and over-speed trip valve. The overspeed trip valve is a mechanically actuated valve which interrupts the supply of steam to the turbine during an over-speed condition or other emergency, thereby bringing the turbine to a complete stop. In the event of over-speed, the valve is activated by the over-speed governor cup, which is attached to the turbine shaft inside the governor housing. In the event of other emergencies, the valve can be activated using the manual trip lever or an optional remote trip.

Governor Valve. The governor valve is automatically controlled by the speed governor to admit the proper amount of steam required to maintain the speed for which the governor is set. When the turbine is not operating, the valve is open, unless options have been selected to close the valve when the turbine is tripped.

If your turbine has a special control system, a diagram is given in Appendix A.

Emergency Valve. The emergency valve, is automatically closed to shut down the turbine on over-speed conditions, and manually when the trip lever is unlatched. Some optional systems to automatically close this valve and shut down the turbines are as follows: (Refer to Appendix A & B for turbines with this equipment.)

Low oil pressure trip — on turbines with a pressure lubricating system.

Low air pressure trip — using the customer's air supply.

Solenoid trip.

High back-pressure trip.

Emergency Over-speed Trip Cup, 17. An emergency overspeed governor assembly, located in a cup on the steam end of turbine shaft shuts down the turbine when the turbine speed reaches the set trip-out speed. (Refer to turbine data sheets for tripping speed of your turbine.) The trip mechanism is factory set and should require no further adjustment. However, the tripping speed may be raised or lowered within small limits. Procedures for this adjustment are given in section E-5.

Hand Valves, 16. Hand-operated nozzle control valves allow maximum efficiency at part loads; rated load at reduced steam pressure, or operation at overload capacity. The valves permit adjustment of the nozzle area to that which most closely conforms to the correct area required by the steam flow for a particular load condition, thus reducing throttling. Performance characteristics relating to the use of hand valves for your turbine are given on the turbine data sheets.

As the steam leaves the governor valve it fills the steam chamber supplying the nozzle ring. In the wall between this steam chamber and the nozzle ring are openings or ports through which steam is fed to certain nozzles or groups of nozzles. In order to permit the adjustment of the nozzle area as stated above, valves may be placed in as many of these ports as is practical or required with the exception of one. This one port is under control of the governor controlled inlet valve at all times. The hand valve ports are numbered, starting with the port located at the lowest point in the steam end and proceeding in a clockwise direction. Thus, if a hand valve is furnished in the first port it is designated as hand valve No. 1, in the second port, No. 2, etc. The valves must be opened in their numerical order for best operation.

The hand valves cannot be used as throttling valves. They should be either fully opened or fully closed. A valve that is partly open will soon have a damaged seat due to steam erosion. This condition is better known as "wire drawing." However, when putting the unit into operation, do not close a valve tightly until the turbine is up to operating temperature and all parts are evenly heated.
The reason for this is that the material of the valve stem is subject to greater thermal expansion than the turbine casing, and if the valve is closed tightly when cold, it may lock the valve in the closed position making it difficult to open.

Main Bearings, 19. The turbine rotor is carried on two main bearings, which are designated as the steam end and exhaust end bearings. The bearings are babbitted sleeve type, with shoulders on the ends to maintain their axial position. A stop pin prevents them from rotating with the shaft. Ball bearings also are main bearing options as well as rare applications of tilt-pad bearings.

Thrust Bearing, 18. A ball or shoe type thrust bearing, located on the steam end of the turbine shaft, prevents axial movement of the turbine rotor beyond designed limits, (See Appendix A for the type of thrust bearing in your turbine.) The bearing is properly positioned on the turbine shaft with shims at the factory and should require no adjustment. However, it should be noted that the shims are responsible for the proper nozzle-to-turbine wheel clearance. This is illustrated in Figure L-8 page 223. In pressure lubricated systems, the bearing operates in a continuous oil bath. For ring oiled turbines, the ball thrust bearing receives the necessary oil supply from the same oil ring that supplies oil to the main bearings.

Oil Rings, 12. For turbines without a pressure lubrication system, an oil ring, located inside a slot in each main bearing, provides for lubrication of the main bearings and the thrust bearing. During operation, the rings, which revolve freely on the shaft, dip into the oil reservoir and carry oil up onto the shaft where it is distributed to each main bearing. The thrust bearing, located inside the shell of the steam end main bearing, receives its lubricating oil from this same action.

Shaft Packing, 7, 13. Carbon or labyrinth rings are provided at each end of the turbine where the shaft passes through the turbine case. The turbine data sheets specify the type and number of packing rings in your turbine, and the longitudinal section drawing in Appendix A demonstrates the typical installation. Procedures for replacement are given in Section L.5.2.

On non-condensing (back pressure) machines, the packing limits and controls the flow of steam along the shaft. On condensing machines, the packing controls the entrance of air into the casing at the packing glands where the pressure inside the turbine case is less than atmospheric.

The carbon rings are individually separated in compartments formed by corrosion resistant steel spacers. The partition rings are located in annular grooves in the packing cases. The carbon rings seal by being forced against the spacers and by being a clearance fit along the shaft. The rings are made in three sections and kept from rotating by a stop on each ring. The ends of the ring segments are kept in contact with each other by interlocking the ends. A stop prevents the assembly from rotating.

Labyrinth packing is essentially a multiple tooth-throttling device, assembled concentrically with the shaft. The rings, which are made of corrosion resistant steel, are assembled in four segments with each joint numbered to facilitate identification during replacement. The rings are located in the packing case by means of machined shoulders.

Gland Sealing Systems. All condensing turbines have a gland sealing system to prevent air from being drawn into the turbine casing through the packing glands. A typical schematic of a sealing system, without a gland condenser arrangement, is shown in Figure C-6. If your turbine requires a gland condenser system, a piping diagram with operating instructions is included in Appendix A, along with a description of the major components that comprise the system.

Pressure Lube Systems. For turbines with a pressure lube system, an oil piping or schematic drawing for your turbine is provided in Appendix A. Ring oiled turbines equipped with a separate, pressure lubricated, gear box may not require a diagram. A typical schematic diagram of this system is shown in Figure 6. Since all turbines with an integral gear box are pressure lubricated, this information, if applicable, is also given in Appendix A. Turbines with pressure lube systems, that do not have an automatic-start auxiliary oil pump, have oil rings to ensure lubrication of the bearings during start-up, low speed operation and shut-down.

Oil Filter or Strainer. Either a strainer or an oil filter is provided in all pressure lube systems. The filters are of the replaceable element type. A drop in normal oil pressure may be an indication that the filter or strainer is clogged.

Twin filters with a transfer valve will allow changing an element without shutting down the turbine. The twin units have a fill valve that should be used to fill the side being placed into service, before the transfer is made. NOTE: Coolers and filters are individually vented and the by-pass valves have been opened at start-up or when any maintenance has been done on either component.

Certain systems, using a single element filter, incorporate a by-pass valve arrangement to allow maintenance on the filter without shutting down the turbine. In general, two basic types are employed; one system uses three separate valves (Figure A-X, view A) and the other system uses a single two-position valve (3-way or 4-way), shown in views B and C.

The two position valves are never closed. They are either positioned open to the filter (normal operation), or open to by-pass (maintenance position). The shutoff valve downstream of the filter in view B must be closed during maintenance. In the three-valve arrangement, two valves are in series with the filter and one valve is parallel. For normal operation, the two series connected valves are open; the parallel-connected valve is closed. For filter maintenance, the three valves are set opposite their normal position.

Main Oil Pump. The pump can be direct-drive or gear driven from either the turbine shaft, gear shaft, or governor shaft, depending on the application. (See Appendix A). No adjustments or special maintenance is required. For motor driven main oil pumps, see turbine data sheets for electrical requirements.

Auxiliary Oil Pump (Motor Driven). Usually controlled automatically by a pressure switch to start and stop at certain line pressure (See Turbine Data Sheets.) A test valve in the system allows simulating a low oil pressure condition to check operation of the pump. The pump should be tested at regular intervals.

Auxiliary Oil Pump (Steam Driven). Steam to drive the pump is controlled automatically by a regulator valve. When oil line pressure is sufficient, the valve is closed and the pump is inoperative. If oil line pressure drops, the regulator valve opens and steam is admitted to drive the pump. A test valve allows simulating a low-pressure condition to check operation of the pump. NOTE: it is important that the pump exhaust is piped to atmosphere, and that the exhaust line be properly drained.

***Low Oil Pressure Trip.** The low oil acts to shut down the turbine when oil pressure drops to an unsafe limit. (See turbine data sheets). The device is mounted on the steam end of the turbine and consists basically of a spring loaded bellows, bellows stem, and a spring loaded plunger rod (See Appendix A). Bearing system oil pressure keeps the device linked to the turbine trip latch. If bearing system oil pressure decreases the device releases the trip latch and the turbine is shut down. On certain turbines, oil pressure must be established in the system before the emergency valve can be latched open.

***Low Air Pressure Trip.** The air pressure trip allows shutting down the turbine from a remote control. The device is identical to the low oil pressure trip described in the preceding paragraph, except that facility air pressure in place of bearing oil pressure keeps the device linked to the turbine trip latch.

*****Turbines with the optional trip and throttle valve do not utilize a separate low oil/low air pressure trip. This is a “built-in” feature of the trip & throttle valve design.

Solenoid Dump Valve. In systems with a low oil/air pressure trip device, a solenoid dump valve allows the shutting down of the turbine from a remote location. The valve, when activated, opens and dumps system oil back to the reservoir or air pressure to atmosphere. This creates a low oil/air pressure condition and the turbine is shut down. (See turbine data sheets for electrical requirements and valve position when energized/de-energized.)

Circulating Systems. The circulating system is the next step up from the ring oil system with water-cooling. This system is used when oil temperature in the bearing housings could exceed 180°F (82°C). This elevated temperature is normally caused by an increase in shaft/bearing rubbing speeds and/or elevated inlet or exhaust steam temperatures being transmitted from the wheel casing to the bearing case itself.

The circulation system is basically a ring lubrication system, the difference being that a shaft driven, direct drive pump, which circulates oil out of the bearing cases for additional cooling, has been added. At high exhaust temperatures, an external oil cooler is added to the system.

The pump supplied with this system is a positive displacement gear type pump. It is mounted on the shaft at the exhaust end of the turbine. The upper half of the exhaust end bearing case serves as a housing for the pump. The same pump is used regardless of turbine rotation. The pump may be mounted off the turbine shaft at the steam end when design allows.

A standpipe or overflow port is located at each bearing case to maintain the correct oil level.

The circulating lube system has very limited options and is not an API system.

Figures A-1, *Dresser-Rand SST Turbine, General View, Non-Drive End*, & A-2, *Dresser-Rand SST Turbine, General View, Drive End*, show major components, as seen on the exterior of a standard turbine. Each major component is described in detail below.

The Dresser-Rand manufactured **Throttle Valve** is contained in the steam chest or valve body upstream of the over-speed trip valve. It controls the amount of steam entering the turbine and thereby determines the speed and power produced by the turbine.

Optional constructions may include separate throttle and/or over-speed trip valves or other equipment configurations. Refer to the certified drawings in Appendix A.

Trip Linkage (not visible). This linkage connects the overspeed trip valve to the trip mechanism inside the governor mounting housing. The trip linkage is activated by the turbine shaft mounted over-speed trip collar, the manual over-speed trip lever or an optional electric or electric/pneumatic trip actuator

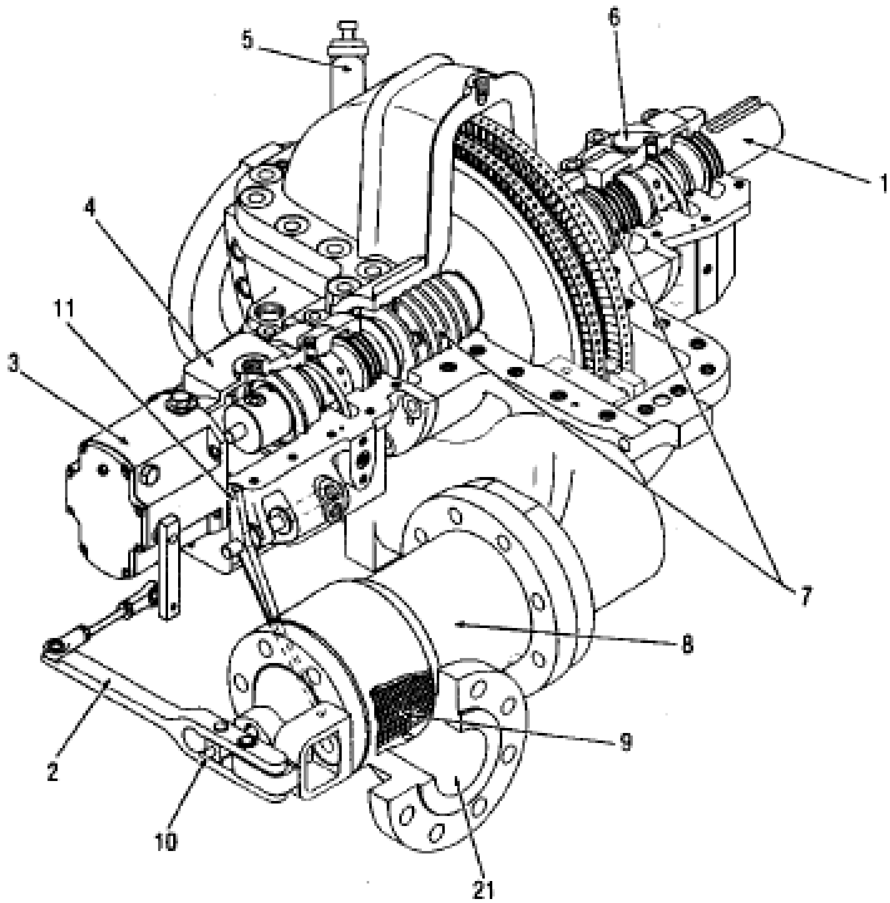
Immersion Heater. For turbines operating in an extreme environment, an optional thermostatically controlled immersion heater may be provided in the main oil tank to heat the oil prior to start-up and to maintain a suitable temperature during operation. If your turbine has this equipment, a supplementary description and parts list is provided in Appendix B. Operating procedures for this equipment are given in Section F. Immersion heaters are not available on circulating lube systems.

Probes and Proximitors. An axial movement probe provides a means of monitoring thrust bearing wear and radial probes monitor shaft vibration. For turbines equipped to monitor vibration and axial displacement of the shaft, a probe assembly drawing and an electrical wiring and layout drawing are provided in Appendix A with supplementary instructions on the monitoring equipment.

In certain designs a key-phasor probe, shown on the electrical wiring and layout drawing, is provided as an instrumentation reference point. The key-phasor is a separate probe that may be axially or radially mounted.

LEGEND FOR FIGURE A-1

1. Turbine Shaft
2. Governor Lever
3. Woodward TG Governor
4. Steam End Bearing Case
5. Sentinel Warning Valve
6. Exhaust End Bearing Case
7. Carbon Packing Rings
8. Steam Chest
9. Steam Strainer
10. Governor Valve Stem
11. Trip Lever
12. Oil Rings (2)
13. Packing Case Leakoffs (2)
14. Turbine Wheels
15. Turbine Case
16. Hand Valve
17. Overspeed Cup
18. Thrust Bearing
19. Main Bearings (2)
20. Exhaust
21. Inlet



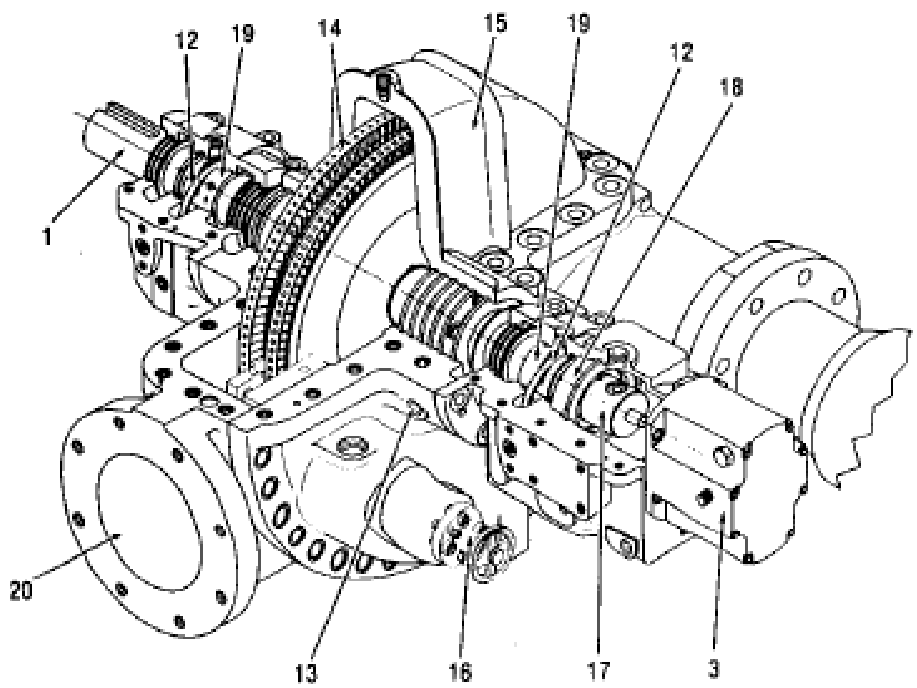


Figure A-1. Dresser-Rand SST, General View, Steam and Exhaust Ends

Governor Lever, 2. This is the linkage between the governor and governor valve.

Over-speed Trip Lever, 11. The overspeed trip lever is part of the trip linkage, allowing manual activation of the over-speed trip valve. Optional electric or electric/pneumatic trip actuators and/or limit switches may be provided to work in concert with the overspeed trip lever.

Over-speed Trip Reset Handle. This handle is used to reset (open) the overspeed trip valve, permitting recovery from an over-speed trip condition. When recovering from a trip condition, the handle is initially opened slightly to permit pilot valve operation, and then is opened fully to reset the valve.

Steam End Bearing Case, 4. SST turbines have one sleeve shaft support bearing and a thrust bearing in this housing. SST turbines can also have two ball bearings serving the same purposes. The overspeed trip mechanism is located in this housing and the over-speed trip lever is typically is mounted on this housing. The standard housing also contains an oil ring, seals, the oil reservoir and the cooling water jacket. Standard construction includes a constant level oiler mounted on the bearing housing, along with the oil filler/vent, oil drain plug, and plugs for cooling water inlet and outlet openings.

Exhaust End Bearing Case, 6. SST turbines have one sleeve shaft support bearing in this housing and can also have one ball bearing serving the same purpose. The standard housing also contains an oil ring, seals, the oil reservoir and the cooling water jacket. Standard construction includes a constant level oiler mounted on the bearing housing, along with the oil filler/vent, oil drain plug, and plugs for cooling water inlet and outlet openings. This housing is similar to the steam end bearing housing.

Oil Level Gauge. The oil level gauge indicates the oil level in the bearing housing. This level corresponds with a mark inscribed on the bearing housing. For turbines with alternate lubrication systems this may not be included.

Constant Level Oiler. The constant level oiler is an oil reservoir that is set to maintain a constant oil level in the bearing housing. For turbines with force feed lubrication or circulating oil cooling systems, oil levels are established by other means.

Gland Housings. Gland housings of the standard SST turbine contain carbon ring seals that prevent steam from leaking along the shaft to atmosphere. Some steam will escape past the carbon rings, lubricating them. This steam is conveyed by the gland leak-off connection to a safe location. Alternate gland housing configurations include labyrinth seals or mechanical seal designs.

Upper Case, 15. The upper case half contains exhaust steam and is the turbine component that seals the turbine exhaust casing. It contains an eyebolt, used for lifting the cover during turbine service. The eyebolt must not be used for lifting the entire turbine.

Steam Chest, 8. The steam chest (or valve body) is the casing section containing the high-pressure inlet steam. Steam enters the steam chest, travels past the trip and throttle valve, trip valve, and through nozzles in the nozzle block.

Lower Case. The lower turbine case (exhaust casing) contains exhaust steam and is integral with the exhaust flange. The exhaust casing supports the drive end bearing housing.

Turbine Supports. The steam and exhaust end supports each consist of fabricated steel or cast iron members that are bolted to the steam end and exhaust end casing. The supports are drilled for mounting bolts and dowel pins that hold the turbine in position and help maintain alignment with the driven equipment.

Exhaust Flange, 20. This flange connects the turbine to the user's exhaust steam line. Flange type, size, and material are a function of steam conditions and customer requirements. Refer to the certified drawings in Appendix A.

Shaft Extension. This is the output shaft of the turbine, which is keyed to accept a coupling.

Sentinel Warning Valve, 5. If specified, the turbine is supplied with a sentinel warning valve. The valve will alarm when exhaust-casing pressure is excessive (high). The valve warns the operator (by a whistle) only; it is not intended to relieve the casing pressure.

A.4 Factory Test

All Dresser-Rand turbines are given a mechanical no-load run test at the factory prior to shipment. The purpose of the test is to ensure the mechanical integrity of the turbine and to adjust its controls, overspeed trip, and accessories, as required.

The standard test includes the following:

- Turbine is run on shop steam conditions at rated speed, maximum continuous speed and just below the overspeed trip speed.

- Vibration levels are measured and recorded at each test speed.
- Turbine rotation & exhaust location are confirmed
- Governor and speed control operation are checked
- The over-speed trip is set and tested
- Turbine is checked for steam and lubrication leaks
- Sentinel warning valve is checked (if supplied)
- For SST turbines a post-test visual inspection of each bearing and sleeve bearing journal is carried out. If evidence of wear, scoring, or overheating is found, the cause of the defect is corrected, and the turbine is re-tested and inspected.

A.5 Shipping Preparation/Crating

Turbines are prepared for shipment and short-term storage (six months) using the following procedure. After testing, the turbine is allowed to cool and all moisture is drained from casings and valves. It is then masked and painted. All unpainted surfaces not inherently corrosion-resistant, such as exposed portions of the shaft, are coated with a rust-preventative and/or wrapped. Flange covers are installed on all open-flanged connections. Rust inhibitor is sprayed inside the turbine. Oil in bearing housings is drained and these cavities are partially filled with a rust inhibiting and vaporizing oil. The turbine is mounted on a heavy wooden skid, and depending on the shipping destination, is placed in a wooden container, covered or wrapped with plastic.

Just prior to crating, the turbine is given a final inspection by a quality inspector, who checks for completeness and appearance. Photographs of every turbine and the accessories shipped with it are taken and become a part of the factory order file for the turbine.

Refer to Section A.8, *Long-term Storage*, for additional measures taken if the turbine is prepared for long-term storage.

A.6 Uncrating and Inspection

Remove the packing material and check all items against the packing list. Ensure that parts are not missing or damaged. Handle all parts carefully. If inspection shows that the turbine has been damaged during shipment, contact the carrier and file a claim immediately.

Take care to ensure that loose parts are not discarded with the packing material.

CAUTION

Do not lift on the turbine shaft, as this could damage seals and/or bearings, or may bend the turbine shaft.

A sling under each end of the turbine case can safely raise the turbine. Do not use the eyelet in the center of the turbine case. This eyelet should be used only for lifting the upper half of the turbine case.

Refer to Figure B-1, *Recommended Lifting Arrangement for Dresser-Rand SST Turbines*.

A.7 Short-term Storage

Dresser-Rand turbines shipped to United States destinations are prepared for short-term storage of up to six months. The turbine should be stored in a clean, non-corrosive atmosphere and protected against damage, loss, weather, and foreign material, such as dust or sand. The equipment should remain on its shipping skid, with all preservatives and covering left intact. Indoor storage is preferred, where the temperature and humidity are maintained at a level preventing condensation. When stored outdoors, the turbine skid should be raised sufficiently so as to avoid contact with excessive moisture.

CAUTION

For turbines which will be subject to ambient temperatures of –30°C (-20°F) or less, review and comply with all requirements outlined in “Low Ambient Temperature Applications of Single Stage ASTM A216-WCB Carbon Steel Pressure Casing Steam Turbines” provided in the “Miscellaneous” section of this instruction manual.

Dresser-Rand turbines shipped to overseas destinations are prepared for short-term storage of up to six months. The same general instructions stipulated for domestic U.S. shipments also apply here.

A.8 Long-term Storage

Long-term storage is defined as storage exceeding six months to one year.

The following instructions apply to turbines that are to be prepared for long-term storage because they are not to be operated in the near future.

Basically these instructions apply equally to new units prepared for long-term storage in the field or to units that have been operated but are to be taken out of service for long-time storage.

The unit should be removed from the installed location (disconnect all steam, water, drain, and leak-off lines) and stored in a clean, dry building which is not subjected to large changes in temperature or humidity.

Long-term storage must be carried out in a warehouse maintained at constant temperature, thereby preventing condensation. As with short-term storage, the turbine should be protected against damage, loss, weather, and foreign material such as sand or dust. The turbine should remain on its shipping skid and be raised sufficiently so as to avoid contact with excessive moisture.

The following is the Dresser-Rand long-term storage procedure. This procedure should be performed on turbines that will be subjected to long-term storage, if they were not so prepared at the factory. The procedure should be repeated after the first 12 months of storage and checked at six-month intervals thereafter:

a. Remove the inlet and exhaust flange covers and spray the interior of the turbine with rust-inhibiting and vaporizing oil; then replace the covers securely. All machined parts (including internal parts such as oil pump gears and shafts, pins, linkages, pilot valves, thrust bearing parts, governor parts (except Woodward governors), couplings, etc.) which are not painted should be coated with heavy slushing compound; we recommend that the slushing compound purchased to MIL-C-16173, Grade 1. All major oil companies can furnish such a slushing compound.

b. Partially fill bearing housings to a level corresponding to the bottom of the sight glass with rust inhibiting and vaporizing oil. For SST turbines with sleeve type bearings, coat the bearing and shaft journal surfaces with a rust preventative.

c. Fill governor with rust inhibiting and vaporizing oil. Woodward governors should be filled to the top of the filler cup with the same type of lubricating oil normally used in the Woodward governor. On units that have been operated in the field, the old oil should be drained out and the Woodward governor should be flushed with a clean light grade of fuel oil or kerosene before filling it with lubricating oil.

d. Spray the exposed bonnet, seal blocks, and linkage areas of the trip and throttle valve assembly with rust inhibiting and vaporizing oil.

e. Apply a rust-preventative coating on all exposed and machined surfaces of the turbine. Do not apply this material to chrome plated areas of the turbine shaft. The turbine rotor, the gear and pinion and the generator rotor can be stored in their normal positions with the bearings in place; or they can be blocked up with wood and the bearings removed for storage; or they can be removed from their normal housings and blocked up for storage. In either case the journals should be carefully cleaned, slushed and wrapped in waterproof, greaseproof, acid- free non-corrosive paper (Sisal-Croft Fibreen or equal).

f. For turbines with carbon rings, after removing the upper case half, remove the carbon rings, garter springs and stop washers. Coat the inside and machined surfaces of the gland housings, along with casing and cover flanges exposed by the removal of the upper case half, with rust-preventative grease. Reinstall garter rings and stop washers on the shaft. Reassemble upper case cover onto the turbine. Store the carbon rings separately and in original matched sets until the turbine is ready for installation. This procedure will help protect chrome-plated areas of the turbine shaft from corrosion damage. Turbines supplied with mechanical seals should not have the seals disassembled. The outer surfaces of the seal may be coated to help prevent external corrosion.

When prepared by Dresser-Rand for long-term storage, SST turbines have had the carbon rings, garter springs, and stop washers removed as their removal helps protect the shaft from corrosion. These components are packaged separately in a box attached to the skid, and the turbine labeled with a long-term storage warning tag. Installation of these components is necessary before the initial turbine start up. Refer to Section L.4, *Carbon Ring Removal and Replacement*. The shaft packing should be removed, tagged and prepared for storage. The packing ring segments should be marked so that they can eventually be replaced in the turbine in their control position.

Be sure that all water pockets are drained to eliminate danger of freezing). Piping should be cleaned, dried and slushed.

To protect electrical insulation from vermin, the generator and exciter can be stored in a vermin- proof housing. Do not get any slushing compound on the generator or exciter insulation. Generator windings must be protected against absorbing moisture.

It has been found that if a unit is stored in a clean dry building in which air is circulated at approximately constant temperature it is not necessary to seal all openings, and the slushing needs only to be moderate. If it is decided to seal all openings (after the flanges are slushed), use the special paper mentioned in Item 3 backed up by wood or light sheet metal. Place a good grade desiccant or some other drying agent in the enclosure and arrange to inspect it at intervals of several months.

If the unit is to be stored in the open, or in an uncompleted building, or in a building that is subjected to large temperature changes, special precautions should be taken such as:

Cover the unit with a tarpaulin and protect it with planking if building construction is progressing in the vicinity of the unit.

Inspect at shorter intervals to determine if the slushing compound needs replacing.

A.9 Dresser-Rand Factory Service/Replacement Parts

Dresser-Rand provides a wide range of services to all its customers, including in-house factory rebuilding of turbines, factory trained field service personnel, replacement parts interchangeability lists, optimum replacement parts inventory recommendations, and replacement parts. Vital spare parts, such as carbon rings, gaskets, bearings, and valve components, are available for next-day shipment.

Selected Dresser-Rand manufacturer's representatives maintain factory-authorized repair facilities at locations throughout the world.

WARNING

Modification of, incorrect repair of, or use of non DRESSER-RAND repair parts on this turbine could result in a serious malfunction or explosion that could result in serious injury or death. Such actions will also invalidate ATEX Directive & Machinery Directive Certifications for turbines that are in compliance with those European Directives. Refer to Section M – *Replacement Parts/Factory Service.*

For assistance with service or spare parts, contact your local Dresser-Rand manufacturer's representative. Refer to Section M, *Replacement Parts/Factory Service*, for additional information regarding identification of turbine parts.

A.10 Re-Rating and Upgrades

Most Dresser-Rand turbines can be re-rated for different steam conditions, speed, or power. Contact your local Dresser-Rand manufacturer's representative to determine if a re-rate can meet your needs.

WARNING

Materials used in turbine construction (cast iron, steel, stainless steel, special alloys) vary with steam conditions, speed, and power. These materials were selected according to the original rating of the turbine. NEVER attempt to RE-RATE a turbine without the assistance of a Dresser-Rand manufacturer's representative and/or the factory. Misapplication of materials COULD result in serious equipment damage and/or personal injury.

Dresser-Rand turbines incorporate start-of-the-art technology and Dresser-Rand is dedicated to making continuous improvements in its equipment to enhance efficiency, maintainability and safety. In an effort to make improvements available to owners of older Dresser-Rand steam turbines, the factory offers upgrade kits for incorporating major design improvements into existing units. Consult your Dresser-Rand manufacturer's representative for information regarding factory upgrades.

A.11 Nameplate Information

The following information is included on the turbine nameplate.

Turbine Serial Number
Turbine Type (Model)
Power
Speed – RPM
Normal Inlet Pressure
Normal Inlet Temperature
Normal Exhaust Pressure
Maximum Inlet Pressure
Maximum Inlet Temperature
Maximum Exhaust Pressure
Calculated First Critical Speed
Maximum Continuous Speed - RPM
Minimum Allowable Speed – RPM
Trip Speed
Purchaser's Equipment number – If Specified
CE Mark – Followed by Notified Body Number when ATEX Category 2 is specified by Purchaser
EX Mark – Followed by ATEX Group, Category, Atmosphere and EN 13463-1 warning related to User/Installer determined Inlet Temperature.
Manufacture Date (on CE/ATEX units)
Manufacturer's name and location

Section B

Technical Data

B.1 General

Your Dresser-Rand single-stage turbine has been built specifically for your application. Frame size, materials used in construction, nozzling, rotor construction, and other items are based on steam conditions, power, and speed specified in the original purchase order. This information is recorded in three locations: 1) on the turbine nameplate; 2) on the turbine data sheet found at the beginning of this manual; and 3) on the certified outline drawing found in Appendix A. These documents also provide other important information, such as installation dimensions, connection identification, connection sizes, weight, component removal clearances, etc.

The turbine nameplate and data sheet specify the turbine serial number. This number is a unique identifier for the turbine; it must be specified when ordering replacement parts and in all correspondence with your local manufacturer's representative, the factory, and service personnel. The number is also stamped on the horizontal flange of the inlet casing.

The following subsections discuss important technical considerations that must be addressed when installing, operating, maintaining, or repairing the turbine.

B.2 Lifting

Turbines shipped on wooden skids should remain on their respective skids until placement onto their permanent foundations. When a turbine is on its skid, the skid should be used for lifting. Turbines shipped on base-plates can be lifted using lifting provisions on the base-plate. Do not attempt to lift the turbine and base-plate by lifting on the turbine or other base-plate mounted equipment.

When lifting the turbine itself, use slings extending around the steam chest and two locations on the turbine casing, as illustrated in Figure B-1, *Recommended Lifting Arrangement for Dresser-Rand SST Turbines*. Do not use the turbine shaft, governor, or the cover (upper exhaust casing) eyebolt for lifting purposes. Lift slowly and carefully to ensure stability and safety.

For correct sling selection, refer to the weights specified on the certified outline drawing in the Appendix A.

WARNING

Never attempt to LIFT the turbine USING the cover (upper exhaust casing) EYEBOLT. This eyebolt is intended for lifting the cover only. Using this eyebolt to lift the entire turbine presents a SERIOUS SAFETY HAZARD.

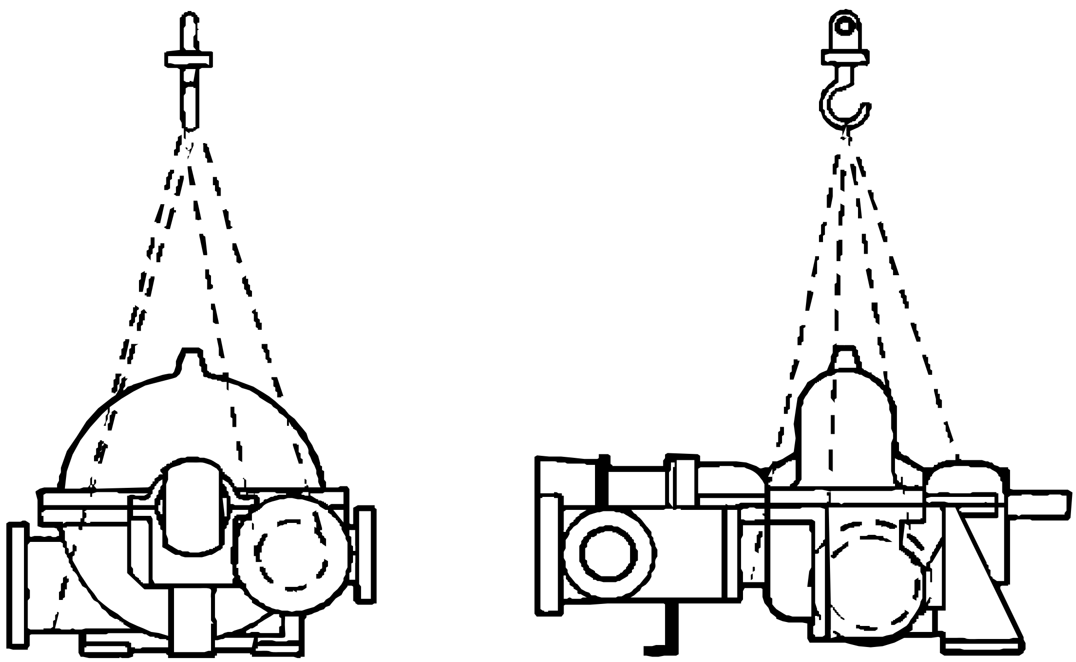


Figure B-1. Recommended Lifting Arrangement for Dresser-Rand SST Turbines

B.3 Alignment

Correct alignment of the turbine to the driven equipment is a primary consideration in turbine installation. Improper alignment can result in vibration, as well as wear and premature failure of bearings, seals, couplings, and shafts. Such failures can occur not only in the turbine but in the driven equipment as well. Alignment should be performed both under cold conditions and with the turbine at operating temperature, using personnel experienced in turbine alignment. Refer to Section C, *Installation*, for cold and hot alignment procedures. Alignment may be affected not only by turbine positioning with respect to the driven equipment, but also by thermal growth of the turbine, piping or the driven equipment, and by mechanical forces imposed by the piping. All of these factors must be considered when installing the turbine.

WARNING

Misalignment with driven equipment or overload due to driven equipment could result in excessive wear and bearing failure. This could create sparks or hot surfaces could ignite lubricant or flammable gasses.

CAUTION

Never put a steam turbine into service without first carefully ALIGNING it to the driven equipment under cold conditions and then again at operating temperature. Failure to do so may result in premature FAILURE of both TURBINE and DRIVEN EQUIPMENT components.

B.4 Thermal Growth

Thermal growth of the turbine casing supports, inlet/exhaust piping, and driven equipment may result in misalignment and/or application of external forces on the turbine. To avoid vibration and premature wear/failure of bearings, seals, couplings and shafts, along with distortion of the turbine casing, the thermal expansion of mating components must be carefully analyzed and compensated for by careful alignment (both hot and cold), as well as the use of flexible shaft couplings, expansion joints in piping, and proper maintenance of these components.

Refer to Section C, *Installation*, for cold and hot alignment procedures.

Refer to Section C-7 (Compensation for Thermal Movement) for further information.

Refer to Appendix A in your manual for turbine thermal growth data.

Concerning temperature differential on turbines with built-up rotors, the disc-to-shaft allowance tends to decrease to unacceptable limits with a 200°F (93°C) temperature differential between the disc and shaft. The existence of such a condition is greatest at approximately five minutes after start-up, rather than immediately at start-up. Loss of the shrink fit can result in axial or wobble movement of the disc on the shaft, possibly resulting in turbine breakdown. The colder the unit at start-up, the greater the probability of the temperature differential occurring. Since the utilization of forged discs in lieu of plate discs allows a higher shrink fit, we normally recommend the customer consider using forged discs.

In general, the subject of "quick," "fast" or "automatic" starting is not something new in the steam turbine industry. Dresser-Rand has not decreased its engineering standards for design of steam turbine shafts, bearings, or shrink fit of discs to shafts. Reliability and durability are compromised by quick starting a turbine and will result in a shortened overall turbine life. Frequent quick starts are particularly severe on bearings and rotating elements. The more rapid the acceleration rate, the higher are the transient loadings and the more severe are the loading effects. Dresser-Rand single stage turbines with standard construction are suitable for start-up in five seconds provided the following conditions are met:

1. The inlet side of the turbine steam line must be trapped.
2. Proper lubrication of bearings must be provided.
3. The inlet temperature of the steam shall not exceed 750°F (399°C).
4. The differential temperature between the inlet steam and exhaust steam shall not exceed 350°F (177°C).
5. Back pressure shall be maintained on the casing during shutdown. (This in itself is not a recommended operating condition due to possible shaft wire cutting or carbon ring seal decay, but it will keep the casing warm.
6. The operating speed o f the turbine shall not exceed 6000 RPM.
7. The unit must be brought up under load.

B.5 Lubricants

The importance of using a proper lubricant cannot be over emphasized. High quality turbo machinery oils are required. Dresser-Rand does not recommend specific brands of oil. Turbine owners should consult reliable oil suppliers regarding the proper selection of turbine oils. As a minimum, the selected oil should be a premium quality rust- and oxidation-inhibited turbine or circulating oil that will readily separate from water and have minimum tendency to emulsify or foam when agitated at actual operating temperatures. Since the proper grade of lubricant may not be available locally, it should be ordered in advance of the initial start-up of the equipment.

Consult Section F, *Lubrication* for viscosity recommendations, bearing housing oil capacities, oil levels, and maintenance of lubrication systems. In addition, a careful review of the certified drawings in Appendix A must be made to insure any specific lubricant requirement applying to the supplied equipment package are accommodated.

B.6 Major Fits, Clearances, and Rotor Balance Criteria

Dresser-Rand steam turbines are precision machines. The fits of the turbine wheel to its shaft, bearings on the shaft and in their housings, and other fits are selected and controlled so as to ensure long, efficient, trouble-free operation, as well as ease of maintenance.

Whenever a turbine is disassembled and reassembled for inspection or parts replacement, factory fits and clearances must be checked and maintained. If parts do not fit properly on re-assembly, the reason must be determined and the problem corrected.

Some major fits and clearances are listed in Tables B-1 *Major Fits, Clearances, & Rotor Balance Criteria – SST 350 and 500*, B-2 *Major Fits, Clearances, & Rotor Balance Criteria – SST 500H Turbine and* B-3 *Major Fits, Clearances, & Rotor Balance Criteria – SST 700 Turbine.* Other clearances are specified in the appropriate subsection of Section L, *Disassembly and Parts Replacement.*

For overspeed governor trip setting see section L.14.1, for overspeed governor trip linkage see L.14.3, for governor valve travel using Woodward PG and UG governors see L.12.8 See L.14.4 for adjustment of the emergency valve travel.

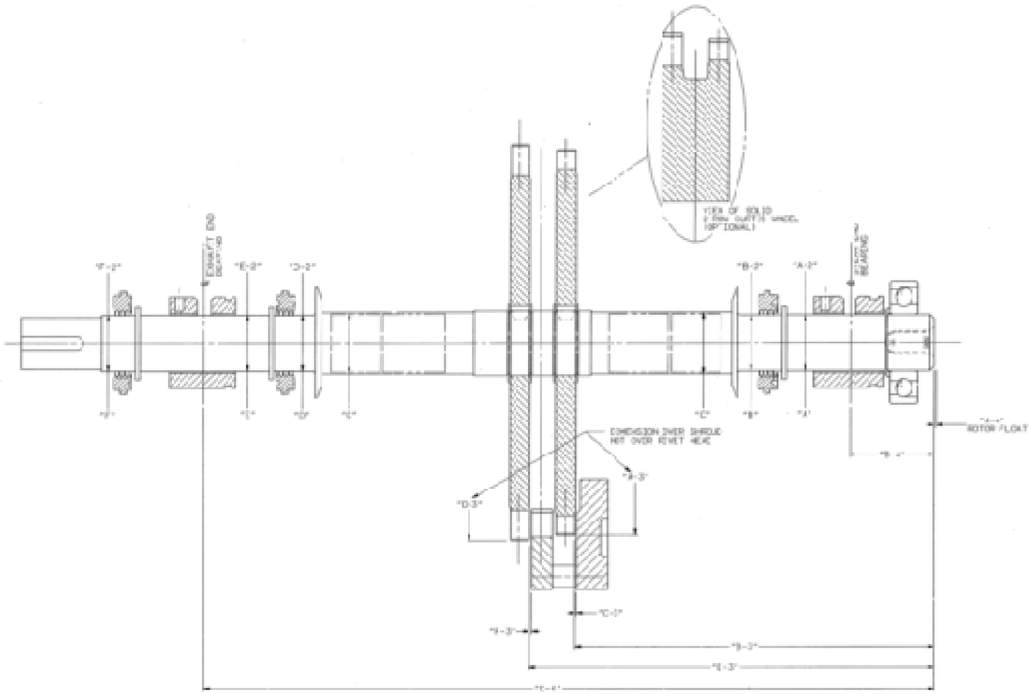


Figure B2 - Major Fits, Clearances and Rotor Balance Criteria – SST 350

	NAME	DESIGN DIM.	CLEARANCE DESIGN	CLEARANCE ACTUAL	ACTUAL DIM.
A	SHAFT	2.165 $^{+.000}_{-.001}$	.004-.008		
A2	BEARING	2.170 $^{+.002}_{-.000}$			
B	SHAFT	2.165 $^{+.000}_{-.001}$	.001-.004		
B2	OIL BAFFLE	2.167 $^{+.001}_{-.000}$			
C	SHAFT	2.3750 ±.0005			
D	SHAFT	2.165 $^{+.000}_{-.001}$	.001-.004		
D2	OIL BAFFLE	2.167 $^{+.001}_{-.000}$			
E	SHAFT	2.165 $^{+.000}_{-.001}$	.004-.008		
E2	BEARING	2.170 ±.001			
F	SHAFT	2.165 $^{+.000}_{-.001}$	.001-.004		
F2	OIL BAFFLE	2.167 $^{+.001}_{-.000}$			

DESIGN	ACTUAL
A ↗ .0002 ON R	
B ◎ A-B .0005 DIA.	
C ◎ A-B .0005 DIA.	
D ◎ A-B .0005 DIA.	
E ↗ .0002 ON R	
F ◎ A-B .0005 DIA.	

	ROTOR FLOAT (AXIAL)	
A4	THRUST CLEARANCE	
	BALL-BEARING PLAY	0.015-0.022
	TOTAL FLOAT	
	THRUST SET	
	NOMINAL DIM.	ACTUAL DIM.
B4	1.5	
C4	28.22	

STEAM END JOURNAL 32√ ACTUAL √

EXHAUST END JOURNAL 32√ ACTUAL √

	CURTIS WHEEL	
	1ST STAGE	
	DESIGN DIM.	ACTUAL DIM.
A3	ø 28.575	
B3	13.045	
C3	0.035MIN-0.050MAX	
	2ND STAGE	
D3	ø 29.000	
E3	14.920	
F3	.113	

Table B1 - Major Fits, Clearances and Rotor Balance Criteria – SST 350

	NAME	DESIGN DIM.	CLEARANCE DESIGN	CLEARANCE ACTUAL	ACTUAL DIM.
A	SHAFT	3.000 +.000 / -.001	.004-.007		
A2	BEARING	3.005 ±.001			
B	SHAFT	3.000 +.000 / -.001	.004-.006		
B2	OIL BAFFLE	3.004 +.001 / -.000			
C	SHAFT	3.5000 ±.0005			
D	SHAFT	3.000 +.000 / -.001	.004-.006		
D2	OIL BAFFLE	3.004 +.001 / -.000			
E	SHAFT	3.000 +.000 / -.001	.004-.007		
E2	BEARING	3.005 ±.001			
F	SHAFT	3.000 +.000 / -.001	.004-.006		
F2	OIL BAFFLE	3.004 +.001 / -.000			

DESIGN	ACTUAL
A ⌭ .0002 ON R	
B ◎ A-B .0005 DIA.	
C ◎ A-B .0005 DIA.	
D ◎ A-B .0005 DIA.	
E ⌭ .0002 ON R	
F ◎ A-B .0005 DIA.	

	ROTOR FLOAT (AXIAL)	
A4	THRUST CLEARANCE	
	BALL-BEARING PLAY	0.015-0.022
	TOTAL FLOAT	
	THRUST SET	
	NOMINAL DIM.	ACTUAL DIM.
B4	1.51	
C4	27.89	

STEAM END JOURNAL 32√ ACTUAL √

EXHAUST END JOURNAL 32√ ACTUAL √

CURTIS WHEEL		
1ST STAGE		
	DESIGN DIM.	ACTUAL DIM.
A3	⌀ 20.775	
B3	13.045	
C3	0.035MIN-0.050MAX	
	2ND STAGE	
D3	⌀ 21.200	
E3	14.920	
F3	.113	

Table B-2. Major Fits, Clearances and Rotor Balance Criteria – SST 500

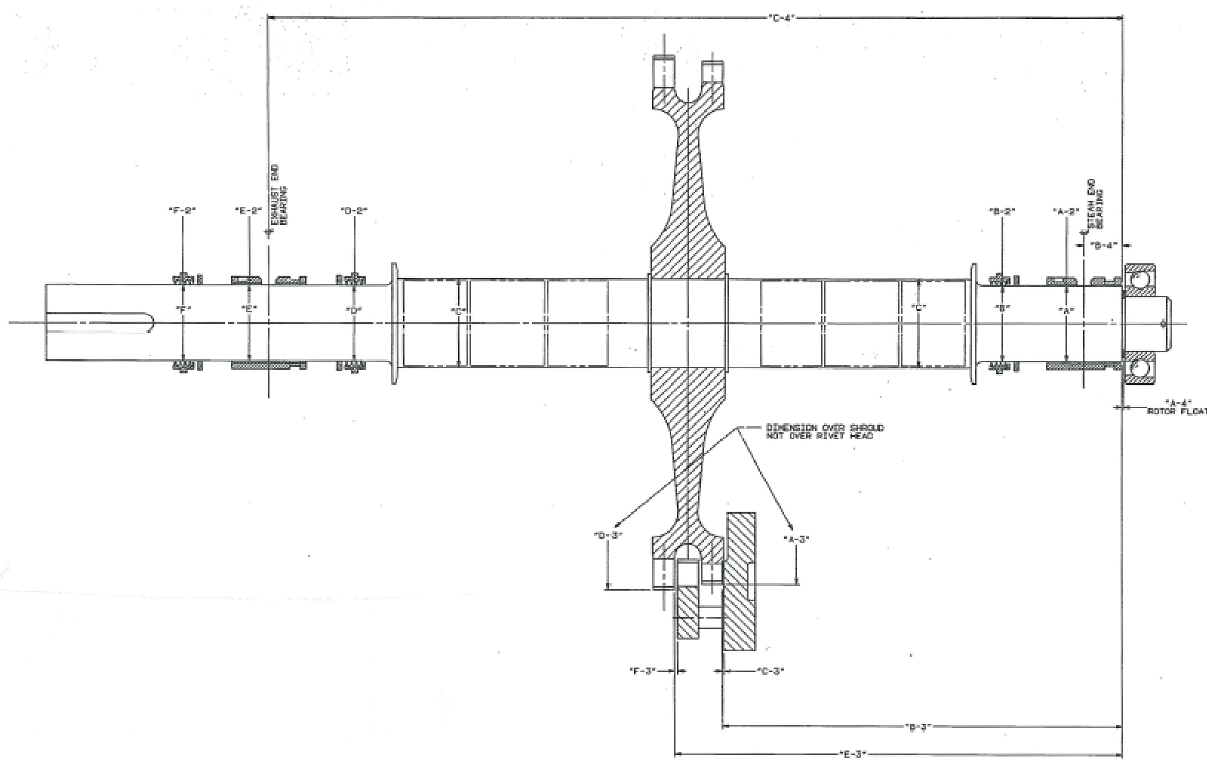


Figure B-3 Major Fits and Clearances, Standard SST 500 Turbine

	NAME	DESIGN DIM.	CLEARANCE DESIGN	CLEARANCE ACTUAL	ACTUAL DIM.
A	SHAFT	3.000 +.000 -.001	.004-.007		
A2	BEARING	3.005 ±.001			
B	SHAFT	3.000 +.000 -.001	.004-.006		
B2	OIL BAFFLE	3.004 +.001 -.000			
C	SHAFT	3.5000 ±.0005			
D	SHAFT	3.000 +.000 -.001	.004-.006		
D2	OIL BAFFLE	3.004 +.001 -.000			
E	SHAFT	3.000 +.000 -.001	.004-.007		
E2	BEARING	3.005 ±.001			
F	SHAFT	3.000 +.000 -.001	.004-.006		
F2	OIL BAFFLE	3.004 +.001 -.000			

DESIGN	ACTUAL
A ⌭ .0002 ON R	
B ◎ A-B .0005 DIA.	
C ◎ A-B .0005 DIA.	
D ◎ A-B .0005 DIA.	
E ⌭ .0002 ON R	
F ◎ A-B .0005 DIA.	

	ROTOR FLOAT (AXIAL)	
A4	THRUST CLEARANCE	
	BALL-BEARING PLAY	0.015-0.022
	TOTAL FLOAT	
	THRUST SET	
	NOMINAL DIM.	ACTUAL DIM.
B4	1.5	
C4	33.27	

STEAM END JOURNAL 32√ ACTUAL √

EXHAUST END JOURNAL 32√ ACTUAL √

CURTIS WHEEL		
1ST STAGE		
	DESIGN DIM.	ACTUAL DIM.
A3	ø 28.575	
B3	13.045	
C3	0.035MIN-0.050MAX	
2ND STAGE		
D3	ø 29.000	
E3	14.920	
F3	.113	

Table B-3. Major Fits, Clearances and Rotor Balance Criteria – SST 500H

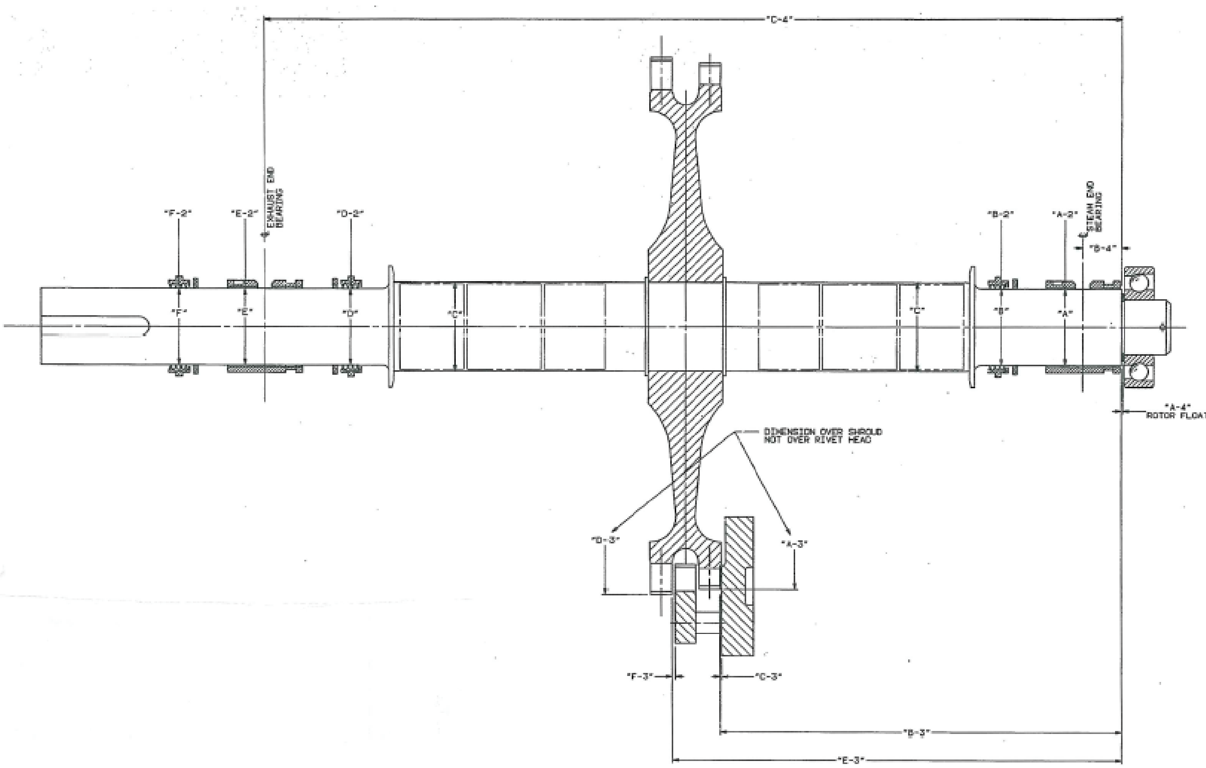


Figure B-4 Major Fits and Clearances, Standard SST 500H Turbine

	NAME	DESIGN DIM.	CLEARANCE DESIGN	CLEARANCE ACTUAL	ACTUAL DIM.
A	SHAFT	3.000 +.000 -.001	.004-.007		
A2	BEARING	3.005 ±.001			
B	SHAFT	3.000 +.000 -.001	.004-.006		
B2	OIL BAFFLE	3.004 +.001 -.000			
C	SHAFT	3.5000 ±.0005			
D	SHAFT	3.000 +.000 -.001	.004-.006		
D2	OIL BAFFLE	3.004 +.001 -.000			
E	SHAFT	3.000 +.000 -.001	.004-.007		
E2	BEARING	3.005 ±.001			
F	SHAFT	3.000 +.000 -.001	.004-.006		
F2	OIL BAFFLE	3.004 +.001 -.000			

DESIGN	ACTUAL
A ⌭ .0002 ON R	
B ◎ A-B .0005 DIA.	
C ◎ A-B .0005 DIA.	
D ◎ A-B .0005 DIA.	
E ⌭ .0002 ON R	
F ◎ A-B .0005 DIA.	

	ROTOR FLOAT (AXIAL)	
A4	THRUST CLEARANCE	
	TOTAL FLOAT	
	THRUST SET	
	NOMINAL DIM.	ACTUAL DIM.
B4	1.51	
C4	27.89	

STEAM END JOURNAL 16√ ACTUAL √

EXHAUST END JOURNAL 16√ ACTUAL √

	CURTIS WHEEL	
	1ST STAGE	
	DESIGN DIM.	ACTUAL DIM.
A3	Ø 28.575	
B3	13.045	
C3	.050	
	2ND STAGE	
D3	Ø 29.000	
E3	14.920	
F3	.113	

Table B-4. Major Fits, Clearances and Rotor Balance Criteria – SST 700

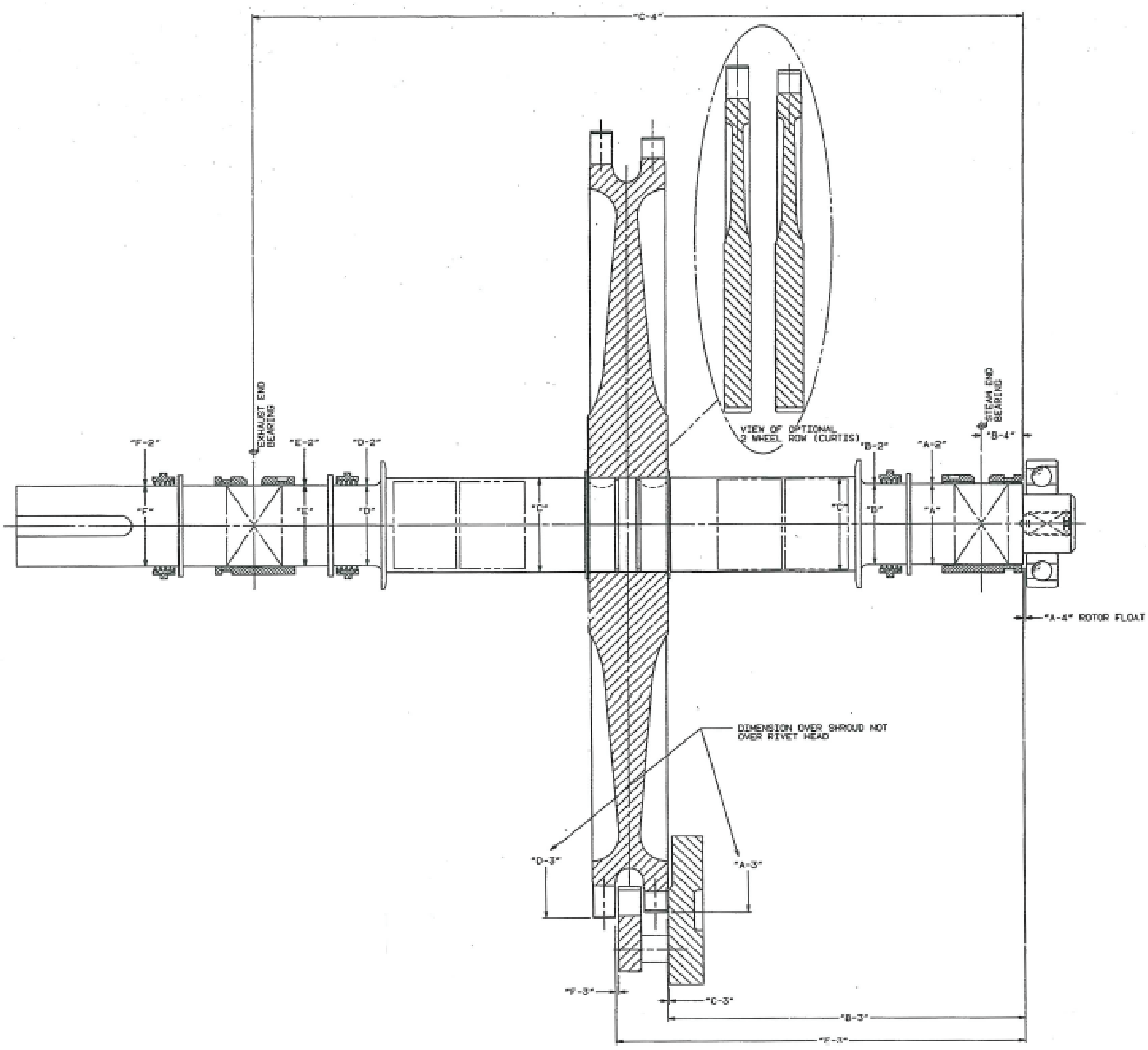


Figure B-5 Major Fits and Clearances, Standard SST 700 Turbine

B.7 Piping Forces

Steam piping, if improperly designed or installed, can impose severe mechanical or thermal forces and moments on the inlet and exhaust flanges of a steam turbine. Such forces and moments can misalign the turbine with its driven equipment, or distort the turbine casing, resulting in internal misalignment of the turbine shaft with bearings, seals, and other components. Such misalignment can cause vibration and premature wear or failure.

To prevent excessive piping forces or moments, the customer must ensure that the piping is designed and installed so as to comply with NEMA SM-23, Section 8, *Allowable Forces and Moments on Steam Turbines*. The maximum allowable forces and moments are a function of pipe sizes and are tabulated in the certified drawings in the *Supplemental Documentation* section, supplied at the end of this manual. Additional piping information, including suggested piping layouts, can be found in Section C, *Installation*.

B.8 Bolt Torques and Materials

The bolts used in Dresser-Rand turbines are carefully selected to ensure adequate strength at the maximum temperatures and pressures the turbine is subjected to. The following general application guidelines are used when selecting bolt materials.

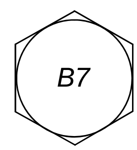
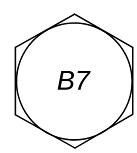
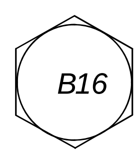
Turbine Construction		Bolt Material	Bolt Marking
A	Steel inlet/iron exhaust casings Bolts on trip and throttle valves	B7	
B	Steel casings (below 775°F) (413°C)	B7	
	All pressure-containing components	B7	
		Or	
	Steel casings (carbon moly) above 775°F (413°C)	B16	

Table B-5. Bolt Material and Markings

WARNING

NEVER REPLACE THE ORIGINALLY SUPPLIED BOLT WITH A SUBSTITUTE BOLT OF UNKNOWN OR LESSER GRADE. DO NOT MIX BOLTS during assembly. Failure to use the proper grade bolt could result in serious failure of pressure-containing components

Bolt or Nut Size (Inches)	Torque ft-lbs. (N-m)		
	Inlet temp below 775°F (413°C)		Inlet temp above 775°F (413°C)
	B-7 45,000 PSI	Bolt Grade	B-16 60,000 PSI
½	53 (72)		71 (96)
5/8	106 (144)		141 (191)
¾	188 (255)		251 (340)
7/8	303 (411)		381 (519)
1	455 (617)		606 (822)
1 1/8	667 (904)		889 (1205)
1 ¼	937 (1270)		1250 (1695)

Table B-6. Standard Bolt Torques for Turbine Bolting

The above torques are based on the thread and nut or bolt seating areas being lubricated with FEL-PRO C5-A high-temperature anti-seize compound or its equivalent.

B.9 Sealants and Joint Compounds

The following sealants and joint compounds are recommended for the joined areas specified.

WARNING

Follow the manufacturer's instructions for application of sealants and joint compounds. Insure that personnel are aware of and take precautions to avoid any hazards described by the manufacturer.

Applicable Joints and Recommended Sealants and Joint Compounds

1. All flanges and joints sealing steam at 600 PSIG (41.4 BAR) or less – Any of the following:

   Silver Seal
   Turbo R and Temp-Tite String
   Copaltite
   Hylomar
   Turboseal
   Alinco or triple boiled linseed oil
   Gortex Tape
   Tem-Flex String Kit
   Permatex #2 and #3

2. All flanges and joints sealing steam at greater than 600 PSIG (41.4 BAR):

   Turbo R and Temp-Tite String
   Copaltite and Temp-Tite

3. All flanges and joints sealing gas

   Locktite Superflex Silicone Sealant

4. Bolt and Stud Threads – Either of the following:

   Never-Seez
   Fel-Pro C-5A

5. Bearing Housing Cover to Base

   Locktite Superflex Silicone Sealant or other RTV style equivalent

B.10 Cooling Water to Bearing Housing Water Jackets

Depending on the service conditions and the type of lubrication system supplied with the turbine, bearing housings may require water cooling to maintain an acceptable bearing oil temperature. Refer to Section F, *Lubrication*, for cooling water requirements.

B.11 Steam Pressure and Temperature Limits

The steam temperature and pressure limits of Dresser-Rand turbines are limited by the materials used in construction and the design of valve bodies, casings, casing joints, seals, gaskets, and bolts.

WARNING

NEVER CONNECT the steam turbine to inlet or exhaust sources of UNKNOWN PRESSURE OR TEMPERATURE, or to sources whose pressure or temperature EXCEED limits stated on the NAMEPLATE.

Dresser-Rand turbines can be re-rated for different steam conditions, powers and speeds. Consult your Dresser-Rand manufacturer's representative or the factory for further information.

B.12 Steam Quality and Steam Purity

WARNING

THE DEGREE OF STEAM CLEANLINESS TOLERANCE ON CONTROL VALVE AND TRIP VALVE COMPONENTS IS LIMITED AND DEPOSITS MUST BE PREVENTED.

Steam quality must be dry and saturated or superheated. There must be provision to remove moisture and condensate from the steam supply system to avoid damaging the turbine. Governor valves, trip valves, trip throttle valves, etc. must be capable of closing in fractions of a second; and their movement cannot be impeded by deposits on valves, seats, stems, etc. Deposits can form rapidly - as a result of improper water treatment and/or entrainment of impurities in the steam supply.

The performance and reliability of a steam turbine can be adversely affected by the admission of contaminated steam. When contaminants enter the turbine with the steam supply, the usual result is the accumulation of deposits, which can be either inert or highly reactive, depending on the contaminants present. If the contaminants are reactive, they can cause serious damage by corrosive attack on the turbine materials.

To avoid these deposits, adequate boiler water chemistry control and other precautions are required along with the need for constant surveillance during operation and inspections. When deposits or material attack are noted during inspection, investigations into the nature and origin of the contaminants should be conducted and a program for corrective action begun.

The boiler water limits shown in Table B-5, *Recommended Limits for Boiler Water*, are recommended for Dresser-Rand steam turbines to avoid the likelihood of adverse affects from deposits and harmful ions. These limits are based on operating history and recommendations from various consultants.

Pressure at Outlet of Steam Generating Unit, PSIG	Total Solids, ppm	OH Alkalinity, ppm	Silica, ppm	Phosphate, ppm	Hardness, ppm	Chloride, ppm
0 – 150	2000	200	50	50	0	250
151- 450	1500	100	35	50	0	200
451 - 750	1000	60	25	25	0	150
750 - 900	750	55	10	25	0	50

Table B-7. Recommended Limits for Boiler Water

B.13 Turbine Rotor Data

Table B-7, Turbine Rotor Data for Standard Two-Row Wheel, provides basic turbine rotor data. If further information is required, consult the factory.

Frame Size	Rotor Weight lb (kg)	Moment Of Inertia lb-ft^2 (kg-m^2)	Shaft Torsional Stiffness lb-in / RAD (N-m / RAD)
SST 350	150 (68.0)	16.7 (0.70)	1.3 x 10^6 (1.47 x 10^5)
SST 500	220 (100.0)	47 (2.0)	5.1 x 10^6 (5.76 x 10^5)
SST 500H	230 (104.3)	47 (2.0)	4.7 x 10^6 (5.31 x 10^5)
SST 700	350 (158.8)	167 (7.0)	5.1 x 10^6 (5.76 x 10^5)
SST 700H	360 (163.3)	167 (7.0)	4.9 x 10^6 (5.53 x 10^5)

Table B-8. Turbine Rotor Data for Standard Two-Row Wheel

Notes:

1. For applications with Rateau rotors and/or non-standard shaft extensions, consult the factory.

Section C

Installation

C.1 General

WARNINGS

Throughout this manual it is assumed that the motive flow applied at the turbine inlet is high-pressure steam, therefore, the word “steam” is used in reference to various aspects of turbine installation, operation and maintenance. For some specialized applications, high-pressure gasses such as Freon, natural gas or other vapors may provide the motive flow In these cases, it can generally be assumed, that the name of the gas in use may be used to replace the word “steam.” The user of the equipment must address all hazards associated with the nature of the specific motive flow in use with the turbine. If flammable or toxic gasses are used as the motive fluid or oil vapor could be emitted the user/installer must pipe leak-offs and drains to a safe location. Explosive gas mixtures must not be used as the motive fluid.

If the turbine is operated on a motive fluid other than steam due consideration must be given to safety issues that might relate to the medium used, including but not limited to the ignition, explosion or poisoning of personnel.

The surface temperature of the turbine and piping will become that of the steam inlet temperature. This could exceed the ignition temperature of some gasses. Therefore if the turbine is installed where explosive gasses could be present it is the user's responsibility to insure that this does not create a hazardous situation.

The turbine must be properly grounded, thereby by preventing electrical shock or sparks that could cause injury or ignition of flammable gasses or liquids in the event of failure of electrical accessories, driven equipment or the creation of a static electrical charge.

WARNINGS

If the turbine is supplied with oil mist lubrication oil mist could escape from the bearing housing vents or constant level oiler. If there is the possibility that these could be ignited by equipment of processes in the proximity of the turbine they should be piped to a safe area.

Lighting must be installed in the installation area to insure that operators can see the turbine and its controls.

Do not install the turbine where ambient temperature could be –20° F or less unless this was specified in the original order and LOW TEMPERATURE materials have been provided. Refer to Section F, *Lubrication System*, for ambient temperature limits based on lubrication.

Proper installation of the turbine and driven equipment is vital for successful operation of the system. It is for this reason that competent, experienced personnel should be employed during installation. Before installing turbine refer to the certified drawings in Appendix A of this manual.

Dresser-Rand recommends that API Recommended Practice RP-686 be consulted for additional guidance in regard to the installation of the turbine and driven equipment package. It provides recommended procedures, practices and quality assurance checklists covering the installation and de-commissioning of turbines, compressors, fans, motors, gear reducers and pumps for use in petroleum, chemical, gas industry and other facilities.

The following subsections, C.2 through C.11, provide basic installation and decommissioning procedures. Follow them in the indicated sequence for complete and correct installation. These recommendations and instructions are provided to assist the purchaser and/or his contractor. Fully qualified labor, including qualified supervision, is required for proper installation, start-up, and subsequent operation of the equipment. The services of a Dresser-Rand serviceman are recommended for the final on site installation review and the initial commissioning and start-up of the turbine.

As a minimum the following steps must be carried out in sequence to achieve satisfactory operation.

WARNINGS

NEVER CONNECT the steam turbine to inlet or exhaust sources of UNKNOWN PRESSURE OR TEMPERATURE, or to sources whose pressure or temperature EXCEED limits stated on the NAMEPLATE.

Misalignment with driven equipment or overload due to driven equipment could result in excessive wear and bearing failure. This could create sparks or hot surfaces could ignite lubricant or flammable gasses.

a. Refer to the certified drawings in Appendix A and carefully read all installation notes, piping connection details, dimensions and clearances, and any other special data.

b. Provide a proper and adequate foundation for the turbine.

c. Provide a proper piping installation, in accordance with NEMA SM23, that will accommodate pressure forces and thermal growth without imposing excessive force on the turbine.

d. Remove all protective coatings and foreign matter from the turbine and all piping. If the turbine was prepared for long-term storage, reinstall the matched carbon ring sets, springs and washers into the turbine gland housings.

e. Refer to coupling alignment instructions supplied by the coupling manufacturer, as well as those supplied in this manual.

f. Perform an accurate cold alignment.

g. Grout the base-plate or sole plate to the foundation, as required.

h. Carefully check hot alignment at operating temperature and adjust it, if necessary, to establish accurate alignment.

i. Dowel turbine and driven machine in place to maintain proper alignment.

C.2 Foundation

WARNING

If the turbine is installed in a location where there is the possibility of an earthquake this must be considered in the design of the piping and foundation.

The foundation is one of the most influential factors governing overall reliability of a turbine. A foundation must maintain alignment under all normal and abnormal conditions. This includes the way a foundation is supported on the soil and/or superstructure, soil settling, soil resonances, thermal distortion, piping forces, and vacuum pull or pressure forces in expansion joints.

The turbine, gear reducer (if used), and driven equipment should all be mounted on a common foundation.

Sufficient space should be provided around and above the foundation to allow for proper installation and maintenance.

The foundation must minimize vibration by being as heavy as possible and non-resonant. It is important that the turbine be isolated from external vibration. Neither the foundation nor related support structure should be resonant within the operating range of the turbine.

Vibration transmissions may occur from the unit to the surroundings, or vice versa; vibration may also be aggravated by resonance at transmission frequencies. Piping, stairways, and ducts may also transmit vibration, which should be prevented by proper isolation.

A certified outline drawing is furnished with each Dresser-Rand turbine and is included in this manual in Appendix A. This drawing includes dimensions for locating anchor bolts, equipment weights, and general information required for determining foundation dimensions and design.

A generous safety factor should be used when determining foundation thickness. The foundation length and width should extend at least 6 inches (152 mm) beyond the anchor bolts.

Anchor bolts must be positioned accurately and provided with sleeves. The sleeve bore diameter should be approximately twice the bolt diameter, but should provide not less than 1/2” (13 mm) clearance all around the bolt.

Carefully constructed templates are required to hold bolts and sleeves in position while the foundation is cast. Templates are usually made of wood and secured to the foundation forms. Experienced workers should be able to set anchor bolts to a tolerance of 1/8” (3 mm) by locating and drilling holes in the template after they have been secured to the braced forms.

Anchor bolts should be threaded at both ends and be of sufficient length to extend one-and-a-half to twice the bolt diameter above the top of securing holes in the base plate or the sole plate. The lower end of each bolt is enclosed in a sleeve and passes through an anchor plate, where it is secured by a nut to which it is welded.

Anchor plates can be either washers or plates of cast iron or steel. They should have a diameter or side dimensions of approximately twice to two-and-a-half the outside diameter of the sleeves.

Notes:

1. Templates must be rigid enough to prevent bolts from shifting while the concrete is being poured.

2. After concrete has been poured and before it has hardened, recheck positions of the anchor bolts.

3. Allow a 1-1/2” (38 mm) gap above the top of the foundation surface for grouting under edges of the base plate or sole plates.

C.3 Piping

WARNING

Improperly designed or installed piping can lead to turbine misalignment and failure of the turbine or driven equipment. It is the user/installers responsibility to insure that the piping system is properly designed, installed and that it meets local codes and regulations. All references to piping design in this section are for reference only.

WARNING

If the turbine is installed in a location where there is the possibility of an earthquake this must be considered in the design of the piping and foundation.

Proper piping of a steam turbine is essential. Correctly designed and installed piping contributes to safe, trouble-free operation and can improve ease of turbine operation and maintenance.

Before installing any piping, installation personnel should read and become thoroughly familiar with this section.

The effects of possible earthquakes should be taken into account when designing the inlet and exhaust piping systems.

C.3.1 Piping Forces

Any pipe connected to the steam turbine casing, valves, gland housing, or bearing housings can exert forces and/or moments on the turbine. This can misalign the turbine with its driven equipment or distort the turbine casing, resulting in internal misalignment of the turbine shaft with bearings, seals, and other components. Such misalignment can cause vibration, premature wear or failure of bearings, seals, couplings and shafts, and casing leaks.

Steam supply (inlet) and exhaust piping, being relatively large and subjected to higher temperatures and pressures, can, if improperly installed, exert relatively large forces and moments on a steam turbine. Leak-off, drain, lube, cooling water and gland seal piping does not normally transmit significant piping forces.

To prevent excessive piping forces or moments, the customer must ensure that the piping is designed and installed so as to comply with NEMA SM-23, Section 8, *Allowable Forces and Moments on Steam Turbines*. The maximum allowable forces and moments are a function of inlet and exhaust flange sizes. Flange sizes are tabulated on the Certified Drawing appearing in Appendix A.

Piping forces can be reduced or eliminated with proper piping design, the use of expansion joints, and correct piping support systems. Figure C-1, *Suggested Steam Inlet and Exhaust Piping Arrangement*, suggests inlet and exhaust piping systems, showing typical expansion joints, piping loops, and spring supports in the piping system.

Optional constructions, which include third-party throttle and/or over-speed trip valves or other equipment configurations, may require the use of additional supports. Refer to the certified drawings in the *Appendix A.*

Refer to a separate sketch in Appendix A for the estimated thermal movement of the inlet flange and exhaust flange. The estimated thermal movements of the inlet and exhaust flanges are used in the design and analysis of the piping support system.

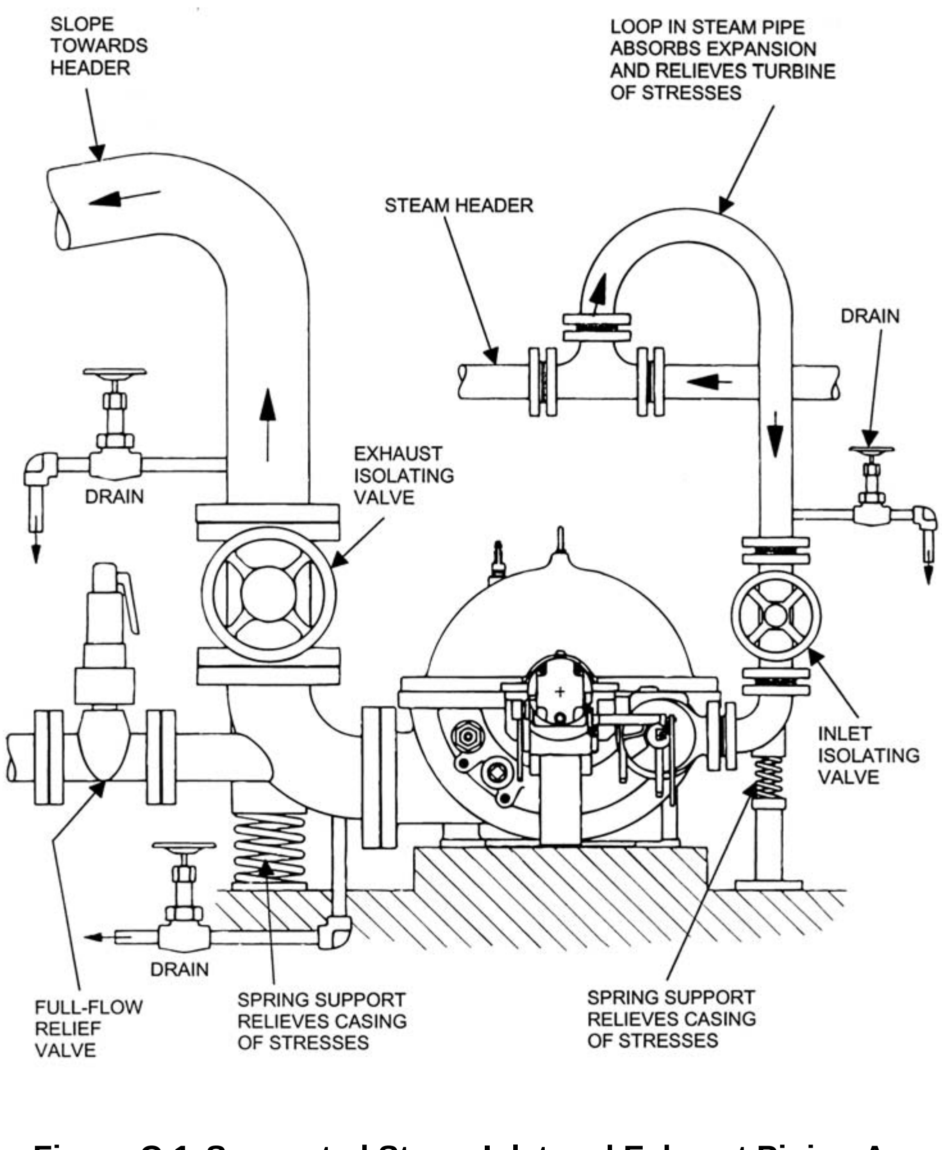


Figure C-1. Suggested Steam Inlet and Exhaust Piping Arrangement

C.3.2 Isolating Valves

Inlet and exhaust lines to a turbine must be provided with isolating valves. The purpose of these valves is to isolate the turbine from inlet and exhaust systems, allowing the turbine to be shut down, along with sealing inlet and exhaust lines if the turbine is to be moved or serviced.

DANGER

NEVER DISCONNECT inlet or exhaust piping of the turbine without first CLOSING and TAGGING the ISOLATING VALVES and then OPENING DRAIN VALVES SLOWLY to relieve any pressure within the turbine. Failure to do so may expose PERSONNEL to SERIOUS INJURY if steam was to be introduced into the piping or captured in the turbine. As an added precaution, always install blank flanges on inlet and exhaust lines after removing the turbine.

The inlet piping isolating valve should be installed immediately upstream of the turbine. Refer to Figure C-1, *Suggested Steam Inlet and Exhaust Piping Arrangement*.

The exhaust piping isolating valve should be installed immediately downstream of the full flow relief valve. Refer to Figure C-1, *Suggested Steam Inlet and Exhaust Piping Arrangement*.

C.3.3 Full Flow Relief Valve

An atmospheric relief valve must be installed between the turbine exhaust flange and the first exhaust line shut-off valve (Refer to Figure C-1, *Suggested Steam Inlet and Exhaust Piping Arrangement*). The purpose of this relief valve is to protect the turbine casing from excessive exhaust pressure. The relief valve must be of ample size to pass the maximum quantity of steam flowing through the turbine at the maximum inlet temperature and pressure steam conditions without allowing the turbine casing pressure to exceed the limit defined below. It is the user’s responsibility to install the relief valve in the piping.

The full flow relief valve shall begin to open at 10% or 10 PSIG (69 kPag) above maximum exhaust pressure, whichever is greater, for non-condensing turbines; and at not more than 10 PSIG (60 kPag) for condensing turbines. The valve shall be fully open with an additional rise in pressure not to exceed 10%. Refer to NEMA-23, *Steam Turbines for Mechanical Drive Service*, for further details.

WARNINGS

It is the USER'S RESPONSIBILITY to INSTALL A FULL-FLOW RELIEF VALVE in the exhaust line between the turbine exhaust casing and the first shut-off valve. This relief valve should be sized to relieve the FULL AMOUNT OF STEAM THAT THE TURBINE WILL PASS, in the event that the exhaust line is blocked.

The optional SENTINEL WARNING VALVE, located on the turbine casing, DOES NOT SERVE as a RELIEF VALVE. The sentinel warning valve WILL NOT PASS SUFFICIENT STEAM FLOW to relieve the turbine casing of EXCESSIVE EXHAUST PRESSURE. The purpose of the sentinel warning valve is to warn visually and audibly that excessive pressure is building in the turbine exhaust casing.

C.3.4 Inlet Piping

As shown in Figure C-1, *Suggested Steam Inlet and Exhaust Piping Arrangement*, inlet piping should come off the top of the steam header and form an expansion relieving loop or other strain relieving device, before coming down to the turbine. A valved condensate drain should be installed in the inlet line upstream of the isolating valve, allowing condensate to drain prior to opening the isolating valve and feeding steam to the turbine. Piping must be supported in such a manner as to allow thermal growth of the turbine and piping, without imposing excessive forces and moments on the inlet flange. Properly installed piping should mate squarely to the turbine inlet flange, without any need to force flanges by twisting them into alignment when connecting them.

The inlet line should be well lagged to prevent heat loss and to avoid burns.

Pipe sizes should be large enough to maintain rated steam pressure at the turbine inlet flange under maximum load conditions. In determining pipe size, proper allowance should be made for pressure drop due to long sections of pipe, elbows, valves, or other fittings between the boiler and the turbine.

If wet or saturated steam is used, it is very important that piping be arranged so that condensate cannot be carried over into the turbine. A steam separator of the proper size, with a trap of ample capacity, should be installed before the turbine inlet. All horizontal runs must be sloped up in the direction of steam flow, with drains at the low points.

The importance of protecting the turbine against slugs of water cannot be overemphasized. The issue is not "wetness" of the steam, but with condensate, which is separated out as water. The harmful effects of water are:

1. Rapid erosion of blading and valves.

2. In the case of turbine wheels with inserted blades, water may have a hammer-blow effect, tearing out the blades and destroying the rotor.

3. Governing is adversely affected.

4. The rotor may be permanently distorted and/or the turbine may be seriously damaged.

5. A danger of thrust bearing failure and consequent destruction of the turbine.

C.3.5 Exhaust Piping

Figure C-1, *Suggested Steam Inlet and Exhaust Piping Arrangement*, shows exhaust piping together with the full flow relief valve and support system. Note that the exhaust line should slope down toward the header or create an overhead loop, to prevent condensate at the header from flowing back toward the turbine. Valved drains should be installed before and after the exhaust-isolating valve.

On each installation, the length of run, elbows, valves, and other fittings in the pipe must be considered, together with all factors, which may cause back-pressure on non-condensing turbines or reduced vacuum on condensing turbines, and a final decision on piping size made accordingly. On non-condensing turbines, back-pressure which is higher than what the turbine was designed for will cause reduction of power and an increase in steam consumption. It may also cause gland leakage, and in extreme cases, can rupture the turbine casing. On condensing turbines, decreased vacuum will have an even greater effect on capacity and economy.

The exhaust pipe must be installed and anchored so that no excessive stress is placed on the turbine from either the weight of the pipe or its expansion and contraction. In cases where such an arrangement cannot be made with certainty, an expansion joint near the turbine can be useful in low pressure lines and is usually required on large pipe sizes. *The use of an expansion joint does not of itself avoid undue stress. It is not as flexible as many people assume and when installed, it must be properly aligned and not indiscriminately exposed to shear or torsion*. In the majority of applications, *axial thrust created on the cross-sectional area* of the largest bellows, by internal pressure, must be restricted by the use of tie rods. They are most effective when the expansion joint is used in shear, instead of tension or compression. When used in either a vacuum or a pressure line, tie rods must be arranged accordingly. They are useless where a joint moves under tension or compression, as they bypass the joint and transmit pipe forces directly to the turbine. Provision must be made to anchor the piping in such a way that excessive forces will not be transmitted to the turbine during shutdown and operational running. Connection to a header must be made at the top, never from the bottom or side, and great care must be taken to avoid draining water back into the turbine. All horizontal runs must be sloped away from the turbine exhaust connection.

Properly installed piping should mate squarely to the turbine exhaust flange, without any need to force flanges by twisting them into alignment when connecting them. The exhaust line should be well lagged to prevent heat loss and avoid burns.

C.3.6 Piping Blow Down

Newly constructed steam piping should be blown-down to remove scale, weld slag and any other foreign material. Such material can cause severe damage if it enters the steam turbine.

After inlet piping has been installed, but before connecting it to the turbine, steam should be blown through the line and into the exhaust line to remove welding slag and debris.

Refer to NEMA SM-23, *Steam Turbines for Mechanical Drive Service* or a reliable piping contractor for a blow-down procedure.

CAUTION

INLET STEAM LINES MUST BE BLOWN DOWN PRIOR TO CONNECTING them to the turbine. Debris and welding slag can cause serious damage to valves, nozzles, and turbine blading if allowed to enter the turbine.

C.3.7 Steam Strainer

Standard SST Dresser-Rand turbines are provided with integral inlet steam strainers to prevent entry of foreign material into the turbine. Part of the throttle valve is located in the same chamber with the steam strainer. The steam strainer will allow small debris particles to pass through the turbine and does not preclude the need for inlet piping blow-down prior to connecting the turbine. The steam strainer should be removed and cleaned at least once a year and replaced at least every three years or as needed.

When a turbine is supplied without an integral or separate y-type strainer, the purchaser must install an appropriate steam strainer in the inlet steam piping.

C.3.8 Check Valve

Where a turbine exhausts or bleeds steam into another system, and a check valve (commonly referred to as a non-return valve) is installed for prevention of reverse flow to the turbine, adequate bracing must be installed to absorb any forces created by water hammer effects occurring in the exhaust line downstream and acting on the check valve. The maximum relief valve settings are found on the turbine data sheets. The sentinel relief valve on the turbine case is a warning valve only.

C.3.9 Expansion Joints

Low pressure and vacuum lines are usually large and relatively stiff. It is common practice to use an expansion joint in these lines to provide flexibility. If an expansion joint is improperly used, it may cause a pipe reaction greater than the one that it is supposed to eliminate. An expansion joint will cause an axial thrust equal to the area of the largest corrugation multiplied by the internal pressure. The force necessary to compress or elongate an expansion joint can be quite large, and either of these forces may be greater than the limits for the exhaust flange. In order to have the lowest reaction; it is best to avoid absorbing pipeline expansion by axial compression or elongation. If it is found that expansion joints are required, it is essential that they be properly located and their foundation rigid. Refer to NEMA SM-23, *Steam Turbines for Mechanical Drive Service* or a reliable piping contractor for steam piping system design and installation guidance.

See Figure C-2 *Unrestrained Expansion Joint (not recommended).*

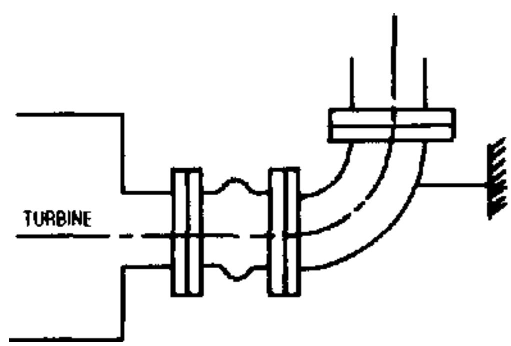


Figure C-2. Unrestrained Expansion Joint (Not Recommended)

The axial thrust from the expansion joint tends to separate the turbine and the elbow. To prevent this, the elbow must have an anchor to keep it from moving. The turbine must also absorb this thrust, and in so doing, it becomes an anchor. This force on the turbine case may be greater than the allowable force. In general, this method should be discouraged.

Figure C-*3 Expansion Joint with Tie Rods (Acceptable)* below shows the same piping arrangement as in the previous figure, except for the addition of tie rods on the expansion joint.

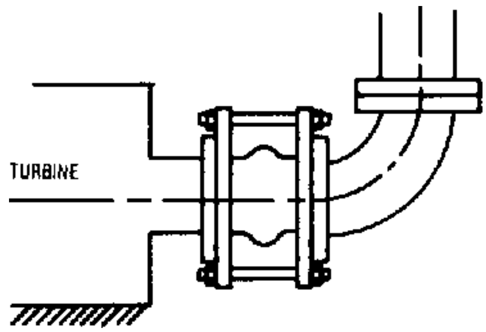


Figure C-3. Expansion Joint with Tie Rods (Acceptable)

The tie rods limit elongation of the joint and take the axial thrust created by the internal pressure so it is not transmitted to the turbine flange. The tie rods eliminate any axial flexibility, but the joint is still flexible in shear, meaning that the flanges may move in parallel planes. The location of this type of joint in the piping should be such that movement of the pipe puts the expansion joint in shear instead of tension or compression.

Figure C-4 *Expansion Joint with Tie Rods for Non-condensing Operation (Preferred)* below is an arrangement frequently used, with tie rods as indicated.

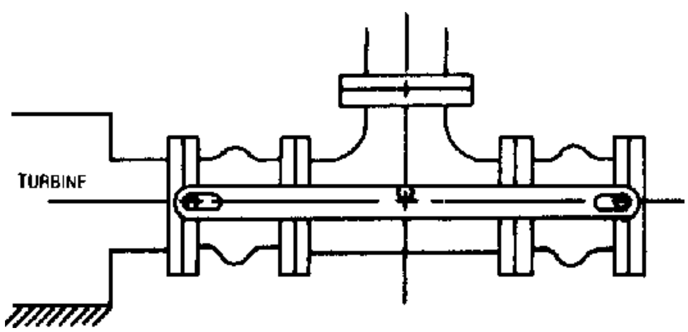


Figure C-4. Expansion Joint w/ Tie Rods Non-Condensing Operation (Preferred)

This arrangement will prevent any thrust, due to internal pressure, from being transmitted to the exhaust flange. It retains the axial flexibility of the joint and may be used for either vacuum or pressure service.

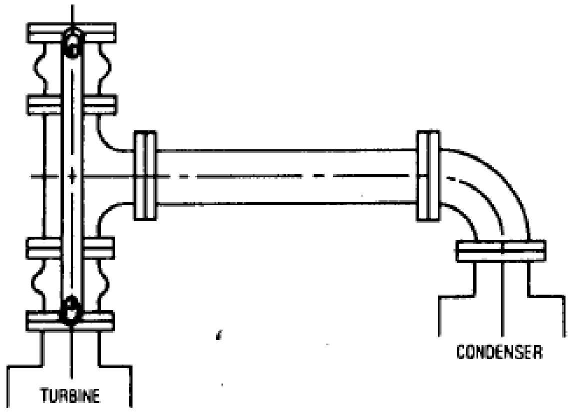


Figure C-5. Expansion Joint w/ Tie Rods Condensing Operation (Preferred)

Figure C-5 shows a suggested arrangement for a condensing turbine with an up exhaust. This arrangement is recommended and frequently used. Due to the large exhaust pipe size normally encountered on condensing turbines, the exhaust piping will be relatively stiff and an expansion joint must be used at some point to take care of thermal expansion. An unrestricted expansion joint placed at the exhaust flange of the turbine will exert an upward or lifting force on the turbine flange, which in many cases is excessive. Figure C-5 provides the necessary flexibility to take care of thermal expansion without imposing a lifting force on the turbine. The expansion joint is in shear, which is the preferred use. The relatively small vertical expansion will compress one joint and elongate the other, which causes a small reaction only and will be well within the turbine flange limits.

On smaller and high-pressure exhaust lines it is frequently better to rely on the flexibility of the piping than on an expansion joint. Only after a careful analysis of the piping shows the need for an expansion joint should they be used.

In order to have flexibility in piping, short direct runs must be avoided. By arranging the piping in more than one plane, torsional flexibility may *be* effectively used to decrease the forces.

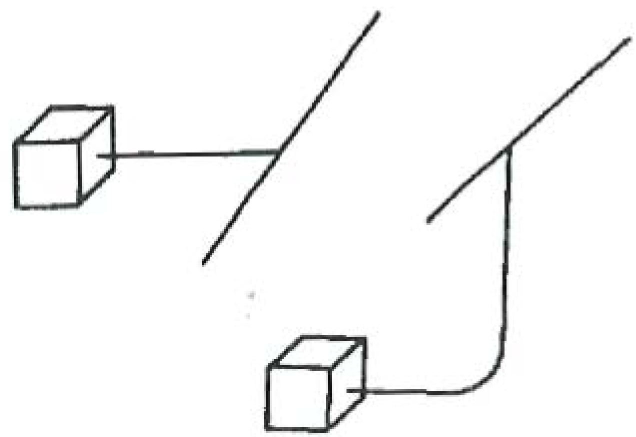


Figure C-6. Short Runs to Exhaust Header

Figure C-6 shows a short direct run to an exhaust header. If the header is free to float in a horizontal plane, thermal expansion of the exhaust line will put very little direct thrust on the exhaust flange. If the header is fixed, the thermal expansion will tend to cause either the turbine or header to move and may cause damage. If thermal expansion causes the *header* to move in an axial direction it will transmit a force and moment to the exhaust flange. Figure C-6 is not recommended, as it is difficult to prevent excessive forces from being transmitted to the exhaust flange.

C.3.10 Leak-Off Piping

WARNINGS

Leak-off and drain connections of turbines operated on flammable or noxious gas must be piped to a safe location to avoid the possibility of ignition of the gas or poisoning of operating personnel.

LEAK-OFF AND DRAIN LINES MUST NOT BE INTERCONNECTED. A leak-off from a high pressure upstream location connected to a steam chest drain or throttle valve leak-off/drain could supply sufficient steam TO ALLOW THE TRIPPED TURBINE TO CONTINUE RUNNING, since such an interconnection would bypass the overspeed trip valve.

LEAK-OFF PIPES that are left UNCONNECTED will allow the escape of HIGH TEMPERTURE STEAM that could cause PERSONAL INJURY or contamination of lubricating oil.

Standard SST Dresser-Rand turbines are supplied with leak-off connections at the gland housings, throttle valve, and overspeed trip valve. Leak-offs are piping connections that allow steam leaking past seals to be carried away to a safe area. Shaft and valve stem seals depend on some leakage for lubrication and to minimize wear. Leakage is therefore acceptable and necessary.

The leak-offs must be pitched down and away from the turbine and connected to open, unrestricted, separate, non-manifolded drain lines, which discharge to a safe and visible area. There should not be any valves on leak-off lines. Leak-off piping should be arranged to insure that no pressure build-up occurs in the system, avoiding any low points where condensate could accumulate and may be connected to a gland condenser, eductor or ejector. No vertical upward pipe runs are to be included in leak-off piping. Unavoidable low points should be trapped.

On gas operated turbines, leak-offs must be piped to a safe area away from the turbine site.

Locations and sizes of leak-off connections are shown on the certified drawing in Appendix A.

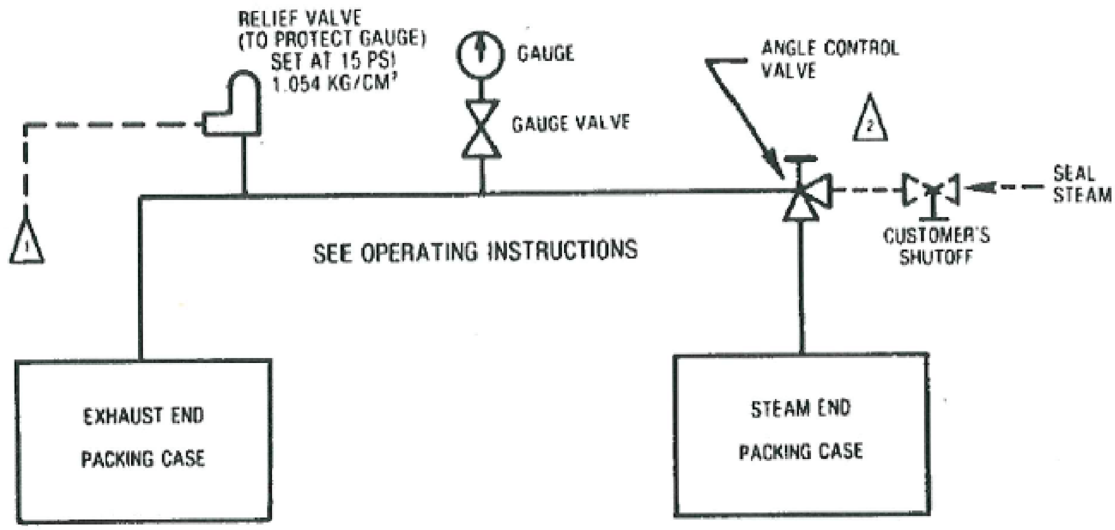
Gland housings on turbines operating with vacuum exhaust or at high back pressure require special Gland Seal leak-off systems.

For turbines operating with vacuum exhaust refer to Section C.3.11 Gland Seal Leak-Off Piping-Vacuum Exhaust

Turbines operating with high back pressure may have intermediate leak-off connections on their gland housings. Refer to Section C.3.12 Gland Seal Intermediate Leak-Off Piping – High Back pressure Exhaust.

C.3.11 Gland Seal Leak-Off Piping – Vacuum Exhaust

On turbines exhausting to a vacuum, sealing steam at 5 to 10 PSIG (34 to 69 kPag) pressures must be furnished through the carbon ring glands to prevent air from entering the exhaust casing.



1. PIPE TO AN AREA WHERE POSSIBLE HIGH PRESSURE STEAM WILL CAUSE NO DANGER TO PERSONNEL.
2. CUSTOMER'S CONNECTION — SEE CHART BELOW.
3. TURBINE FRAME DESIGNATION — SEE TURBINE DATA SHEETS, STEAM END MATERIAL DETERMINED BY LAST DIGIT OF FRAME NUMBER. 1 (CAST IRON), 2 and 3 (CAST STEEL). EXAMPLE: 351, 502, 703.

Figure C-7. Typical Gland Sealing System without Gland Condenser

If gland seal piping is not furnished with the turbine, sealing steam connections should be piped via a common connection to the user's steam supply. A recommended piping diagram for gland seal piping is shown in Figure C-6 Gland Seal Leak-Off Piping – Vacuum Exhaust.

Frame Composition	Relief Valve	Gauge	Gauge Valve	Angle Control Valve	Customer's Connection
All Sizes	Kunkle Cat. Fig. No. 40R Stainless Steel	Ashcroft No. 1009 KGSC Range 30" to 30 lbs. 760 mm to 2.109 Kg/Cm2	Vogt No 9871	Vogt No. 1971 3/8" 600 lbs. Steel 9.52 mm 272 Kg.	1/2" pipe 12.7 mm Max. Press. 600 lbs. 750°F 42.18 Kg/Cm2 399°C

Table C-1. Gland Intermediate Leak-Off Piping—High Back Pressure Exhaust

Turbines to be operated with high back pressure may have intermediate gland leak-offs that must be piped to a steam header with a pressure not less than 35 PSIG (241 kPag) and not exceeding 70 PSIG (483 kPag). This intermediate leak-off piping must include, for start up purposes, an atmospheric vent with a shut off valve near the turbine and a check valve installed between the vent and the steam header to prevent back-flow. Do not connect the intermediate leak-off piping with other leak-off connections. Refer to Figure C-8 *Gland Seal Int. Leak-Off Piping High Back Pressure Exhaust*.

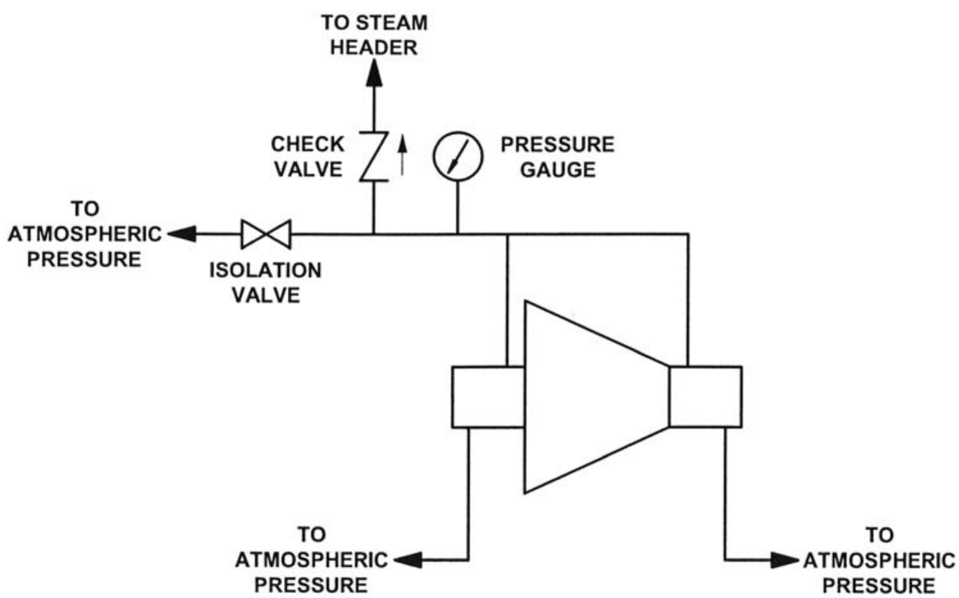


Figure C-8. Gland Seal Intermediate Leak-Off Piping-High Back Pressure Exhaust

C.3.12 Gland Seal Intermediate Leak-Off Piping—High Back Pressure Exhaust

In certain turbines with a high exhaust back pressure, a gland leak-off system is used. Figure 8 shows a typical system using gland ejectors connected to the leak-off piping of both packing cases. The ejectors maintain a constant vacuum in the gland packing case leak-off lines. When the ejectors are shipped separate from the turbine, the piping leak-off connections from the turbine are shown on the outline drawing, Appendix A. If gland ejectors are required for your turbine, the specific part number is listed on the Appendix A contents sheet. On certain designs, a drip drain connection is located adjacent to gland leak-off on each packing case. These drain connections must be plugged.

For leak-off systems that use a gland condenser, a system schematic diagram with operating instructions is included in Appendix A, along with a description of the major components that comprise the system.

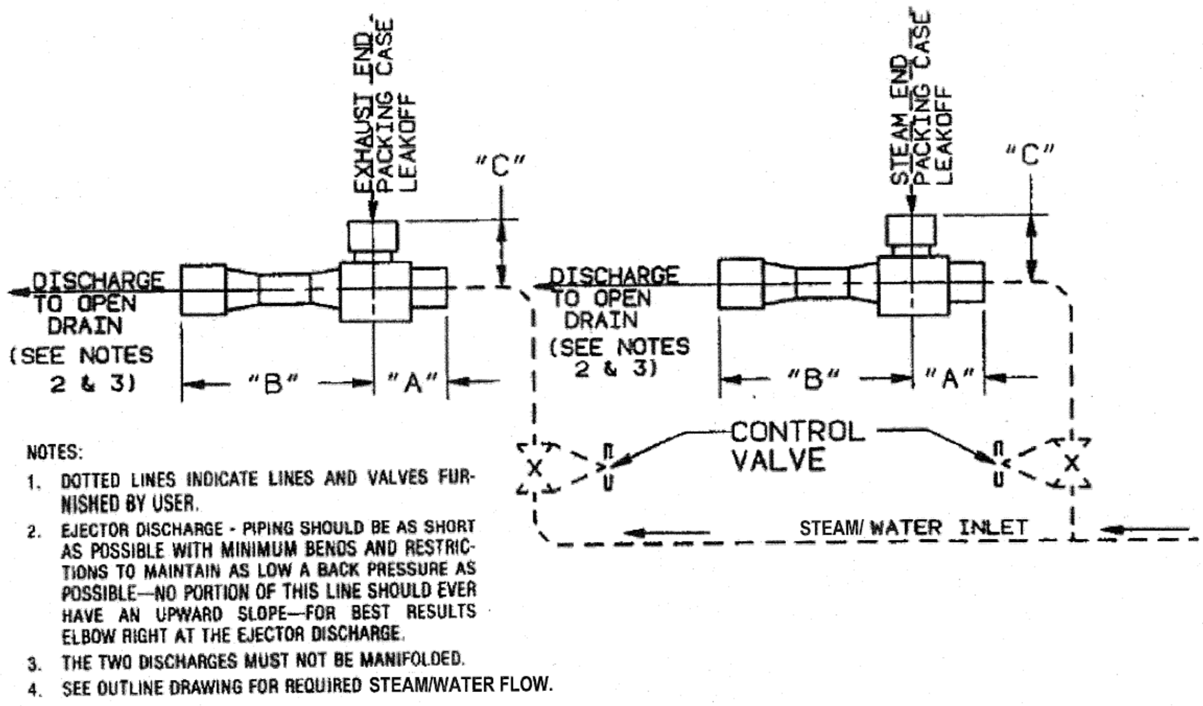


Figure C-9. Gland Leakage Ejector System

C.3.13 Drain Piping

WARNING

DRAIN PIPING flanges and valves must be SELECTED AND INSTALLED BY EXPERIENCED PERSONNEL, taking into account the MAXIMUM OPERATING STEAM PRESSURE AND TEMPERATURE. Improperly designed or installed drain systems could FREEZE, become PLUGGED AND RUPTURE, causing serious personal injury or equipment damage.

Leak-off and drain connections of turbines operated on flammable or noxious gas must be piped to a safe location to avoid the possibility of ignition of the gas or poisoning of operating personnel.

LEAK-OFF AND DRAIN LINES MUST NOT BE INTERCONNECTED. A leak-off from a high pressure upstream location connected to a steam chest drain or throttle valve leak-off/drain could supply sufficient steam TO ALLOW THE TRIPPED TURBINE TO CONTINUE RUNNING, since such an interconnection would bypass the over-speed trip valve.

Drains are low-point piping connections at valves and casings that allow release of condensed water. Drains are opened before starting the turbine, to allow any accumulated water to escape. They are left open during the start-up cycle to allow water condensing in the cold casings to exit. Once the turbine reaches normal operating temperature, drains should be closed.

The user must install drain valves when not supplied by Dresser-Rand.

Drains can be automated with properly sized steam traps, if desired. Refer to C-10 Suggested Steam Inlet, Exhaust and Drain Piping, Manual Start and Figure C-11 Suggested Inlet, Exhaust and Drain Piping, – Auto Start.

Sizes and locations of drains are shown on the certified drawing in the Supplemental Documentation section, supplied at the end of this manual.

C.3.14 Water Cooling Piping to Bearing Housing Water Jackets

Depending on service conditions and the type of lubrication system supplied with the turbine, bearing housings may require water cooling to maintain an acceptable bearing oil temperature.

Refer to Section F, Lubrication, for cooling water application requirements, suggested piping, water flow, pressure and temperature requirements, and oil sump temperature.

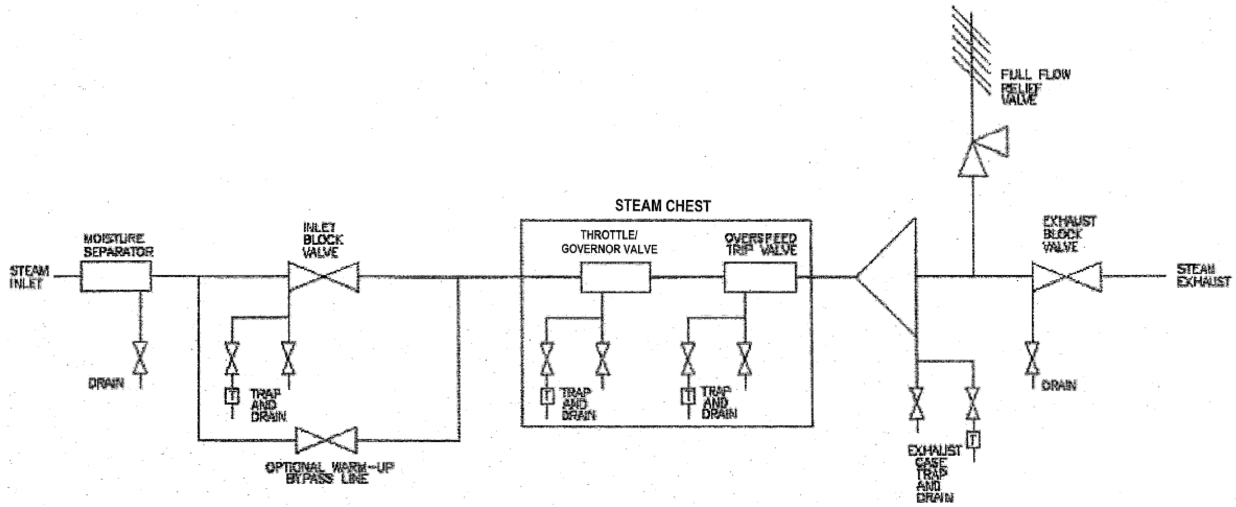


Figure C-10. Suggested Steam Inlet, Exhaust and Drain Piping, Manual Start

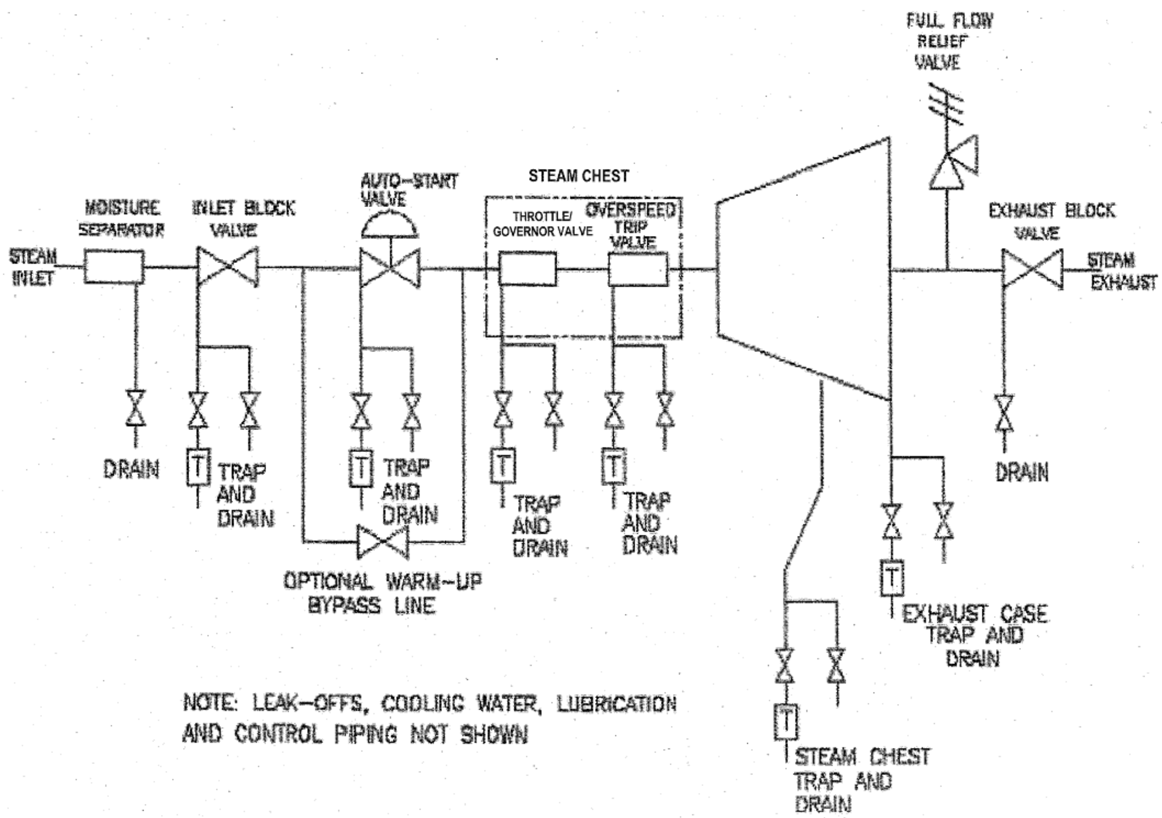


Figure C-11. Suggested Steam Inlet, Exhaust and Drain Piping, Auto-Start

C.4 Alignment Requirements

Many problems experienced with turbines, gears, and driven equipment is due to misalignment. Units must be properly supported and their alignment accurately and permanently established if the installation is to be successful.

WARNING

Misalignment with driven equipment or overload due to driven equipment could result in excessive wear and bearing failure. This could create sparks or hot surfaces could ignite lubricant or flammable gasses.

CAUTIONS

ALIGNMENTS performed by the factory on turbines with gears or other driven equipment mounted on base plates MAY SHIFT during rigging or shipment. These alignments must be RECHECKED before startup.

Never put a steam turbine into service without first carefully ALIGNING it to the driven equipment under cold conditions and then again at operating temperature. Failure to do so may result in premature FAILURE of both TURBINE and DRIVEN EQUIPMENT components.

Excessive vibration, bearing edge loading, and high shaft loads can result from incorrect alignment. Factors affecting alignment can be settling of the foundation, growth in shaft heights due to temperature changes, machine movement of either unit with respect to the foundation due to vibration, worn bearings, or distortion of the casing due to loads from connecting structures (such as piping). A dependable turbine drive system requires that all of these factors be given proper attention prior to and during alignment.

The turbine and driven equipment should always be aligned cold, checked later at operating temperature, and re-aligned if necessary. Both shafts should be parallel and their axes concentric so that there is no offset at operating temperature.

Two types of misalignment must be identified and corrected (if necessary) to be within defined limits.

Angular misalignment occurs when shaft centerlines intersect at an angle.

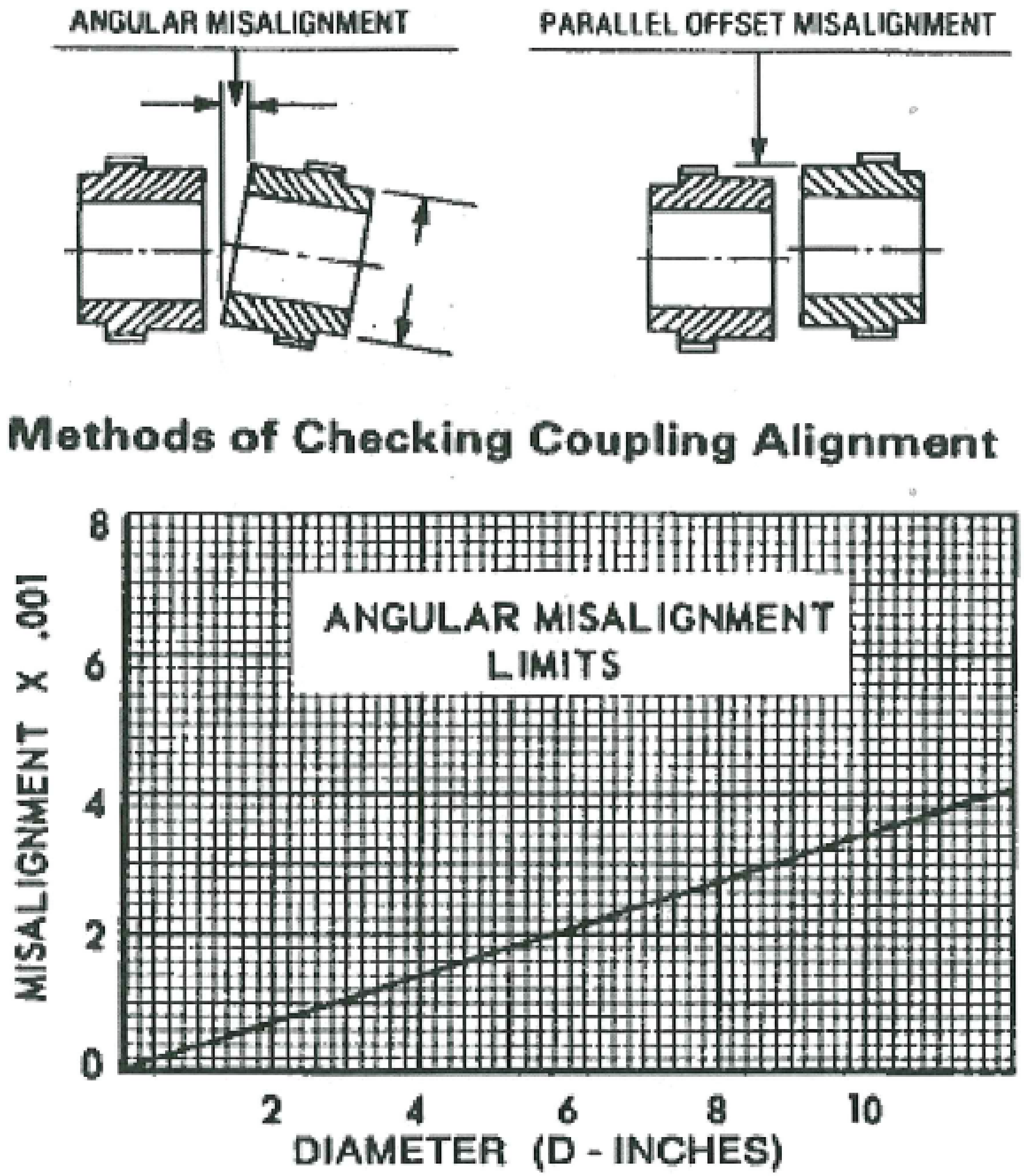


Figure C-12 Coupling Misalignment Limits

Parallel misalignment occurs when shaft centerlines are parallel to each other, but do not intersect.

As previously noted, alignment is influenced by the thermal growth of both the turbine and the driven equipment. This must be compensated for during cold alignment by calculating the growth of each machine and intentionally creating a parallel offset that will disappear when the equipment is hot.

C.5 Couplings

WARNING

A coupling guard must be installed at the coupling between the turbine and driven equipment.

When the coupling guard is to be installed, refer to the coupling guard manufacturer's instructions to insure that it does not contact the running shaft or coupling which could cause a spark that could ignite hazardous gasses in the environment in which the turbine is installed.

CAUTION

Coupling weights should not exceed the allowable limits on the coupling drawing without approval from Dresser-Rand. A heavier than allowed coupling could create a lower critical speed, which could cause excessive vibration within the operating range of the turbine.

A flexible coupling is required to connect the turbine to the driven machine. Couplings should be selected based on power, speed, and characteristics of the driven machine, using selection and balancing guidelines established by the coupling manufacturer.

Correct installation of the coupling hubs is vital to proper operation of the turbine and driven unit; great care must be exercised in assembling hubs onto shafts. Before mounting a coupling, check the coupling bore and shaft diameter with a micrometer to determine that the interference fit is as specified by the coupling manufacturer. Also, inspect the key and keyways, making sure that the key is a drive fit into the shaft keyway and a push fit into the coupling hub keyway. The key should also sit positively on the bottom of the shaft keyway, with clearance on the top of the key to allow expansion within the hub keyway.

If the shaft key extends beyond the back of the coupling hub, the key should fill the entire keyway. The exposed portion of the key must be removed so that it is flush with the coupling back face and must be profiled flush to the circumference of the shaft so that only the keyway in the shaft is filled, maintaining shaft balance. When installing coupling hubs on shafts, it is important to heat them uniformly, taking great care to avoid overheating. A recommended method is to use an oil bath with a temperature control or an induction heater.

When fitting the coupling onto the shaft, it is helpful to have a chamfer on the sides and top of the key, making alignment easy with the hub keyway. Also, a temporary block should be used, to prevent the hub from sliding too far onto the shaft.

Do not use hammers to drive coupling hubs onto the shaft, as this would damage the coupling, shaft, or bearings. As coupling hubs are frequently used for reference in alignment, runout or eccentricity of hubs, which may be caused by damage to the shaft, hubs, or badly fitted keys, must be avoided.

CAUTION

DO NOT drive the coupling on or off the shaft with a HAMMER. The force of the hammer will damage the rotor locating bearing, resulting in internal turbine damage.

NOTE

Axial clearance between the coupling hubs and shaft end faces should be in accordance with recommendations of the coupling manufacturer, when shafts are in their normal running condition.

Lubricate the coupling as required, by following the coupling manufacturer’s instructions.

C.6 Preparation for Alignment

Use the following procedure:

a. Clean turbine mating support surfaces and mount turbine on the foundation.

b. Do not connect the turbine to inlet and exhaust piping.

c. Disconnect the coupling by removing the coupling spacer (if provided) and pulling coupling sleeves away from the hub.

d. Insert suitable shim packs between supporting surfaces of the turbine and/or driven equipment and their respective mounting surfaces. It is important to insert sufficient shims under the equipment so that shims can be removed to lower either piece of equipment if required during hot final alignment. A minimum of 1/16 inch (1.6 mm) is recommended.

e. Level and square the turbine with respect to the driven equipment.

f. Check for base distortion and improper shimming by placing dial indicators in vertical and horizontal planes on the driven equipment, with the indicators detecting turbine shaft movement. Each turbine foot anchor bolt should then be loosened and tightened, while observing the dial indicator reading. Readings should not exceed 0.003 in. (0.075 mm); if they are exceeded, the cause must be determined. Repeat this procedure for driven equipment.

g. Check that all anchor bolts (i.e., turbine, driven equipment and supports) are tightened.

h. Check coupling hub face runout using the following procedure:

    1. Install dial indicator (refer to Figure C-13, *Alignment Using Dial Indicators*) to read a point nearest to the outside circumference on the face of one hub.

    2. Rotate the shaft and hub on which the dial indicator is touching and record the maximum and minimum indicator readings. Axial runout is the difference between the two readings.

    3. Re-position the dial indicator to read on the external outside diameter of the same hub as in step 1 and measure coupling hub diametral runout, as shown in Figure C-13, *Alignment Using Dial Indicators*.

    4. Rotate hub and record the maximum and minimum indicator readings. Lateral runout is 1/2 of the difference between the two readings.

    5. Repeat steps 1 through 4 for the other coupling hub.

6. Any runout exceeding 0.0015 inch (0.038 mm) should be corrected by reinstallation of the hub and keys or their replacement.

7. Hub runout values should be subtracted from the desired alignment setting.

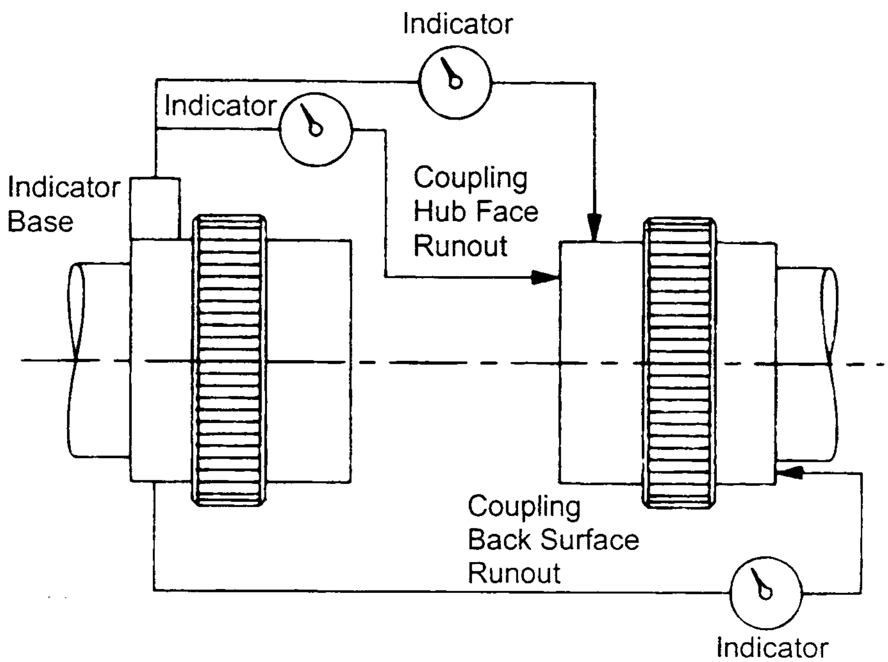


Figure C-13. Alignment Using Dial Indicators

C.7 Compensation for Thermal Movement

During initial alignment, allowances must be made for thermal expansion of the turbine and driven equipment. The shaft centerline of each unit will rise when they reach operating temperature. Therefore, the difference between the two anticipated growths must be incorporated into the cold alignments so that the shafts will come into alignment when operating temperature is attained.

CAUTION

Thermal movement varies significantly with inlet temperature, load, ambient conditions and time. Final hot alignment of the turbine to the driven equipment must be based on actual measured shaft rise under steady state conditions (after at least a two hour run time).

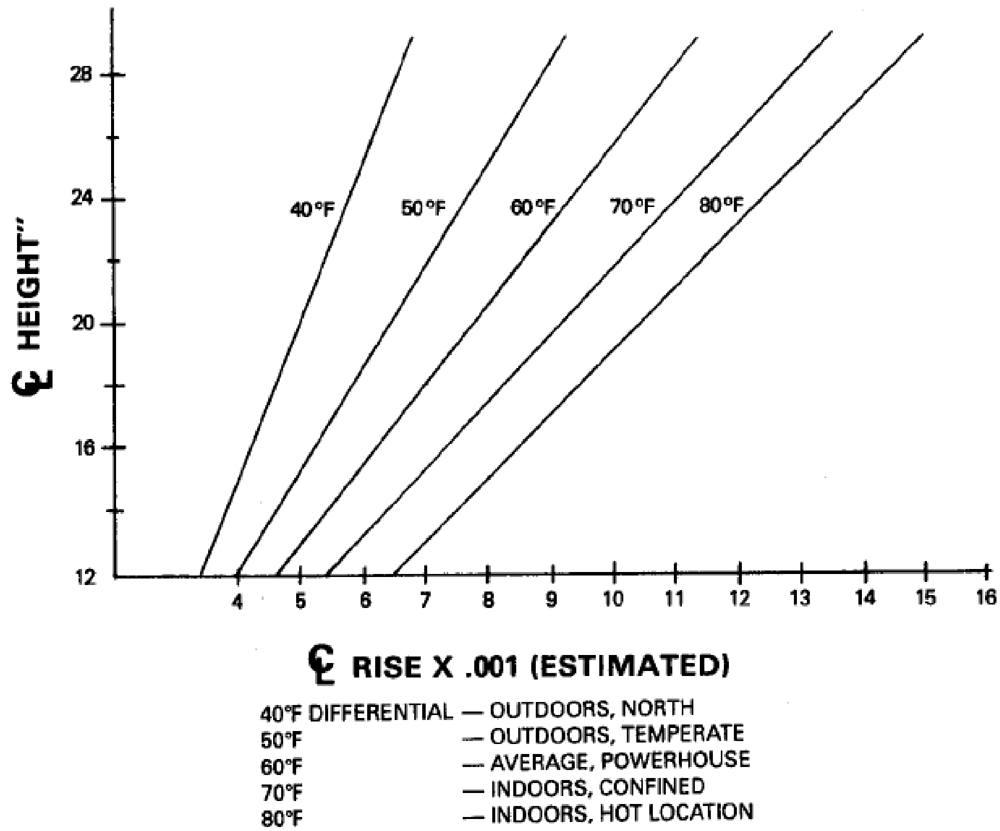


Figure C-14. Centerline Height VS Centerline Rise per Ambient Temperatures

On steam turbines, steam temperatures and insulation of the turbine case, proximity of packing leak-off lines to the supports and type of lagging enclosure affect the support temperatures. The average support temperatures may vary from 130F to 160 F (approximate oil drain temperatures). Judgment will have to be exercised in estimating the support temperature for the initial cold alignment. The curves in figure C-14 may be useful for checking and also for telling the effect of an error in the estimate of support temperature. Refer to the certified drawings in Appendix A for the estimated thermal movement of the turbine shaft extension.

Thermal growth of the driven equipment, or its temperature change, must be obtained from the driven equipment manufacturer.

The unit with the greater thermal growth must be set lower than the other unit, by the difference between their thermal growths. Normally, the turbine has the greater thermal growth.

CAUTION

The initial alignment established with this estimated thermal growth is only approximate. An actual hot alignment must be performed prior to putting the turbine into service.

C.8 Cold Alignment Check

Cold alignment must be completed at ambient temperature (turbine and driven machine in cold condition) and in the proper sequence, with angular misalignment corrected first, followed by correction of parallel misalignment.

C.8.1 Angular Alignment

Use the following procedure:

a. Clamp a dial indicator to one coupling hub and place the finger (contact point) against the finished face of the other hub, as shown in Figure C-13, *Alignment Using Dial Indicators*.

b. Scribe a reference mark on the coupling hub at the point where the finger touches the hub face.

c. Rotate both shafts simultaneously (in the direction they were designed to operate), keeping the finger against the reference mark on the coupling hub. Note the dial indicator reading at each one-quarter revolution.

d. Angular misalignment of the shafts must not exceed the coupling manufacturer's recommendations or a total indicator reading of 0.001 inch (0.025 mm) for each radial inch of the coupling hub.

e. When the distance between coupling hubs does not permit the use of dial indicators, angular misalignment can be established using one of the two following methods:

1. Use feeler gauges to determine the gap between coupling faces at four locations, 90° apart. Adjust the turbine or driven equipment to obtain equal clearance within 0.001 inch (0.025 mm) between coupling faces at each 90° location.

2. Use a dial indicator mounted on a flexible arm to measure run-out on the back surface of the coupling hub, as shown in Figure C-13, *Alignment Using Dial Indicators*.

C.8.2 Parallel Alignment

Use the following procedure:

a. Mark both hub rims so that their relative positions can be maintained at all times during the alignment check.

b. Mount the dial indicator on one of the coupling hubs and position the indicator finger on the rim of the opposite coupling hub, as shown in Figure C-13, *Alignment Using Dial Indicators*.

c. Scribe a reference mark on the machined diameter of the coupling hub at the point of indicator finger contact, or align match marks on the hub rims.

d. Rotate both shafts at the same time, while retaining the indicator finger at the reference mark and the two match points aligned.

e. Note indicator readings at 90° locations (90°, 180°, 270°, 360°). Remember to zero the indicator at the starting point.

f. Repeat steps d and e two or three times to verify accuracy of readings.

   In installations where there is excessive coupling gap (when a coupling spacer is used), it may be necessary to make a reading correction when determining vertical parallel misalignment.

g. Parallel misalignment must not exceed the coupling manufacturer's recommendations or a total indicator reading of 0.002 inch (0.051 mm).

When parallel alignment is complete, connect inlet and exhaust piping, and recheck angular and parallel alignment thoroughly.

C.8.3 If using laser alignment tooling such as Rotalign, you can eliminate Section C.B.1 and C.B.2. Follow recommended instructions included in the laser alignment tooling.

C.9 Grouting

When cold alignment is satisfactory (the turbine has been leveled, and the coupling alignment has been checked), grout the base plate or sole plate to the foundation using the guidelines specified below. (Epoxy grout procedures may differ--follow manufacturer's instructions.)

Mix a test batch of ready-to-use grouting material to verify that the material overcomes settlement and drying shrinkage. This type of material is normally used for clearances less than one inch in thickness, and where the size and shape of the space make placement difficult.

Coarse aggregate is normally used for clearances over one inch (2.5 cm) in thickness, where free passage of the grout will not be obstructed. One part of pea gravel or pea stone may be added to two parts of the ready-to-use grouting material to form coarse aggregate grout.

CAUTION

Do not disturb alignment by removing shims or wedges under the base plate or sole plate.

Grouting must be done with all steam and exhaust piping disconnected from the turbine.

When prepared grout mixes are used, follow the manufacturer's instructions and applicable safety precautions. Be sure that there are no air pockets in the grouting.

A suitable form should be built around the base-plate or sole plate before grout is applied.

With either of the above-described mixes, use the minimum amount of water required to create a flowable grout that completely fills the required space. Excessive water causes segregation and bleeding.

Apply grout quickly and continuously to avoid the undesirable effects from overworking.

Once the grout has acquired its initial set, all exposed edges should be cut off vertically to coincide with the base-plate. Paint the grout with waterproof paint after the grout has thoroughly dried, or apply plaster with Portland cement-sand mortar. Do not connect the piping before the grout is thoroughly dry and alignment has been rechecked.

C.10 Hot Alignment Check

After installation is complete, the grout is fully set, and the tightness of all hold-down bolts have been checked, bring the turbine and driven machine up to operating temperature (this normally takes about two hours run time), shut down the unit, and make a careful and final check of the alignment using the procedure outlined in Section C.8. This should be done as soon as possible after shut down, to avoid erroneous readings due to cooling. Final adjustments should be made so that both shafts are parallel and their axes concentric, resulting in zero offset at operating temperature, consistent with the coupling manufacturer's limits.

If the alignment is not satisfactory, check the following for possible causes:

a. Pipe strains distorting or shifting machines due to thermal growth (disconnect piping and re-check alignment).

b. Springing of the base-plate or sole-plates by heat from the turbine, from a heat source close to the turbine, or due to soft shims or partial shims.

c. Loose hold-down bolts.

d. Shifting of the entire structure due to variable loading, a change in the foundation due to concrete curing, or improper grouting causing non-continuous support.

When final alignment is satisfactory, dowel the turbine and driven equipment in place to maintain proper alignment.

C.11 Fire Protection

All possible precautions should be exercised to avoid fire hazard to operating personnel and equipment, particularly to the oil system. To guard against the event of a serious fire around the turbine, the following protective features should be provided at an accessible location near the unit.

Fire Extinguishing Equipment Type Best Suited for Oil Fires Examples: Carbon Dioxide Multi-purpose Dry Chemical

Provision for emptying oil reservoir quickly by draining oil to waste or distant storage.

A shut-off valve in the steam inlet line and in the steam inlet line to the turbo auxiliary oil pump (if supplied).

C.12 Decommissioning

WARNING

Prior to commencing the decommissioning operation, ensure that the inlet and exhaust stop valve are shut, locked out and tagged to eliminate the possibility of inadvertent start-up during the decommissioning operation.

The decommissioning procedure is as follows:

1. Remove bolts from the inlet and exhaust flanges.

2. Disconnect all turbine piping from permanently installed piping.
3. Drain oil from the bearing housings and the governor. Dispose of the oil in an environmentally responsible manner.

4. Drain cooling water from the cooling system and bearing housings.

5. Remove carbon rings, springs and stops from the gland housings.

6. Remove coupling guard.

7. Disconnect drive half coupling from driven half coupling. Remove spacer coupling if one is installed.

8. Remove hold down bolts/nuts from the base-plate.

9. Sling the turbine and move it to a position where the inlet and exhaust are exposed.

10. Spray the internals with a rust preventative through all available openings.

11. Coat the non-painted machined surfaces with a water-soluble rust preventative.

Seal all flanged connections with a rubber gasket, steel plate and through-bolts and nuts.

Move the turbine to the selected storage location suitable for this type of machinery.

Section D

Speed Control System

D.1 General

Your Dresser-Rand turbine has been designed to produce the rated power, at its rated speed, under the specified steam conditions. This information can be found on the turbine nameplate, on the turbine data sheet at the beginning of this manual, or on the certified drawings in the Appendix A.

When the turbine has been provided with a droop-type governor (WOODWARD TG-13 governor or similar), and the load created by the driven equipment is less than the rated power, the turbine would tend to run faster than the rated speed. When the load is greater than the rated power, the turbine would tend to run slower than the rated speed. Regulating the amount of steam admitted to the turbine can counteract these tendencies. The governor and throttle valve provide this function.

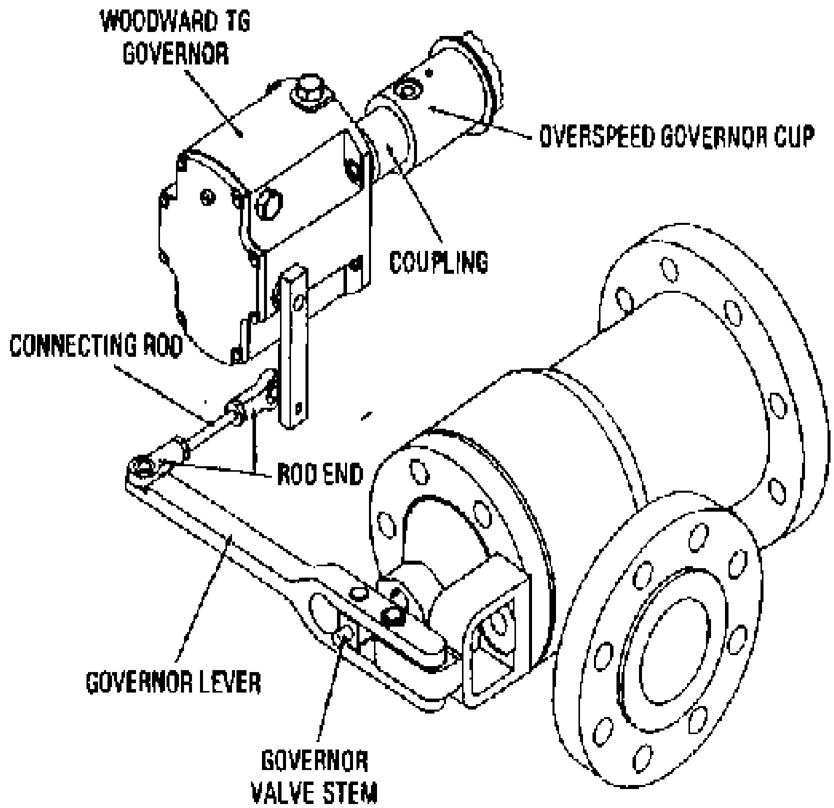
The governor senses the speed, at which the turbine is running and opens or closes the throttle valve; accordingly to maintain the turbine at its predetermined (set) speed.

WARNING

Never operate the turbine with the governor or governor system disabled.

D.2 Standard Governor

The basic hydraulic governor is the Woodward TG mechanical-hydraulic speed control governor. The governor is attached to the governor mounting housing and couples to the turbine shaft via a flexible coupling. The governor linkage connects the governor to the throttle valve.



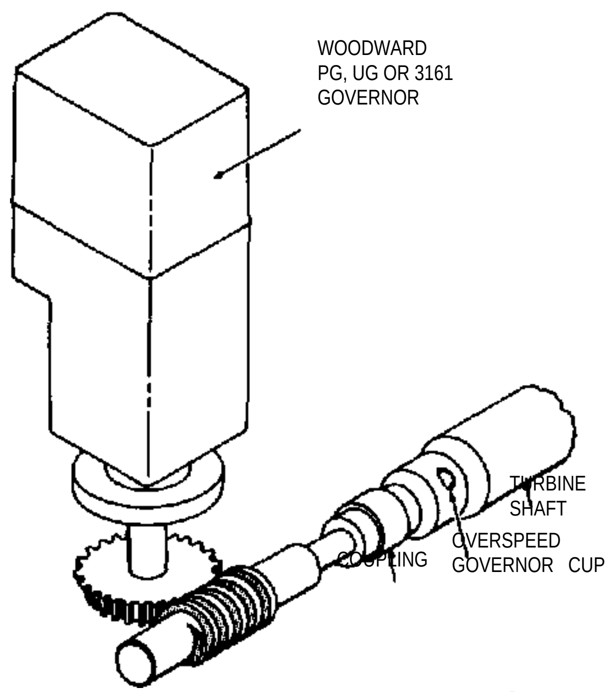


Figure D-1. Throttle Valve Features

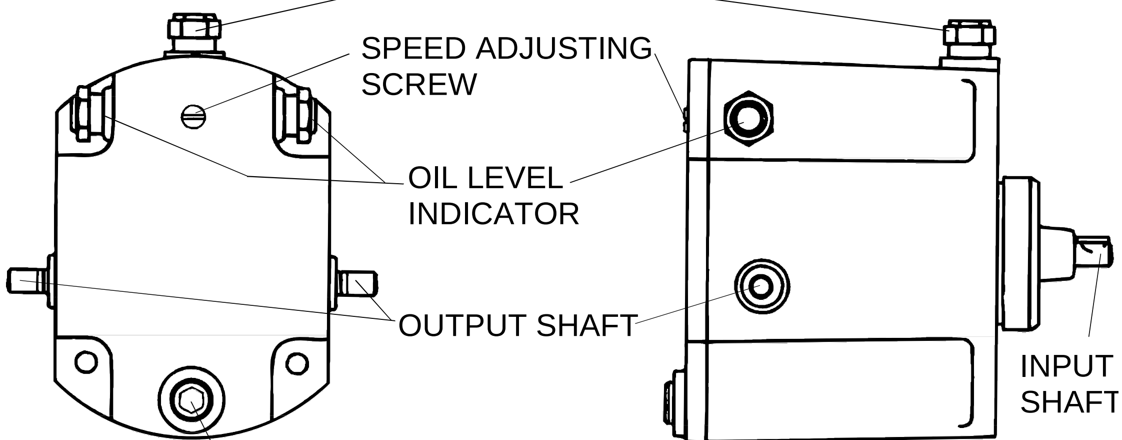


Figure D-2. Woodward Oil Relay Governor Features

The instruction manual for the standard or optional governor is found in Appendix B.
Figure D-2 shows external features of the Woodward TG Governor.

Breather--this is a vent for the oil reservoir and also serves as a plug for the oil filler hole.

Oil Level Indicator--a sight gauge on the side of the Governor for checking the oil level.

Speed Adjusting Screw--this screw, located on the rear of the Governor, increases the turbine speed setpoint when turned clockwise.

Output Shaft--opens and closes the Throttle Valve via the throttle linkage.

Input Shaft--is connected to turbine shaft, sensing turbine speed.

Drain Plug--oil drain on the bottom of the Governor.

D.3 Lubrication and Maintenance

The hydraulic governor has a self-contained, 1.75 quart oil reservoir. Oil level can be checked by viewing the oil level indicator on the side of the Governor.

The turbine is shipped with the governor reservoir filled with oil. Oil level should be checked before starting the turbine and should be maintained at the proper level. Oil should be changed according to recommendations in the Woodward manual, included with this manual. If oil should become contaminated, quality turbomachinery oil is recommended. Refer to Section F, *Lubrication System*, for oil selection guidelines.

WARNING

Operating the GOVERNOR with DIRTY OIL or with a LOW OIL LEVEL can cause the Governor to MALFUNCTION, resulting in damage to the governor and possible overspeed causing damage to the turbine and personal injury.

Refer to the governor manual for governor oil selection guidelines and for any additional maintenance information.

D.4 Speed Range and Droop Adjustment

The hydraulic governor speed range is preset at the factory, with the purchaser's specified turbine rated speed within that range. The user, within the allowable range of the supplied governor, may vary the speed set point by turning the speed adjusting screw on the rear of the Governor. Clockwise rotation of the speed adjusting screw increases turbine speed.

Droop, the variation in speed from no load to full load, can affect speed stability and may need adjustment if the turbine hunts or surges. Refer to the governor manual for details on droop adjustment.

D.5 Optional Governors

Dresser-Rand turbines can be supplied with a variety of optional governors, depending on customer needs. If your turbine is equipped with an optional governor, refer to the appropriate vendor manual in the Appendix B.

WARNING

NEVER attempt to START the steam TURBINE without first reading about and UNDERSTANDING the GOVERNOR CONTROLS.

D.6 Throttle / Governor Valve

The SST throttle/governor valve (refer to Figure D-1, *Throttle Valve Features*) consists of a balanced Venturi valve sliding in a cage contained within the valve body. The valve stem extends through the valve bonnet, which contains a set of hardened bushings. The bushings are captured in the cover, which is provided with a leak-off to direct any steam that escapes past the stem bushings away from the valve. Drain holes at the bottom of the steam chest are used to connect piping, which drains condensate from the valve. The turbine is shipped with pipe plugs in the drain holes. Refer to Section C.3.10, C.3.11, C.3.12 and C.3.13, for leak-off and drain piping recommendations.

The throttle/governor valve needs no regular maintenance other than replacement of the stem bushings if leakage becomes excessive. Valve stem freedom of movement should be checked prior to starting a turbine that has been out of service for any significant length of time.

The steam strainer screen, surrounding the throttle valve cage, prevents foreign matter from entering the turbine. If foreign matter does appear in the steam chest, turbine nozzles exhaust casing, or if blading is damaged, then the steam strainer may be defective. Foreign matter that gets past an intact steam strainer generally has a small particle size, or it could come from within the turbine itself.

Optional construction may include separate throttle and/or over-speed trip valves or other equipment configurations. Refer to the certified drawings in Appendix A.

When a turbine is supplied without an integral or separate Y-type strainer, the purchaser must install an appropriate steam strainer in the inlet steam piping.

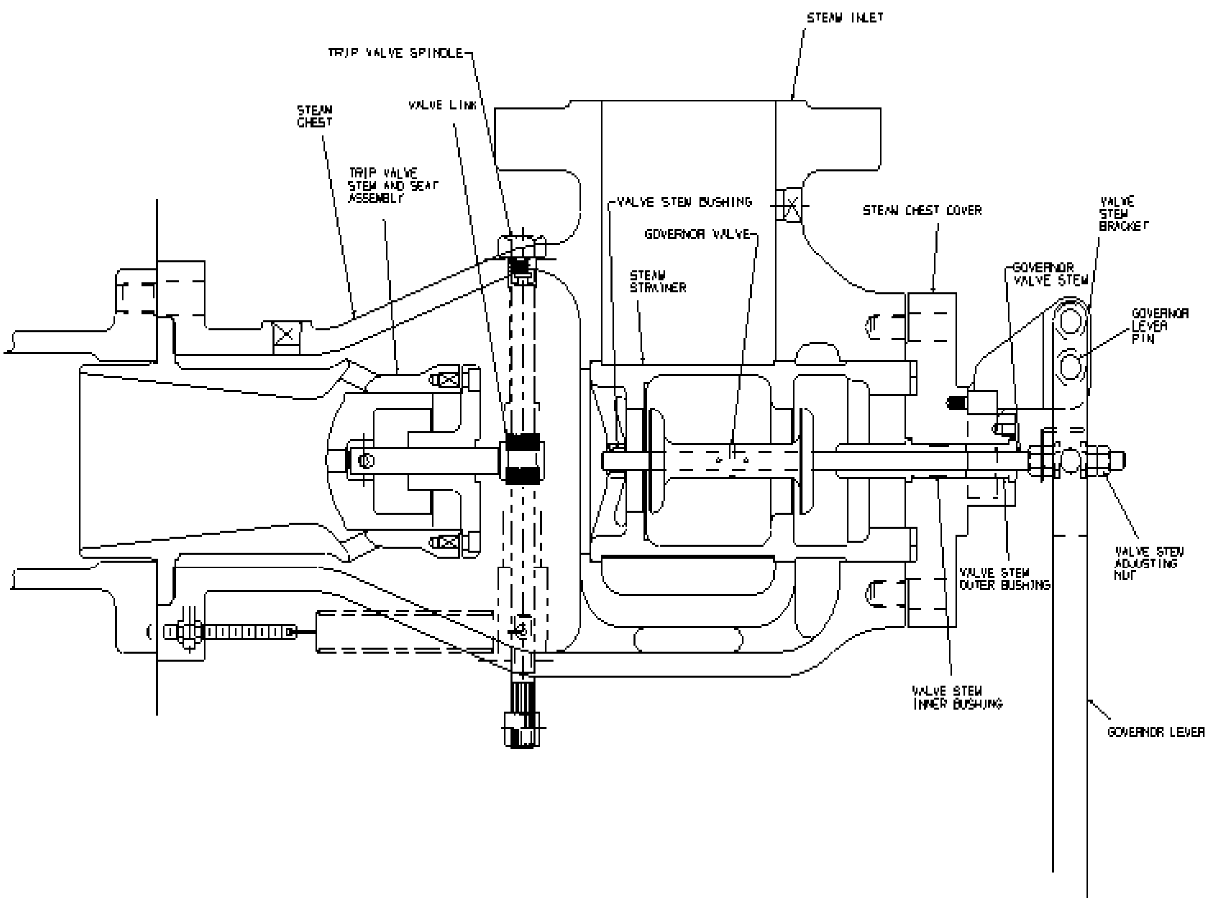


Figure D-3. Governor Valve and Emergency Trip Valve

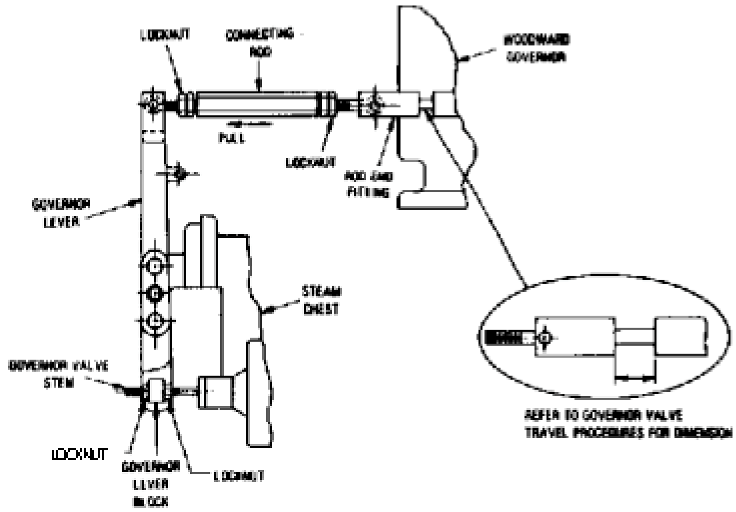


Figure D-4. Woodward Governor Valve Linkage

D.7 Governor Linkage

The linkage between the governor and the throttle/governor valve needs no lubrication or maintenance. However, it should be checked periodically for freedom of movement and for worn parts.

D.8 Hand Valves

The steam turbine may be equipped with one or two optional hand-valves, located on the steam chest. The purpose of the hand-valves is to allow the operator to open or close passages to one or more of the turbine nozzles. Since the turbine is more efficient when operating at the highest possible steam chest pressure, it is advised to operate the turbine with the throttle/governor valve open as wide as possible, while regulating power with the hand-valves. If operating at lower power is necessary, this is accomplished by closing hand-valves one at a time until the governor and throttle/governor valve are no longer capable of maintaining speed (throttle/governor valve is wide open), and then opening one hand-valve. If the load should increase while operating in this mode (more power is required), it will be necessary to open additional hand-valves to maintain speed.

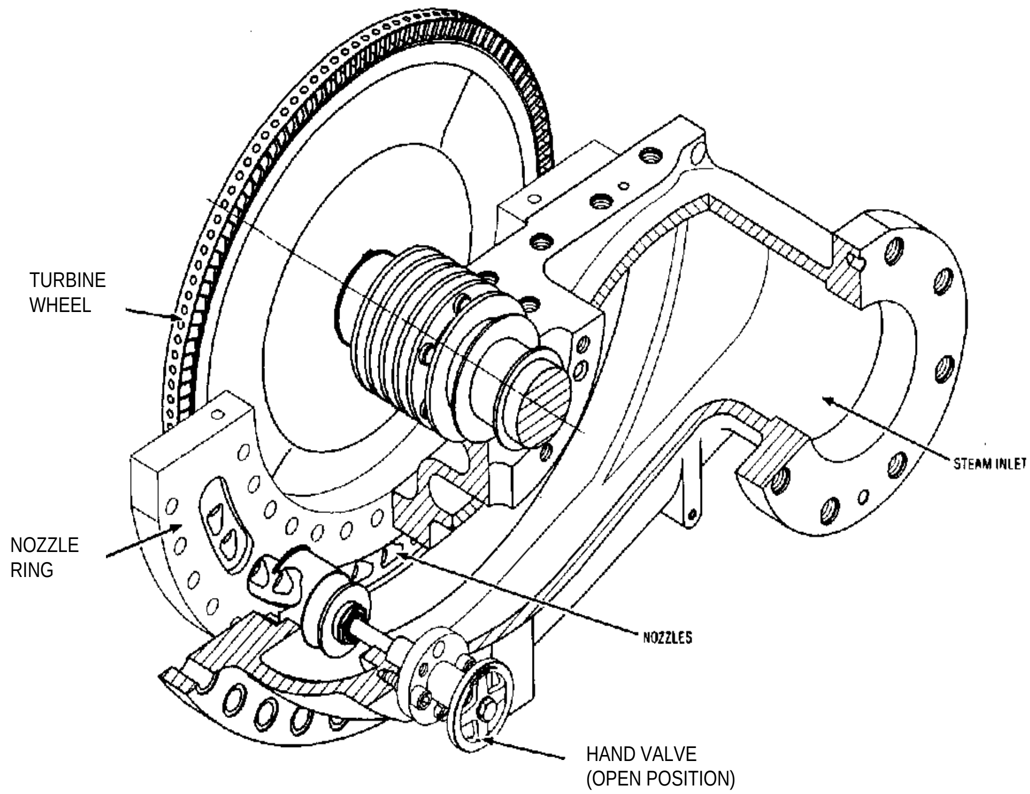


Figure D-5. Hand Valve Arrangement

Hand-valves must be fully open or fully closed. Operation with a partially open hand-valve is equivalent to throttling, meaning that efficiency is lower. It will also cause steam cutting damage to the valve seats.

When closing hand-valves, close the valve furthest from the inlet flange first. Open hand-valves using the opposite sequence. This will prevent interrupted flow from nozzles to the blades, which will subject blades to unnecessary stress cycles and could reduce turbine efficiency.

Section E

Overspeed Trip System

E.1 General

In the event of an overspeed condition, caused by a sudden loss of load or failure of the speed control system, the supply of steam to the turbine must be quickly and positively interrupted, preventing damage to or destruction of the turbine or driven equipment and possible personal injury. The turbine has a fixed amount of stored energy in the steam or gas already downstream of the trip valve at the time that the trip valve is closed. The turbine converts that energy to rotating mechanical energy and transmits it to the driven machine. As it does so, with no additional energy entering the turbine, the turbine slows down and comes to a stop.

An overspeed trip valve, activated by the over-speed governor cup assembly and/or electronic trip system, performs this function.

Per NEMA SM23, *Steam Turbines For Mechanical Drive Service*, normal turbine trip speed is 15% over maximum continuous speed for NEMA A (Woodward TG) governors and 10% over maximum continuous speed for NEMA D governors. Maximum continuous speed is 5% over rated speed; therefore, trip speed is 16% (NEMA D) or 21% (NEMA A) over rated speed. Occasionally the trip speed set point may be lower or higher than normal due to a customer request and/or technical reason. The factory trip setting speed appears on the turbine nameplate.

Standard SST turbines are supplied with an overspeed governor cup assembly (refer to Figure E-2, *Overspeed Governor Cup Assembly*), located within the mounting housing on the steam end of the turbine shaft, which contains a spring-loaded weight, within which resides a speed-adjusting set-screw. The weight, spring, and setscrew are selected and set at the factory so that the weight snaps out of the bushing at a predetermined trip speed. This trip speed is recorded on the turbine data sheet and the turbine nameplate.

When the weight snaps out of the overspeed governor cup assembly (refer to Figures E-2, *Trip System*), it strikes the trip paddle, which in turn releases the trip linkage, causing the trip valve to close. As turbine speed decreases, the weight is pulled back into the bushing by spring action. The trip valve can then be manually reset to the open position under full inlet pressure by first closing the throttle valve and then latching the trip linkage using the reset handle.

Pressing down the manual trip lever, which protrudes from the bearing case, can also trip the turbine.

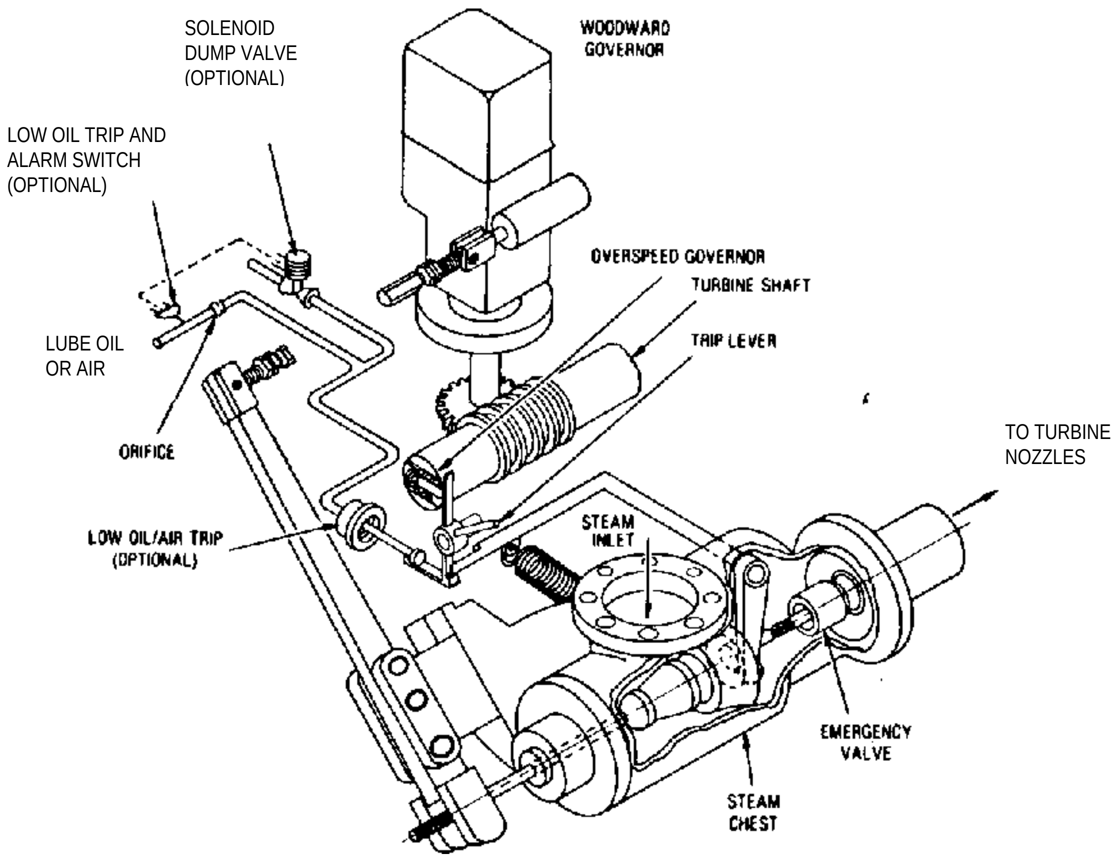


Figure E-1. Typical Trip System Arrangement Diagram

E.2 Warnings

CAUTION
If the KW load on a turbine-generator cannot be reduced in the normal manner, it indicates the possibility of unacceptable deposits on the control valve components. STUCK CONTROL VALVES ARE A DANGER SIGNAL THAT THE TRIP VALVE MAY ALSO BE STUCK. UNDER THESE CONDITIONS IT IS IMPERATIVE THAT THE GENERATOR LOAD NOT BE REMOVED UNTIL THE TRIP VALVE IS CLOSED. If the trip valve cannot be closed by normal means, then other valves in the steam system must be used to cut off the steam supply to the turbine. THE UNIT CIRCUIT BREAKER SHOULD NEVER BE OPENED WHILE LOAD IS ON THE UNIT AND TRIP AND THROTTLE / GOVERNOR VALVES ARE INOPERABLE. FAILURE TO FOLLOW THESE PRECAUTIONS COULD CAUSE A SEVERE OVERSPEED WITH EXTREME DANGER TO THE TURBINE AND OPERATING PERSONNEL.

DANGER
NEVER BLOCK OR DISABLE THE TURBINE TRIP SYSTEM OR ATTEMPT TO ADJUST OR REPAIR IT WHILE THE TURBINE IS OPERATING.

WARNINGS

TESTING, REPAIR AND MAINTENANCE of overspeed trip systems must be performed only by trained and EXPERIENCED PERSONNEL.

The OVERSPEED TRIP SYSTEM must always be TESTED and adjusted, if necessary, when STARTING the steam turbine.

The OVERSPEED TRIP SYSTEM must be TESTED WEEKLY on turbines that operate continuously. This prevents build-up of foreign material in the trip linkage and alerts the operator to deterioration that may affect trip system performance.

The TRIP SYSTEM utilizes HEAVY SPRINGS; use CAUTION when assembling or disassembling the mechanism.

The TRIP LINKAGE MOVES RAPIDLY WITH GREAT FORCE when the turbine trips. Use CAUTION when ADJUSTING the TRIP SYSTEM, MAINTAINING the turbine, or when WORKING IN THE VICINITY of the OPERATING TURBINE.

WARNINGS

Always determine and CORRECT the cause of an OVERSPEED TRIP BEFORE RESETTING THE VALVE AND MECHANISM.

DO NOT SET THE OVERSPEED TRIP SYSTEM to a speed HIGHER than the factory setting without first consulting the factory.

E.3 Description and Function

E.3.1 Overspeed Governor Cup Assembly

The overspeed governor cup assembly (Figure E-2) consists of the following parts.

Legend:

90. Cup – Governor
91. Screw – Adjusting
92. Set Screw
93. Weight
94. Spring
95. Bushing - Weight
96. Ring – Retaining-Open type
97. Ring – Retaining-External type

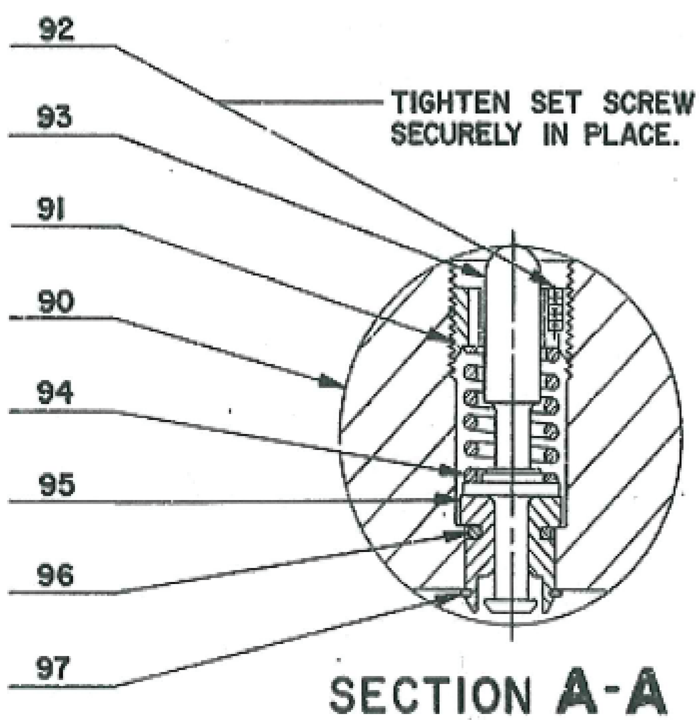


Figure E-2. Emergency Governor Cup Assembly

The weight (93), which is contained via retaining rings (96 and 97) within the emergency governor cup (90), is installed within a lateral hole in the emergency governor cup body (90). The emergency governor cup assembly is installed on the turbine shaft via key and set screw. The weight is heavy at the adjusting screw end (upper part of Figure E-2, *Emergency Governor Cup Assembly*). As the shaft and cup assembly rotates, centrifugal force tends to move the weight out of the cup, compressing the spring (94). When turbine speed reaches the trip speed, centrifugal force at the weight exceeds spring retention force, causing the weight to snap out, tripping the trip linkage.

The speed at which the weight trips the linkage is a function of the weight (93), bushing (95) shape and material, the spring rate of the weight spring (94), and the position of the adjusting screw (91). The factory based on the desired trip speed selects these components. In the field, trip speed is adjusted by changing the position of adjusting screw (91). It is imperative that the setscrew (92) be tightly turned into and locking the adjusting screw (91) from any movement. Refer to Section E.5, *Adjustment of Trip Speed*, for adjustment and maintenance instructions.

WARNING

Weight (93), spring (94), adjusting screw (91) and setscrew (92) are a FACTORY-CONFIGURED SET, selected to obtain the proper trip speed for a specific turbine. DO NOT MIX OR INTERCHANGE THESE PARTS with similar parts from other turbines or attempt to modify these components. Consult your local Dresser-Rand manufacturer's representative or the factory if replacement parts are needed.

E.3.2 Trip Valve

The standard SST turbine trip valve (Figure E-3, *Trip Valve, E-4 Trip System*) is a positive shut-off, force-actuated, sliding trip valve that is spring-loaded to ensure fast action.

When the turbine is running, the trip valve is fully open, held in place by the trip linkage (valve linkage lever (444), latch (445) and trip lever (490)), which is in turn held by trip lever (583) action against the trip finger (584).

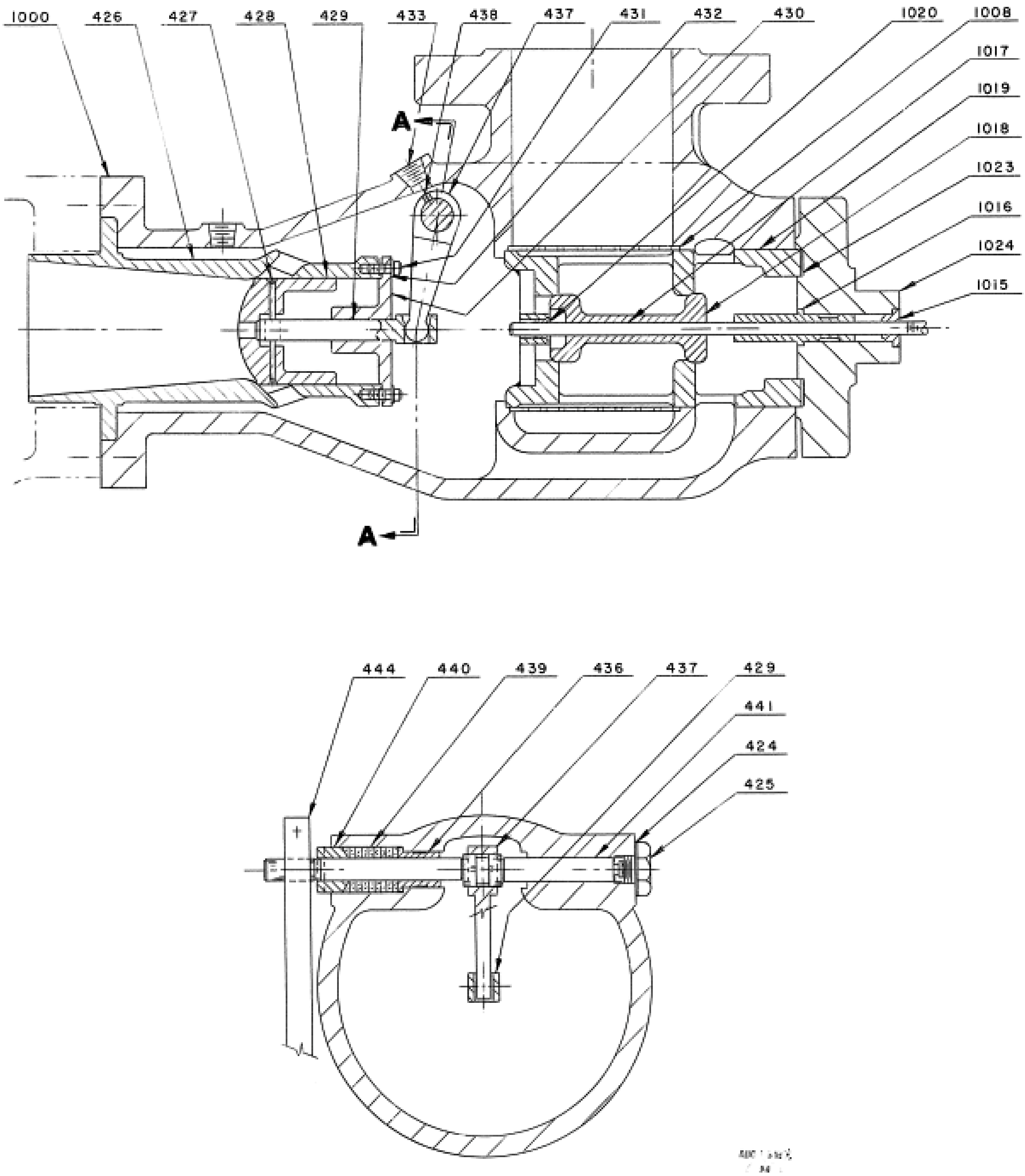


Figure E-3. Trip Valve

424	Washer
425	Retainer

426	Seat
427	Roll Pin
428	Valve
429	Stem
430	Cover
431	Cap Screw
432	Lock Washer
433	Plug
436	Bushing
437	Link
438	Set Screw
439	Packing
440	Gland Follower
441	Valve Spindle
444	Lever
1000	Valve Body

The trip linkage operates as follows:

Refer to Figures E-1, *Typical Trip System Arrangement Drawing*, E-2, *Emergency Governor Cup Assembly*, E-3 *Trip Valve* and E-4, *Trip System.*

During trip valve reset, as the valve (428) approaches the fully open position, reset handle (434) rotates trip lever and latch (444 and 445) into place with the knife edge of the latch (445) into position into the slot on the trip lever (490). The trip pin (577) then engages the trip lever (583), holding the valve in the open position. There is a torsion spring, operating in the valve closing direction, applies tension to trip pin (577). There is also a linear acting spring (510) that is pulling against lever (444). This tension is transferred to the knife-edge, holding the linkage in the open position. With the valve in the open position, inlet steam can now flow into the turbine.

The trip valve can then be tripped, either manually or by an overspeed condition. If overspeed occurs, the weight (93) will snap out of the weight bushing (95), striking the trip lever (584), causing it to release trip lever (490). The trip shaft (441) is rotated by retraction of torsion spring (510), extending the linkage, closing the trip valve via stem (429) and link (437). The force of the longitudinal spring (510) ensures positive closing of the trip valve.

When the system is tripped, a spring acting on pin (577) retracts, rotating lever (490), thus allowing lever (444) and latch (445) to be pulled by spring (510) into the closed position via the trip linkage, isolating the turbine from the steam supply.

DANGER

Under no circumstances should the TRIP VALVE be blocked or held open to render the trip system inoperative. Overriding the trip system, and allowing the turbine to exceed the rated (nameplate) trip speed, may result in FATAL INJURY to personnel and extensive turbine damage. In the event the trip system malfunctions, immediately SHUT DOWN the turbine and remedy the cause.

Refer to Sections C.3.10, C.3.11, C.3.12 and C.3.13 for recommended drain and leak-off piping configurations.

Optional construction may include a separate overspeed trip valve. Refer to the certified drawings in Appendix A.

E.3.3 Trip Linkage

The standard SST turbine trip linkage, set in motion by movement of the weight (93) in the governor cup assembly (90) Fig. E-2 controls the closing of the trip valve. The linkage also allows the valve to be opened and latched in the open position via reset handle (434), Fig. E-4. The design clearance at the end of the governor controlled steam valve(s) and trip or trip and throttle valve stems are required to minimize steam leakage from the turbine.

WARNING

NEVER OPEN A CLOSED TRIP VALVE without first preparing the turbine and driven equipment for operation.

E.4 Trip System Operation

For SST turbines supplied with the standard trip linkage, if the overspeed trip valve is tripped shut and the turbine stopped, either from an overspeed trip condition or manual activation of the trip lever, the trip valve must be reset manually, as described below.

E.4.1 Manual Reset

Use the following procedure to manually reset the over-speed trip valve:

a. Close shut-off valve in inlet steam line as soon as possible after the turbine trips.

b. Determine cause of the trip condition. It may be due to loss of the driven machine load, a turbine fault, or a governor problem. Remedy the cause using procedures detailed in Section K, *Troubleshooting*.

c. If the turbine is not at a complete stop, listen for weight retraction into the weight bushing, or wait for turbine speed to drop to 75% of its rated value to ensure resetting of the trip weight.

d. Lift reset handle (434 in Figure E-4) slightly (approximately 10-15 angular degrees) to open trip valve (428 in Figure E-3).

e. When pressure in the valve body has bled off, continue lifting the reset handle using minimal force, until the trip valve opens and the trip lever (490 in figure E-4) latches on latch (445 in Figure E-4).

CAUTION

DO NOT try to FORCE or jerk open the TRIP VALVE.

g. Gradually open shut-off valve in inlet steam line to bring turbine up to normal operating speed, allowing the governor to take control. Then open shut-off valve to full open position and back off one-quarter turn.

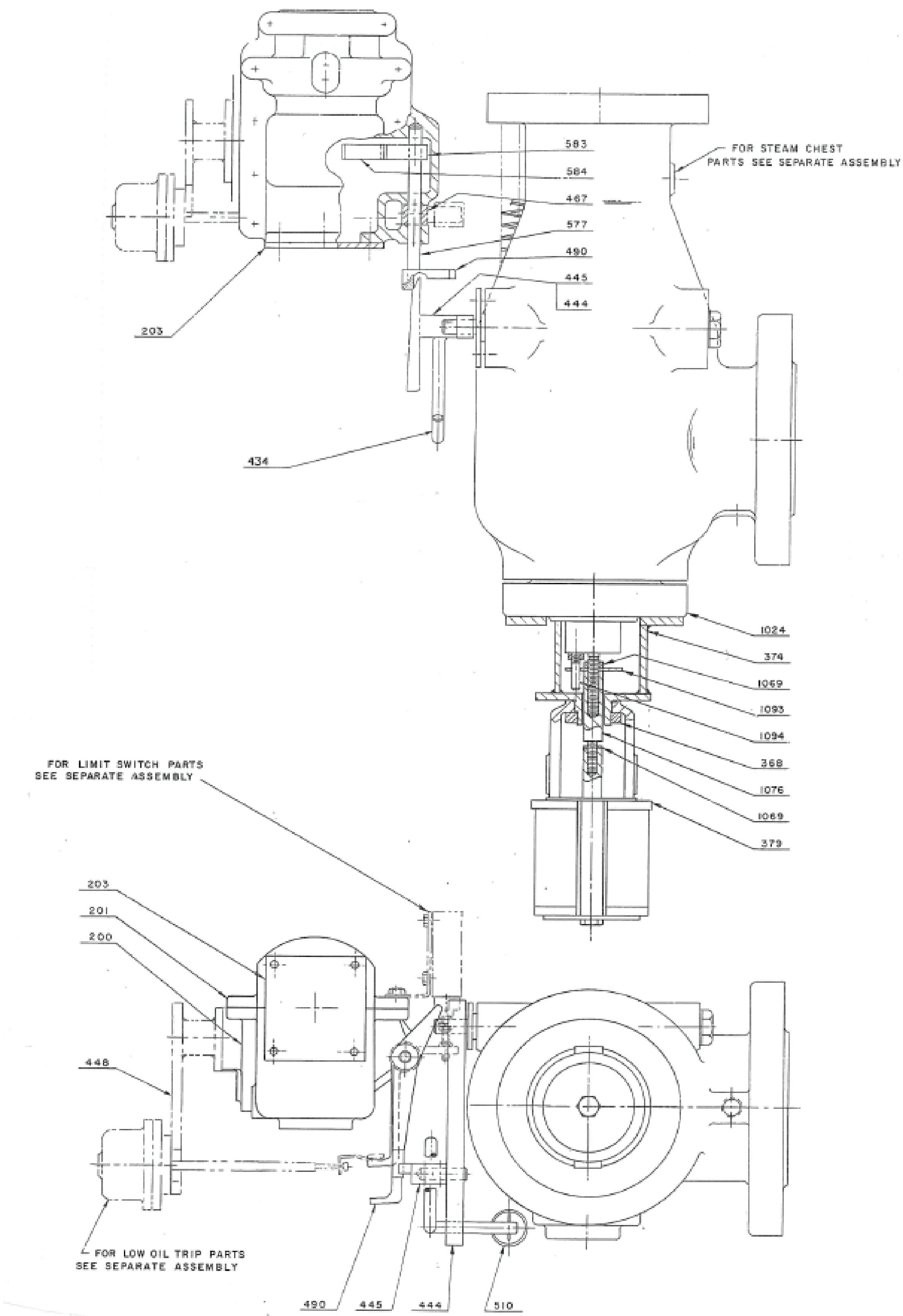


Figure E-4. Trip System

E.5 Adjustment of Trip Speed

E.5.1 Trip Speed Setting

It may become necessary to change the factory speed setting of the trip system due to a change in the normal operating speed of the turbine.

Refer to the following figures:
Figure E-1, *Typical Trip System Arrangement Diagram*
Figure E-2, *Emergency Governor Cup Assembly*
Figure E-3, *Trip Valve*
Figure E-4, *Trip System*
Figure M-2, *Governor, Mounting Housing, and Trip Components*
Figure L-15, *Governor Valve Travel Setting, Woodward TG Governor*

For SST turbines supplied with the standard emergency governor cup assembly, adjusting the position of the adjusting-screw (91) inside the governor cup (90) can change this setting. Use the following procedure to set turbine trip speed:

a. Test the over-speed trip system per the Overspeed Trip Test Procedure specified in Section E.6.2. Record the speed at which the weight triggers the over-speed trip valve, stopping the turbine. Close isolating valve in inlet steam line to prevent accidental restart.

b. For turbines with a Woodward governor with overspeed test device (type TG, PG-PL and PG-D) remove test device cover located on top or end of the governor (refer to Woodward instructions in Appendix B.)

c. Slide the end of the operating rod into its socket and turn it slowly. The turbine speed will increase to tripping, and the turbine will trip out. For type UG governors, the over-speed pin is located adjacent to the “Woodward” logo. Raise up on this pin to over speed the turbine.

d. Turbines with Woodward governors without the over-speed device: Pry open the governor valve, being careful not to damage the linkage. When trip speed is reached, the turbine will trip out.

e. Turbines with electronic governors (Tri-Sen, CCC, and Woodward) -- refer to the instruction manuals located in Appendix B for correct operating and testing procedures.

WARNING

FIELD CONFIGURABLE GOVERNOR

Any change to the control limits, such as (but not limited to) speed, over-speed trip, control logic, other than "tuning" (see governor manual) requires the prior written approval of Dresser-Rand Company to assure that safe operating limits are not exceeded. Failure to comply may result in damage to property, serious injury or death to personnel.

The new trip setting should be approximately 21% above the rated speed for a NEMA A (Woodward TG) governor and 16% above the rated speed for a NEMA D governor.

f. Open inlet isolating valve and test turbine tripping several times after final adjustment. If the trip speed is not repeatable within ±2%, or if erratic operation occurs, investigate and correct the problem before placing the turbine in normal service.

If possible, carry out a daily check of the tripping mechanism during the first week after adjustment, by over-speeding the turbine.

Optional construction may include an electronic overspeed trip system. Refer to the certified drawings and the appropriate vendor instruction manual in Appendix A and Appendix B for instruction on how to adjust the trip speed set point.

E.5.2 Magnetic Pickup Clearances

When supplied, maintaining the proper clearance between the magnetic pickups (located on the turbine mounting housing) and the turbine shaft mounted signal gear/device is crucial to the operation of the turbine electronic trip systems and electronic governor systems. Refer to Figure E-5.

Prior to initial start up of the turbine, the clearances must be checked, adjusted and the pickups locked into position.

As a part of the routine checking and testing of the turbine, the magnetic pickups should be visually checked for damage and the clearances verified to be within tolerance.

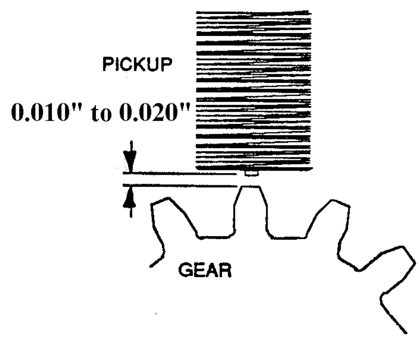


Figure E-5. Air Gap Between Signal Gear and Magnetic Pickup

E.6 Testing the Overspeed Trip Mechanism

E.6.1 General

Before testing the overspeed trip system, the turbine must be visually inspected for defects. Pay particular attention to governor and overspeed trip components and correct the defects prior to initiating any tests.

Exercising of the governor-controlled valves may be performed choking the trip or trip and throttle valve. At the same time, the trip or trip and throttle valve is exercised.

WARNING
RAPID CLOSING OF VALVES SUPPLIED WITH THE TURBINE IS ESSENTIAL TO PROTECT AGAINST OVERSPEED AND POSSIBLE OTHER MECHANICAL PROBLEMS.

DANGER

NEVER BLOCK OR DISABLE THE TURBINE TRIP SYSTEM OR ATTEMPT TO ADJUST OR REPAIR IT WHILE THE TURBINE IS OPERATING.

WARNING

The overspeed trip system may malfunction during testing. Use caution when testing and be prepared to shut the turbine down quickly with the inlet-isolating valve.

The overspeed trip system should be tested weekly to verify its operation, to prevent build-up of foreign material on the trip linkage, and to alert the operator to deterioration that may affect trip system performance.

Dresser-Rand recommends incorporation of testing into the plant operating/maintenance program and the keeping of a log to record tests.
Any malfunction of the trip system should be investigated and corrected prior to returning the turbine to service.

E.6.2 Overspeed Trip Test Procedure

Before testing of the overspeed trip system, the turbine must be visually inspected for defects. Pay particular attention to governor and overspeed trip components and correct any defect prior to initiating any tests.

Use the following procedure to test the SST Turbine over-speed trip system:

a. Start up the turbine per Section I.4.2, *Initial Start-Up Procedure*.

b. Manually trip the turbine by pressing on the trip lever (434). The over-speed trip valve should close, shutting off the turbine steam supply and bringing it to a stop. This confirms operation of the linkage and valve, but not the emergency governor cup assembly. If the valve does not close, refer to Section K, *Troubleshooting*. Otherwise, proceed to Step c.

WARNING

The TRIP LINKAGE MOVES VERY RAPIDLY and abruptly through its full travel when the turbine is TRIPPED. To guard against serious hazards to operating personnel, they must STAY CLEAR OF THE LEVER.

c. Open and latch the overspeed trip valve according to Section E.4, *Trip System Operation*.

d. Increase turbine speed using the governor speed adjusting screw or knob on the governor until trip speed is reached. The turbine should trip within ±2% of the trip speed setting on the turbine nameplate, and come to a complete stop.

e. If the turbine fails to trip at a speed 5% greater than the trip speed setting, manually trip the turbine by pressing down on the trip lever. Refer to Section K, *Troubleshooting*, to determine why the turbine fails to trip properly.

Optional construction may include an electronic overspeed trip system. Refer to the certified drawings and the appropriate vendor instruction manual for instructions on how to test the overspeed trip system.

Section F

Lubrication System

F.1 General

Proper lubrication of turbine bearings and the governor is essential for long, trouble-free service. Turbine oil must be clean, of the proper viscosity and quantity, and maintained at the proper temperature. Oil levels should be checked before starting the turbine and on a daily basis for turbines running continuously.

WARNING

Lack of lubricant or contaminated lubricant could result in bearing failure. This could create sparks or hot surfaces, which could ignite lubricant or flammable gasses.

CAUTIONS

Overloading the turbine drive shaft will cause the turbine to slow down – possibly resulting in insufficient lubrication and/or reduced function and damage to the driven equipment.

If the ambient temperature exceeds 110° F (43° C), cooling water must be provided to the bearing housings to limit the maximum temperature of the lubricating oil to 180° F (82°C). If the ambient temperature falls below freezing a means must be provided to maintain the lubricating oil in the bearing housings to a minimum temperature of 130°F (54°C) and to prevent cooling water from freezing and possibly cracking the bearing housings.

Without immediate and constant oil feed, the heat generated by the shaft in the turbine bearings, unless properly dissipated, can cause bearing failure. Oil ring lubricated bearings receive immediate lubrication as the shaft begins to turn, so long as the proper oil level is maintained in the bearing housings. With pressure lubricated bearings, the lubrication system must be arranged such that oil fills the supply lines and feeds the bearings when the shaft begins to turn.

F.2 Lubrication Requirements

Lubrication requirements are a function of the turbine type, exhaust temperature and required operating speed range. In many cases, several lubrication options are feasible at a given set of operating conditions with the selected method determined by the user.

Major oil companies produce satisfactory oil for turbine use. It is advisable to consult with your oil supplier for specific recommendations. As a minimum, the selected oil should meet the following:

(a) Properly refined highly filtered mineral oil.

(b) Maximum metal wetting ability and ability to prevent the formation of rust on metal parts bathed in oil. High stability toward oxidation and corrosion resistance may be accomplished by the use of rust and oxidation inhibitors, or as a result of a particular refining process.

(c) Free from acid or alkali.

(d) Best possible ability to separate rapidly from water.

(e) Minimum tendency to oxidize or form sludge when agitated at actual operating temperatures when mixed with air and water.

(f) Minimum tendency to emulsify or foam when agitated with water and/or air.

(g) High viscosity index. A fluid with a high viscosity index can be expected to undergo very little change in viscosity with temperature extremes and is considered to have a stable viscosity.

CAUTIONS
CLEANLINESS is ESSENTIAL for long and trouble free service from BEARINGS and GOVERNOR. Care must be taken to ensure that no foreign material enters bearing housings, the governor, and constant level oilers or oil reservoirs when performing maintenance, checking oil, adding oil or making adjustments.

> Overloading the turbine drive shaft will cause the turbine to slow down – possibly resulting in insufficient lubrication and/or reduced function and damage to the driven equipment.

The bearings are made to precision limits on a production basis. When bearing clearances become excessive, new bearings must be installed. Bearing clearances may be considered excessive when they become approximately 0.004"/0.101mm over the normal maximum clearance. (Refer to the turbine data sheets for normal running clearance of your turbine.) The bearings are longitudinally split to permit their removal and replacement with the shaft in place. Procedures for replacements are given in Section L-6.

The recommended bearing temperature limits are as follows:

		Metal Temp.	Oil Temp.
		°F / °C	°F / °C
Maximum	Normal – Pressure Lube		
	Operating	220/104	180/82
	Alarm	230/110	185/86
	Shutdown	250/121	195/90.5
Maximum	Normal – Ring Oiled		
	Operating	220/104	180/82
	Alarm	265/129	185/86
	Shutdown	270/132	195/90.5

Table F-1 Bearing Temperature Limits

F.3 Oil Ring Lubrication

The basic method of lubrication for SST turbines is oil ring lubrication. Carbon steel oil rings running on the turbine shaft pick up oil from reservoirs in the bearing housings. As the shaft and oil rings rotate together, oil flows from oil rings onto the shaft, ultimately flowing into the bearings, providing lubrication. The thrust bearing, located inside the shell of the steam end main bearing, receives its lubricating oil from this same action. The oil level within bearing housings must be maintained at a sufficient level to allow the oil rings to run in the oil. An oil level that is too high results in oil leakage past the shaft seals. Oil rings cease to rotate sufficiently when the shaft runs below 950 RPM, no longer providing adequate lubrication. Therefore, the turbine should not be run at minimum governor speeds less than 950 RPM unless for slow roll speeds of 500 RPM for warm-up purposes.

SST frame turbines must have simple bearing cases, the ambient temperatures must be below 110°F (43°C) and the cooling water supply must not exceed 100°F

(38°C) to qualify for ring oiled lubrication. Heat deflectors and air maze breathers must be used when the maximum operating exhaust temperature exceeds 400°F (204°C).

Cooling water for the bearing case is recommended for all ring-oiled turbines. Approximately 2 GPM of fresh water at 90°F (82°C) or less is required for cooling the lubricating oil for each bearing housing. Cooling water is recommended when the temperature of the bearing case cap exceeds 150°F (82°C). Maximum allowable water pressure is 75 PSIG (517 KPAG). See Figure 25 for a typical bearing case water piping schematic for ring oiled turbines.

The cooling water connections to the oil cooler are shown on the outline drawing or oil piping diagram in Appendix A. The turbine data sheets specify the required volume. The water outlet piping should be arranged to discharge into an open sight drain where the operator can observe it. A water leg of at least six inches in height should be placed in the outlet line adjacent to the cooler to assure the cooler being kept full of water.

CAUTION

DO NOT RUN turbines equipped with oil ring lubrication at speeds LESS THAN 950 RPM. The OIL RINGS WILL NOT OPERATE CORRECTLY at these speeds, causing BEARING FAILURE due to lack of lubrication.

The presence of oil in the constant level oilers does not necessarily mean that oil in the bearing housings is at the proper level.

Note: There are certain speeds and temperatures where Dresser-Rand allows operation without cooling water. (Synthetic oil is required.)

F.4 Mist Oil System Lubrication

WARNING

> If the turbine is supplied with mist oil lubrication, oil mist could escape from the bearing housing vents or oiler. If there is the possibility that these could be ignited by equipment or processes in the proximity of the turbine they should be piped to a safe area.

The turbine may be lubricated by a facility mist oil supply. When a turbine utilizes a system of this type, a diagram that shows turbine connections and piping is provided in Appendix A.

F.5 Circulating Oil Cooling System

The circulating system is the next step up from the ring oil system with water cooling. This system must be used when oil temperature in the bearing housings could exceed 180°F (82°C) and/or the exhaust temperature exceeds 550°F (82°C). This elevated temperature is normally caused by an increase in shaft/bearing rubbing speeds and/or elevated inlet or exhaust steam temperatures being transmitted from the wheel casing to the bearing cases.

The circulating system is basically a ring lubrication system. The difference is that a shaft driven direct drive pump which circulates oil out of the bearing cases for additional cooling has been added. At higher exhaust temperatures, an external oil cooler is added to the system.

The pump supplied with this system is a positive displacement gear type pump. It is mounted on the shaft at the exhaust end of the turbine. The upper half of the exhaust end bearing case serves as a housing for the pump. The same pump is used regardless of turbine rotation. The pump may be mounted off the turbine shaft at the steam end when design allows.

A standpipe or overflow port is located at each bearing case to maintain the correct oil level.

F.6 Pressure Lubrication System

Force-feed (pressure) lubrication systems, mandatory on SST turbines operating above 5000 RPM or when normal exhaust temperature is 650°F (343°C) or higher, employ a positive displacement pump to draw oil from a reservoir which is then cooled, filtered and delivered under pressure to the turbine bearings. The used oil drains from the turbine bearing housings by gravity and flows back to the reservoir to be reused.

Force feed lubrication system reservoir/console assemblies must be located so that the oil drain piping between the turbine bearing housings and the reservoir's oil return connection slopes a minimum of 0.5 inches per foot (40 mm per meter).

CAUTION

The oil drains must be free flowing at atmospheric pressure. Under no circumstances should the oil drains be pressurized or have a vacuum applied. Horizontal pipe runs should be sloped continuously, at least 0.5 inches per foot [40 mm per meter], towards the reservoir.

Refer to instructions from the lubrication system supplier.

CAUTION

All lubrication oil piping tubing, and system components, that have not been pre-charged, should be flushed prior to assembly. The assembled lubrication oil system should be flushed prior to turbine initial start-up.

F.6.1 Design Parameters for Turbine Pressure Lubrication Oil Systems

SST turbines supplied with sleeve bearings and a standard ball thrust bearing require:

Normal Oil Supply Temperature = 120° F (49° C)

Normal Oil Supply Pressure = 20 – 25 psig (137 – 172 kPag)

Oil Filtration = 25 micron or better

Bearing Cases	GPM		Heat Load
	Steam End	Exhaust End	
Simple/Simple	2	1	300 BTU/Min
HiCap/Simple W/Ball Thrust	4	1	500 BTU/Min
HiCap/Simple W/Tilt Pad Thrust	11	1	1000 BTU/Min

Refer to Section F.12, *Lubricating Oil Selection Guidelines*, and to the certified drawings in Appendix A for a description of the supplied hardware, the specific lubricating oil requirements, the oil flow, and the heat load applicable to the purchased equipment package.

CAUTION

SST turbines supplied with a tilting pad thrust bearing or turbines sharing lubrication with a gear reducer or driven equipment, will require additional oil flow and heat load capacity and may require the use of special viscosity lubricants. Refer to the certified drawings in Appendix A for a description of the lubricating oil system requirements.

F.7 Cooling Water to Bearing Housing Water Jackets

Tables F-1, *Cooling Water Requirement*, specifies when cooling water to bearing housing water jackets is required. This requirement is based on the type of lubrication system supplied with the turbine, the steam conditions, and the ambient conditions. Refer to the certified drawings in Appendix A for specific cooling water requirements for your turbines.

Lubrication Type	Cooling Water to Bearing Housing Mandatory	Cooling Water to Bearing Housing Optional
Standard oil ring	X Cooling water supply temperatures must not exceed 100°F (43°C)	
Standard oil ring with circulating oil		X
Force feed		X

Table F-1. Cooling Water Requirement

Cooling water for the bearing case for ring oiled turbines is recommended for all ring-oiled turbines. Approximately 2 GPM of fresh water at 90°F (32°C) or less is required for cooling the lubricating oil for each bearing housing. Cooling water is recommended when the temperature of the bearing case cap exceeds 150°F (65.5°C). Maximum allowable water pressure is 100 PSIG (690 KPAG).

Cooling of the bearing oil is accomplished by water jackets integral to the bearing housings. Under severe service conditions such as high ambient temperatures, partial load (high exhaust temperature) operation, and frequent shutdown (heat soaking), the optional application of cooling water will assist in maintaining recommended oil temperatures.

Cooling water should be piped into one of the lower connections on the bearing housings and out from the upper connection on the opposite side. If interconnection of water jackets on the two bearing housings is desired, connect the outlet of the non-drive end bearing housing to the inlet of the drive end bearing housing. Refer to Figure F-3, *Cooling Water Piping with Interconnecting Pipe*. All unused bearing housing connections should remain plugged.

Valves should be included in the cooling water piping to control the flow of water and allow it to be shut off. The ideal system would employ two valves—one upstream of the bearing housing, acting as a shut-off valve, and one downstream to control flow. This arrangement ensures that water jackets are filled with water and allows water to be shut off without disturbing the flow adjustment. If one valve is used, it should be downstream of the bearing housings.

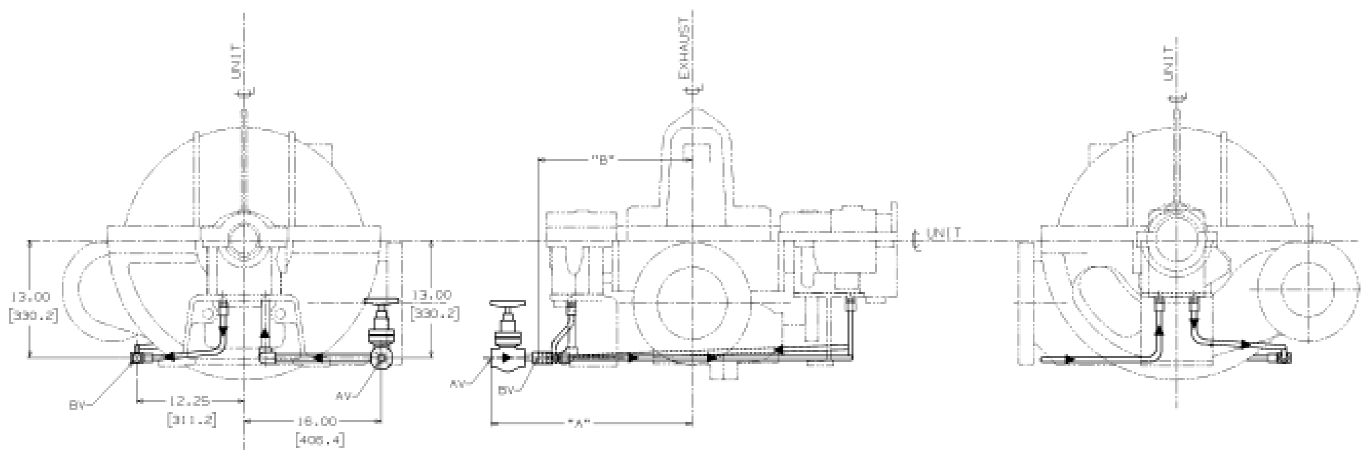


Figure F-1.Typical Bearing Case Water Piping Schematic for Ring Oiled Turbines

Flow should be adjusted to maintain bearing oil sump temperature in the normal range shown in Table F-3, *Recommended Oil Sump and Bearing Temperatures*.

Refer to the certified drawings in Appendix A for the location of cooling water connections on bearing housings.

Single stage ring oiled turbines require cooling water connections to the bearing cases. See Figure F-3 for a typical bearing case water piping schematic for ring oiled turbines.

Pressure Lube Turbines -- The cooling water connections to the oil cooler are shown on the Outline Drawing or Oil Piping Diagram in Appendix A. The turbine data sheets specify the required volume. The water outlet piping should be arranged to discharge into an open sight drain where the operator can observe it. A water leg of at least six inches in height should be placed in the outlet line adjacent to the cooler to assure the cooler being kept full of water.

F.7.1 Bearing Housing Cooling Water Requirements

Cooling water for bearing housings must meet the following specifications.

Flow Rate (per housing):	2 GPM (7.0 l/MIN)
Maximum Inlet Pressure:	100 PSIG (690 KPAG)
Maximum Inlet Temperature	90°F (32°C)
Water Quality:	Clean, non-corrosive

F.7.2 Governor Oil Cooling Water Requirements

Refer to turbine data sheets for water requirements. During operation, admit cooling water as necessary to maintain oil temperature, out of cooler, between 90°F and 180°F (32°C and 82°C).

F.8 Recommended Oil Sump and Bearing Temperatures

Table F-3, *Recommended Oil Sump and Bearing Temperatures*, lists the recommended temperature ranges for the turbine bearing oil sumps and the turbine bearings during normal operation. In addition, the table defines recommended alarm and trip set points for optional instrumentation.

	Oil Sump Temperature—		Bearing Temperature—	
Operating Status	**°F**	**°C**	**°F**	**°C**
Normal Operation	180	82	220	104
Alarm	185	86	230	110
Trip	195	90.5	250	121

Table F-2. Recommended Oil Sump and Bearing Temperatures

For turbines operating in an extreme environment, an optional thermostatically controlled immersion heater may be provided in the main oil tank to heat the oil prior to start-up and to maintain a suitable temperature during operation. If your turbine has this equipment, a supplementary description and parts list is provided in Appendix B. Operating procedures for this equipment are given in Section A-12.

When ambient temperature is approximately at the freezing point 32°F (0°C) or below, the thermostat should be set at its maximum heat setting prior to startup. The heater selected by Dresser-Rand is limited to approximately 250°F (121°C) so that there is no danger of carbonizing the oil.

When oil reaches a temperature where it will flow smoothly, approximately 100°F (38°C) it should be circulated through the oil system. If the oil tank is not equipped with a thermometer, the temperature may be monitored as the oil leaves the system cooler. The cooling water for the oil cooler should not be turned on until the turbine is operating and the temperature of the oil leaving the cooler is approximately 120°F (49°C). After oil pressure is established and stabilized throughout the complete system, the turbine may be started, as described in the Starting Procedure. During operation, the thermostat may be initially set at its minimum setting. Periodic checks of the oil temperature can determine the requirement for adjustment.

Governor Heater--When ambient temperature is approximately at the freezing point, 32°F (0°C) or below, the thermostat should be set at its maximum heat setting prior to startup. When the oil in the governor reaches approximately 90°F (32°C), the turbine may be started and the thermostat set at its minimum heat setting. It should be noted that precise temperature of the oil for normal operation of the governor is not critical, provided that the oil temperature is within the range of 90°F to 180°F (32°C to 82°C).

CAUTION

Do not allow COOLING WATER to COOL OIL SUMP TEMPERATURE TO BELOW 130°F (54°C), as this may interfere with the action of the oil rings or cause ATMOSPHERIC MOISTURE to CONDENSE in the oil reservoir.

F.9 Constant Level Oiler

Turbines lubricated with oil rings typically are equipped with constant level oilers. The purpose of these oilers is to maintain the correct oil level in the bearing housings. When applicable, instructions for constant level oilers may be found in Appendix B.

F.10 Bearing Housing Oil Levels and Capacities

The following table shows the approximate oil quantities required to fill bearing housings based on the SST turbine frame size. In addition, each constant level oiler has a capacity of about 8 oz. of oil.

Frame Size	Steam End Capacity	Exhaust End Capacity
ALL SST'S	64 oz. (1.89 l)	64 oz. (1.89 l)

Table F-3. Bearing Housing Oil Capacity

The following table shows the required oil levels that should be maintained by proper adjustment of constant level oilers. The oil level gauge on the side of the bearing housing indicates the oil level. A mark inscribed on the lower-half bearing housing indicates the proper oil level. If the mark is obscured, refer to the following table.

Frame Size	Distance Below Bearing Housing Horizontal Split in Inches
SST Simple Bearing Case Steam End	3.25 (8.26cm)
SST Simple Bearing Case Exhaust End	2.875 (7.30 cm)

Table F-4. Bearing Housing Oil Levels

For hydraulic governor oil requirements, refer to the governor instruction manual in Appendix B.

F.11 Maintenance/Oil Changes

Oil levels in turbine bearing housings, the governor and/or optional oil reservoirs should be checked daily.

Low point drains in bearing housings and oil reservoirs should be checked weekly for water.

Establish an oil change frequency based on oil tests. Otherwise, oil in bearing housings and oil reservoirs should be changed monthly; or earlier, if there is reason to believe that the oil has been contaminated with water, dirt, or by overheating.

CAUTIONS

The presence of oil in the constant level oilers does not necessarily mean that oil in the bearing housings is at the proper level.

CLEANLINESS is ESSENTIAL for long and trouble free service from BEARINGS and the GOVERNOR. Care must be taken to ensure that no foreign material enters bearing housings, the governor, and constant level oilers or oil reservoirs when performing maintenance, checking oil, adding oil, or making adjustments.

For hydraulic governor oil requirements, refer to the governor instruction manual in Appendix B.

F.12 Lubricating Oil Selection Guidelines

- Reference Table F-6 -- Sleeve Bearing Turbine, Lubricating Oil Selection Guidelines.
- Reference Table F-7 – Ball Bearing Turbine, Lubricating Oil Selection Guidelines

The importance of using a proper lubricant cannot be overemphasized. High quality turbine oils are required. Dresser-Rand Steam Turbine Business Unit does not recommend specific brands of oil. Turbine owners should consult reliable oil suppliers regarding the proper selection of turbine oils. As a minimum, the selected oil should be of premium quality rust and oxidation inhibited turbo-machinery oil, which will readily separate from water and have minimum tendency to emulsify or foam when agitated at actual operating temperatures. EP additives are not recommended. Since the proper grade of lubricant may not be available locally, it should be ordered in advance of start-up time. Comparisons between different viscosity grading systems are shown in Table F-6, *Viscosity Comparisons*.

CAUTION

For SST turbines sharing a forced-feed lubrication system with a gear reducer or driven equipment, refer to the certified drawings in Appendix A for a description of the lubricating oil requirements.

Viscosity Requirements

DESCRIPTION		VISCOSITY SSU VALUES @ 100°F Range	Nominal
*Light Turbine Oil (LTO)	ISO VG 32	130-180	150
**AGMA 1 / SAE 10W {Med)	ISO VG 46	193-235	214
***AGMA 2 /SAE 20	ISO VG 68	284-347	315
****AGMA 3 / SAE 30	ISO VG 100	417-510	464

Typical Recommendations

*** Pressure Fed Lubrication**
**** Pressure Fed Lubrication with Oil Rings Retained**
***** Ring Oiled Lubrication or Units with Reduction Gear.**
****** Mist Oil Lubrication or Units with Ball Bearings**

Table F-5. Viscosity Comparisons

F.13 Air Purge of Bearing Housings

An air purge connection can be furnished as an option on the bearing housing for the supply of low pressure, dry, filtered air or nitrogen. The positive pressure (relative to atmospheric pressure) will prevent the intrusion of dust, moisture, and other contaminants into the bearing housing. The supply pressure should not exceed a 1-inch (25.4 mm) water column.

Section G

Optional Gland Condensers, Eductors, and Ejectors

For some applications, optional ejectors, eductors or gland condensers may be supplied with the turbine package for the removal and recovery of leakage past the turbine shaft seals.

Motive flow is applied to the inlet of the educator or ejector, creating a slight vacuum, which is applied at the turbine gland leak-off connections. The discharge of the eductor, ejector and/or gland condenser is then typically returned to the plant water system when the motive fluid is steam or a safe area when the motive is fluid gas. These items normally ship loose for piping and installation by others. Refer to the certified drawings and optional equipment manuals for details of any items supplied with the turbine package.

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Section H

Optional Instruments and Controls

NOTE

Refer to Appendix B at the end of this manual for instructions for accessory instruments and controls not manufactured by Dresser-Rand.

H.1 Sentinel Warning Valve

If specified as an accessory (applies to turbines to be operated on steam only), the turbine will be furnished with a sentinel-warning valve to alert the operator when excessive pressure arises in the exhaust casing.

WARNINGS

The SENTINEL WARNING VALVE will ONLY WARN that excessive pressure exists in the casing. It will NOT RELIEVE THIS PRESSURE.

It is the USER’S RESPONSIBILITY to INSTALL A FULL-FLOW RELIEF VALVE in the exhaust line between the turbine exhaust casing and the first shut-off valve. This relief valve should be sized to relieve the FULL AMOUNT OF STEAM THAT THE TURBINE WILL PASS, in the event that the exhaust line is blocked.

H.2 Pressure and Temperature Gauges

If specified as accessories, the turbine will be furnished with inlet and exhaust pressure and/or temperature gauges. Inlet and exhaust gages must be connected to the user’s inlet and exhaust steam piping just upstream and/or downstream of the turbine inlet and exhaust flange connections as appropriate. Steam chest pressure gages may be connected to a “T” connection installed into the turbine steam chest drain piping. Gauges are maintenance-free and require no attention.

H.3 Solenoid Trip

WARNING

If the turbine is equipped with a solenoid overspeed trip system it will be activated electrically, hydraulically, pneumatically or with a combination of these power sources. If the required power source is not activated or fails, the over-speed trip system will not operate. The turbine cannot be tripped by this system.

When specified, the turbine can be supplied with a solenoid operated trip system for remote trip functions. The supplied components may include a solenoid actuator, or a solenoid valve and pneumatic actuator. The action of the actuator striking the turbine trip linkage disengages the knife-edges in the turbine trip linkage, causing the overspeed trip valve to close. Trip signals to the solenoid can be automatically or manually transmitted. Electrical power (and for systems with pneumatic actuators air pressure) must be available for the operation of the remote trip functions. Turbines may also include optional mechanical or proximity type limit switches, which may be wired to signal a “turbine tripped” condition. Refer to the certified drawings and appropriate vendor instruction manuals for specifics of the trip system supplied with the Dresser-Rand equipment package.

Refer to turbine data sheets to determine whether solenoid valve trips out turbine (opens) in energized or de-energized mode. Make sure valve is closed before starting.

H.4 Other Optional Instruments and Controls

When specified by the customer, other optional instruments and controls can be supplied. Refer to the certified drawings and appropriate vendor instruction manuals.

Section I

Start-Up and Operation

I.1 Warnings

The operator should read Sections A through H of this manual to become familiar with the turbine before attempting to start and operate it.

WARNINGS

The surface temperature of the turbine and piping will become that of the steam inlet temperature. This could exceed the ignition temperature of some gasses. Therefore, if the turbine is installed where explosive gasses could be present it is the user's responsibility to insure that this does not create a hazardous situation.

DO NOT START OR OPERATE this turbine unless the INSTALLATION has been VERIFIED TO BE CORRECT and all pre-startup SAFETY AND CONTROL FUNCTIONS have been CHECKED.

DO NOT START OR OPERATE this turbine unless you have a COMPLETE UNDERSTANDING of the location and function of ALL COMPONENTS in the steam supply and exhaust systems, including block and relief valves, bypasses, drains, and any upstream or downstream equipment that may affect the flow of steam to or from the steam turbine.

Should an explosion occur in the vicinity of the turbine it is the user/installer’s responsibility to halt it immediately and/or limit the range of explosive flames and explosive pressures to a sufficient level of safety.

DANGERS

NEVER WEAR NECKTIES OR OTHER LOOSE CLOTHING while in the proximity of the turbine or auxiliary equipment. These could be become entangled in the shaft, couplings, linkage or other moving parts and cause serious injury.

Keep body parts (fingers, hands, etc.) away from shaft, coupling, linkage or other moving parts to prevent contact and possible serious injury.

Wear proper eye protection when working on or around the turbine.

WARNING

Never operate the turbine with the governor or governor system disabled.

CAUTION

If the ambient temperature exceeds 110°F (43°C), cooling water must be provided to the bearing housings to limit the maximum temperature of the lubricating oil to 180°F (82°C). If the ambient temperature falls below freezing a means must be provided to maintain the lubricating oil in the bearing housings to a minimum temperature of 130°F (54°C) and to prevent cooling water from freezing and possibly cracking the bearing housings.

DANGER

NEVER BLOCK OR DISABLE THE TURBINE TRIP SYSTEM OR ATTEMPT TO ADJUST OR REPAIR IT WHILE THE TURBINE IS OPERATING.

WARNINGS

DO NOT START OR OPERATE this turbine unless you have a COMPLETE UNDERSTANDING of the CONTROL SYSTEM, the OVERSPEED TRIP SYSTEM, the drain and leak-off systems, the lubrication system, and all auxiliary mechanical, electrical, hydraulic and pneumatic systems, as well as the meaning and significance of all monitoring gages, meters, digital readouts, and warning devices.

When STARTING the turbine, be prepared to execute an EMERGENCY SHUTDOWN in the event of FAILURE of the GOVERNOR, OVERSPEED CONTROL SYSTEMS, linkage, or valves.

The surface temperature of the turbine and piping will become that of the steam inlet temperature. Personnel should wear gloves and protective clothing to avoid burns.

CAUTIONS

Overloading the turbine drive shaft will cause the turbine to slow down – possibly resulting in insufficient lubrication and/or reduced function and damage to the driven equipment.

Turbines should not be subjected to temperatures in a non-running ambient condition of less than 20°F (unless special LOW TEMPERATURE has been specified and low temperature materials have been provided.

Do not operate the turbine above the Maximum Continuous Speed or below the Minimum Allowable Speed as shown on the nameplate, for sustained periods of time.

WARNINGS

The turbine should NOT BE OPERATED unless a properly sized, functional, FULL FLOW RELIEF VALVE or other overpressure protective device has been installed UPSTREAM OF THE SHUT-OFF valve closest to the TURBINE EXHAUST LINE.

VERIFICATION of proper FUNCTIONING and SETTING of the OVERSPEED TRIP SYSTEM during initial start-up is MANDATORY. This should be accomplished with the turbine disconnected from the driven equipment.

WARNINGS

Shown below are turbine noise levels that were measured at three feet (1 meter), while operating at a normal load and exhausting to a positive back pressure. These noise levels are not guaranteed and are published for informational purposes only.

This noise data is based on test measurements that were taken on similar equipment being operated on the factory test stand, and have been extrapolated and/or corrected for background noise as appropriate.

When the turbine is operated under actual field conditions, noise generated in or by the piping, foundation, base plate, couplings, driven equipment, background and other sources, can add significantly to the turbine noise level and to the overall noise levels in the area.

It is recommended that the equipment user assess the noise level(s) of the completed installation and determine if additional sound attention and/or hearing protection for operating personnel is required.

Octave Band Frequency (HZ) - Expected Sound Pressure Levels (dB – Ref. 2 x 10-5 N/m2)									
Accoustic Insulation	**63**	**125**	**250**	**500**	**1K**	**2K**	**4K**	**8K**	**Expected Overall dBA**
YES	96	91	88	86	83	82	81	81	85
NO	97	92	90	89	87	85	84	84	88

Table I-1. Turbine Sound Level Data

I.2 General

The following recommended start-up and operating procedures apply to the basic turbine (ring-oiled, TG governor, without reduction gear). For information on any optional equipment, refer to the appropriate vendor instruction manual in Appendix B.

WARNINGS

None of the recommended start-up and operating procedures contained in this manual shall be construed in any way as relieving the user of his responsibility for compliance with the requirements of any regulatory body, or for the exercise of normal good judgment in the start-up, operation, and care of the turbine.

If a coupling guard is to be installed, refer to the coupling guard manufacturer's instructions to insure that it does not contact the running shaft or coupling which could cause a spark that could ignite hazardous gasses in the environment in which the turbine is installed.

To ensure trouble-free operation, the turbine must be:

a. Cleaned thoroughly prior to start-up and kept clean at all times.

b. Properly lubricated at regular intervals.

c. Subjected to regular checks for the correct functioning of protective devices.

d. Regularly inspected and maintained according to a scheduled preventive maintenance program.

e. Operated according to the procedures specified in this instruction manual.

I.3 Turbine Installation and Start-Up Checklist

The following turbine installation and start-up checklist is provided as a guide on the following pages. Although intended for use by Dresser-Rand servicemen, this checklist is suitable as a guide for end-users as well.

Turbine Installation and Start-Up Checklist

I.3.1 Turbine Information

Customer	________________	Location	______________
Serviceman	________________	Customer Contact	______________
Start Date	________________	Complete Date	______________

Nameplate Data:

	Turbine	Driven Equipment
Serial Number	________________	________________
Rated Speed [RPM]	________________	________________
Overspeed Trip [RPM]	________________	________________
Power [HP]	________________	________________

	Governor	Lube System
Manufacturer	________________	________________
Serial Number	________________	________________
Part Number	________________	________________

Application:
Use: Continuous _______ Standby _________Autostart _________

I.3.2 Site Information

Actual Steam Conditions:

Inlet press. (P1) ______Inlet Temp. (T1) ______Exhaust press. (P2) _____

	Yes	No
Is the base provided level and adequate to support the turbine?	❐	❐
Is piping deadweight supported by hangers or supports?	❐	❐
Do inlet and exhaust flanges line up with piping flanges?	❐	❐
Does the steam inlet pipe have a top take-off from the main header to minimize moisture induction?	❐	❐
Is there a piping run or dead leg beyond the take-off?	❐	❐
Have expansion joints been used?	❐	❐
Has the piping been blown out with steam (including exhaust for backpressure units)?	❐	❐
Has inlet and exhaust piping been drained at low points or trapped to avoid water legs?	❐	❐
Has a full-flow relief valve been installed in the exhaust system upstream of the first shut-off valve? Setting? ___________	❐	❐

I.3.3 Installation

		Yes	No
Is the turbine in good condition without signs of improper storage, mishandling or shipping damage?		❒	❒
Are foundation and base plate securing bolts adequate?		❒	❒
Is the turbine properly secured to the base plate?		❒	❒
Has the base plate been grouted?		❒	❒
Was rust preventative removed from the shaft and other exposed surfaces?		❒	❒
If the turbine was prepared for long-term storage, was the inside of gland housings wiped clean and carbon ring sets installed?		❒	❒
If a sleeve bearing type turbine was prepared for long-term storage, was the bearing and shaft journal surface wiped clean?		❒	❒
Were bearing housings flushed and drained with a light oil prior to filling?		❒	❒
Are lubricating oil levels correct?	Turbine	❒	❒
	Governor	❒	❒

Lubricating Oil Used:
Turbine -- Brand ________________ Type ___________
Governor -- Brand ________________ Type ___________

	Yes	No
Is the coupling properly lubricated and free to oscillate by hand?	❒	❒
Does the turbine rotate freely when turned by hand?	❒	❒
Do the oil rings rotate with the shaft?	❒	❒
Is the turbine rotation correct?	❒	❒

	Yes	**No**
Do the throttle valve, overspeed trip valve and associated linkage move freely?	❒	❒
Does the Overspeed Trip lever reset easily and trip when operated by hand?	❒	❒
Does the emergency weight move freely in the governor cup assembly?	❒	❒
Has the lube system been site flushed?	❒	❒
Are lube oil return lines pitched to the sump?	❒	❒
Is there a Sentinel warning valve? Setting? __________	❒	❒
Is the turbine adequately drained at all points?	❒	❒
Are water-cooling lines to the bearing housings properly installed?	❒	❒
Are there provisions for regulating cooling water flow?	❒	❒
Are steam leak-off connections piped correctly and unrestricted? (I.e., with no valves, manifolds, water legs or pipe size reduction).	❒	❒
Does the user understand the following:		
Overspeed Trip System operation?	❒	❒
Overspeed Trip Valve reset procedure?	❒	❒
Overspeed Trip exercising requirement and procedure?	❒	❒

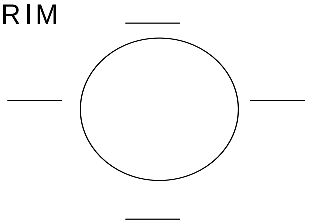
I.3.4 Start Up - Uncoupled

Drive shaft run out? ________ Driven equipment shaft run out? __________

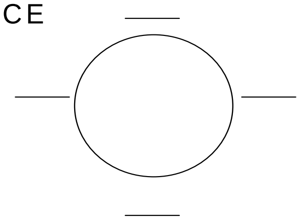
Cold alignment method? (attach print out if available)

Rim & Face	( )	Reverse Indicator	( )
Laser	( )	Other	( )

RIM



FACE



Indicator mounted on ________________ coupling reading _________________
Turbine ____________________ inches low to driven equip.
Coupling Manufacturer __________________ Model ________

	Yes	No
Did governor operate properly?	❒	❒
Is the running speed satisfactory?	❒	❒

Trip speed checks #1 _______ #2 ________ #3 ________ RPM

Overspeed test witnessed by ________________________

Bearing oil temp (sump) Gov end _______ Drive end__________

Lube oil pressure to bearing ________ psig

Lube oil temp- Into Cooler ___________ Out ____________

Are protective devices operating properly?	❒	❒

I.3.5 Start Up - Coupled

Actual Steam Conditions:

Inlet press. (P1) ______ Inlet Temp. (T1) ______ Exhaust press. (P2) _____

	Yes	No
Does the turbine operate at rated speed?	❒	❒
Speed variation? _____________ RPM	❒	❒
Does auxiliary equipment operate properly?	❒	❒
Is steam leakage within acceptable limits?	❒	❒

Vibration: (in/sec) (mils) filtered unfiltered
(Indicate speed if mils are used __________ rpm)

Turbine	(Vert/Horiz/Axial)
Gov Bearing	___/__/___
Coupling Bearing	__/___/___

Driven equipment	
Driven End Bearing	___/___/__
Non-Driven End Bearing	___/___/__

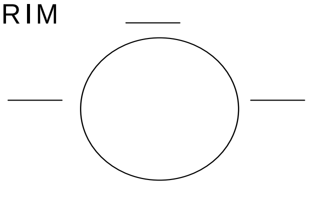
	Yes	No
Are oil levels correct with no evidence of leakage?	❒	❒

Oil temp at discharge? Gov. End _______ Drive End ________

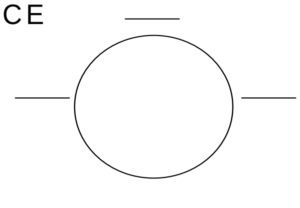
Hot alignment method? (attach print out if available)

Rim & Face	( )	Reverse Indicator	( )
Laser	( )	Other	( )

RIM



FACE



Indicator mounted on _______________ coupling reading ________________
Turbine ___________________ inches low to driven equip.

	Yes	No
Were piping changes required to correct hot alignment readings? To turbine? Describe ____________________________________	❐	❐
To driven equipment? Describe ___________________________	❐	❐
Is turbine doweled to baseplate?	❐	❐
Is driven equipment doweled?	❐	❐
Was a copy of this report left with the customer?	❐	❐

Comments:

____

____

____

____

____

____

____

____

____

I.4 Start-Up Procedure

WARNING

Turbine installation, operation, repair and service must be performed by EXPERIENCED PERSONNEL ONLY. Read and understand this instruction manual before installing, operating, repairing or servicing turbines.

I.4.1 Restoration of Turbine from Shipping Condition

The turbine was completely assembled, adjusted for proper operation, and tested immediately prior to shipment. A quick reference check list of tasks to complete prior to placing the unit into operation is as follows: (Storage information is provided at the end of this section.)

- Unpacking and inspection
- Cleaning of shipping preservatives
- Selecting and preparing foundation
- Bearing inspection and seal oil baffle outside diameters
- Aligning turbine and driven machine
- Connect steam and exhaust piping
- Connect water piping
- Preparation for initial starting and start-up

We recommend that Dresser-Rand Service Representatives oversee the installation and initial start-up of this steam turbine unit.

Before starting a turbine for the first time, or one that has been in storage, it is important to have the bearing cases, shaft packing areas, and the governor parts clean. Solvent may be used for this purpose. (See Commercial Products for Dresser-Rand Service List at the end of section

After factory testing, turbines are prepared for shipping and storage. The following two sections describe activities to be performed prior to initial start-up.

I.4.1.1 Flushing/Filling of Bearing Housings

Before starting the turbine for the first time, open bearing case drains and allow any residual oil to drain. Close the drains.

The oil recommended for permanent operation should now be added to the turbine through the oil hole covers, until levels reach their respective permanent marks on bearing housings. Add oil as necessary to constant level sight feed oilers mounted at each bearing case. Note that a low oil level may result in improper lubrication and a high oil level may cause leakage past the seals and/or overheating.

Refer to Section F, *Lubrication System*, for oil recommendations.

I.4.1.2 Shaft Packing

If the turbine was prepared for short-term storage, then no additional steps are required.

For turbines in long-term storage, the upper half of the turbine case must be removed to gain access to the shaft packing and turbine rotor. The garter springs and stop washers should be wiped clean to remove the rust preventative. Matched carbon ring sets (shipped with the turbine) should be installed. Labyrinth and carbon ring seals, the inside of the turbine case and all internal components should be cleaned of the water-soluble preservative.

I.4.2 Initial Start-Up Procedure

The following recommended start-up procedure applies to the basic turbine (ring-oiled, TG governor, without reduction gear). For information on any optional equipment, refer to the appropriate vendor instruction manual.

On ring-oiled units, the oil should be warmed up to a viscosity such that the oil rings will turn and pick up oil; this may be done by circulating hot liquid through the water jackets, or by means of electric heating elements in the oil compartments. On units equipped with a flood lubricating system the oil should be warmed up to a viscosity such that the oil pump will pick up its prime; this may be done by means of a steam heating coil or an electric heating element. If electric heating elements are used, they should be limited to approximately 250°F. temperature, to avoid carbonizing the oil. After the oil is warmed up, circulate some of the warm oil by means of a hand, motor or steam driven pump.

It may not be necessary to pre-heat the oil unless the ambient temperature is well below 32° F, depending on the relationship between temperature and oil viscosity. Experience will determine the temperature at which it is necessary to preheat the oil.

After heating the oil or determining that it does not require heating, start the unit in the usual manner, taking special care that all drain valves are left open long enough to drain all condensed steam from the steam line and the turbine. Turn the unit over slowly for a short time, making sure that the oil rings are turning and/or the oil pump is delivering oil.

Before connecting steam piping to the turbine for the first time, all piping should be thoroughly blown out with steam to ensure that solid particles such as welding beads and rust are not carried along with the steam inlet into the turbine. Refer to Section C, *Installation*. Thereafter, the following precautions must be taken:

a. Review warnings outlined in Section I.1. If this is the first time the turbine is put in service, review the Installation Start-Up Checklist in Section I.3.

b. Check the driven machine and verify that it is ready to start.

c. Check oil levels in bearing housings and the governor.

d. Verify that the magnetic pick-up to signal gear clearance is correct (if supplied).

e. Verify that all valves downstream of the exhaust-isolating valve are open.

f. On condensing units, admit sealing steam to carbon ring glands.

g. For turbines supplied with gland leak-off connections, open the leak-off atmospheric valve. Refer to Section C.3.12 , *Gland Seal Intermediate Leak-Off Piping–High Back Pressure Exhaust*

h. Open the exhaust-isolating valve.

i. Open all hand-valves.

j. Drain all condensate from low points in the inlet steam line, from the casing or low points in the exhaust steam line, and from overspeed trip and throttle valve bodies. Drain valves may be left open while the turbine is started, to allow condensate to drain as the turbine warms up.

k. If a cooling water system is used, admit cooling water to bearing housing water jackets. Flow should be adjusted to maintain bearing oil sump temperature in the normal range, as shown in Table F-3, Recommended Oil Sump and Bearing Temperatures. Refer to Section F, *Lubrication Syste*m.

l. If a gland seal condenser is used, admit cooling water. If a steam ejector or water eductor is used, admit the motive flow.

m. Start the lubrication system, if applicable.

n. Verify that the overspeed trip valve is latched open, by raising the manual reset handle.

DANGER

NEVER BLOCK OR DISABLE THE TURBINE TRIP SYSTEM OR ATTEMPT TO ADJUST OR REPAIR IT WHILE THE TURBINE IS OPERATING.

o. Provide a means for measuring turbine speed, either with a tachometer or with a stroboscope.

WARNING

Never operate the turbine with the governor or governor system disabled.

p. Turn the governor-adjusting screw on the end of the governor fully counterclockwise to the low speed position. Refer to Figure D-1, *Woodward Oil Relay Governor Features*, for screw location.

q. Admit sufficient steam through the inlet-isolating valve to turn the turbine over slowly (950 RPM minimum) and continue to operate at this speed until the turbine is fully warmed. Close all drain valves when condensate no longer drains. Some of the incoming steam will condense on the “cold” turbine walls.

CAUTIONS

DO NOT RUN turbines equipped with oil ring lubrication at speeds LESS THAN 950 RPM. The OIL RINGS WILL NOT OPERATE CORRECTLY at these speeds, causing BEARING FAILURE due to lack of lubrication.

Do not operate the turbine above Maximum Continuous Speed or below Minimum Allowable Speed as shown on the nameplate, for sustained periods of time.

r. Listen for uneven running or vibration. Shut down and correct, if required. Refer to Section I.5, *Turbine Vibration Limits*, when measuring shaft axial displacement, shaft radial displacement, or bearing housing vibration.

s. Open isolating valve in the inlet steam line gradually, bringing turbine speed up slowly until the governor takes control at the low speed setting. If the governor has not assumed speed control by the time rated speed is reached, shut down immediately and refer to Section K, *Troubleshooting*.

t. For turbines supplied with gland housing leak-off connections, open the leak-off isolation valve and close the leak-off atmospheric valve. Refer to Section C.3.12, *Gland Seal Intermediate Leak-Off Piping–High Backpressure Exhaust*.

u. Once speed control has been established, open the throttle valve by adjusting the speed setting screw on the governor clockwise to bring the turbine up to the required operating speed of the driven equipment.

v. Monitor turbine operation until stable operation is attained.

I.5 Turbine Vibration Limits

I.5.1 Shaft Displacement Measured with Proximity Probes

Radial Displacement:

When the turbine has been provided with provisions for radial proximity probes, the turbine shaft has been burnished and degaussed at the probe locations to limit the electrical and mechanical runout of the shaft. API 611 specifies that when the turbine is brand new and operated on the factory test stand that the vibration level must be at or below the “shop limit + runout”. Actual coupled, loaded field conditions tend to be higher.

Radial displacement in any plane during coupled, loaded, field conditions should be at or below the alarm level as shown in the figure below. If the level of vibration increases to greater than the trip level, the turbine should be stopped and the cause of the vibration identified and corrected.

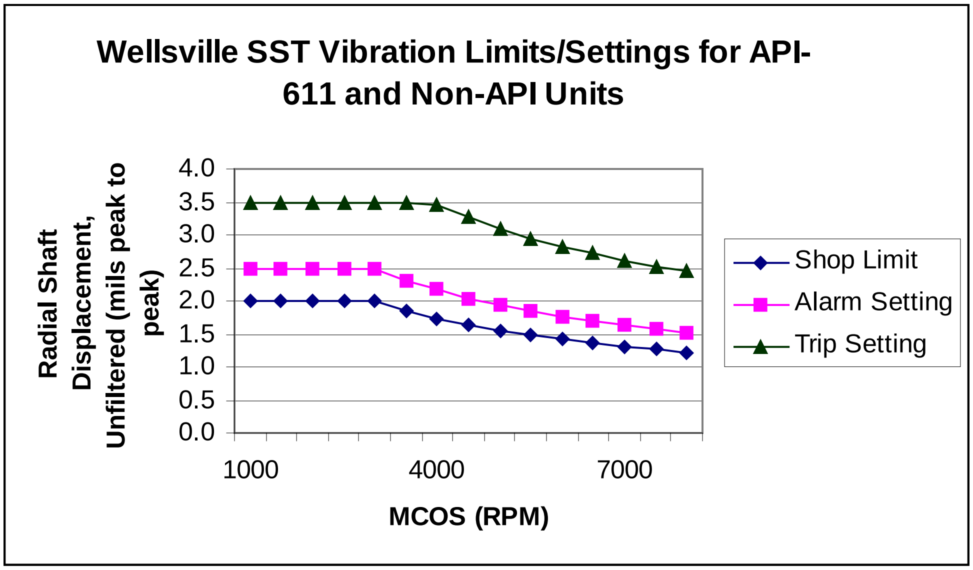


Figure I-1. Radial Shaft Displacement

Axial Displacement:

For turbines provided with standard ball thrust bearings, the shaft axial position is typically not measured. Refer to tables B-1, *Major Fits, Clearances, & Rotor Balance Criteria - SST*, and B-2, *Major Fits, Clearances, & Rotor Balance Criteria* - for shaft endplay.

Turbines provided with tilting pad thrust bearings are designed to have some axial clearance between the active and inactive thrust faces known as float. When these turbines have been provided with provisions for axial position probes, the Alarm and Trip set points are specified in Table I-1, *Axial Shaft Displacement Tilting Pad Thrust Bearings.* If the level of displacement increases to greater than the trip level, the turbine should be stopped and the cause of the displacement identified and corrected.

Note: For API 612 turbines the shop limit is 1.0 instead of 2.0.

Turbine Model	Alarm	Trip
ALL SST MODELS	+/- 17 mils	+/- 22 mils

Table I-2. Axial Shaft Displacement Tilting Pad Thrust Bearings

I.5.2 Bearing Housing Vibration

When shaft proximity probes are not installed, the bearing housing vibration can be used as an indirect measure of the shaft displacement.

API 611 and 612 specify that when the turbine is brand new and operated on the factory test stand, the peak vibration measured on the bearing housing while it operates at the maximum continuous speed shall not exceed 0.12 inches per second [unfiltered] and 0.08 inches per second [filtered]. When measuring bearing housing vibration, the alarm and trip set points are specified in the table below. If the level of vibration increases to greater than the trip level, the turbine should be stopped and the cause of the vibration identified and corrected.

Bearing Housing Vibration [inches per second, unfiltered]		
Turbine Model	Alarm	Trip
ALL SST MODELS	0.24	0.36

Table I-3. Bearing Housing Vibration

I.6 Testing the Overspeed Trip Mechanism

Refer to Section E.6, *Testing the Overspeed Trip Mechanism*.

I.7 Governor Speed Adjustment

Standard SST turbines are supplied with WOODWARD TG-type hydraulic governors. Operating speed of the turbine is adjusted using the TG governor speed adjustment screw, located in the cover plate of the governor. Refer to Figure D-1, *Woodward Oil Relay Governor Features*, for adjusting screw location. The speed adjustment mechanism is provided with sufficient internal friction to eliminate the need to externally lock the screw. A screwdriver, coin, or key may be used to adjust speed, and only light torque is required to turn the adjusting screw.

Turning the adjustment screw clockwise increases the turbine speed setting. Exercise care when increasing the speed setting, to ensure that driven machine speed limits or trip speed are not inadvertently exceeded as a result of such increases.

Turning the adjustment screw counterclockwise decreases the turbine speed setting. Continuous governing below 1100 RPM for the low-speed governor, below 2200 RPM for the medium-speed governor, or below 4000 RPM for the high-speed governor is not recommended because governor oil pressure may not be sufficient to actuate the governor valve.

Optional construction may include alternate governor configurations. Refer to the certified drawings and appropriate vendor manual for complete description.

I.8 Governor Droop Adjustment

For WOODWARD TG-type hydraulic governors, droop is factory adjusted to provide a no-load speed of approximately 106% to 110% of the full-load or normal speed. If it becomes necessary to alter droop from this initial setting, follow instructions in the Woodward governor manual.

Exercise caution whenever the governor is opened. The TG governor is a precise hydraulic mechanism, and the entry of dirt or any other foreign material can cause the governor to malfunction.

Optional construction may include alternate governor configurations. Refer to the certified drawings and appropriate vendor instruction manual for complete description.

WARNING

GOVERNORS should NOT be DISMANTLED OR REPAIRED by INEXPERIENCED PERSONNEL. Governors contain powerful springs that could cause PERSONAL INJURY and have delicate components which, if damaged, could result in GOVERNOR FAILURE.

WARNING

FIELD CONFIGURABLE GOVERNOR

Any change to control limits, such as (but not limited to) speed, overspeed trip, control logic, other than “tuning” (see governor manual) requires the prior written approval of Dresser-Rand Company to assure the safe operating limits are not exceeded. Failure to comply may result in damage to property, serious injury or death to personnel. Refer to the instruction manual for detailed instructions.

I.9 Hand-valve Adjustments

SST turbines can, as an option, be fitted with up to three hand-valves (350 frame turbines: 1; 500 and 700LP frame turbines: 2; and 700, 700H, and 700 HLP frame turbines: 3). These hand-valves provide the operator with the ability to increase or decrease the number of nozzles admitting steam to the turbine wheel.

The turbine will operate most efficiently when the pressure in the steam chest is at a maximum (approximately 90% of line pressure). The highest chest pressure occurs when the fewest number of hand-valves are open, which will allow the desired operating speed.

To adjust hand-valves for maximum efficiency, proceed as follows:

With all hand-valves open and the normal load applied, adjust the governor to the required operating speed. Beginning with the hand-valve farthest from the inlet flange close one hand-valve at a time until the turbine speed falls off sharply. Then reopen the last hand-valve that was closed. The speed should return to the required value. If both hand-valves are closed and no sharp drop in speed occurs, leave both hand-valves closed.

Caution: When putting the unit into operation, do not close a hand-valve tightly until the turbine is up to operating temperature and all parts are evenly heated. The reason for this is that the material of the valve stem is subject to greater thermal expansion than the turbine casing, and if the valve is closed tightly when cold, it may lock the valve in the closed position making it difficult to open.

CAUTION
Do not leave any hand-valve partially open, as this may result in steam cutting of the valve and seat. Hand-valves should be completely open or completely closed. Turbine speed should not be controlled by the hand-valves; this is the function of the governor.

I.10 Shutdown

The following recommended shutdown procedure applies to the basic turbine (ring-oiled, TG governor, without reduction gear). For information on any optional equipment, refer to the appropriate vendor instruction manual.

After the unit is shut down in accordance with normal operating routine, special care should be taken to be sure that all water is drained from the steam line, exhaust line, turbine casing, valves, oil cooler, etc. Pockets of water could cause damage due to freezing, and could cause trouble during the next start-up.

Shutting down the turbine may be accomplished as follows:

a. Check shutdown instructions for the driven equipment.

b. Trip the overspeed trip lever manually.

b. Close the isolating valve in the inlet steam line.

WARNING
Do NOT USE the OVERSPEED TRIP VALVE as a permanent SHUT-OFF VALVE.

d. For turbines supplied with intermediate gland housing leak-off connections, open the leak-off atmospheric valve and close the leak-off isolation valve. Refer to Section C.3.12, Gland Seal Intermediate Leak-Off Piping–High Back Pressure Exhaust.

f. If cooling water is used, turn off cooling water to the bearing housings after the turbine has cooled down, unless on standby or automatic start.

> **CAUTION**
>
> WATER-COOLING JACKETS must be DRAINED if there is a possibility of FREEZING TEMPERATURES.

f. Close the exhaust-isolating valve.

g. For condensing units, turn off sealing steam to carbon rings.

h. If a gland seal condenser is used, turn-off cooling water. If a steam ejector or water eductor is used, turn-off the motive flow.

i. Open all condensate drains.

j. If the turbine is on standby service, or is to be shut down for an extended time period, it should be started up, or at least turned over one or two times by hand, once or twice each month to distribute oil to bearings, preventing rust.

k. Turbines in standby service, where bearing housing cooling water continues to be supplied, must be checked periodically to ensure that moisture is not condensing in the lubricating oil. Refer to Section F, *Lubrication System*.

> **WARNING**
>
> After operating the turbine, allow sufficient time for the turbine to cool down prior to performing an inspection, repair or maintenance function.

I.11 Restart Procedure

Before restarting the turbine, refer to Section I.1, *Warnings*.

I.11.1 Non-Condensing Turbines

The following recommended procedure applies to the basic turbine (ring-oiled, TG governor, without reduction gear). For information on any optional equipment, refer to the appropriate vendor instruction manual.

Use the following procedure:

a. Check all oil levels. Fill lubricators as necessary. Start lube oil system, if applicable.

b. Place any controls, trip mechanisms, or other safety devices in their operating positions.

c. Open all drain valves on steam lines, turbine casing, and steam chest, and fully open hand-valves, if furnished.

d. Open the turbine exhaust-isolating valve.

e. If cooling water is used, introduce cooling water to bearing housing cooling chambers to prevent overheating. Cooling water flow should be adjusted to maintain bearing oil sump temperature in the normal range, as shown in Table F-3, *Recommended Oil Sump and Bearing Temperatures*.

f. If a gland seal condenser is used, admit cooling water. If a steam ejector or water eductor is used, admit the motive flow.

g. Open the steam inlet isolating valve and bring the turbine up to desired speed.

h. Make necessary governor adjustments to attain desired speed as load is applied to the turbine.

i. Close all drain valves when drain lines show the system is free of condensate.

j. Close hand-valves, as appropriate, to attain maximum efficiency.

k. Check bearing temperatures and overall operation for any abnormal conditions.

l. Monitor turbine operation until stable operation is attained.

I.11.2 Condensing Turbines

The following recommended procedure applies to the basic turbine (ring-oiled, TG governor, without reduction gear). For information on any optional equipment, refer to the appropriate vendor instruction manual.

Use the following procedure:

a. Check all oil levels. Fill lubricators as necessary. Start lube oil system, if applicable.

b. Place any controls, trip mechanisms, or other safety devices in their operating positions.

c. Open all drain valves on steam lines, turbine casing, and steam chest, and fully open hand-valves, if furnished.

d. Turn on sealing steam to carbon rings. Open supply valve until a wisp of steam flowing out of the outboard leak off is observed.

e. If a gland seal condenser is used, admit cooling water. If a steam ejector or water eductor is used, admit the motive flow.

f. Open the turbine exhaust-isolating valve.

g. If cooling water is used, introduce cooling water to bearing housing cooling chambers to prevent overheating. Cooling water flow should be adjusted to maintain bearing oil sump temperature in the normal range, as shown in Table F-3, *Recommended Oil Sump and Bearing Temperatures*.

h. For turbines supplied with intermediate gland housing leak-off connections, open the leak-off atmospheric valve. Refer to Section C.3.12, Gland Seal Intermediate Leak-Off Piping–High Back Pressure Exhaust.

i. Open the steam inlet isolating valve and bring the turbine up to desired speed.

j. Make necessary governor adjustments to attain desired speed as load is applied to the turbine.

k. Close all drain valves when drain lines show the system is free of condensate.

l. Close hand-valves, as appropriate, to attain maximum efficiency.

m. Check bearing temperatures and overall operation for any abnormal conditions.

n. Monitor turbine operation until stable operation is attained.

I.12 Standby Operation

Turbines that are not running continuously are often in standby operation where they must be ready to operate at any time with little or no advance notice. Turbines in standby service must be capable of starting quickly and reliably in emergency situations to prevent damage to large, costly systems, such as boilers or large rotating machinery.

Turbines in standby operation present unique operational and maintenance situations which must be understood and addressed. Listed below are the most frequently encountered issues:

- Need to prevent collection of condensate in piping, valves or turbine casing. Such condensate could slug or otherwise damage the turbine.
- Need to avoid thermal shock (casing and rotor stress) on rapid start-up.
- The need to start quickly with little or no intervention or effort by an operator.
- Avoidance of corrosion and fouling of control linkages, valves, glands, packing, seals, etc., through lack of use.
- Degradation of lubricant by leakage, oxidation due to excessive heat, or contamination from water, condensate, dirt or chemicals.
- Freezing of condensate or lack of lubrication due to extremely cold ambient conditions.

Some methods and equipment employed to deal with the problems above are:

STEAM TRAPS - Steam traps are "smart valves" used in turbine drains and inlet piping. Traps sense the presence of condensate and automatically open to allow it to drain. When the condensate is drained the traps automatically close. Steam traps are rated by pressure, temperature and flow. The amount of condensate passed will vary, depending on the steam conditions and the steam piping design. Steam traps should be valved to allow for maintenance and isolation. Manual drains that bypass the trap are also recommended. When specifying steam traps the highest pressure and temperature the trap might be exposed to should be taken into account. This is often inlet pressure and temperature.

AUTO START VALVE - A valve in the inlet steam piping which can be automatically and remotely opened to start the turbine. The auto start valve actuation speed should be sufficiently slow to minimize thermal shock to the turbine and to allow sufficient time for the turbine governor to establish speed control.

BYPASS VALVE - A small valve typically used to pass a small amount of steam around an auto start or isolating valve to provide warming and in some instances slow roll of the rotor.

IDLING NOZZLE - A special nozzle, usually piped separately via a bypass valve, that is optimally chosen to provide warming and slow roll of the rotor with minimal steam consumption.

SLOW ROLL - The steam powered slow turning of a turbine rotor, usually several hundred RPM. Slow rolling a turbine will maintain the bearings, seals and carbon rings free and operable. It provides warming that will reduce thermal shock on start up and prevents freezing of condensate. Slow rolling maintains lubricant moisture free and flowing. Some types of driven equipment cannot be slow rolled. When a turbine is slow rolled special considerations may be required for lubrication depending on turbine design, lubrication design, speed, exhaust temperature and ambient conditions. Consult factory if slow roll operation is under consideration.

EXHAUST WARMING - A means of warming a turbine by closing the inlet block or auto start valve and opening the exhaust isolating valve. This is only effective when exhaust pressure is greater than atmospheric. Precautions are necessary to prevent introduction of foreign material into the turbine via the exhaust steam and excessive exhaust pressure that might exceed the turbine's rated exhaust pressure. No slow roll occurs. Condensate must be drained or trapped prior to auto starting.

When operating on standby, the following practices and precautions are necessary:

- The turbine should be started periodically to verify that it is in proper operating condition. This must include test and exercise of the overspeed trip system.
- Steam traps should be checked periodically to insure that they are operating.
- An idling nozzle provides more efficient operation than a simple bypass valve for slow roll.

- To prevent excessive bearing temperatures, bearing housing cooling water may be required during slow roll or exhaust warming operation.
- Excessive cooling water flow during standby operation could cause condensation to contaminate lubrication oil. Maintain bearing oil sump temperature in the normal range, as shown in Table F-3, *Recommended Oil Sump and Bearing Temperatures*.
- Lubrication oil levels in the bearing housings and governor must be checked periodically.
- When a standby turbine is started, cooling water must be turned on if required.
- Prior to start up, standby turbines must be drained of all condensate using traps or manual valves.
- The exhaust isolating valve on a turbine with auto start must be open at all times to prevent over pressurization of the exhaust casing on start up.
- When it is not possible to periodically operate or slow roll a standby turbine, it should be periodically turned by hand.
- If a turbine in standby operation is exposed to freezing temperatures, provisions must be made to prevent damage and clogging of drains with frozen condensate.

I.13 Auto Start Operation

If a standby turbine must be started quickly and automatically or from a remote location, then the turbine must be equipped with an auto start valve and trapped drains. The exhaust-isolating valve must be kept open.

Refer to Section I.12, *Standby Operation*, for additional information and considerations.

Refer to Section C.3.14, *Suggested Piping Schematics for Standard SST Turbines*, for additional information and considerations.

I.14 Manual Start Operation

If a standby turbine is to be started manually the inlet isolating valve is normally closed, drains do not require steam traps and the turbine is put into service by manually opening these valves.

Refer to Section I.12, *Standby Operation*, for additional information and considerations.

Refer to Section C.3.14, *Suggested Piping Schematics for Standard SST Turbines*, for additional information and considerations.

I.15 Quick Start

In some applications, it is desirable to start up the turbine rapidly. Auxiliary oil pumps and boiler feed pumps are often called upon to start quickly in emergency situations. In such applications, condensate ingestion (slugging) and thermal shock to the casing and rotor are concerns. Piping should be carefully designed and trapped to prevent accumulation of condensate upstream on the inlet. Turbine drains should be trapped as well. A small amount of inlet steam should be bled into the inlet line to heat the turbine. Exercise care to ensure that the line, supplying this warming steam, is not large enough to supply enough steam to drive the turbine. Exhaust back pressure can be used for this purpose as well. Refer to Section I.12, *Standby Operation*, and I.13, *Auto Start Operation*, and I.15.3, *General*, for additional information.

I.15.1 Acceleration Rate

With steam turbine applications that are started with no load, the acceleration rate of a low inertia rotating element can be so high that the control system response to close the steam admission valve does not react prior to overspeed trip. This is particularly true of the turbine generator sets, which may also require limited frequency variations in the electrical system. In instances such as this, a ramp effect on governor valve closure may be built into the control system.

I.15.2 Temperature Differential

On turbines with built-up rotors, the disc-to-shaft allowance tends to decrease to unacceptable limits with a 200°F (93°C) temperature differential between the disc and shaft. The probability of such a condition existing is greater at approximately five minutes after start-up, rather than immediately at start-up. Loss of shrink fit can result in axial or wobble movement of the disc on the shaft, possibly resulting in turbine breakdown. The colder the unit at start-up, the greater the probability of the temperature differential occurring. Since the utilization of forged discs in lieu of plate discs allows a higher shrink fit, we normally recommend the customer consider using forged discs.

Operate in accordance with normal operating routine; except that in maintaining suitable lubricating oil temperature and viscosity, it may be necessary to heat the oil instead of cool the oil.

On some types of turbine governors, a change in the oil viscosity has some effect on the speed of the units; therefore, when operating a unit under varying oil temperature conditions, it may be necessary to make manual adjustments on the speed governor.

I.15.3 General

The subject of "quick," "fast" or "automatic" start is not something new in the steam turbine industry, nor has Dresser-Rand decreased its engineering standards for design of steam turbine shafts, bearings, or shrink fit of discs to shafts.

In general, reliability and durability are compromised by quick starting a turbine and will result in a shortened overall turbine life. Frequent quick starts are particularly severe on bearings and rotating elements. The more rapid the acceleration rate, the higher are the transient loads and the more severe are the loading effects.

Dresser-Rand single stage turbines with standard construction are suitable for start-up in five seconds provided the following conditions are met:

1. The inlet side of the turbine steam line must be trapped.

2. Proper lubrication of bearings must be provided.

3. The inlet temperature of the steam shall not exceed 750°F (399°C).

4. The differential temperature between the inlet steam and exhaust steam shall not exceed 350°F (177°C).

5. Back pressure shall be maintained on the casing during shutdown. (This in itself is not a recommended operating condition due to possible wire cutting or carbon ring decay, but will keep the casing warm.)

6. The operating speed of the turbine shall not exceed 6000 RPM.

7. The unit must be brought up under load.

In operating a turbine under the above conditions, the user must bear the responsibility for bearing failure, loss of disc-to-shaft shrink fit, and carbon ring decay.

Dresser-Rand does not recommend quick starting turbines that are in locations where the ambient temperature is less than 0°F (-18°C).

Units operating at very low ambient temperatures should be supplied with a lubricating oil especially selected by a reputable oil company as being suitable for the operating conditions. Special consideration should be given to insulating the entire unit, including the lubricating oil lines and the oil tank (on units equipped with a flood lubricating system), to avoid excessive heat losses and excessive condensation of steam.

I.16 Function Check of Sentinel Warning Valve

A sentinel warning valve (when provided) is mounted on the turbine casing to warn of excessive exhaust pressure. It is not a pressure-relieving device. The following test of this valve can be performed when the turbine is not running and should be carried out at least yearly. The sentinel warning valve should be set to operate just before the full-flow relief valve starts to open.

The sentinel warning valve can be tested as follows:

a. Close the inlet-isolating valve.

b. Open the exhaust-isolating valve.

c. Latch the overspeed trip mechanism.

d. Open exhaust casing drain valve two turns.

e. Slowly open inlet isolating valve until a little steam flow is visible from the exhaust casing drain.

f. Close the exhaust drain valve.

f. Slowly close isolating valve in exhaust line and observe pressure on a pressure gauge mounted to the turbine casing, or in the exhaust line before the isolating valve. The sentinel-warning valve should open at the pressure value stamped on it.

CAUTION
DO NOT allow EXHAUST PRESSURE to EXCEED the stamped setting value by more than 10 PSIG (69 kPag).

h. Relieve pressure in casing by rapidly and fully opening isolating valve in exhaust line.

i. Close the inlet-isolating valve.

j. Open all drains.

k. If sentinel warning valve does not function properly, replace it and repeat the above test procedure.

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Section J

Maintenance, Maintenance Schedule and Inspection Schedule

J.1 Introduction

The Dresser-Rand SST Turbine is a high-quality prime mover that has been carefully assembled and thoroughly tested at the factory. As with any machinery, the turbine requires periodic maintenance and service. This section discusses periodic maintenance requirements and procedures. Please refer to Section L, *Disassembly and Parts Replacement*, for major service and overhaul instructions.

DANGER

DO NOT attempt to SERVICE, REPAIR, OR ADJUST A RUNNING TURBINE, unless explicitly recommended in this manual.

WARNINGS

MAINTENANCE PERSONNEL should be THOROUGHLY FAMILIAR with the TURBINE, its CONTROLS and ACCESSORIES, before attempting any maintenance or service. Thorough familiarity with this manual is recommended.

If INTERNAL COMPONENTS of the turbine require REPAIR or replacement, CLOSE, SEAL AND TAG INLET AND EXHAUST ISOLATING VALVES and open all turbine drain valves, thereby isolating the unit and preventing ACCIDENTAL INTRODUCTION OF STEAM into it. Ensure that driven equipment cannot rotate turbine shaft or uncouple the turbine from the driven equipment.

WARNINGS

When RESTARTING a turbine that was stopped for maintenance or service, TESTING of the OVERSPEED TRIP SYSTEM is MANDATORY prior to returning the unit to service.

After operating the turbine, allow sufficient time for the turbine to cool down prior to performing inspection, repair or maintenance functions.

J.2 Maintenance and Inspection Schedule

Maintenance requirements and the corresponding schedule will vary with the application and service conditions. The following maintenance and inspection guidelines are recommended for turbines operated under normal conditions.

Frequency	Maintenance or Inspection Procedure
Daily	Check oil levels in bearing housings and governor. Add oil if required.
	Check for smoothness of operation, unusual noises, or other changes in operating conditions.
	Check overall appearance of turbine system for steam, oil, or coolant leaks, and for external damage.
	Check bearing oil temperatures and pressures; check coupling temperature. **WARNING** DO NOT attempt TO MEASURE COUPLING TEMPERATURE while the turbine is RUNNING.

Table J-1. Suggested Maintenance and Inspection Schedule

Frequency	Maintenance or Inspection Procedure
Weekly	Test the over-speed trip system. Refer to Section E, *Overspeed Trip System*, for the test procedure. This exercise will not only confirm operation of the trip system, but will prevent sticking of the over-speed trip valve and linkage due to corrosion or steam deposits.
	Check operation of auxiliary oil pump (on turbines with this equipment). See oil system schematic diagram in Appendix for location of test valve.
	Check operation of all low air/oil pressure shut down device(s).
	Drain small quantity of oil from system and conduct an oil analysis. Determine the need for an oil change. If system is equipped with and oil filter element, change the element at the time of the oil change.
	Check throttle valve and linkage for freedom of movement.
	Lubricate the governor lever connection.
Monthly	Check bearing housings for sludge, sediment, or water (condensate). Flush and refill, as required.
	Check that oil rings rotate freely and smoothly.
	Check throttle and overspeed trip linkage for looseness, wear, and freedom of movement. Check governor drive coupling for wear
Yearly	Change oil in the Woodward TG governor.
	Remove and clean the steam strainer. Replace every three years.
	Inspect internal components of the throttle valve for wear. Replace, if required. Replace valve stem seals.
	Clean and inspect the over-speed trip valve. Replace worn parts. Replace valve stem seals.
	Thoroughly inspect the throttle linkage and overspeed trip linkage for wear. Check governor drive coupling for wear. Replace as required.

Table J-1. Suggested Maintenance and Inspection Schedule (Cont.)

Yearly Continued	Inspect, clean, and flush bearing housings, oil reservoirs, and cooling water chambers.
	Inspect carbon ring gland seals. Replace as required.
	Check operation of the Sentinel warning valve.
	Check alignment and foundation.
	Remove top half of turbine casing and: Clean scale and foreign material from wheels, buckets and nozzles. Check carbon rings for wear—remove, clean and reassemble (refer to shaft packing section L.4.1 and L.4.2). Check thrust bearing endplay.
	Check calibration of all instrumentation.

Table J-1. Suggested Maintenance and Inspection Schedule (Cont.)

WARNING

Modification of, incorrect repair of, or use of non-DRESSER–RAND repair parts on this turbine could result in a serious malfunction or explosion that could result in serious injury or death. Such actions will also invalidate ATEX Directive & Machinery Directive Certifications for turbines that are in compliance with those European Directives. Refer to Section M *-Replacement Parts/Factory Service*

J.3 Major Inspection

Dresser-Rand recommends that the turbine be periodically shut down and subjected to a major teardown and inspection. The frequency of this inspection will depend on turbine service conditions, its maintenance history, the convenience of scheduling a shutdown, the user’s experience with this or similar machines, or the customer’s insurance company’s requirements..

J.4 Inspection Checklist

The following list summarizes parts that should be inspected during a major inspection.

Parts to be Inspected	Area to Be Examined	Inspect for	Action Required
Turbine and sector blades	Shrouds	Cracks, poor rivet heads	Consult manufacturer's representative or factory.
	Blades	Corrosion, cracks, erosion	File or grind smooth (Note: removal of excessive material will affect balance and blade integrity. Consult manufacturer's rep. or factory if in doubt.)
Bearings	Surfaces	Wear, signs of foreign matter, scratches (pitting, corrosion, galling, excessive radial play on ball bearings)	Replace if defective. Check condition of oil system. Drain oil & clean thoroughly.
Bearing Housings	Oil Reservoir	Fouling, scale, rust, and water	Refill with new oil.
Bearing housing oil seals	Labyrinth seal rings	Wear, dents in surface, scale, dirt	Clean thoroughly.
Glands	Carbon rings	Breakage, wear, high spots, dirt	Replace if badly worn or broken. Clean. Carefully scrape high spots.
	Stainless steel high velocity oxy fuel	Blistering, peeling	Replace shaft.
	Labyrinth steam seal teeth	Wear, dents in surface, scale, dirt	Clean thoroughly. Replace labyrinths if wear excessive.

Table J-2. Inspection Checklist

Parts to be Inspected	**Area to Be Examined**	**Inspect for**	**Action Required**
Throttle valve	Stem	Scale	Remove with solvent and/or crocus cloth.
		Galling, wear	Replace.
	Valve and cage	Cutting, scaling	Replace valve or cage, as required.
	Seal sleeves	Wear, excessive clearance, steam leakage	Replace.
	Steam strainer	Cracks, dents, or obstructions	Remove obstructions and dents. Replace if cracked or broken. Determine cause of damage and correct.
Governor linkage	Connecting rod ends, linkage pins, bushings, Governor drive coupling	Wear, excessive clearance/play, corrosion	Replace worn components. Clean with solvent and polish, if necessary.
Overspeed trip valve	Valve Spindle	Scale and boiler compound, dirt	Remove with solvent and/or crocus cloth.
	Valve Spindle Spindle packing	Wear, excessive clearance, steam leakage	Replace.
	Valve seat	Wear, cutting, cracks	Replace.
	Pilot valve	Wear	Replace.
Overspeed trip system	Trip collar assembly	Binding, scale, corrosion, wear	Disassemble and clean; inspect for wear; replace as an assembly.
	Linkage, connecting rod ends, bushings, pins, reset handle	Foreign material, wear, corrosion, freedom of movement	Clean and inspect. Replace worn and defective parts. Adjust and confirm correct operation before returning turbine to service.

Table J-2. Inspection Checklist (Cont.)

Parts to be Inspected	Area to Be Examined	Inspect for	Action Required
Hand Valves	Stem and packing	Corrosion, foreign material, wear	Replace packing; remove foreign material from stem; replace stem if pitted or worn.
Pressure lube system (when used)	Piping reservoir	Fouling, scale, rust, water, flaking paint	Clean thoroughly to remove. Filter oil to remove dirt. Drain oil; remove access covers to clean out any accumulated scale and refill with new oil.
	Oil filter(s)	Increased pressure drop	Replace filter element
	Oil cooler(s)	Fouling and corrosion on both oil and water side	Clean according to manufacturer's instructions

Table J-2. Inspection Checklist (Cont.)

Refer to the certified drawings and the appropriate vendor manual for inspection and maintenance requirements for optional equipment.

J .4.1. Protective Devices and Steam Cleanliness

RAPID CLOSING OF VALVES SUPPLIED WITH THE TURBINE IS ESSENTIAL TO PROTECT AGAINST OVERSPEED AND POSSIBLE OTHER MECHANICAL PROBLEMS. Such valves (governor valves, trip valves, trip throttle valves, etc.) must close in fractions of a second; and deposits on valves, seats, stems, etc cannot impede their movement. Deposits can form rapidly - as a result of improper water treatment and/or entrainment of impurities in the steam supply.

The design clearance at the end of the governor controlled steam valve(s) and trip or trip and throttle valve stems are required to minimize steam leakage from the turbine.

The stem clearances used by Dresser-Rand are based on many years of practical experience and will prevent binding under normal temperatures and steam cleanliness. HOWEVER, THE DEGREE OF STEAM CLEANLINESS TOLERANCE ON

CONTROL VALVE AND TRIP VALVE COMPONENTS IS LIMITED AND DEPOSITS MUST BE PREVENTED.

Steam cleanliness at the turbine flange is essential to reliable turbine operation. Control of steam cleanliness is the responsibility of the turbine user and his system operator. Cooperation with boiler manufacturers and water treatment specialists is strongly recommended to maintain steam purity and cleanliness. Boiler operation must prevent boiler compounds from being carried over to the steam turbine and causing deposits on the valves.

DRESSER-RAND RECOMMENDS THAT THE TURBINE USER PERFORM CAREFUL AND FREQUENT INSPECTION OF TRIP SYSTEM TO ASSURE NO DEPOSIT BUILD-UP OCCURS that could cause the safety devices and valves to become inoperative.

WE RECOMMEND THAT FREQUENT EXERCISING OF (I.E. LIMITED MOVEMENT/PARTIAL STROKING) THE CONTROL COMPONENTS BE PERFORMED, especially if boiler carryover deposits may have occurred.

Exercising of the governor controlled valves may be performed by either a small load change (where practical) or steam inlet pressure change. This can be accomplished by choking the trip or trip and throttle valve. At the same time, the trip or trip and throttle valve is exercised.

CAUTION: If the KW load on a turbine-generator cannot be reduced in the normal manner, it indicates the possibility of unacceptable deposits on the control valve components. STUCK CONTROL VALVES ARE A DANGER SIGNAL THAT THE TRIP VALVE MAY ALSO BE STUCK.

UNDER THESE CONDITIONS IT IS IMPERATIVE THAT THE GENERATOR LOAD NOT BE REMOVED UNTIL THE TRIP VALVE IS CLOSED. If the trip valve cannot be closed by normal means, then other valves in the steam system must be used to cut off the steam supply to the turbine. THE UNIT CIRCUIT BREAKER SHOULD NEVER BE OPENED WHILE LOAD IS ON THE UNIT AND TRIP AND THROTTLE / GOVERNOR VALVES ARE INOPERABLE. FAILURE TO FOLLOW THESE PRECAUTIONS COULD CAUSE A SEVERE OVERSPEED WITH EXTREME DANGER TO THE TURBINE AND OPERATING PERSONNEL.

J.5 Factory Service

Dresser-Rand maintains repair and rebuild facilities worldwide. In addition, factory-trained servicemen are available for start-up, field service, and troubleshooting. Consult your Dresser-Rand manufacturer’s representative or the factory for service needs. Refer to Section M, *Replacement Parts/Factory Service*.

J.6 Factory Replacement Parts

WARNING

Modification of, incorrect repair of, or use of non-DRESSER-RAND repair parts on this turbine could result in a serious malfunction or explosion that could result in serious injury or death. Such actions will also invalidate ATEX Directive & Machinery Directive Certifications for turbines that are in compliance with those European Directives. Refer to Section M -*Replacement Parts/Factory Service*

Dresser-Rand recommends that only Dresser-Rand-supplied parts be used in Dresser-Rand turbines. The use of Dresser-Rand parts ensures that replacement components are manufactured from the highest quality materials, to exacting tolerances and specifications, thereby assuring efficient, long-lasting, and maintenance-free operation, under service conditions that the turbine was built for.

Dresser-Rand and selected Dresser-Rand manufacturer’s representatives maintain a supply of the most frequently requested spare parts for immediate shipment worldwide. Parts requested less frequently can be manufactured quickly on an emergency basis when required.

Your Dresser-Rand manufacturer’s representative can supply you with an interchangeability list and a suggested stocking list of recommended spare parts for your turbine or turbines, allowing you to stock spare parts at your facility. Refer to Section M, *Replacement Parts/Factory Service*.

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Section K

Troubleshooting

K.1 Introduction

This section should be consulted when the turbine is not operating satisfactorily. The table in Section K.2 lists the more common symptoms, probable causes, and corrective actions in each case. If the problem cannot be completely remedied using the table, refer all questions to your local Dresser-Rand manufacturer's representative, or to:

Dresser-Rand Company
Wellsville Operations, P.O. Box 592
Steam Turbine Business Unit
Wellsville, NY 14895-0592
www.dresser-rand.com
800-828-2818
585-596-3100

If corrective actions specified in items 5 through 8 of Section K.2 are attempted and are not successful, and if the factory must be consulted, it is imperative to provide exhaust pressure, speed, horsepower, and chest pressure. Chest pressure is measured by installing a pressure gage in a hand-valve chamber drain hole and reading the pressure with the hand-valve closed.

K.2 Troubleshooting

The following table lists common problems, possible causes, and the appropriate corrective action of turbines that have operated successfully and develop problems during the course of normal operation. Problems encountered during initial start-up should be referred to the above contact information.

No.	Symptom	Probable Cause	Corrective Action
1	Excessive vibration or noise	Misalignment.	Check the alignment when the turbine is hot. Disconnect coupling between turbine and driven machine; run the turbine alone. If the turbine runs smoothly, there is either misalignment, a worn coupling, or the driven equipment is at fault. To check alignment, refer to Section C. If the turbine drives a coupled gear, and the gears run together at the top, allow for the pinion running in the top of its bearing when under load.
		Worn bearings	Replace bearings. Refer to Section L.
		Worn coupling to driven machine.	Check condition of coupling. Replace if necessary.
		Glands fitted too tightly.	Tight carbon rings may cause vibration and overheating. Refer to Shaft Packing Section for proper clearance.
		Loose wheels are extremely unusual, but may be caused by a runaway, excessive steam temperature or shock loading.	Rotor should be returned to the factory to be repaired.
		Bent shaft	May be caused by hot bearings (see “Bearing Heating and Wear”), tight glands (see “glands Fitted too Tightly”), or mechanical damage.
			Check the shaft runout near the center, as well as at the shaft extension. Replace the shaft if runout is excessive. Refer to Section L.
		Unbalanced coupling to driven machine	Remove coupling halves and check for unbalance.
		Unbalanced wheel	Check if turbine wheel has become unbalanced due to fouling, over-speeding, or loss/damage to shrouds or blades. Check if the turbine has been standing idle for a long period without drainage of the exhaust casing. Solid matter can build up in the lower half of the wheel, causing unbalance. The turbine wheel must be cleaned, re-balanced or replaced. Refer to Section L.

Table K-1. Troubleshooting Guide

No.	Symptom	Probable Cause	Corrective Action
		Piping strain	Both the inlet and exhaust steam lines should be properly supported to prevent strains from being imposed on the turbine. Sufficient allowance should be made for thermal expansion. Refer to Section C.
		Excessive end play	Check the axial position of rotor. If the endplay exceeds 0.020”, replace thrust bearing. Verify that coupling is cleaned and installed properly so that excessive thrust is not imposed on turbine from driven equipment.
2	Bearing Failure	Improper lubrication	Refer to Section F to verify that the proper lubricant is being used. Check oil periodically to ensure that it is free of condensate and sediment.
		Improper water cooling	When water-cooling is required, the water flow must be adjusted to maintain bearing oil sump temperature in the normal range, as shown in Table F-2.
		Wear and/or scratches in sleeve bearing	Replace the sleeve bearings, drain oil reservoirs, clean bearing housings, and add new oil. Inspect journal surfaces.
		Rough or untrue thrust collars. (shoe-type bearing)	Rough or untrue thrust collars on single-stage machines may cause rapid wear on thrust facings of the sleeve bearings. This could eventually increase thrust clearance to a point where the turbine wheels would rub on the guide or reversing ring. Rough or untrue collars should be replaced or repaired at the first opportunity.
		Misalignment	Misalignment is one of the common causes of bearing failure. Refer to remedies for Misalignment under Vibration above.

Table K-1. Troubleshooting Guide (Cont.)

No.	Symptom	Probable Cause	Corrective Action
		Bearing fit	Ball bearings should fit on the turbine shaft with a light press fit. Too tight a fit can cause cramping; too loose a fit will allow the inner race to turn on the shaft. Either condition results in wear, vibration, overheating, and ultimate bearing failure. Replace the shaft if worn below recommended or specified size. Refer to Section L.
		Excessive thrust	Verify that the coupling is clean and is installed so that excessive thrust is not imposed on the turbine from the driven equipment. If a fairly high thrust is imposed on the turbine, consult the factory to determine whether the thrust bearing is suitable for the application.
		Excessive belt pull	On belt driven units, verify that belts are not too tight and consult the factory to determine whether the turbine bearing is suitable for the application.
		Unbalance	Refer to Unbalanced Wheel under Vibration above. Unbalance can cause excessive bearing wear and early failure.
		Excessive tension in spring type speed changer.	The tension on the speed changer spring must be sufficient to hold the governor lever firmly against the governor spindle connection under all conditions. Avoid any unnecessary loading on this spring, as this would impose excessive load on the thrust bearing.
		Speed governor trying to close a leaking or stuck governor valve.	Leaking or stuck valve should be corrected, as it constitutes a safety hazard, besides being detrimental to the thrust bearing. Excessive wear is also imposed on the governor ball thrust bearing.
		Heavy slugs of water in the steam.	This condition can be avoided through proper boiler control. Damage to the thrust bearings and wheels will result from water slugs.

Table K-1. Troubleshooting Guide (Cont.)

No.	Symptom	Probable Cause	Corrective Action
		Rust	Rust may develop on bearing surfaces when the turbine is improperly stored; refer to Section A for details. Rust may also develop when the turbine is out of service for long periods, without receiving proper attention; refer to Section J.
3	Excessive steam leakage past shaft seals	Dirt under rings	Steam leaking under carbon rings may carry scale or dirt, which can foul the rings. Remove rings and clean, as per Section L. The rings should be free to float axially, and the downstream face of the ring must seat perfectly against the smooth, true and clean surface of the adjacent carbon ring spacer.
		Shaft scored	The shaft surface under carbon rings must be smooth to prevent leakage. Factory-supplied shafts are hard chrome plated. Polish minor shaft imperfections or replace the shaft, per Section L.
		Worn or broken carbon rings	Replace with new carbon rings, as per Section L. Although there are 3 segments per ring, the entire ring must be replaced. Carbon rings should have a slight clearance on the shaft when cold, as carbon expands much less with heat than steel.
		Corroded, worn or dirty partition plate surfaces	Steam will leak past the carbon ring partition surface if dirt, corrosion or scoring prevents a good seal. Polish sealing surfaces. Replace partitions (when used) if badly worn or pitted. Refer to Section L.
		Labyrinth steam seal improperly installed	Refer to Sections L and Supplemental Data for proper installation procedure.
		Worn or broken labyrinth steam seal teeth	Replace labyrinths. Refer to Sections L and Supplemental Data for proper installation procedure.
		Excessive exhaust pressure	Packing cases are designed for a pre-determined backpressure. Excessive backpressure causes leakage, which is a common cause of water in the lubricating oil.
		Excessive joint sealing compound in gland housing	When replacing carbon rings, use joint compound sparingly. Excess compound may foul carbon rings and gland housing sealing surfaces.

Table K-1. Troubleshooting Guide (Cont.)

No.	Symptom	Probable Cause	Corrective Action
		Leak-off pipe plugged	Verify that all steam and condensate can discharge freely. Refer to Section C.3.10.
4	Oil leaks past laby seal	High oil level	Reduce the oil level to coincide with marks on bearing housings. Refer to Section F.
		Scratched or rough shaft under laby seal	Polish the shaft under the laby seal and install a new laby seal. Refer to Sections F and L.
		Seal improperly installed	Refer to Sections F and L for proper installation procedure.
		Shaft vibration	Refer to all causes under *Vibration* above. Install a new laby seal, if necessary, as per Sections F and L.
5	Insufficient power (turbine does not run at rated speed)	Too many hand-valves closed	Open additional hand-valves. Refer to Section I for proper adjustment of hand-valves.
		Oil relay governor set too low	Refer to Section D for speed adjustment and speed range limits.
		Inlet steam pressure too low or exhaust pressure too high	Check the steam pressure at the turbine inlet and exhaust pressure close to the exhaust casing, using accurate gauges. Refer to the turbine nameplate for intended steam conditions. Low inlet pressure may be the result of auxiliary control equipment such as a pump governor which is too small, improper piping size, excessive piping length, etc.
		Load higher than turbine rating	Determine the actual load requirements of the driven equipment. In some instances, modifying a few components can increase available turbine power. Consult the factory for this determination.
		Throttle valve not opening fully	Close the main inlet valve and disconnect throttle linkage. The valve lever should move freely from fully open to fully closed. If not, disassemble the throttle per Section L and free up the assembly, as required.
		Low governor oil level	Refill—Refer to Section D.

Table K-1. Troubleshooting Guide (Cont.)

No.	Symptom	Probable Cause	Corrective Action
		Nozzles plugged	Remove the cover and rotor and inspect nozzle openings. Remove nozzle block to clean nozzles as required.
		Steam strainer	Remove all foreign matter from steam strainer. Refer to Section L.
6	Speed increases excessively as load is decreased	Throttle valve not closing fully, governor responds slowly due to worn parts or sticking.	Refer to *governor valve not opening fully* under *Insufficient power* above. Free the sticking valve and inspect all pivot points in linkage for signs of sticking or binding or excessive wear.
		Throttle valve and valve seats cut or worn	Remove governor valve, as per Section L. Check valve and seats for wear or steam cutting. Replace if necessary.
7	Excessive speed variation	Governor droop adjustment	An increase in the internal droop setting will reduce speed variation or hunting. Refer to Droop Adjustment in the Woodward Governor Manual.
		Governor lubrication	Low governor oil level, or dirty or foamy oil may cause poor governor operation. Drain, flush, and refill governor with the proper oil. Refer to Section D.
		Governor valve assembly friction	Disassemble the governor valve per Section L. Inspect for free and smooth movement of all moving parts. If required, polish throttle valve, governor valve and bushing assembly, and valve stem with very fine Emery cloth. Inspect valve stem for straightness and for build-up of foreign material. Replace components as required.
		Governor valve seal friction	Check the valve stem for free and smooth motion through the throttle bonnet assembly. If friction or binding occurs, disassemble throttle bonnet assembly and repair or replace seal components, as necessary. Refer to Section L.
		Rapidly changing load	Rapidly changing load can sometimes cause governor hunting. Consult the factory, providing details of the application.

Table K-1. Troubleshooting Guide (Cont.)

No.	Symptom	Probable Cause	Corrective Action
		Governor knife edges worn.	These must be replaced if badly worn. There is no effective repair for these parts.
		Lost motion so the governor valve does not always follow the motion of the governor.	This is usually the result of excessive wear at the pivot points in the linkage. Bearing in the linkage should be replaces, as well as the linkage pins.
		Light load and high inlet steam pressure	In some cases, where the turbine provides a large amount of reserve power and the inlet steam pressure is quite high, there is a tendency for excessive speed variation. Try operating the turbine with additional hand-valves closed. This condition can sometimes be corrected by replacing the governor valve and bushing assembly. Consult the factory, providing details of the application.
8	Sluggish governor response.	Governor droop adjustment	Reduce the droop setting. Refer to Droop Adjustment in Woodward Governor Manual.
		Turbine carrying very heavy load, little reserve power.	Open necessary hand-valves to increase horsepower.
9	Slow start-up	General	Refer to all causes under *Insufficient power* above.
		High starting torque of driven equipment	Obtain the required starting torque from the driven equipment manufacturer and consult the factory to determine whether the turbine is overloaded in the application.
10	Governor not operating	Governor valve travel restricted	Refer to *Governor valve not opening fully* under *Insufficient power* above.

		No governor control on start-up	If the speed increases continuously on start up and the governor does not close the throttle valve, the governor pump may be installed in the wrong direction of rotation. Also verify that the installed governor operates in the proposed speed range. If pump rotation appears to be the problem, remove the governor according to Section L. Replace it with a governor of the proper rotation. Refer to the Woodward Governor Manual for instructions on changing governor rotation or consult the factory.

Table K-1. Troubleshooting Guide (Cont.)

No.	Symptom	Probable Cause	Corrective Action
11	Governor oil leakage	General	Isolate the source of leakage. If leakage is at the cover plate gasket, drain plug or oil breather, replace the gasket and/or tighten these components to stop the leak. If leakage occurs at terminal shaft seals or the drive shaft seal, replace the governor per Section L.
		Drive assembly vibration	Vibration of the turbine shaft or governor drive coupling may induce leakage at the governor drive shaft seal. Refer to all causes under *Excessive vibration or noise* above. Inspect and tighten the coupling per Section L. Check for misalignment or bent turbine or governor shaft.
12	Overspeed trip actuates on load changes	Overspeed trip set too close to turbine operating speed	The over-speed trip should be set at approximately 16% OR 21% above the rated speed, depending on the NEMA rating (D or A) of the governor. Refer to Section E.
		General	Refer to all causes under *Speed increases excessively as load is decreased* above.
		Light load and high inlet steam pressure	Refer to *Light load and high inlet steam pressure* under *Excessive speed variation* above.
13	Overspeed trip actuates at normal operating speed	Excessive vibration	Replace the trip lever and/or trip latch if latching surfaces are worn, after resolving cause of excessive vibration.

		Trip speed setting too low	If the turbine consistently trips at or close to the same speed, the trip setting may be set too low. The setting should be approximately 16% OR 21% over rated speed, depending on the NEMA rating (D or A) of the governor. Refer to Section E for adjustment procedures.
14	Overspeed trip does not actuate at overspeed	Trip speed setting too high	If the overspeed trip has not actuated when the turbine reaches 25% above rated speed, the trip speed setting may be too high. The setting should be approximately 16% OR 21% over rated speed, depending on the NEMA rating (D or A) of the governor. Refer to Section E for adjustment procedures.

Table K-1. Troubleshooting Guide (Cont.)

No.	Symptom	Probable Cause	Corrective Action
		Overspeed cup mechanism	Examine mechanism. Verify that it is clean and in good working order, and that the trip weight can be moved easily by a small screwdriver or similar tool.
		Improper adjustment or poor condition of the tripping mechanism, springs or latches.	The trip valve must be tested frequently. To test the valve, trip the over-speed mechanism by hand. Make sure the trip valve closes promptly and stops the turbine.
		Excessive friction in trip valve spindle packing. Scaling, wear, or mechanical damages in trip valve or its supports.	These serious faults should be corrected by cleaning, repairing or replacing parts so that this important safety device can operate effectively.
		Governor does not trip at or near the proper speed.	Gain access to and examine the overspeed governor. Make sure it is clean, in good order, and that the emergency weight can be easily and freely moved in the governor cup by a small screwdriver or similar tool. Adjust as described in Section VI. Test the unit by actually over-speeding. If it still does not trip at the proper speed, adjust the setting of the emergency governor as required. If low oil pressure trips, solenoid trips, high back pressure trips, or similar devices are provided, check them at the same time.

		Overspeed trip valve unable to close	Overspeed trip valve may be frozen in place due to steam deposits, corrosion, or other contaminants. Disassemble and clean valve assembly according to Section L.
			A broken steam strainer, or other foreign objects, may interfere with proper seating of the over-speed trip valve. Disassemble and inspect combination valve according to Section L.
15	Excessive steam consumption.	Load greater than realized.	The operator, after acquainting himself with the correct hand valve use on the turbine, must make sure the correct combinations of hand valves are open for various loads.

Table K-1. Troubleshooting Guide (Cont.)

No.	Symptom	Probable Cause	Corrective Action
		Speed below normal.	Check the steam pressure and backpressure. Make sure the governor is fully opening the valve. Check and see if the hand valves are in use as designed.
		Too many hand valves open.	This situation gives a turbine excessive capacity which requires throttling by the governor valve to maintain the proper speed. This is inefficient and uses more steam than necessary. Close the hand valves to eliminate throttling.
		Steam pressure low, or exhaust pressure too high.	These conditions must be corrected if the turbine is to carry a full load. Better boiler control will provide steam pressure correction. Horsepower goes down as exhaust pressure goes up over designed pressure.
		Steam is wet, or the super- heat low.	This condition not only causes loss of power, but also is dangerous since it causes excessive erosion on the nozzles and blades. Adjust steam conditions as per manufacturer's recommendations.
		Worn or damaged nozzles and blades.	This adversely affects the efficiency of the turbine. Nozzles and/or blades should be replaced or repaired at the earliest opportunity.

Table K-1. Troubleshooting Guide (Cont.)

Refer to the certified drawings and the appropriate vendor manual for Troubleshooting Guidelines for optional equipment.

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Section L

Disassembly and Parts Replacement

L.1 Warnings/Cautions

DANGERS
DO NOT attempt to ADJUST, REPAIR, DISASSEMBLE OR MODIFY this turbine WHILE IT IS IN OPERATION, unless such action is expressly described in this instruction manual. NEVER DISCONNECT INLET OR EXHAUST FLANGES of the turbine without first isolating the turbine from inlet and exhaust systems by CLOSING AND TAGGING ISOLATING VALVES and de-pressurizing the turbine casing and steam chest by opening all drains. Open connections not protected by isolating valves should be covered with blank flanges. Do not remove any covers, guards, gland housings, drain covers, etc. while the unit is operating.

WARNING
After operating the turbine, allow sufficient time for the turbine to cool down prior to performing inspection, repair or maintenance functions.

CAUTION

Do not operate the turbine above Maximum Continuous Speed or below the Minimum Allowable Speed as shown on the nameplate, for sustained periods of time.

WARNINGS

Modification of, incorrect repair of, or use of non-DRESSER-RAND repair parts on this turbine could result in serious malfunction or explosion that could result in serious injury or death. Such actions will also invalidate ATEX Directive & Machinery Directive Certifications for turbines that are in compliance with European Directives. Refer to Section M – *Replacement Parts/Factory Service*

NEVER REPLACE ANY ORIGINALLY SUPPLIED BOLT WITH A SUBSTITUTE BOLT OF UNKNOWN or LESSER GRADE. DO NOT MIX BOLTS during disassembly. Failure to use the proper grade bolt could result in SERIOUS FAILURE of pressure-containing components. Refer to Section B, *Technical Data*.

MAINTENANCE PERSONNEL should be THOROUGHLY FAMILIAR with the TURBINE AND ITS CONTROLS AND ACCESSORIES, before attempting any maintenance or service. A complete reading of this manual is recommended.

CAUTIONS

If the turbine is equipped with a throttle valve manufactured by a party other than Dresser-Rand refer to Appendix B for installation, operation, repair, and maintenance instructions.

If the turbine is equipped with a trip valve manufactured by a party other than Dresser-Rand refer to Appendix B f this manual for installation, operation, repair and maintenance instructions.

WARNINGS

Dresser-Rand turbine components are manufactured from a variety of materials, depending on steam pressure, steam temperature, speed and horsepower. Before replacing any components, be absolutely certain that the REPLACEMENT PART was INTENDED for use in the TURBINE UNDER REPAIR.

When RESTARTING a turbine after repair, maintenance or rebuilding, always TREAT the turbine as if it were a NEW TURBINE being started for the first time. Refer to Section I, *Start-Up and Operation*.

CAUTION

CLEANLINESS is ESSENTIAL for long, trouble-free service from BEARINGS and the GOVERNOR. Take care to ensure that no foreign material enters bearing housings, the governor or constant level oilers when performing maintenance, checking oil, adding oil, or making adjustments.

L.2 General

This section describes disassembly and parts replacement for Dresser-Rand SST turbines. Some parts of a SST turbine can be replaced in the field using instructions presented in this section, if qualified personnel and facilities are available. If not, it is recommended that a Dresser-Rand service representative be employed to make the field repairs, or that the turbine be returned to the factory, where a complete inspection can be made. If returned, the factory will prepare an estimate of the cost of cleaning the turbine, replacing parts as required and restoring the turbine to practically new condition. After factory repair, the turbine will be no-load tested and preserved just as a new machine would be. A factory-rebuilt turbine receives a new turbine warranty.

L.3 Turbine Case Upper Half Removal and Replacement

The upper half of the turbine case must be removed to gain access to the shaft packing and turbine rotor. NOTE: Make sure that the steam inlet and the exhaust line shut-off valves are shut before starting work.

In some applications, special bolting is supplied. Consult the factory before replacing or torquing the bolts in the turbine.

WARNING

NEVER REPLACE THE ORIGINALLY SUPPLIED BOLT WITH A SUBSTITUTE BOLT OF UNKNOWN or LESSER GRADE. DO NOT MIX BOLTS during disassembly. Failure to use the proper grade bolt could result in serious failure of pressure-containing components.

If the applicable bolt torque is not specified in the Assembly/Disassembly section, the following table may be used as a guideline.

The procedure for removing and replacing the case upper half is specified below. Refer to the following figures:

L-1 *Case Upper Half Removal*

L-2 *Flange Bolt Torque Sequence*

L-3 *Flange Bolt Torque Sequence, 700H Casing*

L-9 *Hand Valve Assembly*

M-8 *Case, Rotor and Mechanical Gland Seals*

M-9 *Case, Rotor and Carbon Ring Gland Seals*

<u>Turbine Cover Removal (Upper half of the exhaust casing)</u>

a. Remove the bolts from the horizontal flange of the turbine.

b. Break horizontal joint (cover/case mating surfaces) by inserting jacking bolts in holes provided at the four corners of the cover flange.

c. Using a hoist and center eyebolt at the top of the upper case half, lift turbine cover slowly and carefully so as to avoid damaging the rotor inside. Refer to Figure L-1 *Case, Upper-Half, Removal*.

Place turbine cover on a clean surface so as to prevent damage to its sealing face.

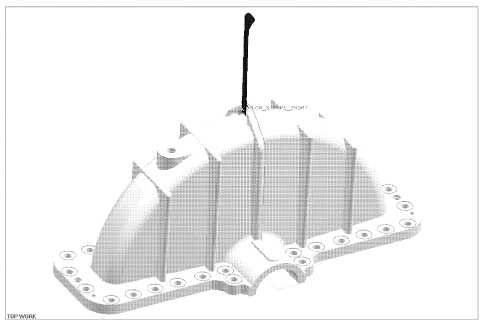


Figure L-1. Case Upper-Half Removal

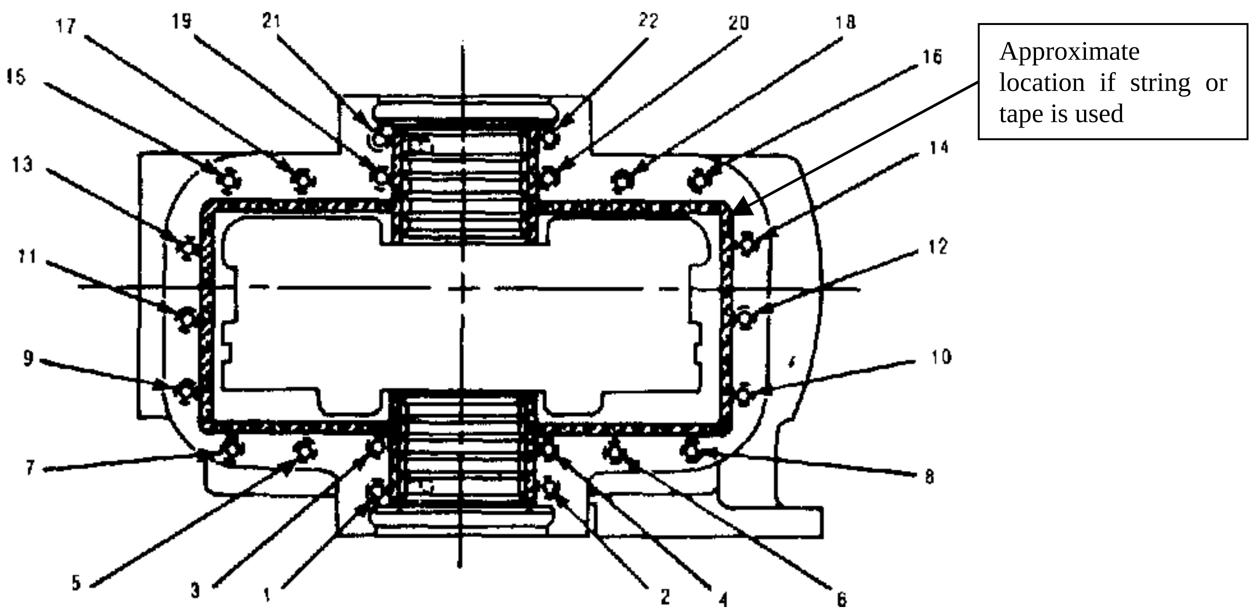
Turbine Cover Replacement (Upper half of the exhaust casing)

a. Inspect the interior of the turbine cover and exhaust casing. Remove any foreign material.

b. Remove all old sealant from both surfaces of the horizontal joint. Do not file, gouge or scratch these surfaces. If the surfaces are warped, steam-cut or otherwise damaged, a leak-tight seal may not be possible.

c. Apply joint sealant after cleaning the split surface on case and cover. Apply a light coat of Hylomar (recommended by Dresser-Rand) to sit for 15 minutes before putting the cover on the case.

Exhaust End



Steam End

Figure L-2. Flange Bolt Torque Sequence

TORQUE — STUDS AND STUD BOLTS

TORQUE VALUES BELOW ARE TO ATTAIN APPROXIMATELY 45,000 PSI STUD STRESS

SIZE	THREADS PER INCH	TORQUE (FT.•LBS.)
0.500	13	53
0.625	11	106
0.750	10	188
0.875	9	303
1.000	8	455

Table L-1. Applied Bolt Torques for Case Flange Bolts

1. After the joint is properly prepared, the threads that protrude through the flange should be lightly coated with a thread lube/anti-seize compound.
2. Tighten all nuts in the sequence shown to approximately 50 percent of the specified torque for the first pass and to the full torque value for a second and third pass.
3. Check and, if required, retighten after the turbine is at normal operating temperature using the sequence shown.

d. Apply anti-galling thread lubricant to the threads of all bolts.

e. Lower turbine cover onto lower half of casing. Ensure the cover seats evenly.

f. Install and tighten the horizontal flange bolts in accordance with Figure L-2, *Flange Bolt Torque Sequence* and Table L-1, *Applied Bolt Torques for Case Flange Bolts*. Tighten all nuts uniformly to approximately 10% of the specified torque; then using the illustration as a guide, tighten to full torque. Check and re-tighten after turbine is at normal operating temperature, using the sequence shown.

g. For the SST 700H casing, tighten all bolts in sequence indicated in Figure L-3 to level 1, and then repeat the sequence at level 2, and then at level 3 indicated in table L-2.

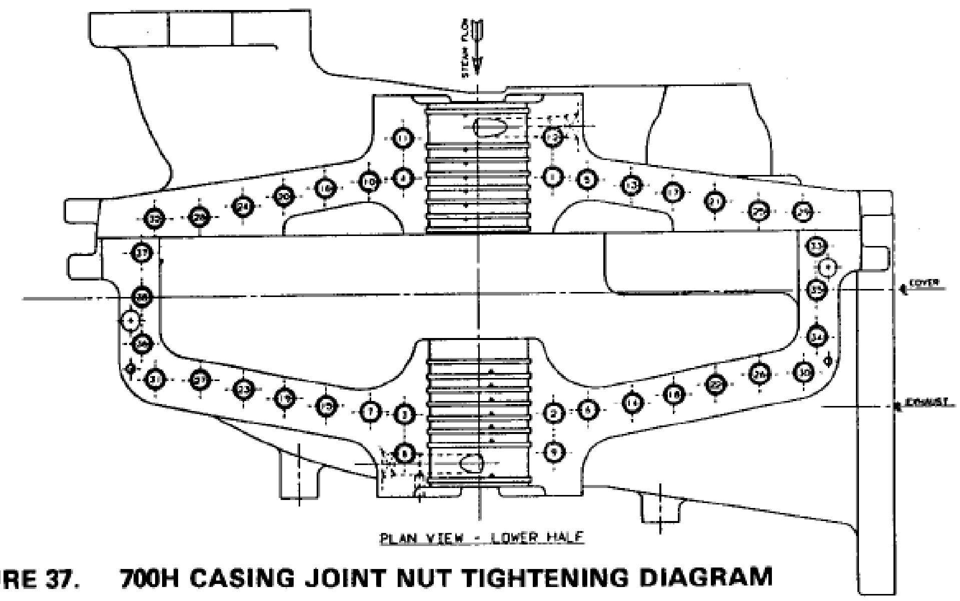


FIGURE 37. 700H CASING JOINT NUT TIGHTENING DIAGRAM

Figure L-3. Flange Bolt Torque Sequence, Series 700H

	BOLTS #1-#24	BOLTS #25-#38
FIRST PASS	2601-FT-LBS	2001-FT-LBS
SECOND PASS	5251-FT-LBS	4001-FT-LBS
THIRD PASS	5251-FT-LBS	4001-FT-LBS

Table L-2. Applied Bolt Torques Case Flange Bolts

h. Complete installing flange bolts using the sequence in Figure L-3 and the applied torques in Table L-2.

i. After the turbine is completely re-assembled and the coupling is made up, it should be brought up to operating temperature and the bolts checked again. There should be no slacking off of the bolts as a result of heating and cooling.

j. When removing or replacing the top half of the casing, great care must be exercised to avoid damage.

L.4 Carbon Ring Removal and Replacement

L.4.1 Carbon Ring Removal

Refer to the following figures:

L-4 *Carbon Ring Assembly, Non-Condensing Turbine*

L-5 *Carbon Ring Assembly, Condensing Turbine*

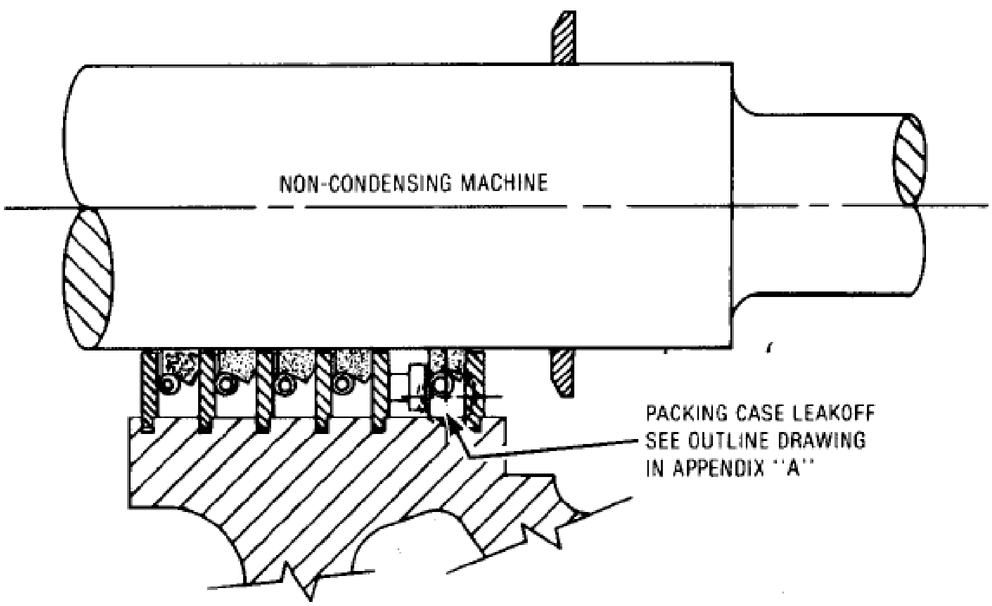


Figure L-4 Carbon Ring Assembly, Non-Condensing Turbine

When removing the packing rings, be sure to keep each ring by itself. Note that the ring segments are marked; these marks should be placed together when fitting or replacing the rings in the turbine. When gland leakage indicates the necessity of packing ring maintenance, it is recommended that new rings be installed.

New packing rings furnished by Dresser-Rand will be made with the correct diametral clearance, based on the original contract steam conditions. A packing ring diagram, EW-33275 located in Appendix A, shows the part number and location of each ring in the turbine.

When it is necessary to refit old rings (due to emergency condition) remove a small amount, approximately 0.001"/0.025 mm from the ends of each segment, maintaining flat square ends. The diametral clearance between the carbon rings and the shaft should be as specified in the Packing Ring Diagram.

When installing new rings, the shaft surface should be smooth and highly polished, clean and free of dust, water or oil. The spacer rings should be clean and smooth with a true surface. If the sealing surface of the spacer ring is warped, the carbon ring cannot seal. Warped spacer rings should be replaces. To install new carbon rings, see Figure L-6 for procedure.

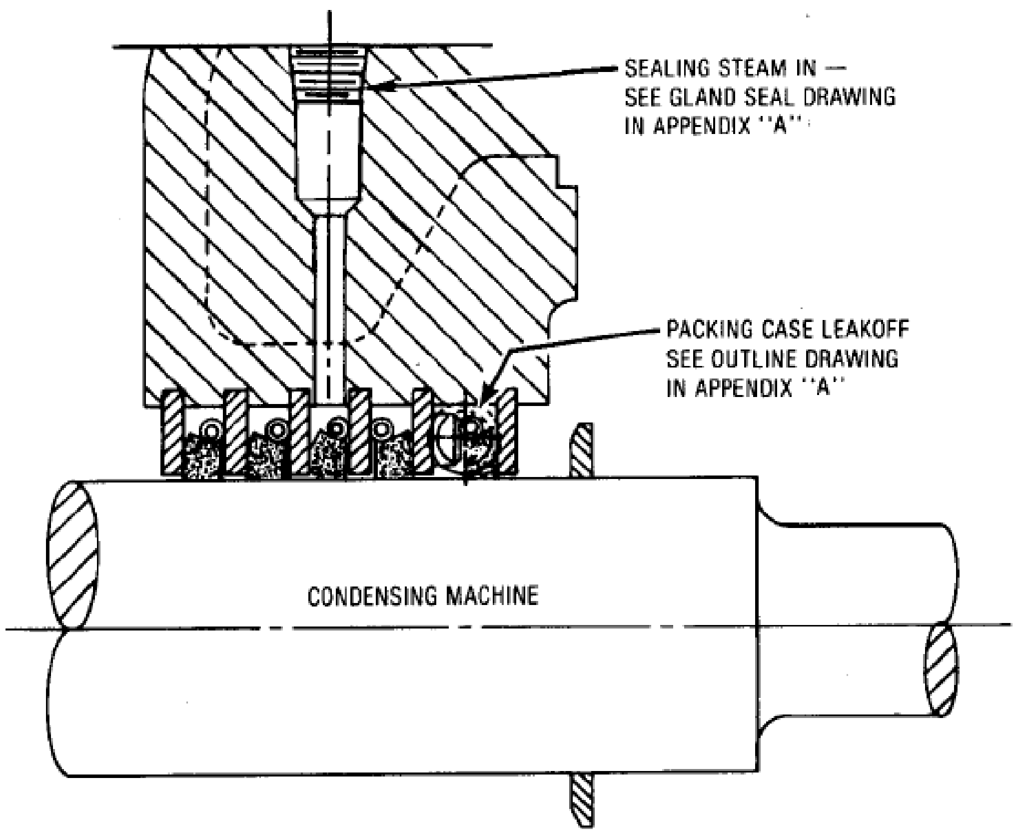


Figure L-5 Carbon Ring Assembly, Condensing Turbine

a. If there is a leak-off connected to the cover disconnect this and remove the pipe from the cover.

b. Remove turbine cover according to the procedure specified in Section L.3.1.

c. Disconnect the garter spring ends. Remove the garter springs and carbon ring segments. Note that the anti-rotation pin in the packing case may interfere with carbon ring segment removal. If so, simply rotate the segment in the opposite direction, or rotate the partition plate.

d. Inspect and clean the spacer rings. If the spacer rings are damaged they should be replaced. The shaft will have to be removed. Refer to Section L.9 *Rotor and Turbine Wheel Removal and Replacement*.

e. Clean the stainless steel high velocity oxy fuel-coated surfaces of the shaft with stainless steel high velocity oxy fuel spray. Inspect the stainless steel plating. If plating is bubbled, split or peeling the shaft must be replaced.

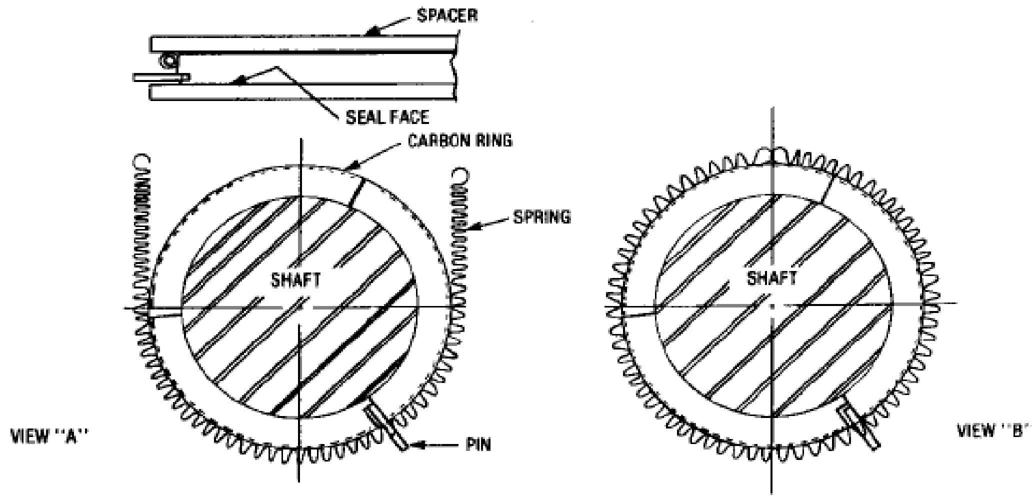
L.4.2 Carbon Ring Replacement

a. Thread the garter springs into the slots between the spacer rings.

b. Install the carbon ring set one complete set at a time. Be certain to maintain the correct relationship between carbon ring segments by matching dots stamped on each segment. Dots should face toward the wheel. The anti-rotation notch must engage the anti rotation pin.

c. Connect the garter springs to retain the carbon rings.

d. Replace the turbine cover per Section L.3.1.



TO INSTALL:

1) PIN IS PERMANENTLY INSTALLED IN LOWER HALF OF PACKING CASE.
2) INSTALL SPRING AS IN VIEW "A".
3) NOTE MATCH MARKS ON END OF CARBON RINGS AND DIRECTION OF SLANT AS SHOWN IN FIGURE 34
4) FASTEN LOOSE ENDS OF SPRING TOGETHER (VIEW "B").

FIGURE 32. TYPICAL CARBON PACKING INSTALLATION

Figure L-6. Typical Carbon Packing Installation

L.5 Casing Labyrinth Seal Removal and Replacement

No field repairs of labyrinth are recommended. Slight deposits of the labyrinth on the turbine shaft is an acceptable condition.

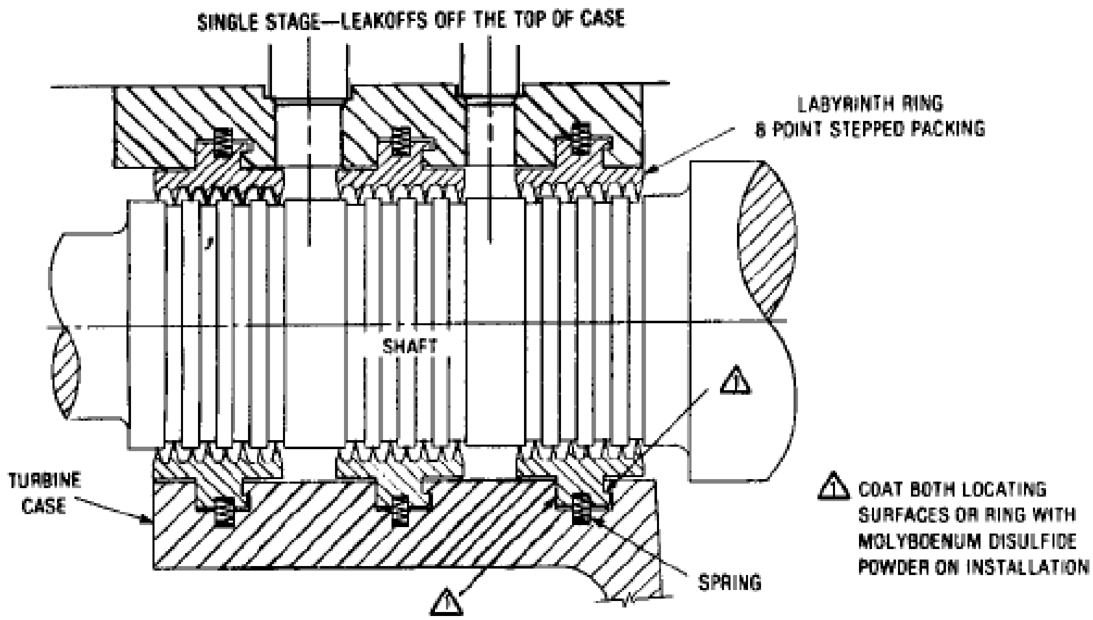
When installing new labyrinth rings, polish the shaft clean to remove any deposits which may have formed.

Make sure that the quadrants of each ring are matched and that the rings are installed in their proper position as identified in the packing ring diagram, EW-33275. On installation of each quadrant of a gland-packing ring, make sure a compression ring is installed in each hole. (See Figure L-7)

All SST turbine designs require removal of the turbine cover to remove, inspect, and replace labyrinth seals. Refer to the appropriate section below to service these labyrinth seals.

L.5.1 Casing Labyrinth Seal Removal

Refer to the following figure:



L-7 Labyrinth Seal Assembly

a. Remove the turbine cover according to the procedure specified in Section L.3.1. The labyrinth seal segment(s) in the cover will be removed during this operation.

b. Remove leak-off piping before removal of seals.

c. Inspect labyrinth seal segments, locating springs, and the shaft for corrosion, scoring, or other damage. Clean all components. Replace any part that is no longer serviceable. Labyrinth seal segments must be replaced as a set. Severe rubbing one side of all labyrinth teeth may indicate a worn or failed thrust bearing. Refer to Section L.6.2, *Thrust Bearing Removal and Replacement,* if the thrust bearing is suspect.

L.5.1 Casing Labyrinth Seal Replacement

a. Install labyrinth seal segments into the lower half casing by rotating them between the shaft and casing. Install the locating springs in the depressions, in the segment and compress the springs as the segment is rotated.

b. Install the labyrinth seal segments into the seal housing lower half with springs. Note that the labyrinth seal segments are matched-marked. Insure that they are installed with their match-marks next to each other.

c. Install the labyrinth seal segments and springs in the seal housing upper half.

d. Replace the turbine cover and gland-housing cap according to the procedure specified in Section L.3.1.

L.6 Turbine Bearing Removal and Replacement

SST turbines can be supplied with two, split sleeve journal bearings and one ball thrust bearing. Shaft journal and bearing dimensions are shown on the turbine data sheets. When running clearance is excessive, the bearings should be replaced not re-babbitted. Approximately 0.004”/0.101mm over the maximum clearance is considered excessive. However, if conditions permit and the unit runs smoothly, bearings may be kept in service when clearances exceed the recommended maximum clearance. It is left up to the discretion of the operating engineer as to when bearing replacement is necessary. The bearings are longitudinally split to permit removal and installation without removing the shaft.

Refer to the following figures:

M-4 *Bearing Housing Assembly, Exhaust End Simple Bearing Case*

M-5 *Bearing Housing Assembly, Exhaust End Hi Cap Bearing Case*

M-6 *Bearing Housing Assembly, Non-Drive End Simple Bearing Case*

M-7 *Bearing Housing Assembly, Non-Drive End Hi Cap Bearing Case*

L.6.1 Sleeve - Type Journal Bearing Removal and Replacement

The journal bearing can be inspected and replaced without removing the turbine upper case.

Sleeve Bearing Removal

a. Remove the bolts securing the governor mounting housing to the steam end bearing cap.

b. Use a soft drift and hammer to loosen the upper half of the bearing housing. Tap on the area where the upper half overlaps the lower half. Remove the upper half.

c. Lift, raise, and slide oil rings over to allow removal of the upper bearing half.

d. Raise the shaft slightly (0.040 inch/1 mm) to expose the bearing split line and remove the upper bearing half.

e. Rotate lower bearing half out of the bearing housing with the locating tab exiting the housing upon initial rotation.

f. The shaft can then be rested on the labyrinth seal or optional Inpro/Seal after the bearing is removed.

g. Inspect bearings for wear or scoring. Replace if necessary. Refer to Section B.9 for recommended sealant.

h. Inspect shaft journals. If journals are worn or scored, the shaft must be replaced. Slight scratches or nicks can be removed by stoning or with crocus cloth.

Sleeve Bearing Replacement

a. Verify that the bearing journal is clean and undamaged. Coat the journal with turbine oil.

b. Lift the shaft (0.040 inch/1 mm) to permit sufficient room to rotate the lower bearing half into the housing.

c. Rotate lower bearing half into bearing housing with the locating tab correctly aligned with the slot in the housing. Note that the bearing split line is below the bearing housing split line. On installation, the bearing stops will act as dowels and properly locate the bearings.

d. Lower the shaft onto the lower bearing half.

e. Snap the upper half of the bearing into the upper bearing housing half, aligning the tab so that it fits into the milled slot. After installation, check clearance using plasti-gage or lead wire.

f. Place the oil ring(s) into slot(s) on the upper bearing half and verify that they are free to turn.

g. Drain and clean bearing housing reservoirs and refill to the proper level with clean oil.

h. Apply a thin coating of sealant to the horizontal joint of the bearing housings. Refer to Section B.9 for recommended sealant.

i. Replace the bearing cap carefully, so as not to crush the sleeve bearing tabs.

j. Insert and drive in the dowel/taper pin.

k. Install washer and nuts on studs. Torque the nuts first to 25 ft-lbs (34 N-m) and then to 55-65 ft-lbs (75-88 N-m).

l. Install bolts and torque them to 55-65 ft-lbs (75-88 N-m).

m. Rotate shaft by hand and observe oil rings through inspection holes in the bearing cap to verify that rings rotate freely.

n. Install bolts holding upper bearing housing half to governor mounting housing.

L.6.2 Thrust Bearing Removal and Replacement

The standard thrust bearing is a ball bearing located in the non-drive end bearing housing. Tilting pad thrust bearings are supplied optionally on some turbines. Refer to the appropriate vendor manual for details.

For turbines where the governor is coupled to the shaft, remove steam end bearing case cap and then uncouple and remove the governor. For gear driven Woodward governors disconnect the governor linkage without disturbing the length of the connecting rod, then remove the bolts that fasten the governor to the housing and lift off the governor.

The thrust bearing is properly positioned on the turbine shaft by shims at the factory and should require no adjustment. These shims are used to adjust the nozzle ring-to-wheel clearance. See figure L-8. Shims are also used to set the running clearance (float) on a shoe or collar type thrust bearing. Recommended running clearance for the thrust bearing is 0.010” to 0.020”.

Thrust Bearing Removal

a. Remove the turbine rotor according to the procedure specified in Section L.9.

b. Remove lock nut and lock-washer from the turbine shaft.

c. On turbines with ball bearing journal bearings, remove the oil ring and oil ring sleeve.

d. Using a suitable puller, remove the thrust bearing from the shaft. Tag both sets of upper and lower shims to facilitate re-assembly.

e. Using a suitable puller, remove the journal ball bearings from the shaft.

CAUTION

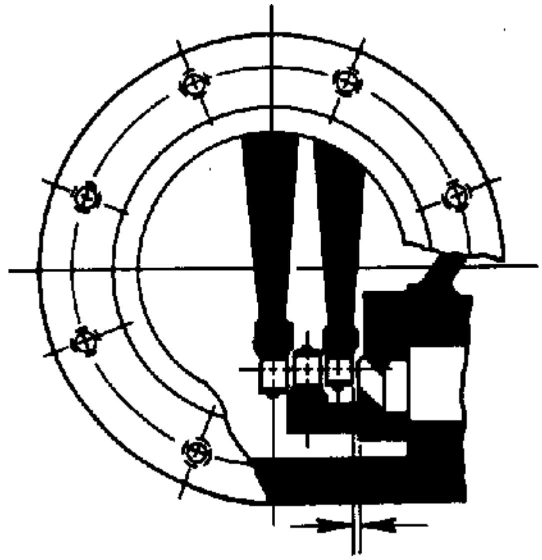
When removing or replacing ball bearings mounted on a shaft, NEVER PRESS OR APPLY FORCE to the OUTER RACE, as this may damage the races or balls. NEVER HAMMER on either the inner or outer races. Bearings should be pressed on or off shafts with a steady force. Always inspect the shaft for burrs or foreign material and remove them as necessary, prior to removal or installation of bearings. If a BEARING BINDS during installation or removal, DETERMINE THE CAUSE and CORRECT it rather than apply more force. Installation should be performed by heating bearings prior to assembly. Heat bearings slowly and evenly to a temperature not exceeding 250°F (120°C). Special electrical heaters are available from industrial suppliers for bearing heating. Alternatively, bearings may be heated in an oil bath.

f. On turbines with sleeve journal bearings, take care not to lose the flat spring located in the bottom of the bearing housing groove. This spring prevents rotation of the outer race of the thrust bearing.

Thrust Bearing Replacement

a. Install thrust bearing on the shaft with the shield (if so equipped) facing out. Make sure that the bearing is installed with the manufacturer's marking, such as a bearing number or "thrust here", facing upstream (towards the steam end of the shaft). Before installing the bearing case cap, check thrust bearing adjustments for the proper thickness of shims: 0.050", 1.27mm minimum with assembled shaft moved fully towards steam end. Set the clearance by properly positioning the thrust bearing. See Figure L-8 below:

Figure L-8 Nozzle Ring-To-Wheel Clearance



b. On turbines with ball bearing journal bearings, replace the oil ring sleeve and the oil ring.

c. Replace lock-washer and lock nut.

d. Bend the lock tab(s) to lock the nut into position.

e. Replace the turbine rotor into the turbine casing according to the procedure specified in Section L.9.

f. To replace a ball-type thrust bearing, see steam end bearing case assembly and longitudinal section drawings in Appendix A and proceed as follows:

g. Remove governor.

h. Remove steam end bearing case cap.

i. Remove bearing case end cover.

j. Disassemble parts from steam end of turbine shaft as necessary to gain access to the thrust bearing; then remove the bearing. Tag both sets of upper and lower shims to facilitate reassembly.

k. Reassemble by reversing the removal procedure. Make sure that the bearing is installed with the manufacturer's marking, such as bearing number or "thrust here", facing upstream (towards the steam end of the shaft). Before installing the bearing case cap, check the thrust bearing adjustments for the proper thickness of shims.

L.6.3 Ball-Type Journal Bearing Removal and Replacement

Bearing removal and replacement on SST 500 and SST 700 turbines with ball bearing journal bearings is accomplished using the same procedure as that specified for the thrust bearing in section L.6.2, *Thrust Bearing Removal and Replacement*. The only exception is that there is no lock washer or nut retaining the bearing on the drive end of the shaft. Removal of the exhaust end bearing requires the removal of the coupling and outboard bearing housing seal. Refer to Section L.5, *Casing Labyrinth Seal Removal and Replacement*.

L.7 Bearing Housing Shaft Seal Removal and Replacement

Bearing housings are provided with either labyrinth-type oil seals or optional inpro seals or magnetic seals. These seals prevent oil leakage from bearing housings and also prevent penetration of steam, dust, and dirt into the housings.

Bearing housing shaft seals are mounted on the turbine shaft. There are two seals on the drive end bearing housing and one on the non-drive end bearing housing.

Inpro seals & magnetic seals are optional, non-contacting bearing housing oil seals that replace the three standard labyrinth-type bearing housing seals. The drive end bearing housing has both an inboard and outboard seal. The non-drive end has only an inboard seal.

Inpro or Magnetic Seal Removal (Steam End)

Refer to the following figure:

L-9 *Bearing Housings With Optional Inpro/Seals*

a. Remove the half-coupling from the shaft.

b. Remove the rotor from the turbine according to the procedure specified in Section L.9.

c. On sleeve bearing turbines, remove the thrust bearing from the shaft according to the procedure specified in Section L.6.2

d. Clean the turbine shaft outboard of the seal.

e. Slide the seal assembly off the turbine shaft.

Inpro or Magnetic Seal Replacement (Steam End)

a. Clean the shaft and remove any burrs that could damage the seal O-ring.

b. Lubricate the shaft and seal O-ring with turbine oil to facilitate seal insertion on the shaft.

c. Slide the seal assembly onto the shaft, placing it at is approximate final position.

d. On sleeve bearing turbines, replace the thrust bearing according to the procedure specified in Section L.6.2

e. Replace the rotor according to the procedure specified in Section L.9, using care to correctly position the seal when installing upper halves of the bearing housings.

f. Replace half-coupling on the shaft.

Inpro or Magnetic Seal Removal (Exhaust End)

(Note: Rotor must be out of the turbine.)

a. Remove the half-coupling from the turbine shaft.

b. Remove journal bearing, oil slingers, and any other items located outboard of the innermost seal.

c. Slide the seal out of the recess in the bearing housing and off the shaft.

Inpro or Magnetic Seal Replacement (Exhaust End)

a. Clean drive end of the shaft and remove any burrs that could damage the seal O-ring.

b. Lubricate the shaft and seal O-ring with turbine oil to facilitate seal insertion on the shaft.

c. Slide the seal onto the shaft, placing it into the recess in the lower bearing housing half.

d. Replace the upper bearing housing half according to the procedure specified in Section L.6.

e. Replace half-coupling on the shaft.

f. Reassemble rotor into the turbine along with the steam seals.

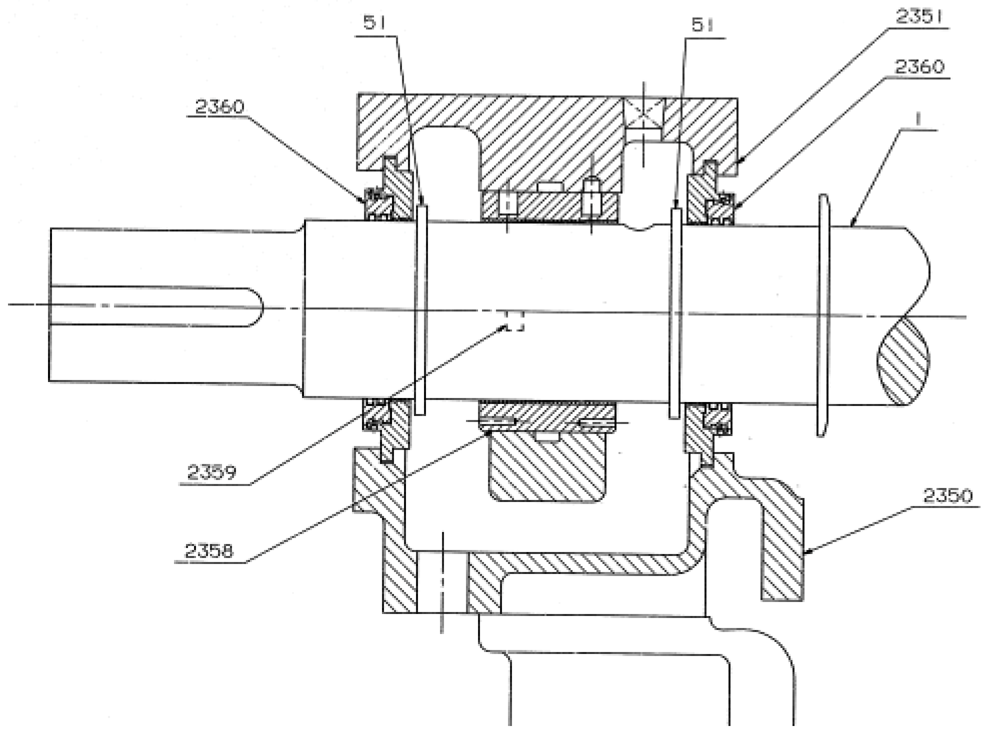


Figure L-9. Bearing Housings with Inpro/Seals

L.8 Bearing Housing Removal and Replacement

SST bearing housings are attached to the lower turbine casing with bolts. Two dowel pins on each housing, maintain their position. Alignment of bearing housings to the casing and to each other is essential for vibration-free operation and long bearing life. Bearing housings are accurately aligned at the factory prior to pinning. Should it be necessary to remove or replace a bearing housing, it is essential that the alignment be checked and corrected, if necessary, prior to re-installation of the rotor.

Bearing housing alignment is a precision process that requires skill, experience, and precise measurement. If there is any question regarding the ability of site personnel to properly align bearing housings, Dresser-Rand recommends that a factory-trained serviceman be engaged to perform the service. Contact your Dresser-Rand manufacturer's representative or the Dresser-Rand factory to schedule a service visit.

L.9 Turbine Rotor & Turbine Wheel Removal and Replacement

Refer to the following figures:

M-0 *SST Turbine, General View*

M-1 *Trip Throttle Valve Assembly*

M-2 *Governor, Mounting Housing, and Trip Components*

M-3 *Gland Sealing Elements*

M-4 *Hi-Cap Bearing Case Assembly, Exhaust End*

M-5 *Bearing Housing Assembly, Exhaust End*

M-6 *Bearing Housing Assembly, Steam End*

M-7 *Bearing Housing Assembly, Steam End*

M-8 *Case, Rotor and Mechanical Gland Seals*

M-9 *Case, Rotor and Carbon Ring Gland Seals*

L.9.1 Turbine Rotor Removal & Replacement

The governor, turbine cover, casing labyrinth seals (if so equipped), and carbon rings must be removed or disassembled to remove the rotor.

Turbine Rotor Removal

a. For turbines where the governor is coupled to the shaft, remove the steam end bearing case cap; then uncouple and remove the governor. (See longitudinal section, Appendix A). For a gear driven Woodward governor, disconnect the governor linkage without disturbing the length of connecting rod, remove bolts that fasten the governor to the housing and lift off the governor.

b. Remove the over-speed trip collar according to the procedure specified in Section L.14.

c. Remove upper halves of bearing housings according to the procedure specified in Section L.6.1.

d. Remove the top half of the turbine case according to the procedure specified in Section L.3.

e. Remove shaft packing according to Section L.5.

f. Remove cap from the exhaust end bearing case and steam end bearing case (if not already removed in step 1.

g. Remove both main bearing top halves.

h. Arrange a suitable support for the rotor assembly. Verify that turbine wheel blades and bearing journal surfaces on the shaft will not make contact with any surrounding object. Verify that the assembly will not roll off the support.

i. Use slings and a crane or hoist to lift the rotor assembly just out of the lower half of bearings; then remove lower half of bearings. Use extreme care when lifting the assembly to avoid damaging the wheel, blades, shaft, or sector.

j. Place rotor assembly on the support.

Turbine Rotor Replacement

a. Verify that the interior of the turbine casing is clean and that all foreign objects have been removed.

b. Clean or replace journal bearings (if so equipped) and lubricate journal area of the shaft to prevent scratching or scoring.

c. If so equipped, place lower journal half into the bearing housing. Position oil rings so that they fit into openings provided in the bearing housings.

d. Using slings and a crane or hoist, lower the rotor assembly into the casing. Use care to avoid damage to the wheel, blades, shaft, or sector.

e. Check clearance between first wheel and nozzle ring. This clearance is obtained by properly locating the thrust bearing. See figure L-8 and thrust bearing adjustment procedure in section L.6.2.

f. Replace casing labyrinth seals (if so equipped) according to the procedure specified in Section L.5.

g. Replace turbine cover and gland housing upper halves (if so equipped) according to the procedure specified in Section L.3.1.

h. Replace the sleeve bearing upper halves (if so equipped) and bearing housing upper halves according to the procedure specified in Section L.6.

i. Replace the governor mounting housing

j. Replace over-speed bolt trip collar according to the procedure specified in Section L.14.

k. Replace governor drive coupling governor and associated linkage according to the procedure specified in Section L.12.

L.9.2 Turbine Wheel Removal and Replacement

This operation is to be referred to Dresser-Rand service facilities.

CAUTION

DO NOT allow the heating FLAME TO IMPINGE on turbine BLADES, as this could anneal and WEAKEN them.

WARNING

Exercise appropriate CAUTION in handling the HOT WHEEL during disassembly and assembly.

CAUTION

Be certain to assemble the wheel and shaft with THE SHORTER BLADES TOWARD the NON-DRIVE END OF THE SHAFT. Otherwise, the rotor cannot be installed.

L.9.3 Turbine Rotor Balancing

Whenever a wheel or shaft is replaced, the wheel and shaft subassembly should be dynamically balanced. This procedure must be performed by a Dresser-Rand repair facility.

L.10 Nozzle Ring Removal and Replacement

Nozzle rings contain one or more nozzles which expand the inlet steam to a lower pressure, creating the necessary kinetic energy (velocity) at the entrance of the first wheel blading.

L.10.1 Nozzle Ring Removal

After the rotor and guide ring have been removed from the lower half turbine casing—

a. Loosen and remove nozzle ring cap screws. This may, at times present a problem. Broken screws will have to be extracted or drilled out.

Note: When nozzle ring is secured with inner and outer bolts, no caulking strip is used.

b. The nozzle ring may now be lifted out of the casing. Mark the ring to identify its location if reused (upper or lower half).

L.10.2 Nozzle Ring Replacement

Nozzle rings are caulked in at the outer periphery and bolted to the steam ring nozzle bolting face of the main casing when a single row of bolting is used. When a double row of bolting is used, there is not a caulking strip.

a. Identify the upper and lower half nozzle ring. If necessary check that the valve port bridge walls match their seal surfaces using bluing or white lead.

b. Check that the clearance holes in the nozzle ring and tapped holes in the steam ring face agree.

c. Thoroughly clean the sealing surface at the steam ring face. If the surface is smooth, the most common sealing compounds are Turbo R or Turbo 50. If the surface is rough, use Copaltite. If these compounds are not available, use a key paste or a mixture of graphite and oil. If none of these compounds is available, call Dresser-Rand Technical Support.

d. Bolt the nozzle ring half in place. The cap screws should be pulled tight but not over-tightened. If Allen wrenches bend during tightening, the screws are overstressed and their heads may snap off when the unit comes up to temperature. Over-tightening of screws must be avoided. Prick-punch head clearance holes at four positions so that cap screw heads (if broken off) cannot come out into the steam path.

L.11 Hand-valve Removal and Replacement

Hand-valves are optional items. Depending on steam conditions, required power and speed, and initial customer requirements, the turbine may incorporate no hand-valves, one hand-valve, or two hand-valves.

The purpose of hand-valves is to isolate a nozzle or group of nozzles from inlet steam, thereby allowing the turbine to operate at reduced power output without excessive throttling. When operated at reduced power in this fashion, the turbine is more efficient than it would be if all nozzles were active.

Hand-valves should be either fully open or fully closed, never in between. Operating with a partially closed hand-valve is not only inefficient, but could result in steam cutting of the seat resulting in excessive leakage. When putting the unit into operation, do not close a hand-valve tightly until the turbine is up to operating temperature and all parts are evenly heated. The reason for this is that the material of the valve stem is subject to greater thermal expansion than the turbine casing, and if the valve is closed tightly when cold, it may lock the valve in the closed position making it difficult to open.

Refer to Figure L-10, *Hand-valve Assembly*.

L.11.1 Hand-valve Removal

WARNING

Close and tag inlet and exhaust isolating valves and open drains to depressurize the turbine casing and steam chest before maintaining hand-valves.

Note: Removal of the hand-valve is done from inside the turbine case.

a. Remove the turbine casing cover and bearing case covers, uncouple the turbine rotor, and remove the carbon rings. See instructions in other sections of this manual for these steps.
b. Remove the turbine rotor. Remove the nozzle ring.
c. Once the nozzle ring is removed you can see the hand-valve seat (761). Pull out the hand-valve seat. The fit is on-line to 0.004” loose.
d. Remove the hand wheel (758). Remove the hand-valve bonnet (750).
e. Push the stem and disc assembly out towards the inside of the turbine. Remove the old hand-valve packing (754). Note: Count the rings removed.
f. Clean the seat area, nozzle ring face, and all areas that might have sealant.

L.11.2 Hand-valve Replacement

a. Inspect the stem and disc assembly. Hand-valve collar (752) should be tight and staked to the disc (751).
b. Insert the new stem and disc assembly into the turbine hand-valve location.

c. Make sure the seat (761) and the bore of the turbine case are clean. Insert the seat into the hole where it was removed. If there is a slight interference, cool down the seat in a freezer or with liquid Nitrogen.
d. Install the nozzle ring in accordance with instructions in other sections of this manual.
e. Assemble new packing (754). Put in the same number of packing rings as were removed.
f. Assemble bonnet (750) and hand wheel (758). Tighten the bonnet to compress the packing until you feel a slight drag on the stem when you screw it in and out.

L.11.3 Reassembly of the Turbine Rotor and Upper Half Casing

a. Clean all surface areas (turbine casing split-line, bearing case split-lines, etc).
b. Assemble the carbon rings, turbine cover, and bearing case covers per instructions given in other sections of this manual.

L11.4 Hand-valve Adjustment

a. One steam is admitted into the unit, re-tighten the hand-valve bonnet so there is no steam leaking out of the steam area. This might have to be done again when there is full pressure inside the casing to prevent leakage at the high internal pressure.
b. The valve stem should be screwed fully closed or fully open. It should never be partially open or closed.

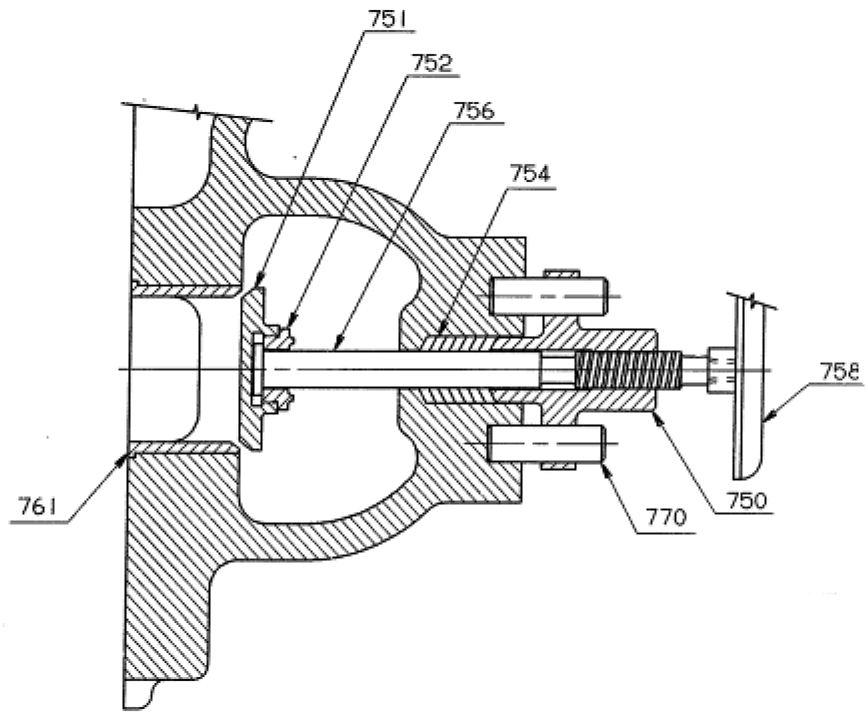


Figure L-10. Hand Valve Assembly

L.12 Governor Removal and Replacement

Refer to the following figures:

M-2 *Governor, Mounting Housing, and Bolt Trip Components*

L-11 *Direct Drive Governor Assembly*

L-12 *Gear Drive Governor Assembly*

L.12.1 General

Field service on the oil relay governor is normally limited to yearly oil changes per Section J, and droop setting adjustment, which is described in the governor manual provided in Appendix B.

In the event that the governor exhibits operational problems, Dresser-Rand recommends that the governor be removed as a unit and returned to the factory for repair or overhaul, as required. In the meantime, a replacement oil relay governor can be quickly and easily installed to keep the turbine in operation. The Dresser-Rand factory maintains a stock of certain TG replacement governors for rapid field delivery, and is equipped to perform comprehensive repair, overhaul, and testing of oil relay governors.

For shipment, care should be exercised to support the governor by its mounting flange and not by its shaft extension.

Some governors are direct-drive types coupled to the end of the turbine shaft by couplings, as shown in Figure L-11. Others, due to speed requirements, are connected by right-angle gear reduction units, as shown in Figure L-12.

L.12.2 Governor Removal (Direct Drive)

a. Drain oil from governor (300) at drain.

b. Disconnect connecting rod (1075) at governor lever (445) by removing connecting rod end (1070). Do not disturb position of rod end (1070) bearing on rod (to preserve open/close stroke adjustment).

c. Rotate turbine shaft (1), if necessary, to disengage coupling hub (303) by loosening coupling setscrew.

d. Prop or support governor (300); then, unbolt governor from mounting housing (201) and slide governor out of mounting housing. Be careful not to lose the governor key.

e. Remove governor trip latch (446) (if same governor is not to be used as temporary replacement) by loosening its setscrew.

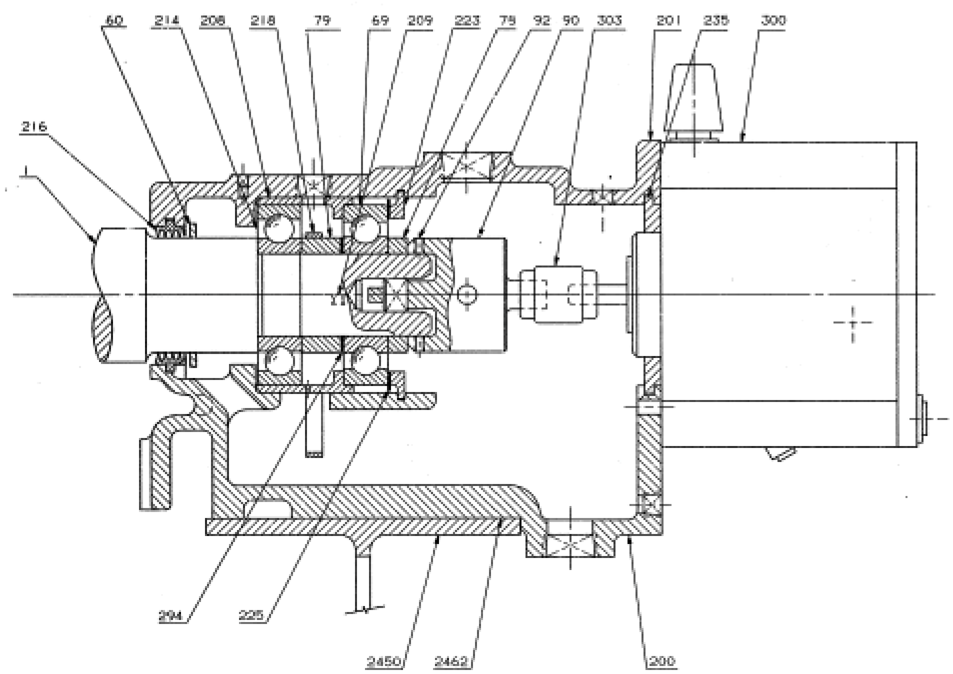


Figure L-11. Direct Drive Governor Assembly

L.12.3 Governor Replacement (Direct Drive)

a. Install governor trip latch (446) and tighten lever set-screw securely.

b. Slip coupling spider between jaws of coupling (303) hub on turbine shaft extension.

c. Install coupling hub (303) on governor shaft.

d. Slide governor (300) into place on mounting housing (201), verifying that coupling (303) engages properly.

e. Install and tighten screws to secure governor to mounting housing (303). There should be 1/16 inch (1.6 mm) play for the coupling spider between coupling hubs. Coupling access is available through the open side of the mounting housing. Tighten screw to secure coupling.

f. Reconnect connecting rod (1075).

g. Remove governor breather cap and fill governor with oil to proper level indicated on sight glass.

h. Rotate turbine shaft (1) slowly by hand to ensure that governor and coupling are free to turn when placed in operation.

L.12.4 Governor Removal (Gear Drive)

a. Drain oil from governor (300).

b. Disconnect connecting rod (1075) at governor lever (445) by removing connecting rod bolt. Do not disturb position of rod end bearing on rod (to preserve open/close stroke adjustment).

c. Remove cap screws securing governor (300) to gearbox (316) adapter; then, lift governor vertically from adapter. The coupling (303) will remain on the governor shaft at removal. Do not remove governor lever or coupling from governor if same governor is to be installed again. If a new governor is to be installed, transfer lever and coupling (with keys) to new governor. The lever and coupling are secured to governor shafts by setscrews.

Note: The coupling, which joins the governor and gearbox shafts, is supplied with the gearbox.

L.12.5 Governor Replacement (Gear Drive)

a. Verify that coupling and keys are installed on governor shaft, and that the governor lever is mounted to its shaft at the side of the governor.

b. Lower governor (300) on gearbox (316) adapter with coupling key slots positioned to allow mating of keys and key slots of shaft and coupling (303) as governor and adapter flanges meet.

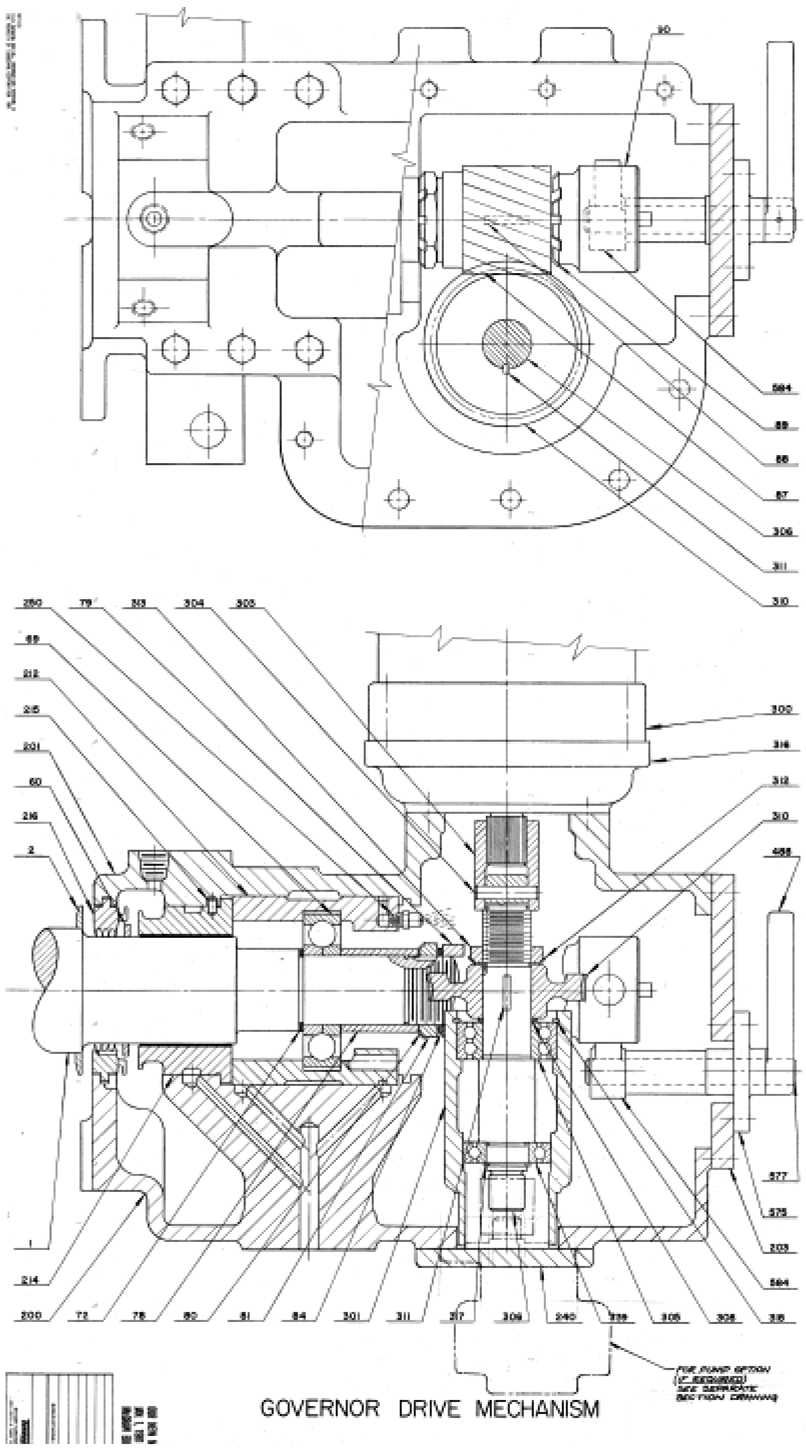
c. Rotate governor to align cap screw holes; then, install cap screws tightly.

L.12.6 Governor Drive Gearbox Removal

The governor (300) must be removed according to the procedure specified in Section L.12.4, above, before the gear (310) and governor drive shaft (306) can be removed.

a. Drain oil from steam end bearing case (200).

b. Remove pin (304) from coupling (303) to release coupling from governor drive shaft (306).



PART NO.	NAME OF PART
1	SHAFT - TURBINE
2	SLINGER
60	SLINGER - OIL
69	BEARING
72	SHIM
78	SLEEVE
79	SPACER
80	LOCKWASHER
81	LOCKNUT
84	SHIM
87	GEAR
88	KEY
89	LOCKWASHER
90	GOVERNOR CUP - ASSEMBLY SEE NOTE # 2
200	CASE - STEAM END BEARING
201	CAP - STEAM END BEARING CASE
203	COVER - END
212	SHELL
214	BEARING
215	STOP
216	BAFFLE - OIL
240	COVER
250	OIL SPRAY
300	GOVERNOR
301	HOUSING
303	COUPLING
304	PIN
305	BALL BEARING
306	SHAFT - GOVERNOR DRIVE
309	SHIM
310	GEAR
311	KEY
312	LOCKWASHER
313	LOCKNUT
316	ADAPTER
317	SNAP RING
318	SNAP RING
339	BALL BEARING
488	LEVER
575	BRACKET
577	PIN
584	FINGER

NOTE - 1
WHEN ORDERING REPAIR PARTS GIVE THE FOLLOWING INFORMATION
1 - THIS DRAWING NUMBER
2 - PART NUMBER AND NAME OF PART
3 - SIZE, TYPE, AND SERIAL NUMBER OF UNIT

NOTE - 2
FOR EMERGENCY TRIP PARTS SEE SEPARATE ASSEMBLY

Figure L-12. Gear Drive Governor Assembly

c. Remove lock-nut (313) and lock washer (312) retaining gear onto governor drive shaft (306). Slide gear (310) up off of shaft (306), being careful not to lose key (311).

d. Remove shim (308) being careful to document order of removal/replacement.

e. Remove snap ring (318) retaining bearing into housing (301). At this point the governor drive shaft (306) can be extracted from the housing (301).

f. Prop or support governor drive shaft (306) in a vice being careful not to scar the shaft surface and remove the snap ring (318) retaining the ball bearing (339). At this point both ball bearings (339) and (305) can be pressed from the governor drive shaft (306) for replacement.

The Dresser-Rand factory maintains a stock of replacement governor drive shaft parts for rapid delivery to the user, and is equipped to perform complete repair and overhaul service on gearboxes.

L.12.7 Governor Drive Gearbox Replacement

a. Install governor drive shaft (306) into housing (301) and install snap ring (318). Replace shim (308), locate key (311) into slot on governor drive shaft (306) and install gear (310), lock washer (312) and lock-nut (313) securing gear onto governor drive shaft (306).

b. Install coupling (303) and pin (304) into and onto governor drive shaft (306).

c. Before installing the governor, check and record the backlash of the new gear. In future inspections, use this dimension as a guide in determining the necessity for replacement. If backlash is questionable use Dyken layout blue or printers ink to check for proper mesh of gears. When a good mesh is indicated, the gear may remain in service.

c. Mount governor (3004) onto housing (316), verifying that the splines on the governor shaft slide into the coupling (303) easily. Install mounting bolts to secure governor (300) onto housing (316).

d. Fill hydraulic governor with oil. Refer to Woodward Bulletin 25071 in Appendix B.

e. Fill steam end bearing case (200) with recommended lubricant to required level, as indicated by oil sight gage plug.

L.12.8 Governor Valve Travel and Linkage Adjustment

Refer to the following figures:

M-1 *Trip Throttle Valve Assembly*

M-2 *Governor, Mounting Housing, and Trip Components*

L-11 *Direct Drive Governor Assembly*

L-12 *Gear Drive Governor Assembly*

L-13 *Trip Valve Linkage*

Adjustment of the linkage between the governor and throttle should be carried out whenever linkage components, or the governor itself, are replaced. Rig the throttle linkage as follows:

a. Check that the governor linkage is approximately at right angles to governor connecting rod. (See upper view of figure L-13). Adjust the length of the connection rod as necessary.

b. Back off the lock nuts on both sides of the governor lever block.

c. Pull the connecting rod out of the Woodward governor as far as it will go.

d. Push the connecting rod back toward the governor 3/16”/4.76mm. (To hold this position while making the adjustment, place a block equal to the existing clearance between the connecting rod end and the mating fitting on the governor—see lower view in Figure L-18.

e. Push the valve stem in until the valve just seats.

f. Tighten the lock nuts on both sides of the governor lever block to secure the ajdustment.

L.13 Trip and Throttle Valve Maintenance

CAUTION

If the turbine is equipped with a throttle or trip valve manufactured by a party other than Dresser-Rand refer to the accessory documentation section of this manual for installation, operation, and repair and maintenance instructions.

Refer to the following figures:

M-1 *Trip and Throttle Valve Assembly*

M-2 *Governor, Mounting Housing, and Trip Components*

L-13 *Trip Valve Trip Linkage*

L-14 *Throttle Valve Trip Linkage*

The design of the Dresser-Rand trip and throttle valve assembly permits routine maintenance (disassembly and assembly) procedures while still mounted on the turbine and without disconnecting the inlet piping. For major overhaul or necessary machine work, remove the valve as indicated below.

WARNING
BEFORE SERVICING ANY COMPONENT of the combo valve, verify that the ISOLATING VALVE in the INLET LINE is CLOSED AND TAGGED. If the turbine is connected to the exhaust steam header, CLOSE the ISOLATING VALVE in the EXHAUST LINE AND TAG IT. OPEN ALL TURBINE DRAINS to ensure venting of all pressure before disassembly begins.

CAUTION
In the following procedures, remove and replace all parts slowly and carefully to avoid damage (digs, bends, scoring, chipping, etc.) to conditioned surfaces. DO NOT use excessive force to remove parts. Use backup bracing for unsupported parts when taper pins or dowels are removed by hammer and drifts.

L.13.1 Valve Removal from Turbine

The steam strainer should be removed and cleaned at least once a year and replaced every three years. Since it is necessary to remove the governor valve before the strainer can be withdrawn, the governor valve and its seats should be inspected and reground if necessary. To replace either the governor valve or the steam strainer, proceed as follows: (See Figure L-14).

a. Remove valve adjusting nut and washer.

Note: Do not disturb settings of lock nuts and connecting rod-ends (17 and 19) on rod (18) unless parts need to be replaced. These are factory-set to provide the required stroke for the rod.

b. Remove snap ring from the governor lever pin; then remove the pin and carefully slide the governor lever off the governor valve stem.

c. Remove the nuts that secure the steam chest cover to the steam chest and carefully remove the cover without contacting the valve stem.

d. Pull out the governor valve (see governor section, Appendix A).

e. Remove bolting at turbine flange; then, lift valve by slings and hoist to service area for further disassembly.

f. Remove as an assembly together with the steam strainer.

g. Perform necessary maintenance and reassemble by reversing the removal procedure.

h. After completing installation, set the following:

Overspeed Trip

Overspeed Trip Linkage

Governor Valve Travel

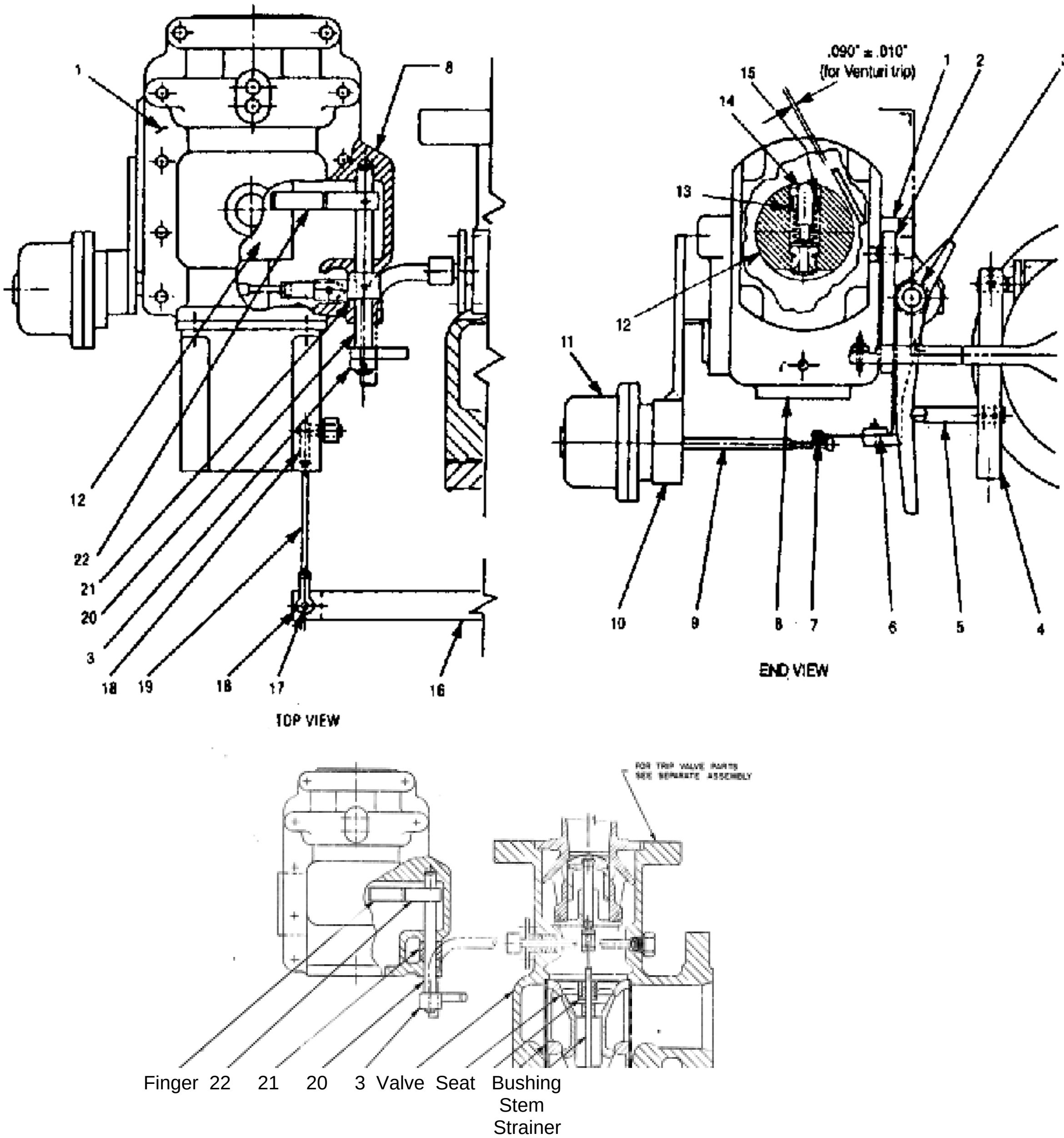


Figure L-13. Overspeed and Governor Valve Linkage

Legend

1. Cap
2. Lever
3. Lever – Trip
4. Lever – Trip Connection
5. Rod – Trip Connection
6. Plate – Top
7. Latch – Trip Assembly
8. Case – Steam End
9. Steam – Bellows
10. Bracket - Low Oil Trip
11. Low Oil Trip
12. Governor Cup
13. Adjusting Screw
14. Emergency Weight
15. Lockscrew
16. Lever - Governor
17. Pin
18. Rod End
19. Rod - Connecting
20. Shaft - Trip
21. Collar
22. Trip Finger & Lever

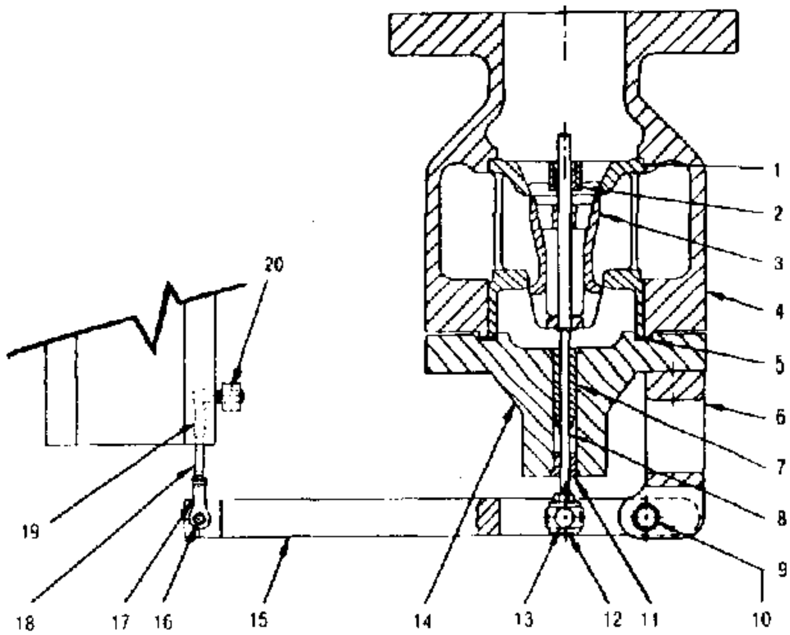


Figure L-14. Throttle Valve Linkage

Legend

1. Bushing – Valve Seat
2. Bushing — Valve Stem
3. Valve
4. Steam Chest
5. Gasket
6. Bracket – Governor Lever
7. Bushing - Valve Stem - Inner
8. Stem - Valve
9. Pin
10. Bearing
11. Bushing – Valve Stem-Outer
12. Block - Pivot
13. Block – Sliding
14. Cover – Steam Chest
15. Lever - Governor
16. Pin
17. Rod End
18. Rod- Connecting
19. Rod End
20. Lever

L.13.2 Woodward TG Governor Valve Travel Setting

a. Remove pin that connects the governor lever to the connecting rod end. (See Figure L-15.)
b. Push the governor lever in until valve just seats and hold this position.
c. Push connecting rod toward the valve closing direction (see arrow on illustration) as far as it will go and hold this position.
d. Adjust the length of the connecting rod so that the hole for the pin in the rod end is approximately 1/8”/3.75mm beyond the mating hole in the governor rod.
e. Release the connecting rod and insert the connecting pin.

L.13.3 Woodward TG-13L Governor with Fisher Control

The Fisher pneumatic speed mechanism acts in conjunction with the Woodward TG-13L governor to adjust the turbine speed to refined limits. If speed re-adjustment is desired, re-locate the pin to another hole in the lever (see Governor Speed Control Schematic, Appendix A).

The Fisher control can be used as a direct or reverse type control; either to increase governor speed settings as control air pressure signal increases, or the reverse type to increase governor speed as control air pressure signal
decreases.

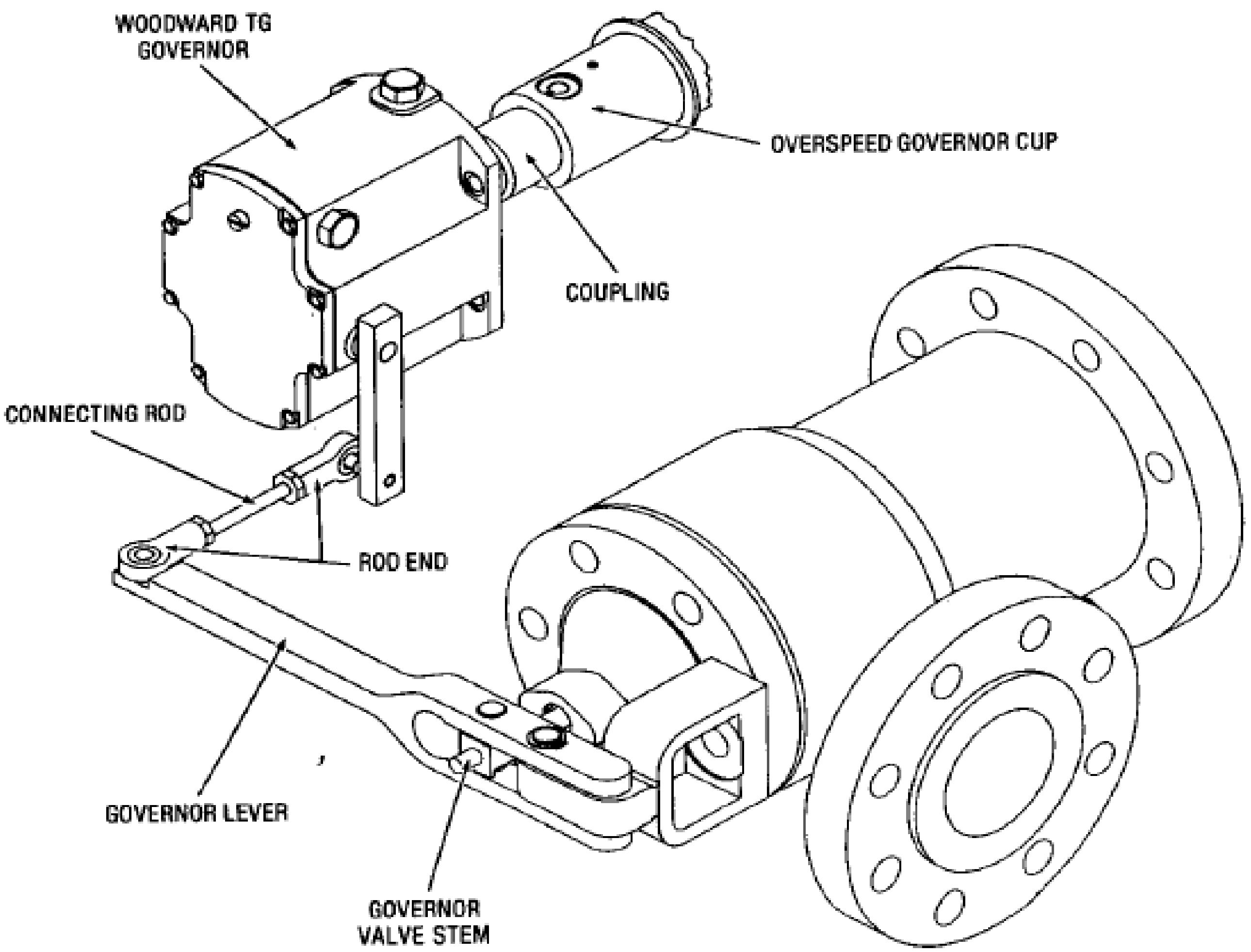


Figure L-15. Governor Valve Travel Setting – Woodward TG Governor

L.13.4 Alternate Governor Valve Stem Connection

Some Dresser-Rand turbines may be equipped with an alternate method of securing the governor valve stem to the rotating governor lever. This connection should be installed so that the inner and outer washers are tight against the alignment pin. The operator should be able to turn the washers by hand with no lost motion after tightening the inner and outer jam nuts.

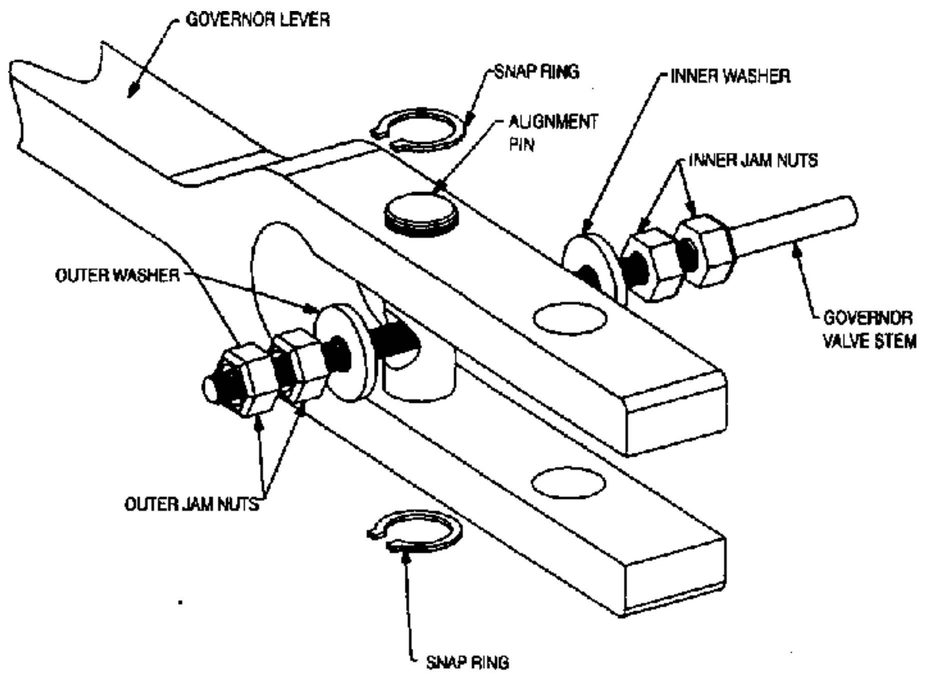


Figure L-16 Alternate Governor Valve Stem Connection

L.14 Emergency Valve Maintenance

> **WARNING**
>
> BEFORE SERVICING ANY COMPONENT of the Overspeed Trip Mechanism, verify that the ISOLATING VALVE in the INLET LINE is CLOSED AND TAGGED. If the turbine is connected to the exhaust steam header, CLOSE the ISOLATING VALVE in the EXHAUST LINE AND TAG IT. OPEN ALL TURBINE DRAINS to ensure venting of all pressure before disassembly begins.

The overspeed trip mechanism may be readily disassembled or assembled at a workbench and then mounted to the turbine as a subassembly. Prerequisites for this process are removal of the governor and coupling according to the procedure specified in Section L.12, followed by removal of the overspeed trip collar (90) from shaft (1), as described below.

It is important that the entire emergency trip system be properly adjusted and free of binding or lost motion. The operation of the overspeed trip should be tested as often as possible, especially at times that maintenance is performed and a permanent record should be kept of these tests. The over-speed trip should function to shut down the turbine within 2% of the speed specified on the turbine data sheets. If the operational tests in Section I.6 indicate a requirement for adjustment, proceed as follows:

L.14.1 Governor Cup Removal

Refer to the following figures:

L-13 *Overspeed and Governor Valve Linkage*
L-14 *Throttle Valve Linkage*
L-15 *Governor Cup Assembly*

a. Gain access to the overspeed governor cup.

For turbines with a Woodward gear driven governor – remove bearing case end cover.

For turbines with a Woodward governor that is coupled to the shaft – remove the steam end bearing case cap.

b. Manually rotate the turbine shaft (1) until the lock screw (P/N 15, Figure L-13 or P/N 92, Figure L-15) is accessible; then loosen the lock screw.

CAUTION

If the Overspeed Governor Cup Assembly is replaced, the rotor may need to be re-balanced with the new assembly attached.

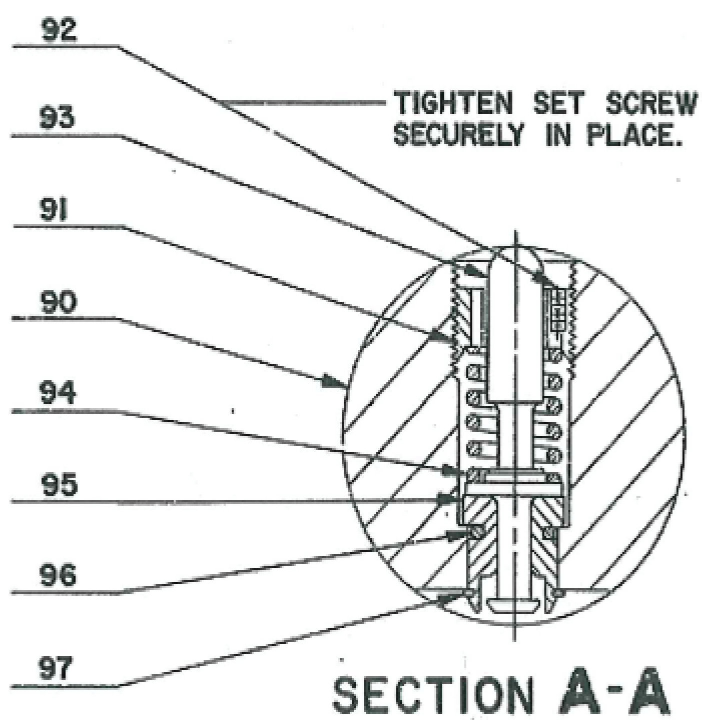


Figure L-17. Governor Cup Assembly

Legend:

90. Cup – Governor
91. Screw – Adjusting
92. Set Screw
93. Weight
94. Spring
95. Bushing - Weight
96. Ring – Retaining-Open type
97. Ring – Retaining-External type

b. Using a suitable spanner tool, turn the adjusting screw (91) clockwise to raise the tripping speed or counterclockwise to lower, as necessary.
c. Tighten the lock screw (15 or 92) (setscrew) securely to lock the adjustment position, then repeat the over-speed trip test (see warning below).

WARNING

The overspeed trip assembly should be locked in place before starting the turbine. Four checks to make are as follows:

1. The overspeed governor cup must be tightly screwed into the shaft.

2. If supplied, one of the tabs of the lock-washer is bent into the miller slot of the overspeed cup. (The overspeed cup will have two milled slots for the tabs of the lock-washer, but it will only be possible to line up one of the tabs. This is due to the fact that the tabs are not symmetrically located around the outer diameter. There is no need for concern as long as one of the tabs can be **completely** bent over into the slot.)

3. If the overspeed cup has drilled and tapped holes for half dog point set screws, the shaft must be drilled at final assembly with the overspeed cup in accordance with the table below to ensure the tip of the dog point locks into the shaft. The set screws must be tightened and staked into place.

4. The run-out of the cup must also be checked and adjusted to within 0.002 inch (.05 mm) total indicated run-out.

L.14.2 Governor Cup Replacement

CAUTION
The adjusting screw/spring combination has been pre-set at the factory for the trip speed originally set when the turbine was shipped. Refer to Section L.14.7, *Trip Linkage Adjustment*, if minor trip speed changes are to be made.

WARNING
Adjusting Screw (91), spring (94), and setscrew (92) are a FACTORY-CONFIGURED SET, selected to obtain the proper trip speed for a specific turbine. DO NOT MIX OR INTERCHANGE THESE PARTS with similar parts from other turbines or attempt to modify these components. Consult your local Dresser-Rand manufacturer's representative or the factory if replacement parts are needed.

L.14.3 Trip Mechanism Disassembly

For 4" and 6" trip and throttle valve systems, the clearance between the overspeed trip lever (Figure L-13) and the emergency weight (P/N 14) or (P/N 93 in Figure L-14) is properly set at the factory for 0.060"/1.524mm plus or minus 0.010"/0.254mm. Gain access to the over-speed governor cup as described in the preceding section L.14.1.

For 4" and 6" Venturi trip systems, the clearance between the over-speed trip lever (figure L-13) and the emergency weight (P/N 14 or P/N 93) is properly set at the factory for (0.090"/2.286mm plus or minus 0.010"/0.254mm. Gain access to the overspeed governor cup as described in section L.14.1.

Rotate the turbine shaft (1) to position the overspeed weight adjacent to the overspeed trip lever and measure the clearance. If adjustment is necessary, proceed as follows:

a. Loosen lock screw that secures the valve lever trip connection to the valve spindle.

b. Slide valve lever connection along the valve spindle away from the steam chest to increase the clearance, toward the steam chest to decrease the clearance.

c. Tighten the lock screw to securely hold the valve lever connection.

L.14.4 Emergency Valve Travel

a. Unlatch valve lever (P/N 3, Figure L-13) to close emergency valve.

b. Manually pull out on the governor linkage to close the governor valve. On the turbine, it may be necessary to remove the pin from the connecting rod. (See lower view of Figure L-18)

c. With the governor valve fully closed, raise the valve lever until the emergency valve will not open further (do not spring the valve lever).

d. Measure the clearance between the latch surface of the valve lever and the latch surface of the trip lever. The clearance should be approximately ¼"/6.35 mm.

e. If adjustment is required, loosen the lock screw in the valve lever connection; then reposition the valve lever connection and serrated valve spindle clockwise or counter-clockwise as necessary to obtain the correct clearance.

NOTE: After making this adjustment, it will be necessary to re-check the setting of the over-speed trip linkage.

L.14.5 Emergency Valve Removal and Replacement

a. Remove governor valve and steam strainer as described in section L.13.1.

b. Remove lock screw in the valve lever connection; then slide the valve lever connection off the serrated valve spindle.

c. Remove access plug in the steam chest located above the valve spindle; then remove the lock screw that secures the valve spindle to the valve link.

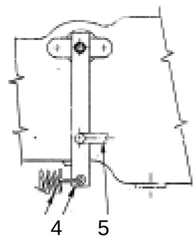
d. Remove access plug in the steam chest in line with the valve spindle and withdraw the valve spindle.

e. Remove the valve link by sliding up and away from the valve stem.

d. Remove the valve portion of the assembly and inspect the valve seat.

NOTE: If the valve seat must be replaced, the steam chest must be removed from the turbine.

e. Re-assemble and install the emergency valve by reversing the removal procedure.



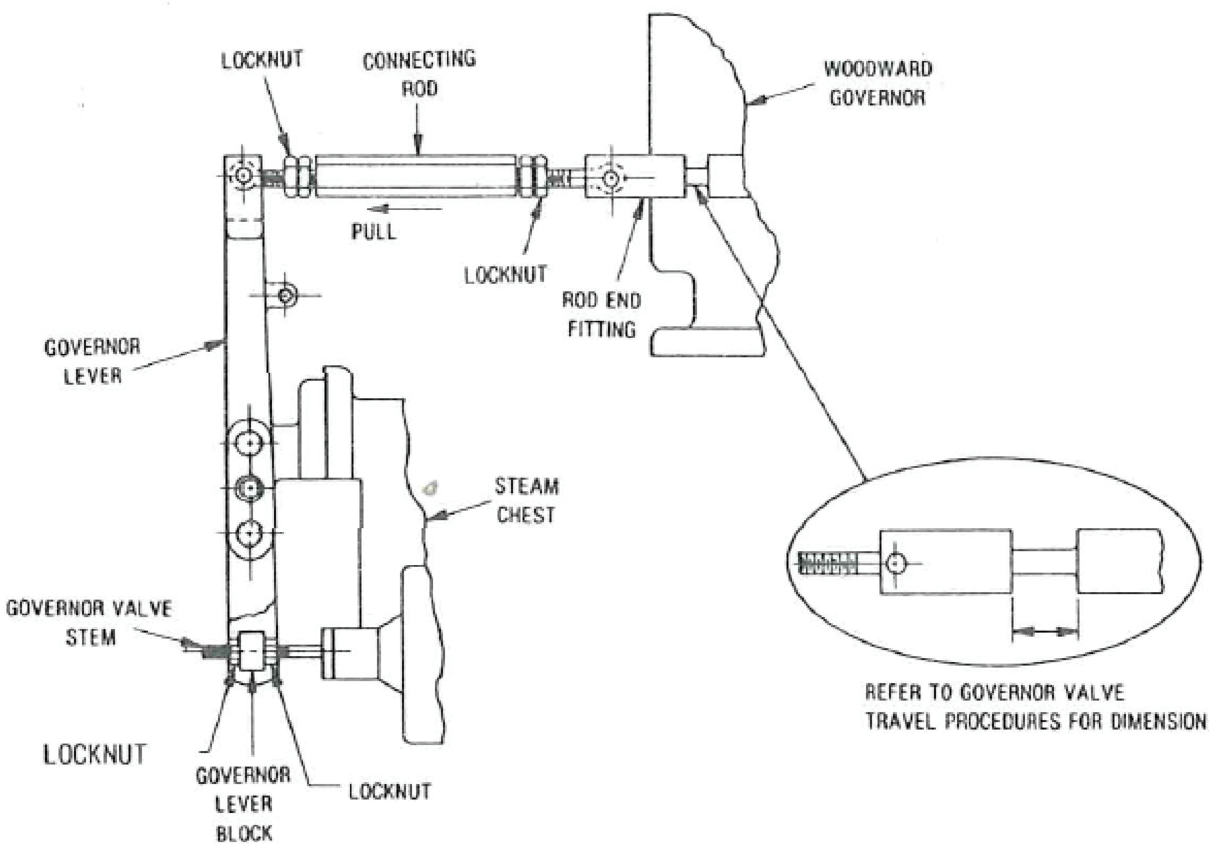


Figure L-18. Trip Valve Lever Orientation-Trip Valve Open and Closed

After completing installation, set the following:

Overspeed trip
Overspeed trip linkage
Governor valve travel
Emergency valve travel

L.14.6 Trip and Throttle Valve and Steam Strainer

The following are procedures for replacement of the steam strainer:

a. Close the main steam valve.

a. Disconnect the pressure and drain line connections at the oil cylinder flanges.

c. Disconnect the linkage from the governor lever.

d. Remove the bolts that fasten the trip throttle valve body to the valve body cover.

e. Remove the bolts that fasten the valve body cover to the valve body; then lift off the valve body cover.

f. Lift out the emergency valve guide.

g. Pull out the steam strainer.

h. Perform the necessary maintenance and re-assemble by reversing the removal procedure.

i. For procedures on a vendor valve, see Appendix B.

NOTE: The 6” trip and throttle valve cover is equipped with a throttle screw that regulates the amount of steam from the inlet side of the valve to the chamber above the main disc. If chattering of the main disc is encountered when opening the valve, it is necessary to increase the leakage to the chamber by turning the throttle screw counter-clockwise. If, however, the hand-wheel effort appears excessive, it can be reduced by turning the throttle screw clockwise, thus decreasing the leakage to the chamber. A pipe tap is provided in the cover to be used for a pressure gauge to check the pressure chamber after the pilot valve has been opened. This leakage pressure should be approximately 25% of the line operating pressure.

Section M

Replacement Parts/Factory Service

M.1 Factory Replacement Parts

Dresser-Rand Turbine recommends that only Dresser-Rand-supplied parts be used in Dresser-Rand turbines. The use of Dresser-Rand parts ensures that replacement components are manufactured from the highest quality materials, to exacting tolerances and specifications, thereby assuring safe, efficient, long-lasting, and maintenance-free operation under service conditions for which the turbine was designed and built.

Dresser-Rand and selected Dresser-Rand manufacturer’s representatives maintain a supply of the most frequently requested spare parts for immediate shipment worldwide. Parts requested less frequently can be manufactured quickly on an emergency basis when required.

Your Dresser-Rand manufacturer’s representative can supply you with a stocking list of recommended spare parts for your turbine or turbines, allowing you to stock spare parts at your facility. Refer to Section M.4, *Recommended Spare Parts.*

M.2 Turbine Identification

Dresser-Rand SST turbines are marked with a serial number, which appears on the nameplate and is also, stamped on horizontal flange of the inlet casing. This serial number is used by the factory to identify the turbine and should be used in all inquiries and parts orders.

M.3 Parts Identification

When inquiring to determine parts availability, or when placing an order for spare parts, the following minimum information is required:

Item	**Typical Example**
Turbine serial number:	XXXX
Part description:	Shaft
Reference number:	21

Section Drawing	LE-169235-N

If the turbine parts list is available, then the Dresser-Rand part number should also be specified.

WARNING

Modification of, incorrect repair of, or use of non-DRESSER-RAND repair parts on this turbine could result in serious malfunction or explosion that could result in serious injury or death. Such actions will also invalidate ATEX Directive & Machinery Directive Certifications for turbines that are in compliance with those European Directives. Refer to Section M – *Replacement Parts/Factory Service.*

M.4 Recommended Spare Parts

The recommended spare parts for a turbine owner is provided in the service manual. The inventory recommendation for spare parts is based on Dresser-Rand's long experience with turbine applications.

M.5 Ordering Parts

Contact your local Dresser-Rand manufacturer's representative to order parts. Your representative will be pleased to provide any assistance you may require, as well as to quote prices and delivery dates.

The following information is required when placing a parts order:

1. Your purchase order number.
2. Complete billing, shipping, and marking instructions.
3. Turbine serial number--from nameplate or horizontal flange of inlet casing.
4. Turbine frame size--from nameplate, i.e., 300, 500, 700, etc.
5. Quantity of each part or assembly.
6. Part or assembly reference number from drawing, illustration, or text.
7. Section drawing the reference number was taken from.
8. Description of part or assembly.

9. Dresser-Rand part number, if known (optional).

M.6 Service

Dresser-Rand Turbine maintains repair facilities on a worldwide basis to repair equipment needs with OEM manufactured parts. When contacting Dresser-Rand, please have your turbine serial number available.

Contact a service center nearest you by using the link below:
http://www.dresser-rand.com/contactUs.php

A Service Representative can also be dispatched to your site to assist you in start-ups, general maintenance, and troubleshooting by using the same link (above). Have your turbine serial number available along with a date for when services will be required.

The Technical Support group at the factory can address your technical questions by using the contact information below:

Dresser-Rand Wellsville Operations
37 Coats St.
Wellsville, NY 14895
USA Tel: (Int'l +1) 585-596-3100
Fax (Int'l +1) 585-593-5815

When contacting the representative or factory, please specify the turbine serial number, frame size, nature of the problem or service requirement, and date that service is required.

M.7 Revamps (Rerates)

It's not uncommon for the requirements of the steam turbine to change due to a process change, more product output, or just a need to reduce energy consumption. Steam turbine can have a broad operating range. Powers and speeds can be modified with simple internal hardware changes while still maintaining the same steam turbine case and footprint.

If you would like to have Dresser-Rand review your equipment, please use the contact information above the find the nearest service center or contact the factory direct. Have your serial number available along with the new conditions you would like to operate at.

WARNING

Materials used in turbine construction (cast iron, steel, stainless steel, special alloys) vary with steam conditions, speed, and power. These materials were selected according to the original rating of the turbine. NEVER attempt to re-rate a turbine without the assistance of a Dresser-Rand manufacturer's representative and/or the factory. Misapplication of materials could result in serious equipment damage and/or personal injury.

M.8 Upgrades

Many of older turbines can be modified or upgraded to improve performance and reliability. Improved designs in seals, bearings, controls, and blading can all be incorporated into the existing machine when required.

If you would like to have Dresser-Rand review your equipment, please use the contact information above and find the nearest service center or contact the factory direct. Have your serial number available.

M.9 Factory Start-Ups

Authorized Dresser-Rand service representatives are available for start-up service and to train operating personnel in the operation and maintenance of Dresser-Rand steam turbines. An experienced service representatives will review your installation prior to start-up, following established Dresser-Rand procedures. Piping, alignment, lubrication, overspeed trip, etc. will be carefully checked. Upon commissioning the new installation, operating personnel will be trained.

Consult your Dresser-Rand manufacturer's representative to schedule a start-up.

M.10 Parts Catalog

Refer to the applicable turbine cross sectional drawings included in the instruction manual for a listing and location of the replacement part reference numbers used on your turbine.

Section N Miscellaneous

N.1 Low Ambient Temperature Applications of Single Stage ASTM A216-WCB Carbon Steel Pressure Casing Steam Turbines

Dresser-Rand has been asked to provide a quotation for steam turbines that may be installed into an area with an ambient temperature of –30°C (-20°C) or less.

The quoted D-R single stage turbine is offered with ASTM A216 Grade WCB carbon steel pressure casing material that will meet the Charpy V-Notch Energy requirements of ASME Pressure Vessel Code Section VIII, Division 1, UG-84 as required by API 611 for ambient temperatures –30°C (-20°F) or higher. The pressure vessel bolting is ASTM A193 Grade B7, and nuts are ASTM A194 Grade 2H or ASTM A563 Grade A, which also meet the requirements of the Pressure Vessel Code and API 611for ambient temperatures of –30°C (-20°F) or higher. If the offered turbine is installed into an area with ambient temperatures of lower than –30°C (-20°F), the equipment user must take precautions to insure that the turbine casing be kept warm and/or be warmed prior to equipment start-up to meet the requirements of ASME Section VIII, Division 1, UG84, as appropriate.

When a steam turbine is in operation, the casing temperature s above the brittle/ductile transition temperature of the casing material. Therefore, a low ambient temperature is not a concern. However, to insure that the low ambient temperature does not result in damage or failure of the turbine and its accessories, it must be installed, started, operated, and shut down as described in the Low Ambient Steam Turbine Application Guidelines outlined below. If compliance with these guidelines and acceptance of the offered standard materials is not possible, consult Dresser-Rand for further discussion or an alternate material offering.

Prior to the purchase of the turbine, the final equipment user, driven equipment vendor, and Dresser-Rand shall agree to the special precautions necessary with regard to low ambient conditions that can occur during operation, maintenance, transportation, erection, commissioning, and testing.

Dresser-Rand shall assume no liability of any nature for the offered turbine if not transported, erected, installed, started, operated, maintained, and shut down as described in compliance with the “Low Ambient Steam Turbine Application Guidelines” outlined in this document.

Low Ambient Steam Turbine Application Guidelines

Note these requirements apply to both API and non-API applications.

General:

When a steam turbine is to be installed where the ambient temperature could be –30°C (-20°F) or lower, the following issues require special attention to insure that the low temperature does not result in damage or failure of the turbine and/or its accessories.

See the turbine instruction manual for additional turbine installation and operational details and the accessory instruction manuals for their cold start/low ambient precautions and recommendations.

Transportation:

The turbine is suitable for transporting to site, unloading, and placing in storage, or transporting to site, unloading, and placing on its foundations, or moving from on-site unheated storage to its foundations, only when ambient temperature is at or above –30°C (-20°F).

Installation:

The turbine and its auxiliaries can remain out of service with no external source of heat when the ambient temperature is at or above –45°C (-49°F), provided the turbine is not disturbed when its metal temperature is below –30°C (-20°F), Turbine maintenance cannot occur unless the temperature of the turbine and all its mechanical components is at or above –30°C(-20°F).

Turbine installation cannot proceed until the turbine and all its mechanical components are t or above –30°C (-20°F). Alternatively, if the turbine components are below –30°C (-20°F), the area musts be hooded and heated to raise the component temperature above –30°C (-20°F).

Care must be taken to insure that the steam inlet and exhaust piping is properly supported or equipped with flexible connections so they will not put excessive force on the turbine when it is shut down. The turbine casing and inlet and exhaust flange material are more prone to cracking when the ambient temperature is cold ad their temperature is below the brittle/ductile transition temperature. This is of increased concern if the piping is hot when the turbine is shut down and the inlet and exhaust shut off valves are closed.

All turbine condensate drain connections and steam piping low points must be properly drained to insure all condensate can be removed from the turbine and steam system during shot-down. Similarly, cooling water lines to bearing housings and water coolers, bearing housing water jackets, and oil coolers must be equipped with drains to insure that water can be removed during shut-down.
Failure to remove all water from the turbine casing, piping, cooler,, bearing housing, etc. when temperatures are below freezing could result in failure of the piping and various other components.

If oil reservoirs, oil or water piping, bearing housings, and other components are heat-traced, all local safety regulations and electrical codes must be adhered to.

Lubrication:

Dresser-Rand offers a variety of lubrication systems including oil ring lubrication, oil ring lubrication with circulating oil cooling, circulating oil lubrication, mist oil lubrication, and force feed lubrication.

When the ambient temperature is 15°C (60°F) or lower, it must be ensured that the lubricating oil will circulate and that cooling water, if required, does not freeze during operation or shut-down. Heat tracing or insulation of oil lines, bearing housing, oil tanks, and water cooling lines may be required. Lubricant type and required oil viscosities for turbine equipment packages are defined in the certified drawings and data package and the applicable operation and maintenance manuals. Viscosities for turbine lubrication are application specific, and the required viscosity may range from ISO 32 (32cSt@40°C (100°F) 150 SUS @40°C (100°F) up to ISO 100 (100 sSt @ 40°C (100°F) 550 SUS@40°C (100°F),

Use of the correct lubricants at the correct temperatures and viscosities is critical to the trouble free operation of the turbine and its accessory equipment.

Accessories:

Some turbine accessories may require installation, heat tracing, special lubrication, or adjustments for use in low ambient conditions. Others may require installation into heated locations or preheating before use. The accessory instruction manuals or accessory vendor must be consulted for additional guidance and precautions.

A partial list of typical turbine accessories might include governors, gauges, oil pumps, control panels, instruments, reduction gears, lube oil systems, couplings, steam piping, valves, solenoid valves, tachometers, ejectors, condensers, etc.

Turbine Start-Up:

Warming the Turbine Pressure Casing:

If metal temperature is at or below –30°C (-20°F), a warm-up of the complete turbine must be performed prior to start-up, including the use of hooding and space heating to elevate the metal temperature of all steam-contacted components to a temperature of at least –30°C (-20°F) prior to the introduction of steam to the turbine.

If metal temperature is above –30°C (-20°F), steam from the client's exhaust steam header piping may be used to preheat the cold back pressure turbine prior to start-up. If exhaust steam is not available for this purpose, a small steam bypass line, equipped with a valve, may be installed around the inlet block valve or start-stop valve to allow preheating of the turbine casing with a small flow of inlet steam. Allow the turbine casing to reach 15°C (60°F) or exhaust steam temperature before proceeding further.

During warming, all turbine casing and associated steam piping drain valves must be opened to allow liquid to drain from the turbine casing and its associated steam piping. Take special care to insure all liquids are drained prior to closing the valves for turbine start-up.

Prepare the Lubrication System for Start-Up

If the ambient temperature is less than 15°C (60°F), lubricating oil and, if supplied, the lubrication system and oil piping must be warmed to 15,C (60°F) to insure that the oil will flow to the bearings and back to the oil reservoir or oil tank.

For ring-oiled turbines, the oil temperature should be such that the oil rings will turn and pick up the oil. This may require that a hot liquid be circulated through the bearing housing "cooling" water jackets. "Cooling water," if less than 15°C (60°F), which may be required during normal turbine operation, should not be applied to the bearing housing water jackets until the bearing housing temperature exceeds 15°C (60°F), which may be required during normal turbine operation. For turbines equipped with pressure lubricating or circulating oil systems, the lubricant must be warmed to a viscosity such that the oil pump will prime and deliver lubricant to the turbine bearings. His may be accomplished by use of a steam heating coil or electric heating element. If electric heating elements are used, the watt density should not exceed 23W/in^2 (3.5W/cm^2), and a sheath temperature of 100°C (212°F) to avoid carbonizing the oil. After the lubricant is warmed, it must be circulated throughout the entire lubrication system by means of a hand, motor, or steam driven pump to warm all the associated lubrication system components prior to turbine start-up.

After heating the lubricating oil or determining that it does not require heating, start the turbine per the instruction manual. Turn the turbine over slowly for a short time, insuring that the oil rings are turning and/or the lubrication system is delivering lubricant to the turbine bearings.

Operation:

Operate in accordance with normal operating routine, except that to maintain suitable lubricating oil temperature and viscosity, it may be necessary to heat the oil instead of cool the oil, especially if there are long un-insulated or unheated oil lines between the turbine and a remote lubrication system.

With some turbine speed governors, a change in the governor oil viscosity may have an effect on the speed of the turbine. Therefore, when operating a turbine in low ambient temperature, it may be necessary to make manual adjustments on the speed governor.

Shut Down

After the unit is shut down in accordance with the instruction manual, special care must be taken to insure that all water is drained from the steam lines, turbine casing, bearing housing water jackets, valves, oil coolers, etc. Freezing water in the turbine or its associated systems can cause major damage or problems during the next turbine start-up. Any lubricant or accessory heating system should be turned off to avoid overheating unless advised otherwise by the manufacturer’s instruction manual.

If there is steam from other processes in the exhaust piping, leave the exhaust valve open. If the turbine is to be shut down or a short period of time or is on standby, thereby avoiding the need to preheat the pressure casing on restart. Case drain valves should be left open.

When properly drained of water, the turbine and its auxiliaries can remain out of service with no external source of heat when the ambient temperature is at or above –45°C (-49°F) as long as the turbine is not disturbed when its metal temperature is below –30°C (-20°F). Turbine maintenance cannot occur unless the turbine and all is mechanical components are at or above –30°C (-20°F).

N.2 "Quick" Start,"Fast" Start, "Automatic" Start
Dresser-Rand Single Stage Steam Turbines

In the case of a "quick" start when the turbine is not thoroughly warmed nor gradually brought up to the minimum governor speed, the principal areas of concern are: (1) water slugging (2) bearing lubrication, (3) rotor acceleration rate, and especially (4) sudden temperature differentials across the turbine.

1 Water Slugging

Since the velocity of a water particle passing through a turbine is low relative to the steam and rotating blade velocity, such particles can cause extensive damage as they impinge on the rotating blading. Furthermore, the downstream force generated by such particles impinging on the rotor blading can be high enough to cause thrust bearing failure. The warming of a steam turbine allows for vaporization and removal of condensate in the steam inlet line ahead of the turbine and in low points of the casing.

2 Lubrication

Without immediate and constant oil feed, the heat generated by the shaft in the turbine bearings, unless properly dissipated, can cause bearing failure. Oil ring lubricated bearings provide immediate lubrication as the shaft begins to turn, so long as the proper oil level is maintained in the bearing housings. With pressure lubricated bearings, the lubrication system must be arranged such that oil fills the supply lines and feeds the bearings when the shaft begins to turn.

3 Acceleration Rate

With steam turbine applications that are started with no load, the acceleration rate of a low inertia rotating element can be so high that the control system response to close the steam admission valve does not react prior to overspeed trip. This particularly true of the turbine generator sets which may also require limited frequency variations in the electrical system. In instances such as this, a ramp effect on governor valve closure may be built in the control system.

4 Temperature Differential

On turbines with built-up rotors, the disc-to-shaft allowance tends to decrease to unacceptable limits with a 200°F (93°C) temperature differential between the disc and shaft. The probability of such a condition existing is greater at approximately five minutes after start-up, rather than immediately at start-up. Loss of shrink fit can result in axial; or wobble movement of the disc on the shaft, possibly resulting in turbine breakdown. The colder the unit at start-up, the greater the probability of the temperature differential occurring. Since the utilization of forged discs in lieu of plate discs allows a higher shrink fit, we normally recommend the customer consider using forged discs.

5 General:

The subject of “quick,” “fast,” or “automatic” start is not something new in the steam turbine industry. Nor has Dresser-Rand decreased its engineering standards for design of steam turbine shafts, bearings, or shrink fit of discs to shafts.

In general, reliability and durability are compromised by quick starting of a turbine and will result in shortened overall turbine life. Frequent quick starts are particularly severe on bearings and rotating elements. The more rapid the acceleration rate, the higher are the transient loadings and the more severe are the loading effects.

Dresser-Rand single stage turbines with standard construction are suitable for start-up in five seconds provided the following conditions are met:

1. The inlet side of the turbine steam line must be trapped.
2. Proper lubrication of bearings must be provided.
3. The inlet temperature of the steam shall not exceed 750°F (399°C).
4. The differential temperature between inlet steam and exhaust steam shall not exceed 350°F (177°C).
5. Back pressure shall be maintained on the casing during shut-down. (This in itself is not a recommended operating condition due to possible shaft wire cutting or carbon ring seal decay, but will keep the casing warm).
6. The operating speed of the turbine shall not exceed 6000 RPM.
7. The unit must be brought up under load.

In operating a turbine under the above conditions, the user must bear the responsibility for bearing failure, loss of disc-to-shaft fit, and carbon ring decay.

N.3 Dresser-Rand Standard Policy on Equipment Sound Levels

It is Dresser-Rand's intention to design and manufacture turbines with satisfactory sound levels and work cooperatively with the user to make the overall installation as quiet as possible. However, there are many environmental factors affecting sound measurements which are beyond Dresser-Rand's control. These might include piping, room size, and other equipment or structures near the unit which may tend to focus, reflect, or amplify sounds, as well as emit other sounds. In view of this, Dresser-Rand is unable to guarantee noise levels other than to commit to a willingness to assist the end user in corrective action (at end user's cost) in cases where a noise problem may be perceived to be present.

Expected sound levels for various types of Dresser-Rand-built equipment operating at full load in a typical field installation are given below. Sound levels for the turbine or gear alone isolated in a non-reflecting environment may be significantly lower.

Octave Band Center Frequency (HZ.)	Expected Sound Pressure Levels (dB-Ref. 2 x 10^5 Nm²					
	Single Stage Turbines		Multistage Turbines		Reduction gears	
Acoustic Insulation >>	No	Yes	No	Yes	No	Yes
63	97	96	105	104	103	102
125	92	91	97	96	99	98
250	90	88	91	89	93	91
500	89	86	90	87	91	88
1000	87	83	87	82	87	82
2000	85	82	87	82	87	82
4000	84	81	87	82	87	82
8000	84	81	87	82	87	82
Expected Over-All (dBA)	88	85	90	85	90	85

The breakdown above gives maximum expected dB levels for each octave band under typical operating conditions. Actual values for each octave band would normally not equal all these maximum values. Hence, expected over-all sound levels given above for each type of equipment are lower than the sum of the individual (maximum) values.

Section O

LOW VOLTAGE ELECTRICAL COMPONENTS

O.1 LIST OF POSSIBLE INSTALLED ELECTRICAL PARTS AND THEIR APPLICATIONS ON 350/500/700 SST TURBINES

There are numerous combinations of electrical devices installed in some turbines. Below is a listing of the possible electrical components found on SST turbines in various configurations.

Electronic Governor. Some of the electronic governors used on the SST turbines are manufactured by Tri-Sen, Compressor Controls Corporation, and Woodward. Magnetic speed sensors, in most cases a quantity of two, are installed either external to the exhaust end bearing case or internally or externally on the steam end bearing case. The sensors read a gear internally mounted on the rotor shaft and are wired typically by the customer to the electronic governor input location. The electronic governor serves the same purpose as a mechanical governor (covered elsewhere in this manual) for controlling turbine speed. The electronic governors provide an analog signal output which can be utilized for remote customer DCS monitoring purposes. Electronic governors also provide a means for relay control which can be programmed to alarm and or trip other customer processes, as well as an option for remote control via a switch panel either provided by the customer or installed by Dresser-Rand. The electronic governors maintain turbine speed through the use of an actuator. The actuator adjusts the governor valve in response to the typical 4-20 mA signal received from the electronic governor.

A governor program is part of the documentation provided the customer when an electronic governor is applied. Within the governor program are the parameters, which are entered via keypad into the governor, when it is programmed for operation.

Magnetic Speed Sensors. The electronic governors, tachometers, and electronic over-speed protection require the use of speed probes to provide a voltage-pulsed input for accurate turbine control. Each sensor is factory set to the recommended adjustment gap between the probe tip and target.

Limit Switch. The trip and throttle valve may have a limit switch mounted on the valve to indicate closed position of the valve. The contacts can be configured as normally open or normally closed per customer requirement.

Solenoid operated emergency trip valve. The over-speed tripping of the turbine can be accomplished by a mechanical method covered elsewhere in this manual. Electronic options are available to trip the turbine in an over-speed condition through a solenoid valve which dumps the air or control oil from the trip valve operational configuration. D-R recommends that the solenoid valve be wired through an interposing relay to safely sustain the current required for the solenoid valve operation.

A customer controls interface is required if it is desired to have a customer trip signal incorporated into the emergency tripping of the turbine. This set of controls needs to be accomplished via a trip string of series interconnected contacts, any of which would de-energize the trip solenoid valve, thereby tripping the unit.

Vibration Monitoring. The turbine shaft radial movements at both the steam end, exhaust end, and axial thrust bearing displacement can be accomplished by vibration probe and proximitor hardware. In addition to the radial and axial probes is the inclusion of a keyphasor probe for the Bently Nevada asset monitoring equipment, which is D-R's standard vibration monitoring recommended vendor. The vibration probes are sized and installed in the bearing cases for optimum length to clear accessories mounted on or near the bearing case. Proximitors are typically shipped installed into a junction box or loose. In some cases provisions only are provided the customer and installation holes in the bearing cases are plugged.

Bearing Temperature Monitoring. D-R offers RTD or thermocouple electronic bearing temperature monitoring capabilities. The bearings can be equipped with the customer-specified instruments embedded within the bearings by D-R. The temperature instrument wires exit through the bearing case through Minco trade name seals where terminal heads are then installed, providing wire termination points. Single and dual element temperature instrumentation is available. When provisions for future temperature monitoring are requested by the customer, bearing cases have installation holes machined and plugged so that bayonet style RTDs or thermocouples could be installed at a later time.

Seismic Bearing Case Monitoring. Accelerometers are available for installation on the bearing cases, an alternative to the more sophisticated probe and proximitor type of shaft monitoring. They monitor the rotational vibration levels being transmitted to the bearing case.

Electronic Speed Monitoring (tachometer). Electronic tachometers are available for local and remote speed monitoring. Some tachometers have programmable relays for optional alarm and trip interface with customer DCS or PLC equipment. Self-powered tachometers are an available option. In most cases only one magnetic speed sensor is required for use with the tachometer.

Electronic Overspeed Protection. Over-speed tripping of the turbine can be accomplished by a mechanical method covered elsewhere in this manual. Electronic options are available to trip the turbine in an overspeed condition through a solenoid valve which dumps the air or control oil from the trip valve operational configuration. D-R recommends that the solenoid valve be wired through an interposing relay to safely sustain the current required for the solenoid valve operation. There are three magnetic pickup speed probes supplying signals to the over-speed protection device.

Over-speed trip devices are composed of three separate modules which are in communication with each other. If one magnetic pickup fails, the unit will continue to operate with the two remaining speed input signals but will trip when one of the signals exceeds the over-speed trip setting on one of the modules. Normal operation compares the three speed signals and takes the two highest out of the three signals to trip the turbine, hence the name two out of three.

During the programming of the over-speed device it is of utmost importance that the exact number of targets being read by the speed probes be correctly entered.

Electronic/pneumatic throttle valve actuator and controls. Any SST turbine with an electronic governor requires an actuator to be attached to the inlet governor valve to receive the signals from the governor for valve movement and positioning and, if desired, provide valve position feedback for monitoring. The most common actuator used, the electro-pneumatic actuator, has a current to pressure interface where the electronic governor, via analog signal, is electrically connected to the actuator and accurately controls its force/movement on the throttle valve.

Electronic pressure transmitters. There are some instances where a remote pressure measurement is required, which can be provided with an electronic pressure transmitter. There are several types of communication methods available by which the transmitter can interface with the customer PLC or DCS.

Electronic temperature transmitters. There are some instances where a remote temperature measurement is required, which can be provided with an electronic temperature transmitter. There are several types of communication methods available by which the transmitter can interface with the customer PLC or DCS.

O.2 Electrical Component Removal and Replacement

CAUTION

DO NOT perform work on any live electrical device or component without a thorough lockout/tagout procedure in place.

WARNING

Only professionally certified electricans are to be working on the SST electrical components.

The upper half of the turbine exhaust and steam end bearing cases must be removed to gain access to the shaft bearings and turbine rotor for RTD and thermocouple access. See section L.3 for turbine case disassembly.

The procedure for removing and replacing the radial and journal bearings, which contain the temperature monitoring hardware, is presented in section L.6.

Magnetic pickups are mounted on either the steam end or exhaust end bearing cases and can be removed and replaced per field instruction procedures without the removal of the bearing cases. Terminal heads can be removed from the pickup via the union and wiring removed from the terminal blocks. In some instances the magnetic speed probes are installed inside the bearing cases, in which case the bearing case must be disassembled to facilitate probe removal.

Limit switches indicating T&T valve position can be accessed from the outside of the valve and removed by removal of the flexible conduit attached to the switch and removal of wiring from the terminal blocks.

Vibration probes are mounted into the external cover of the bearing cases and can be removed and replaced without turbine disassembly. Adjustment of the probes is accomplished with a voltmeter set on DC voltage and turned until the voltage reads 9 volts DC whereby the locking nut is secured in place.

The electro-pneumatic actuator is readily removable from the throttle valve body and removal of flexible conduit and wiring disconnection from the terminal blocks.

The governor and over-speed protection equipment are shipped loose to be installed in the customer control room, in most cases. For those cases where they are not shipped loose, both devices are installed in a skid-edge enclosure with operators mounted on the external enclosure door allowing for local governor operation when installed in a hazardous location. Wiring can be removed from the terminal blocks allowing the components to be replaced.

In some cases, where there are RTDs and vibration probes as well as limit switch indicators of the T&T valve position, there could be enclosures containing terminal blocks. These enclosures could be installed on the turbine base on a junction box stand with conduit running from each electrical device, mounted on the steam turbine, to the enclosure.

Accelerometers are installed externally on the bearing case caps and are readily accessible for removal and probe cable disassembly and re-assembly.

Tachometers are shipped loose in most cases. They can be easily removed and replaced by removal of the flex conduit at the union and disconnection of wiring from the terminal blocks.

Pressure and temperature transmitters are typically locally mounted by D-R and wired by the customer. In cases where there is a skid-mounted enclosure, disconnection and reconnection from terminal blocks and flex conduit with a union can remove the transmitter wiring.

O.3 Electrical Certification and Standards

The electrical components installed on all SST turbines are selected to satisfy the specific electrical area classifications indicated/required by the customer. All wiring is performed to meet current codes of the various countries where the SST turbines will be operating: NEC (National Electric Code), IEC (International Electric Code), ATEX Low Voltage criteria, ATEX Machinery Directive, CSA (Canadian Electric Code), CCOE (Chief Controller of Explosives) in India, GHOST in Russia among others. If required, the turbines will be wired to satisfy intrinsically safe (IS) wiring methods as well as providing purged enclosures and barriers.

Dresser-Rand wiring protection standard for electrical packaging is using conduit. D-R can provide armored cable and tray for a cost adder.

O.4 Electrical Maintenance

O.4.1 Routine maintenance

It is the customer’s responsibility to carry out the routine maintenance per the Dresser-Rand maintenance manual.

O.5 Electrical Packaging

O.5.1 How wiring is marked, protective conductor marking

Wiring is marked using electrical schematic drawing component tag numbers with permanently embossed wire markers of heat shrinkable sleeve slip on type labels at each end of the wire. If customer tag numbers are required, these labels are installed on each conductor in addition to the Dresser-Rand label markers. The terminal numbers to which the wires are terminated to are always provided on the wire marker.

See Figure O-1 of a typical electrical schematic showing the wiring marker information and termination methods. The wire markers are to be used from the information in the bubbles (D-R standard tag number) as well as customer tag numbers (located adjacent to D-R tag bubbles) if provided. Customer wiring is shown as dotted lines.

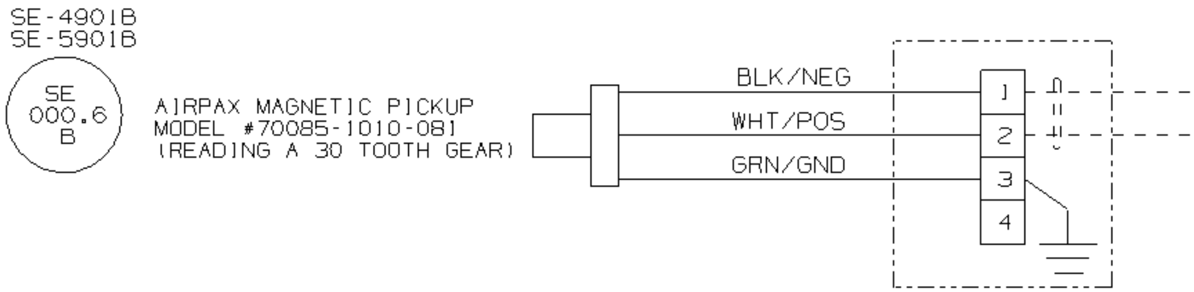


Figure O-1 Typical Electrical Schematic Tag Numbers for Wire Marking

O.5.2 Control devices labeled

Control devices such as trip valve test pushbuttons and emergency stop buttons are labeled with descriptive nameplates mounted on the housing of the operator spelling out their specific function. If the customer has tag numbers, these are included as a separate label or included in the wording of the label. See Figure O-2 for the detail of the tags indicated on the electrical schematic.

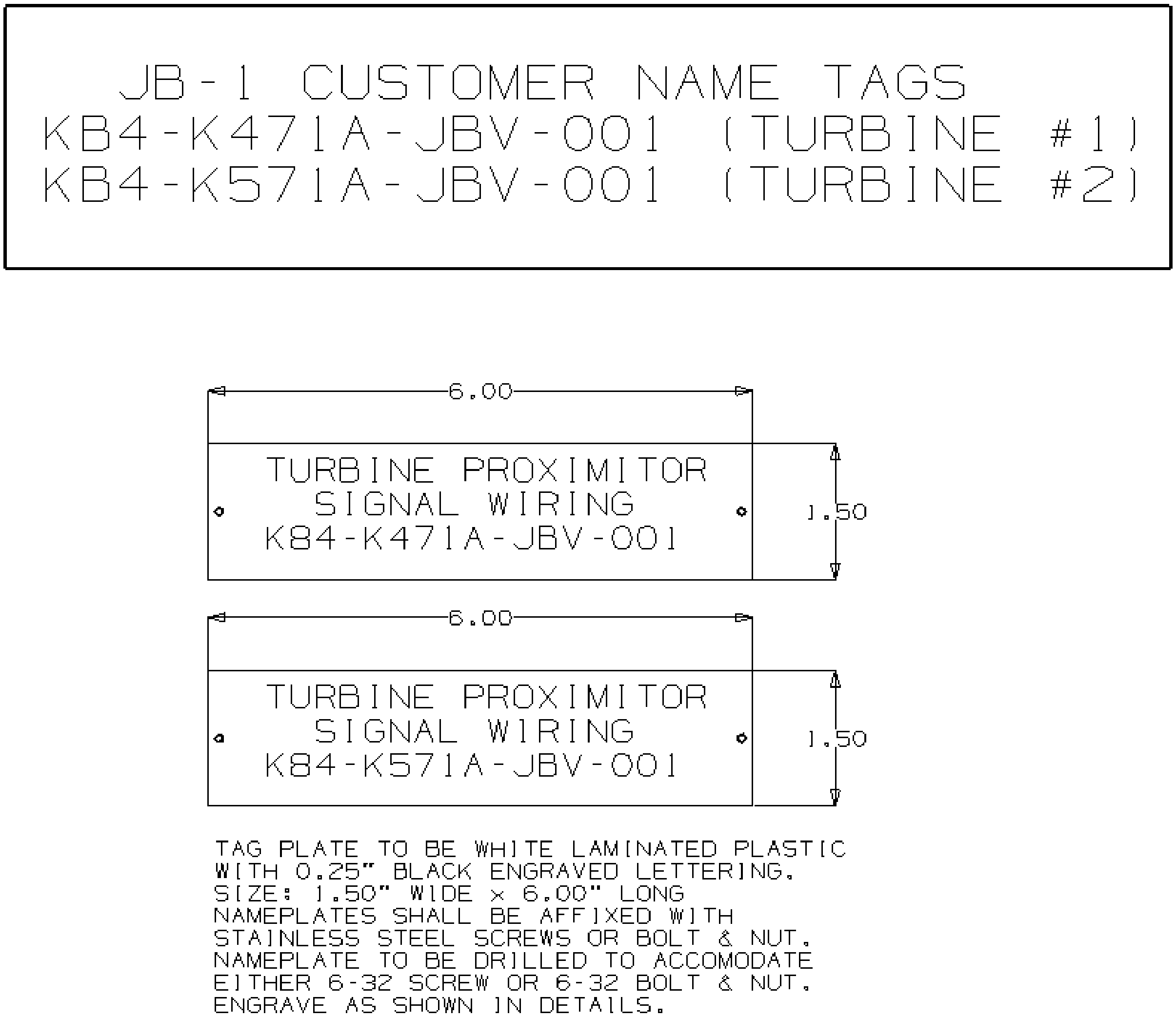


Figure O-2 Typical Tag Number Labels Attached to Junction Boxes

O.5.3 As built connection boxes and wiring routing

Enclosures are supplied either to be shipped loose or are installed on the turbine which house the vibration proximitors and temperature monitoring devices with customer wiring termination access. The Dresser-Rand standard is for 20% spare terminal blocks to be provided. Weidmuller SAK-4EN terminal blocks are Dresser-Rand standard.

No splices shall be permitted in any wire of cable and no more than two wires per terminal shall be used.

All wiring shall be terminated in centrally located junction boxes. Wiring in the boxes shall be run and laced together in an orderly fashion with all nylon tie wraps from where it leaves the conduit bushing to where it connects in the terminal box.

Here is a list of electrical components which have resistance loads and therefore power consumptive heat can be generated. Calculations are analyzed to insure that enclosures are selected in a large enough size to dissipate excess heat generated from housing electrical components.

COMPONENT	WATTAGE
Peak 150 governor	38 Watts
Solenoid dump valves	36 Watts
Tachometer	15 Watts
Magnetic pickup	50 Watts
Electro-pneumatic actuator	5 Watts

TABLE O-1 WATTAGES OF ELECTRICAL COMPONENTS USED ON SST

From this table it is demonstrated that there are minimal thermal loads being added to the overall thermal contribution from the electrical components used on SST turbines.

O.5.4 Materials of conduit and how supported

Dresser-Rand’s standard for wiring protection is to use rigid galvanized steel conduit supported with Unistrut installed on the baseplate, if provided. See figure O-2 section O.5.9 for a graphic example of conduit routing on a baseplate.

All conduit runs are are to be a minimum of 10” distance from all steam lines and steam casings, both horizontally and vertically.

Liquidtight (flex conduit) shall be used for connections to all equipment where adjustments or vibration requires flexible connections. Maximum length of the Liquidtight is 36”. Internal grounding wires are provided when applicable from the device to the grounding bar installed inside the junction boxes.

O.5.5 Percentage fill of conduit

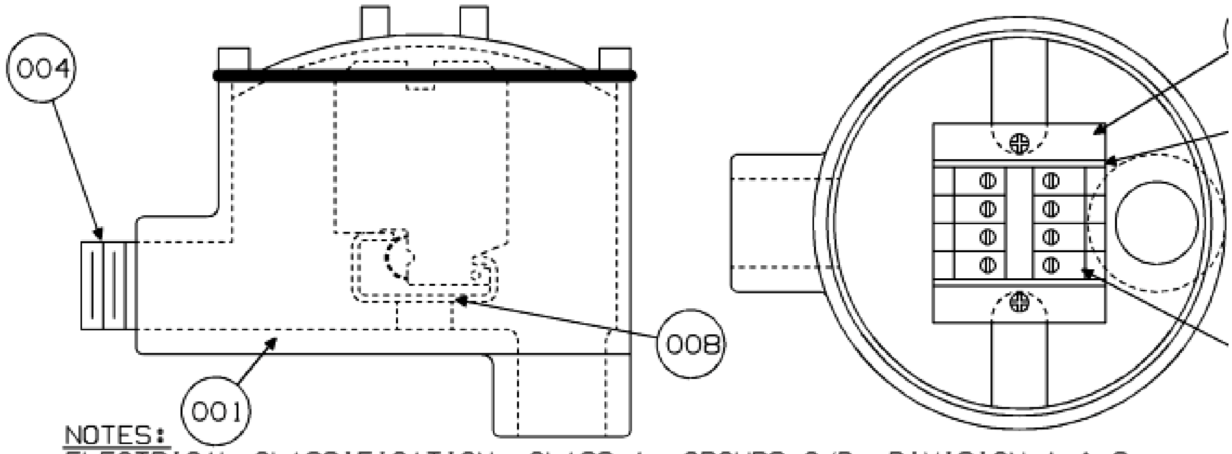
All wiring for the SST turbine does not exceed the minimum percentage fill limits per the sizes of conduit applied.

O.5.6 Procedure to protect wiring when shipped loose

If electrical components are to be shipped loose, the wiring from the turbine to the component will be coiled up with protective wrapping applied to the coils. The wiring markers are installed on the wires for determination of connection to the correct termination point per the electrical schematic and layout drawings associated with the contract.

O.5.7 Terminal head drawing

Figure O-3 is of a standard supplied ¾" terminal head which typically are installed on limit switches, solenoid valves, magnetic pickups and other electrical components which do not have their own wiring termination protective hardware.



NOTES:
ELECTRICAL CLASSIFICATION: CLASS 1, GROUPS C/D, DIVISION 1 & 2
RATED FOR CLASS 1 GROUPS B/C/D, DIVISION 1 & 2 IF SEALING
FITTINGS ARE INSTALLED ADJACENT TO THE GUA OUTLET BOX AND ALUMINUM
CONNECTION HEADS(701 AND 702) ARE USED.
701, 702 BOX AND COVER ARE MADE FROM COPPER-FREE ALUMINUM
703, 704 BOX AND COVER ARE MADE FROM GALVINIZED STEEL

Figure O-3 Standard ¾" Terminal Head

O.5.8 Wiring into J-box

Junction boxes shall be arranged for side or bottom entry only. Top entry is not allowed. Conduit unions shall be provided to facilitate replacement or removal of instruments and junction boxes.

Seals are provided for wiring entrance into all enclosures if the hazardous area classification requires them.

Hubs are installed into the bottom of the enclosure for Dresser-Rand electrical shop wiring entrance. Customer connections are left for field installation unless customer requests hub installation at the factory.

Vents and drains are provided in the top and bottom of the enclosures to allow moisture from condensation to be drained. The drains and vents are specified in accordance with the level of protection provided with the enclosure.

Dresser-Rand incorporates Crouse-Hinds and Hoffmann enclosures unless there are customer requirements for other suppliers. At a minimum the enclosures are 304 Stainless Steel with NEMA 4X ingress protection ratings.

Here is a description of the ATEX-certified (NEXT) Crouse-Hinds enclosure gasketing:

Features include thirteen basic sizes in two standard depths to optimise the accommodation of rail-mountable terminals or components.

- Fully removable lid, concealed hinges provide 180° opening
- Lid fixing, two or three stainless steel captive screws on one side
- Lip on upstand increases gasket contact area, ensuring high degree of ingress protection
- Internal / external earth stud
- 40mm wide fixing lugs for assembly on standard frames
- Option of 0, 1, 2, 3 or 4 gland plates with earth stud
- One piece gasket on lid and gland plates
- Padlock hasp available as additional accessory

The retained stainless steel slotted hex bolt fastenings provide a rapid means of achieving high integrity ingress protection (IP) of 66 for reliable & rapid environmental protection. The high integrity "single piece" sealing gasket for superior ingress protection (IP) of 66 and excellent recovery and re-sealing properties for continuous environmental protection. An integral drainage channel prevents liquids or other solids contaminates from running in or falling into the enclosure when the door is opened, and to minimize gasket path contamination. An integral external & internal feed through brass earth / ground stud assembly enables rapid and reliable protective earth / ground connection mounted on the side of the enclosure for ease of access.

Here is a description of a Hoffmann ATEX certified enclosure:

- Easy-to-use Type 316 stainless steel quarter-turn door latching
- 3-mm double-bit insert for security
- Slot and through-hole side-mount hanging brackets
- Lift-off door hinges
- Fabricated from Type 316 stainless steel
- Type 316 stainless steel external fasteners
- Gray silicone high-temperature gasket on doors and gland plates

Internal/external brass earth/ground provision

CERTIFICATIONS & COMPLIANCES

- ATEX II 2 GD EEx e II T6
- Certified IP66 to EN60529
- cULus to UL50
- C22.2 no. 94-M91
- Type 3S and 4X

MATERIALS & FINISHES

Enclosure:	316L (1.4404 to EN 10088) Stainless Steel
	304 (1.4301 to EN 10088) Stainless Steel
Finish:	Superior corrosion resistant 'Chromium enriched" electro-polished surface
Gasket:	High integrity "one piece" foam-in-place polyurethane gasket
Keyed Lock Fastening Mechanism:	Chromium plated zinc metal die cast
Door Hardware:	Stainless steel hinges on door
Enclosure Mounting:	4 x external 3mm Stainless Steel welded lugs, 11mm Ø holes / slots
Equipment Mounting:	4 x stand off pillars 9mm Ø, 25mm high, tapped M6 x10, for rail / mounting plate
Enclosure Earth:	M10 external & internal brass earth stud assembly
Operating Temp:	-20°C to +60°C
Impact Resistance:	7 J (Nm) to EN 50014

FEATURES

The cover features a ¼ turn keyed lock fastening mechanism that provides a rapid means of achieving a rating of IP66 environmental seal for reliable environmental protection.

An integral drainage channel prevents liquids or other solid contaminates from running in or falling into the enclosure when the door is opened, and to minimize gasket path contamination.

The high integrity "one piece" sealing gasket provides an IP 66 rating and excellent recovery and re-sealing properties for continuous environmental protection

FIGURE O-4 Enclosure Gasketing Details

O.5.9 Wiring routing drawing

In most cases the electrical wiring is in the customer's scope from the magnetic pickup termination head, the solenoid valve termination head, the limit switch termination hardware, and the temperature monitoring device termination head. In a few cases the turbine is sold with a baseplate and conduit runs from the termination heads to the baseplate mounted junction boxes. Figure O-5 shows an example of non-typical conduit routing into baseplate mounted enclosures.

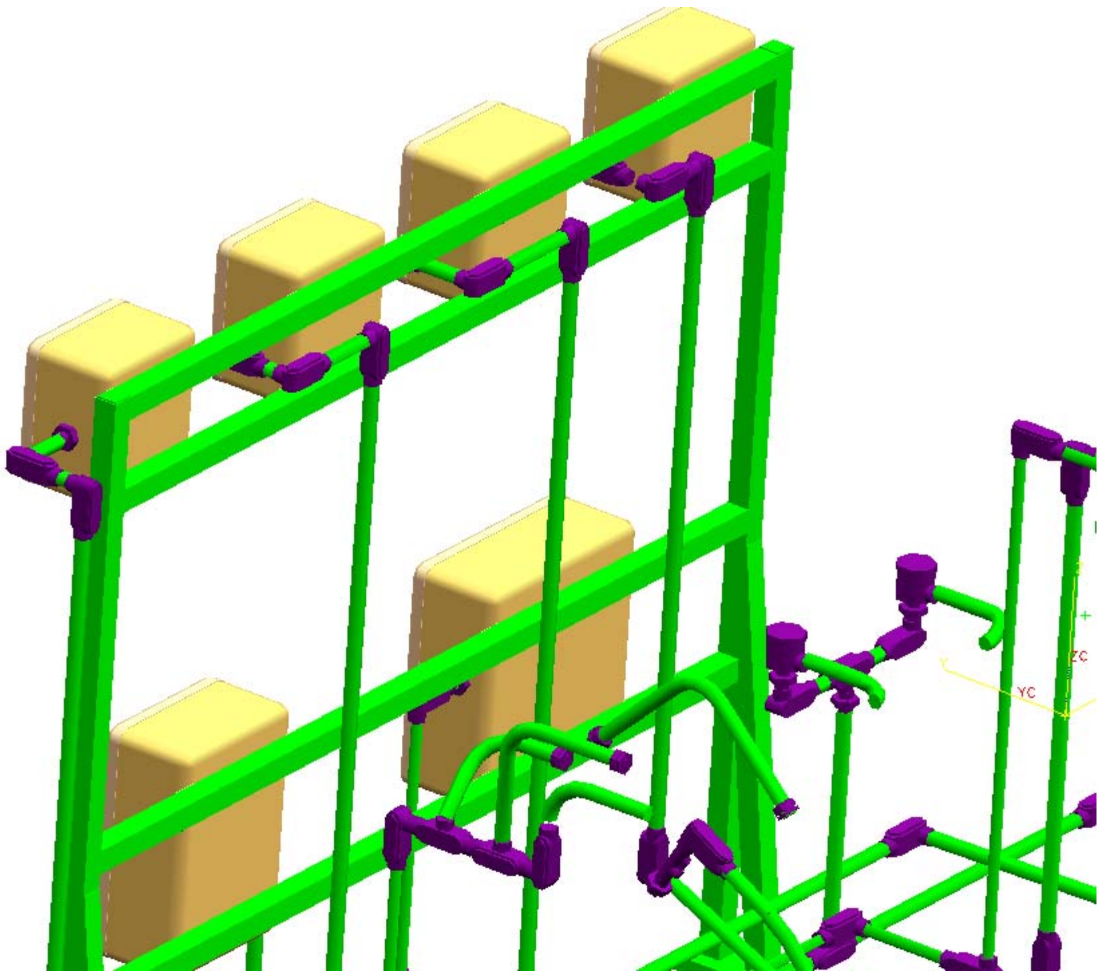


Figure O-5 Example

of conduit routing, non-typical application

O.5.10 Details of neutral conductor

On the Dresser-Rand electrical schematic the conductor information is provided in the notes section of the drawing.

O.5.11 Drawing stating markers for terminals and conductors

Dresser-Rand's standard electrical schematic states the terminal type and manufacture on the enclosure sheet of the schematic. Conductor data is located in the notes section of the electrical schematic drawing, providing manufacture and conductor part number data.

O.5.12 Drawing showing how cover plates are tied into bonding

On the Dresser-Rand electrical schematic/layout drawings the details of the enclosure are provided with notes on gounding and bonding of components.

O.5.13 Drawing showing how protective bonding cross-sectional area of circuit conductors.

Maximum impedance for protective bonding. Details of the circuit conductors are provided in the notes section of the electrical schematics.

O.5.14 CE listed components are wired per manufacturer's instructions.

Testing of component wiring per CENELEC EN60204-1 standards and data are recorded on FAT form.

O.5.15 Prevention of touch voltage

Testing of touch voltage test limits per CENELEC EN60204-1 standards and data recorded on FAT form.

O.5.16 Electrical shock hazard warning

There are electrical shock hazard warnings attached to the turbine per CENELEC EN60204-1 standards and the verification data is recorded on FAT form that all applicable drawings are showing correct warning placement.

O.5.17 Peak starting currents and permitted voltage drops.

The electronic governors are capable of riding out minimal electrical supply disturbances

O.5.18 Confirmation of use of SST electrical components:

A. Temperature

Electrical components provided by Dresser-Rand are selected for use within the environmental parameters presented by the customer. The terminal blocks, Weidmuller SAK-4EN, have a maximum temperature rating of 100°C.

B. Altitude

Electrical components provided by Dresser-Rand are selected for use within the environmental parameters presented by the customer. The terminal block creepage and clearance values were calculated for 2000m above sea level.

C. Containment

Electrical components provided by Dresser-Rand are selected for use within the environmental parameters presented by the customer.

D. Ionizing and non-ionizing radiation

Electrical components provided by Dresser-Rand are selected for use within the environmental parameters presented by the customer.

E. Vibration

Electrical components provided by Dresser-Rand are selected for use within the environmental parameters presented by the customer.

F. Shock

Electrical components provided by Dresser-Rand are selected for the use in environmental conditions presented by the customer specifications.

G. Physical environment

Electrical components provided by Dresser-Rand are selected for the use in environmental conditions presented by the customer specifications.

H. Operating conditions

Electrical components provided by Dresser-Rand are selected for the use in operational conditions presented in the customer specifications.

I. Voltage ride-through

Electronic governors, electronic overspeed protection, solenoid valves, limit switches and all other electrical equipment requiring external power will revert to shelf state in the event of disconnection from the power supply. It is the customer responsibility to provide backup power supply capabilities if it is imperative that the turbine stay operational at all times. The Woodward Peak 150, the most common governor used on SST machines, has a ride-through characteristic of 28 milliseconds for the 24 VDC power source range of 18-32 VDC. Ride-through is 50 milliseconds for a 120 VDC power source range of 90-150 VDC and 4 cycles ride-trhough for 100 VAC power source range of 88-132 VAC with a frequency range of 47-63 Hz. Input voltage fluctuations within the acceptable ranges listed above will not affect operation of the Peak 150 control.

J. Harmonics

The power quality of the electrical power supply is the responsibility of the customer. It is the customer's responsibility to insure that the supplied electrical power provided to the steam turbine is absent of power harmonics per the IEC standards.

K. Ingress protection

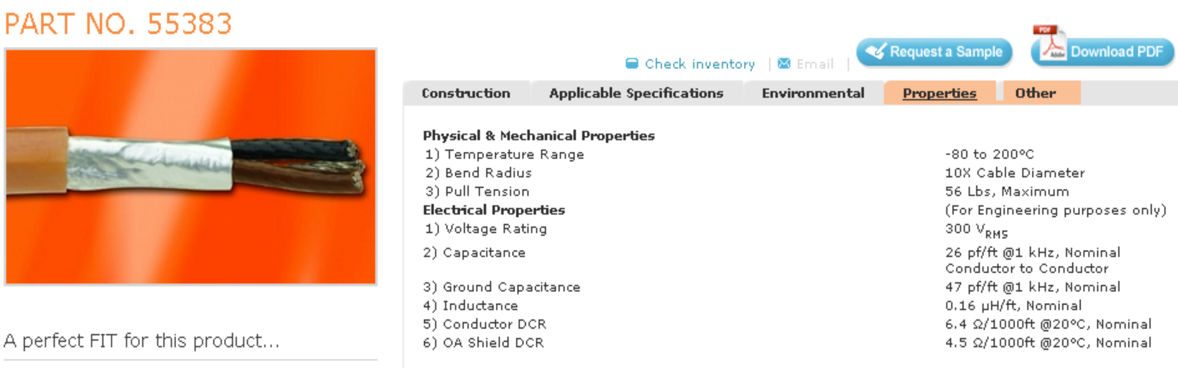
The levels of ingress protection which are spelled out in the customer specifications will be applied in the equipment installed on the turbine.

L. Gaskets on Enclosures

The enclosures specified by Dresser-Rand have the proper gasketing seals on the enclosure doors to meet the customer specifications. See Figure O-4 above for typical enclosure gasketing standards.

M. Tensile stress in cables

See Figure O-6 below for pull tension in Alpha Xtra Guard 5 cables or equivalent typically used for wiring of RTDs and speed probes. The pull tension of the 20 AWG is 298 N/mm2 and the pull tension of the 18 AWG wire is 302 N/mm2 both well beyond the maximum requirements of 15 N/mm2 per EN 60204-1:2006.



PART NO. 55383

A perfect FIT for this product...

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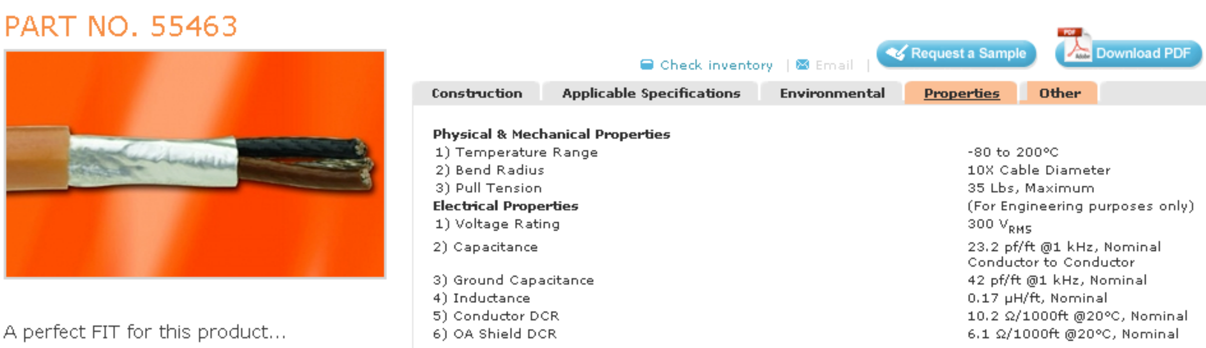
Construction | Applicable Specifications | Environmental | Properties | Other

Physical & Mechanical Properties	
1) Temperature Range	-80 to 200°C
2) Bend Radius	10X Cable Diameter
3) Pull Tension	56 Lbs, Maximum
Electrical Properties	(For Engineering purposes only)
1) Voltage Rating	300 V_{RMS}
2) Capacitance	26 pf/ft @1 kHz, Nominal Conductor to Conductor
3) Ground Capacitance	47 pf/ft @1 kHz, Nominal
4) Inductance	0.16 µH/ft, Nominal
5) Conductor DCR	6.4 Ω/1000ft @20°C, Nominal
6) OA Shield DCR	4.5 Ω/1000ft @20°C, Nominal



PART NO. 55463

A perfect FIT for this product...

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Construction | Applicable Specifications | Environmental | Properties | Other

Physical & Mechanical Properties	
1) Temperature Range	-80 to 200°C
2) Bend Radius	10X Cable Diameter
3) Pull Tension	35 Lbs, Maximum
Electrical Properties	(For Engineering purposes only)
1) Voltage Rating	300 V_{RMS}
2) Capacitance	23.2 pf/ft @1 kHz, Nominal Conductor to Conductor
3) Ground Capacitance	42 pf/ft @1 kHz, Nominal
4) Inductance	0.17 µH/ft, Nominal
5) Conductor DCR	10.2 Ω/1000ft @20°C, Nominal
6) OA Shield DCR	6.1 Ω/1000ft @20°C, Nominal

Figure O-6 Cable Pull Tension and Capacitance Properties

N. Types of insulation and documentation Figures O-6 and O-7

O. Heating effect on conductors

The wiring insulation provided by Dresser-Rand is certified to the highest temperature rating available. In the notes section of the electrical schematics are instructions to the electricians to place conduit runs at a minimum of 10” from steam lines.

P. Drains

It is a Dresser-Rand standard to install vertical drains on all conduit low points. Junction box vents and drains are installed as prudent engineering practice.

Q. Potential earth terminal leakage current

O.6 Electrical Testing

Which specific electrical testing is required for each turbine is delineated in the Inspection and Test Plan (ITP) which is created for each turbine contract. In this section is information pertaining to the possible tests which could be required.

O.6.1 Insulation test plan and certification

High potential (hipot) voltage testing with use of an insulation testing device known as a MegOHM (meggar) resistance tester determines the condition of insulation of the turbine wiring. Wires can be checked for good isolation between the parts of a circuit, which helps to guarantee the safety and quality of electrical circuits. Hipot tests are helpful in finding nicked or crushed insulation, stray wire strands or braided shielding, conductive or corrosive contaminants around the conductors, terminal spacing problems, and tolerance errors in IDC cables. All of these conditions might cause a device to fail.

The Insulation Resistance test is typically done on every cable tested. It is usually done at 300 to 500 Vdc with 100 to 500 Megahoms resistance. The test is a very sensitive to contamination in the assembly process. Solder flux, oils, mold release agents, and skin oil all can cause problems. This test excels at identifying insulation that will conduct in the presence of moisture.

O.6.2 Functional preliminary testing

Each unit with an electronic governor is subjected to a Functional Acceptance Test (FAT) . Items checked, signed and dated are:

b. Dimensions and correct construction of the panels are checked that they conform to the drawings.
c. All components and instrumentation are checked for conformity.
d. Panel hardware is checked that it conforms to drawings.
e. All AC and DC power inputs are checked for shorts and isolation between circuits and grounds
f. Panel is checked for internal grounding circuits.
g. Circuit breakers are closed and checked for governor and interface wiring.
h. All AC and DC power inputs to the panel are checked with proper voltage supplies.
i. Electronic governor program is checked for accuracy.
j. All alarm inputs to panels are simulated for proper indication .
k. All trip modes in control system are simulated for proper indication on panel. Trip signals are verified.
l. The balance of control loops are simulated, checking for correct operation, indication, and outputs.
m. All circuits are checked for continuity.

O.6.3 Functional bonding test data

Testing of bonding per CENELEC EN60204-1 standards and data recorded on FAT form.

O.6.4 High leakage current test limits and terminal leakage current

Testing of high leakage current test limits per CENELEC EN60204-1 standards and data recorded on FAT form.

O.6.5 Analysis and test report documents showing barrier protection

Testing of barrier protection per CENELEC EN60204-1 standards and data recorded on FAT form.

O.6.6 Documentation on insulation of Wire and Terminal Blocks

Testing of insulation current test limits per CENELEC EN60204-1 standards and data recorded on FAT form.

Here are some of the details of the Alpha wire which is a standard Dresser-Rand component. Bend radius is 10X cable diameter, pull tension is 56 pounds maximum, voltage rating is 300 Volts RMS, capacitance is 26 picofarads per foot at 1 kHz nominal, ground capacitance is 47 picofarads per foot at 1 kHz nominal. Inductance is 0.16 micro henries per foot nominal, conductor DCR is 6.4 ohms per 1000 feet at 20 degrees C, nominal, OA shield DCR is 4.5 ohms per 1000 feet at 20 degrees C.

The maximum and minimum temperature rating range of the typically used Alpha wire is from –80 to 200°C. This wiring is used for the actuator, magnetic speed probes and RTD temperature monitoring and very infrequently is located within conduit runs which are near the bearing cases and actuator. The steam chest is typically jacketed with a thermal insulation barrier for protection of surrounding equipment and personnel. In most cases the customer is providing the wiring to the actuator terminal head as well as the RTD and magnetic speed probe termination heads installed on the bearing cases. The temperature levels are much lower than the inlet temperatures in proximity to the bearing cases.

O.6.7 Documentation showing no residual voltage

Testing of residual voltage test limits per CENELEC EN60204-1 standards and data recorded on FAT form.

O.6.8 Documentation showing size and location of terminal points, all wire is copper, PE connections

Dresser-Rand standard electrical schematics show the size and location of terminal points as well as wire type and manufacture and PE connections.

O.6.9 Test report on SST conductor clearances with each other.

Testing of conductor clearances per CENELEC EN60204-1 standards and data recorded on FAT form. The values for the conductor clearances and creepage were calculated from an Extract DIN VDE 0110-04.97. This standard is a technical adaptation of IEC Report 664/664A. Installation Category II was used, which is for equipment intended for use in installations or parts of installations in which no overvoltages can occur.The clearance calculations were conducted per the dimensions and characteristics of the Weidmuller SAK-4EN terminal blocks which are standard offering of D-R. The clearance calculations indicate a maximum of 1.2 mm for these terminal blocks. The clearance between the terminals of the SAK-4EN terminal blocks is 6.5 mm, more than 5 times the minimum clearance allowed.

O.6.10 Test report on SST creepage of Conductors

Testing of creepage per CENELEC EN60204-1 standards and data recorded on FAT form. The creepage calculations were checked per the Weidmuller SAK-4EN terminal block dimensions. The distances between the conductors minimum calculated value due to creepage is 1.5 mm which is 1/5 of the 6.5 mm terminal block distances being used.

O.6.11 Test report on SST mechanical damage caused by short circuits.

Testing of short circuit test limits per CENELEC EN60204-1 standards and data recorded on FAT form.

O.6.13 Analysis on SST enclosure gasketing construction.

Dresser-Rand incorporates Crouse-Hinds and Hoffmann enclosures unless there are customer requirements for other suppliers. At a minimum the enclosures are 304 Stainless Steel with NEMA 4X ingress protection ratings.

O.7 Programming of Electrical Devices

O.7.1 Peak 150 programmer and program entry

In the Woodward Peak 150 Installation and Operation manual 85565 complete and thorough instructions are provided for the programming of the Peak 150 governor. Dresser-Rand provides a governor program which has the values that are punched into the governor via the supplied hand held programmer.

O.7.2 Tachometer program entry

A. Tachtrol 30
   For each turbine which has a AI-Tek tachometer, D-R provides programming parameters on the associated electrical schematic drawing.
B. Moore
C. Red Lion
   For each turbine which has a Red Lion speed meter, D-R provides programming parameters on the associated electrical schematic drawing.

D. Beka
For each turbine which has a Beka tachometer, D-R provides programming parameters on the associated electrical schematic drawing.

O.7.3 Valtek Calibration

The electro-pneumatic actuators are calibrated at the Dresser-Rand factory before the no-load testing of each unit.

O.8 Customer Responsibilities

O.8.1 Power supply disconnect method

Typically the customer is responsible for the design and installation of power supply disconnect hardware for the electronic governor, electronic over-speed protection, solenoid valves and other power consuming components mounted on the turbine. There must be an acceptable disconnect (isolation) at each single incoming source when required (for example: for work on the machine, including electrical equipment). When two or more supply disconnecting devices are provided, protective interlocks for their correct operation shall also be provided in order to prevent a hazardous situation, including damage to the machine or to the work in progress.

The supply disconnecting device shall be one of the following types:

A. Switch-disconnector, with or without fuses, in accordance with IEC 60947-3, utilization category AC-23B or DC-23B
B. Disconnector, with or without fuses, in accordance with IEC 60947-3, that has an auxiliary contact that in all cases causes the switching devices to break the load circuit before the opening of the main contacts of the disconnector.
C. A circuit breaker suitable for isolation in accordance with IEC 60947-2
D. Any other switching device in accordance with an IEC product standard for that device and which meets the isolation requirements of IEC 60947-1 as well as a utilization category defined in the product standard as appropriate for on-load switching of motors or other inductive loads
E. A plug/socket combination for a flexible cable supply.

When the supply disconnecting device is one of the types listed in the above sections A to D, it shall fulfill all of the following requirements:

a) Isolate the electrical equipment from the supply and have one OFF (isolated) and one ON position marked with “O” and “I” (symbols IEC 604178-5008 (DB:2002-10) and IEC 60417-5007 (DB:2002-10)).

b) Have a visible contact gap or a position indicator which cannot indicate OFF (isolated) until all contacts are actually open and the requirements for the isolating function have been satisfied.

c) Have an external operating means (for example—handle), (exception: power-operated switchgear need not be operable from outside the enclosure where there are other means to open it). Where the external operating means is not intended for emergency operations, it is recommended that it be colored BLACK or GRAY.

d) To be provided with a means permitting it to be locked in the OFF (isolated) position (for example by padlocks). When so locked, remote as well as local closing shall be prevented.

e) Disconnect all live conductors of its power supply circuits. However, for TN supply systems, the neutral conductor may or may not be disconnected except in countries where disconnection of the neutral conductor (when used) is compulsory.

f) Have breaking capacity sufficient to interrupt the current of the largest motor when stalled together with the sum of the normal running currents of all other motors and/or loads. The calculated breaking capacity may be reduced by the use of a proven diversity factor.

When the supply disconnecting device is a plug/socket combination, it shall fulfill the following requirements:

Have the switching capability, or be interlocked with a switching device that has a breaking capacity sufficient to interrupt the current of the largest motor when stalled together with the sum of the normal running currents of all other motors and/or loads. The calculated breaking capacity may be reduced by the use of a proven diversity factor. When the interlocked switching device is electrically operated (for example: a contactor) it shall have an appropriate utilization category.

Where the supply disconnecting device is a plug/socket combination, a switching device with at appropriate utilization category shall be provided for switching the machine on and off. This can be achieved by the use of the interlocked switching device described above.

Operating Means—
The operating means (for example, a handle) of the supply disconnecting device shall be easily accessible and located between 0.6 m (1.9 ft.) and 1.9 m (6.2 ft.) above the servicing level. An upper limit of 1.7 (5.6 ft.) is recommended.

Excepted Circuits—
The following circuits need not be disconnected by the supply disconnecting device:

a) Under-voltage protection circuits that are only provided for automatic tripping in the event of supply failure.
b) Where such a circuit is not disconnected by the supply disconnecting device: permanent wiring label(s) in accordance with 16.1 shall be appropriately placed in proximity to the supply disconnecting device.

Local operation of the supply disconnecting device to effect emergency switching off shall be readily accessible and should meet the color requirements.

O.8.2 Customer responsibility for emergency stop controls and devices, location description of emergency devices

It is the customer's responsibility to provide emergency stop controls and devices and provide the location description and accessibility of these emergency devices.

Combined start and stop controls. Push-buttons and similar control devices that, when operated, alternately initiate and stop motion shall only be provided for functions which cannot result in a hazardous situation.

Use of more than one operator control station. Where a machine has more than one operator control station, including one or more cable-less control stations, measures shall be provided to ensure that only one of the control stations can be enabled at a given time. An indication of which operator control station is in control of the machine shall be provided at suitable locations as determined by the risk assessment of the machine.

Devices for emergency stop shall be readily accessible by being located at each operator control stations and at other locations where the initiation of an emergency stop can be required.

There can be circumstances where confusion can occur between active and inactive emergency stop devices caused by disabling the operator control station. In such cases, means (for example: information for use) shall be provided to minimize confusion.

Emergency switching off devices shall be located as necessary for the given application. Normally, those devices will be located separate from operator control stations. Where it is necessary to provide a control station with an emergency stop device and an emergency switching off device, means shall be provided to avoid confusion between these devices.

Color of actuators. Actuators of emergency switching off devices shall be colored RED. If a background exists immediately around the actuator, the background shall be colored YELLOW.

O.8.3 Customer responsibility for earth faults - required accidental start protection

The customer is responsibility to provide earth fault interrupt equipment and lockout process and procedure to prevent accidental startup.

Earth faults on any control circuit shall not cause unintentional starting, potentially hazardous motions, or prevent stopping of the machine.

O.8.4 Customer responsibility for potentiometer rotation stop

The customer is responsible for providing rotation stops on any and all potentiometer installations.

Devices having a rotational member, such as potentiometers and selector switches, shall have the means of prevention of rotation of the stationary member. Friction alone shall not be considered sufficient.

O.8.5 Customer responsibility for stopping by de-energizing

The customer is required to institute controls which will facilitate the turbine stopping by de-energizing the controls.

O.8.6 Customer responsibility that control circuits are connected to bonding circuit

The customer is responsible for ensuring the control circuits are connected to the bonding circuit which is also within the customer's responsibility.

Protection by automatic disconnection of supply: This measure consists of the interruption of one or more of the line conductors by the automatic operation of a protective device in case of a fault. This interruption shall occur within a sufficiently short time to limit the duration of a touch voltage to a time within which the touch voltage is not hazardous.

These measures necessitate the coordination between:

a) The type of supply and earthing system.
b) The impedance values of the different elements of the protective bonding system
c) The characteristics of the protective devices that detect insulation fault(s). Automatic disconnection of the supply of any circuit affected by an insulation fault is intended to prevent a hazardous situation resulting from a touch voltage.

This protective measure comprises both protective bonding of exposed conductive parts and either:

a) Over-current protective devices for the automatic disconnection of the supply on detection of an insulation fault in TN systems, or
b) Residual current protective devices to initiate the automatic disconnection of the supply on detection of an insulation fault from a live part to exposed conductive parts or to earth in TT systems, or
c) Insulation monitoring or residual current protective devices to initiate automatic disconnection of IT systems. Except where a protective device is provided to interrupt the supply in the case of the first earth fault, an insulation monitoring device shall be provided to indicate the occurrence of a first fault from a live part to exposed conductive parts or to earth. This insulation monitoring device shall initiate an audible and/or visual signal which shall continue as long as the fault persists.

O.8.7 Customer responsibility that battery control station will not cause hazardous condition

The customer has the responsibility to insure that the battery control station will not cause any hazardous condition to exist in the SST operation.

Battery-powered operator control stations. A variation in the battery voltage shall not cause a hazardous situation. If one or more potentially hazardous motions are controlled using a battery-powered cable-less operator control station, a clear warning shall be given to the operator when a variation in battery voltage exceeds specified limits. Under those circumstances, the cableless operator control station shall remain functional long enough for the operator to put the machine into a non-hazardous situation.

O.8.8 Customer responsibility for operator control station stop over-ride precedence

The customer is responsible for instituting the hardware/software to guarantee operator control station stop over-ride precedence.

O.8.9 Customer responsibility for enabling control requirements

The customer is responsible for enabling control requirements.

Start functions. Start functions shall operate by energizing the relevant circuit.

Enabling control is a manually activated control function interlock that:

a) When activated allows machine operation to be initiated by a separate start control

b) When de-activated---
---initiates a stop function and----prevents initiation of machine operation.

Enabling control shall be so arranged as to minimize the possibility of defeating the shut-down command, for example: by requiring the de-activation of the enabling control device before machine operation may be re-initiated. It should not be possible to defeat the enabling function by simple means.

O.8.10 Customer responsibility that ES (Emergency Stop) shuts off motive force

The customer is responsible for proper design of the emergency stop controls which will shut off any and all of the motive force to the turbine.

Emergency stop operations (emergency stop, emergency switching off). Once active operation of emergency stop or emergency switching off of the actuator has ceased following a command, the effect of this command shall be sustained until it is reset. This reset shall be possible only by manual action at that location where the command has been initiated. The reset of the command shall not restart the machinery but only permit restarting.

O.8.11 Customer responsibility that resetting of ES requires manual intervention

The customer has the responsibility to properly incorporate into the turbine controls that the resetting of the emergency stop components requires manual intervention for the reset of the turbine controls.

The emergency stop shall function either as a stop category 0 or as a stop category 1. The choice of the stop category of the emergency stop depends on the results of a risk assessment of the machine.

In addition to the requirements for stop, the emergency stop function has the following requirements:

a) It shall override all other functions and operations in all modes.
b) Power to machine actuators that can cause a hazardous situation(s) shall be either removed immediately (stop category 0) or shall be controlled in such a way to stop the hazardous motion as quickly as possible (stop category 1) without creating other hazards.
c) Reset shall not initiate a start

O.8.12 Customer responsbility that any stop function over-rides any start function

The customer has the responsibility to design and incorporate into the controls the capability of any and all stop functions to over-ride any and all of the start function controls.

Stop Function.

a) Stop category 1: A controlled stop with power available to the machine actuators to achieve the stop and the removal of power when the stop is achieved.
b) Stop category 2: A controlled stop with power left available to the machine actuators.

Where more than one control station is provided, stop commands from any control station shall be effective when required by the risk assessment of the machine.

O.8.13 Customer responsibility to provide over-current protection

It is the customer's responsibility to properly design, install, and maintain over-current protection equipment. The measures to be taken to protect the equipment against the effects of over-current arising are from a short circuit, abnormal temperature, loss of or reduction in the supply voltage, earth fault/residual current, and over-voltage due to lighting and switching surges. General over-current protection shall be provided where the current in a machine circuit can exceed either the rating of any component of the current carrying capacity of the conductors, whichever is the lesser value.

Supply conductors. Unless otherwise specified by the user, the supplier of the electrical equipment is not responsible for providing the over current protective device for the supply conductors to the electrical equipment Dresser-Rand states on the P&I list the data necessary for selecting the over current protective device.

Power circuits. Devices for detection and interruption of over current shall be applied to each live conductor.

The following conductors, as applicable, shall not be disconnected without disconnecting all associated live conductors:

a) Neutral conductor of AC power circuits
b) The earthed conductor of DC power circuits
c) DC power conductors bonded to exposed conductive parts of mobile machines

Control circuits. Conductors of control circuits directly connected to the supply voltage and of circuits supplying control circuit transformers shall be protected against over-current. Conductors of control circuits supplied by a control circuit transformer or DC supply shall be protected against over-current:

a) In control circuits connected to the protective bonding circuit, by inserting an over-current protective device into the switched conductor.
b) In control circuits not connected to the protective bonding circuit.
c) Where the same cross sectional area conductors are used in all control circuits, by inserting an over-current protective device into the switched conductor.
d) Where different cross-sectional areas conductors are used in different sub-circuits, by inserting an over-current protective device into both switched and common conductors of each sub-circuit.

Lighting circuits. All unearthed conductors of circuits supplying lighting shall be protected against the effects of short circuits by the provision of over-current devices separate from those protecting other circuits.

O.8.14 Customer responsibility that start functions shall operate by energizing relevant circuit

The customer's responsibility is to insure that the start functions shall operate by energizing the specific circuit which starts the turbine.

In the case of machines requiring the use of more than one control station to initiate a start, each of these control stations shall have a separate manually actuated start control device. The conditions to initiate a start shall be:

a) All required conditions for machine operation shall be met.
b) All start control devices shall be in the released (off) position.
c) All start control devices shall be actuated concurrently.

O.8.15 Customer is responsible for DC power supplies

The customer is responsible for the proper sizing, installation and maintenance of DC power supplies.

O.8.16 Customer is responsible for protective bonding circuit

The customer is responsible for the proper installation and maintenance of protective bonding circuitry.

Dresser-Rand, when the contract requires it, provides bonding/grounding lugs on the sole-plates, gauge-boards, and base-plates as shown in figures O-7 through O-9.

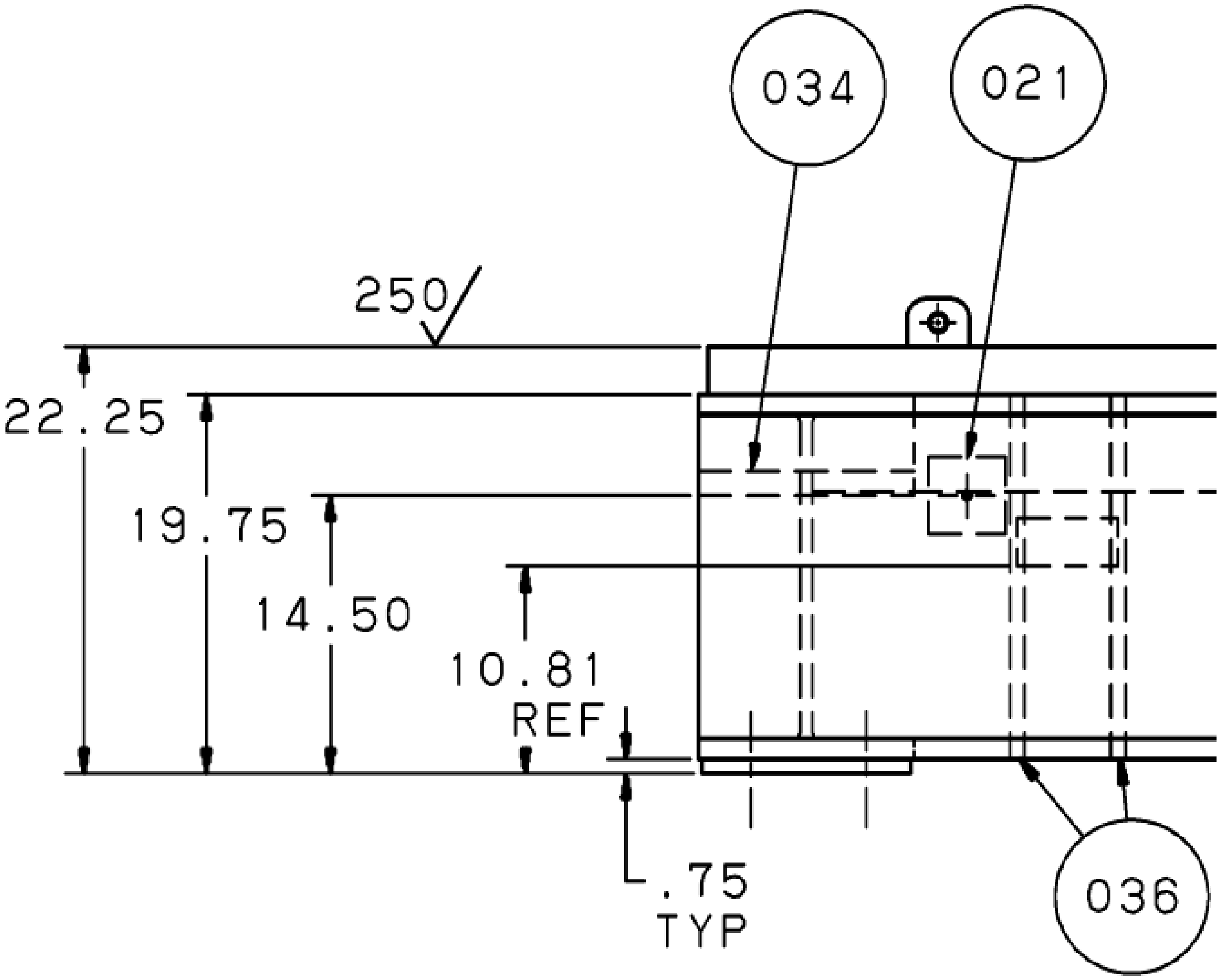

Figure O-7 Location of grounding lug (021) on turbine baseplate

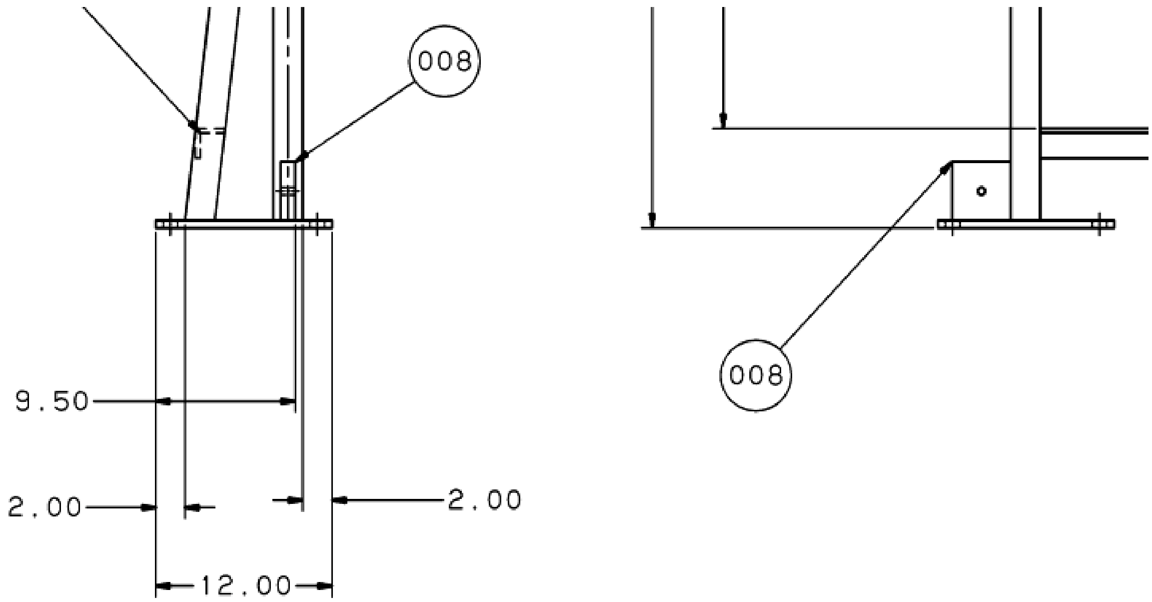

Figure O-8 Grounding lug (008) on gaugeboard

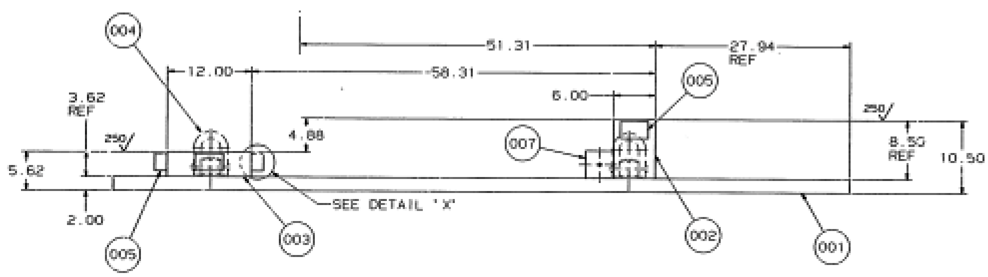

Figure O-9 Grounding lug (007) on soleplate

Equi-potential bonding. Normally functional grounding is achieved by connection to the protective bonding circuit. But where the level of electrical disturbances on the protective bonding circuit is not sufficiently low for proper functioning of electrical equipment, it may be necessary to connect the functional bonding circuit to a separate functional earthing conductor.

Protective bonding circuit. The protective bonding circuit consists of PE terminal(s). All parts of the protective bonding circuit shall be so designed that they are capable of withstanding the highest thermal and mechanical stresses that can be caused by the earth-fault currents that could flow in that part of the protective bonding circuit. Where the conductance of structural parts of the electrical equipment or of the machine is less than that of the smallest protective conductor connected to the exposed conductive parts, a supplementary bonding conductor shall be provided. This supplementary bonding conductor shall have a cross-sectional area not less than half that of the corresponding protective conductor.

If an IT distribution system is used, the machine structure shall be part of the protective bonding cirduit and insulation monitoring shall be provided.

Protective conductors. Copper conductors are preferred. Where a conductor material other than copper is used, its electrical resistance per unit length shall not exceed that of allowable copper conductor and such conductors shall be not less than 16 square mm in cross-sectional area.

The cross-sectional area of protective conductors. This requirement is met in most cases where the relationship between the cross-sectional area of the phase conductors associated with that part of the equipment and the cross-sectional area of the associated protective conductor is in accordance with Table 1.

Continuity of the protective bonding circuit. All exposed conductive parts shall be connected to the protective bonding circuit.

Exclusion of switching devices from the protective bonding circuit. The protective bonding circuit shall not incorporate a switching device or an over-current protective device (for example, switch or fuse). No means of interruption of the protective grounding conductor shall be provided. Exception: Links for test or measurement purposes that cannot be opened without the use of a tool and that are located in an enclosed electrical operating area. Where the continuity of the protective bonding circuit can be interrupted by means of removable current collectors or plug/socket combinations, the protective bonding circuit shall be interrupted by a first-make last-break contact.

Protective conductor connecting points. The protective conductor connecting points shall have no other function and are not intended, for example, to attach or connect appliances or parts. Each protective conductor connecting point shall be marked or labeled as such using the symbol IEC 60417-5019 (DB:2002-10), or with letters PE, the graphical symbol being preferred, or by use of the bi-color combination GREEN-AND-YELLOW, or any combination of these.

Functional bonding. Protection against mal-operation as a result of insulation failures can be achieved by connecting to a common conductor.

Measures to limit effects of high leakage current. The effects of high leakage current can be restricted to the equipment having high leakage current by connection of that equipment to a dedicated supply transformer having separate windings. The protective bonding circuit shall be connected to exposed conductive parts of the equipment and, in addition, to the secondary winding of the transformer.

Control circuits supply. Where control circuits are supplied from an AC source, a control transformer shall be used for supplying the control circuits. Such transformer shall have separate windings.

Where DC control circuits derived from an AC supply are connected to the protective bonding circuit, they shall be supplied from a separate winding of the AC control circuit transformer or by another control circuit transformer.

O.8.17 Customer is responsible for over-voltage suppression (lightning arrestors)

The customer is responsible for the proper installation and maintenance of over-voltage surge protection (lightning arrestors).

Protection against over-voltages due to lightning and to switching surges. Protective devices can be provided to protect against effects of over-voltages due to lightning or to switching surges where provided:

a) Devices for the suppression of over-voltages due to lightning shall be connected to the incoming terminals of the supply disconnecting device.

b) Devices for the suppression of over-voltages due to switching surges shall be connected across the terminals of all equipment requiring such protection.

O.8.18 Customer is responsible for transformer over-current protection.

The customer is responsible for all transformer over-current protection devices to be installed properly and maintained.

Transformers shall be protected against over-current in accordance with the manufacturer instructions. Such protection shall also avoid nuisance tripping due to transformer magnetizing inrush currents. The type and setting of the over-current protective device should be in accordance with the recommendations of the transformer supplier.

O.8.19 Customer is responsible for certifications

The customer is responsible for maintaining the certification documentation required for customer ATEX/EU compliance.

O.8.20 Customer is responsible for accidental disabling of electricity to SST turbine

The customer is responsible for proper design and installation of equipment to prevent accidental power interruption to the SST turbine.

Protection against supply interruption or voltage reduction and subsequent restoration. These conditions can cause a hazardous situation, damage to the machine or to work in progress. Under-voltage protection shall be provided by, for example, switching off the machine at a pre-determined voltage level. Upon restoration of the voltage or upon switching on the incoming supply, automatic or unexpected restarting of the machine shall be prevented where such a restart can cause a hazardous situation.

O.8.21 Customer is responsible for prevention of unwanted startup

It is the customer's responsibility to design, install, and incorporate lockout hardware and procedures to prevent unwanted turbine startup.

Devices for switching off for the prevention of unexpected startup (for example: where, during maintenance, a start-up of the machine or part of the machine can create a hazard).

Such device shall be appropriate and convenient for the intended use, shall be suitable placed, and readily identifiable as to their function and purpose (for example: by a durable marking in accordance with 16.1 where necessary).

Means shall be provided to prevent inadvertent and/or mistaken closure of these devices either at the controller or from other locations. Devices that do not fulfil the isolation function (for example, a contactor switched off by a control circuit) may only be provided where intended to be used for situations that include:

a) Inspections
b) Adjustment

O.8.22 Customer is responsible for locking of emergency off isolation operators

It is the customer's responsibility to incorporate locking out of emergency shut-down isolator hardware.

Emergency switching off should be provided where there is the possibility of other hazards or damage caused by electricity.

Emergency switching off is accomplished by switching off the relevant incoming supply by electromechanical switching devices, effecting a stop category 0 of machine actuators connected to this incoming supply. When a machine cannot tolerate this stop category 0 stop, it may be necessary to provide other measures, for example: protection against direct contact, so that emergency switching off is not necessary.

O.8.23 It is the customer responsibility to ensure that there is not a connection between the neutral conductor and the protective bonding circuit

According to CENELEC EN60204-1 it is the customer responsibility to insure that there is not a connection between the neutral conductor and the protective bonding circuit.

There shall be no connection between the neutral conductor and the protective bonding circuit inside the electrical equipment nor shall a combined PEN terminal be provided. Exception: a connection may be made between neutral terminal and the PE terminal at the point of the connection of the power supply to the machine for TN-C systems.

O.8.24 It is the customer responsibility to guarantee that the electrical components on the SST turbine are connected to a single incoming power source.

A single point connection for the turbine power must be provided by the customer that meets the parameters outlined in this chapter.

Incoming supply conductor terminations: It is recommended that, where practicable, the electrical equipment of a machine is connected to a single incoming supply. Where another supply is necessary for certain parts of the equipment (for example, electronic equipment that operates at a different voltage), that supply should be derived, as far as is practicable, from devices (for example, transformers, converters) forming part of the electrical equipment of the machine.

O.8.25 Power supply testing is the responsibility of the customer.

The customer is responsible for the power supply testing per the requirements of CENELEC EN60204-1.

The connection of the power supply and of the incoming external protective conductor the the PE terminal of the machine, shall be verified by inspection. The conditions for the protection by automatic disconnection of supply shall be verified by both:

1) Verification of the fault loop impedance by

    a) Calculation
    b) Measurement

2) Confirmation that the setting and characteristics of the associated over-current protective device are correct.

Functional tests. The function of electrical equipment shall be tested. The function of circuit for electrical safety (for example: earth fault detection) shall be tested by the manufacturer.

Re-testing. Where a portion of the machine and its associated equipment is changed or modified, that portion shall be re-verified and re-tested as appropriate. This re-testing is the responsibility of the customer.

O.8.26 Power quality customer requirements.

The customer is required by the IEC low voltage directive EN60204-1 to provide power to the electrical load of supplied devices with harmonic distortion not exceeding 10% of the total r.m.s. voltage between live conductors for the sum of the 2^{nd} through to the 5^{th} harmonic. An additional 2% of the total r.m.s. voltage between live conductors for the sum of the 6^{th} through to the 30^{th} harmonic is permissible.

O.8.27 Customer responsibility for protection from electric shock.

The customer is responsible for the wiring and connection of electrical components and equipment of electrical components which is in their scope (any wiring and installation of equipment not installed and wired by Dresser-Rand) per the component manufacturer instructions.

The electrical equipment shall provide protection of persons against electric shock from:

a) Direct contact
b) Indirect contact

O.8.28 Customer responsible for abnormal temperature protection.

Resistance heating or other circuits that are capable of attaining or causing abnormal temperatures (for example, due to short-time rating or loss of cooling medium) and therefore can cause a hazardous situation shall be provided with suitable detection to initiate an appropriate control response.

O.8.29 Customer responsible for motor over-speed protection.

The over-speed protection of auxiliary motors, such as lube oil pump motors, which are in the customers' scope of supply, are the responsibility of the customer to provide over-speed protection controls.

O.8.30 Customer responsibility for operation and minimizing risks.

Where a machine has more than one control station, measures shall be provided to ensure that the initiation of commands from different control stations do not lead to a hazardous situation.

Control functions in the event of failure. Where failures or disturbances in the electrical equipment can cause a hazardous situation or damage to the machine or to the work in progress, appropriate measures shall be taken to minimize the probability of the occurrence of such failures or disturbances. The required measures and the extent to which they are implemented, either individually or in combination, depend on the level of risk associated with the respective application.

The electrical control circuits shall have an appropriate level of safety performance that has been determined from the risk assessment at the machine. The requirements of IEC 60261 and/or 13849-1:1999, ISO 13849-2:2003 shall apply.

Measures to reduce those risks include but are not limited to:

a) Use of proven circuit techniques and components
b) Provision of partial or complete redundancy or diversity
c) Provision for functional tests

Measures to minimize risk in the event of failure – Use of proven circuit techniques and components.

These measures include but are not limited to:
a) Bonding of control circuits to the protective bonding circuit for functional purposes.
b) Connection of control devices 1
c) Stopping by de-energizing
d) Switching devices having direct opening action (see IEC 60947-5-1)

O.8.31 Physical separation or grouping (11.2.2) customer responsibility.

Control devices mounted in the same location and connected to the supply voltage, or to both supply and control voltages, shall be grouped separately from those connected only to the control voltages.

Terminals shall be separated into groups for:
a) Power circuits
b) Associated control circuits
c) Other control circuits, fed from external sources (for example: for interlocking)

The groups may be mounted adjacently, provided that each group can be readily identified (for example: by markings, by the use of different sizes, by use of barriers or by colors). When arranging the location of devices (including interconnections), the clearances and creepage distances specified for them by the supplier shall be maintained, taking into account the external influences or conditions of the physical environment.

O.8.32 Customer responsibility for prevention of indirect contact

For each circuit or part of the electrical equipment, at least one of the measures shall be applied:

a) Measure to prevent the occurrence of a touch voltage or
b) Automatic disconnection or the supply before the time of contact with a touch voltage can become hazardous

Prevention of the occurrence of a touch voltage. Measures to prevent the occurrence of a touch voltage include the following:

a) Provision of class II equipment by equipment insulation
b) Electrical separation

Protection by provision of class II equipment or by equivalent insulation. This measure is intended to prevent the occurrence of touch voltage on the accessible parts through a fault in the basic insulation. This protection is covered by one of the following:

a) Class II electrical devices or apparatus (double insulation, reinforced insulation or by equivalent insulation in accordance with IEC 61140)
b) Switch-gear and control-gear assemblies having total insulation in accordance with IEC 60439-1
c) Supplementary or reinforced insulation in accordance with 413.2 of IEC 60364-4-41

Protection by electrical separation of an individual circuit is intended to prevent a touch voltage through contact with exposed conductive parts that can be energized by a fault in the basic insulation of the live parts of that circuit. For this type of protection, the requirements of 413.3.5 of IEC 60364-4-41 apply.

Section P

User Notes and Maintenance Records

Date	Observation or Service Performed	Comments	By

Date	Observation or Service Performed	Comments	By

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