

HYDRAULIC TURBINE AND GOVERNOR
FIELD ERECTION INFORMATION

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The information contained in this publication deals with the field erection of hydraulic turbines, governors and accessory equipment, and is intended to assist purchasers and installation contractors in understanding the general procedures to be followed and to point out the care and precision required to obtain satisfactory operation.

It has been developed from many years experience in installing such equipment and in observing its operation. The procedures, methods and precautions outlined, when carefully and closely followed by groups, organizations and manufacturers' field representatives responsible for erection should minimize difficulties and should result in satisfactory installation and in good operation.

I. Receipt and Storage of Equipment

A. As the equipment is received at the job site, the purchaser checks all shipments against the bill of lading for omissions and damage. Any omission or damage should be reported immediately to the transportation company, and a copy of the report forwarded to the manufacturer.

B. All materials are to be checked against the manufacturer's packing lists, and any discrepancies reported immediately to the manufacturer. This checking should be done in the presence of the manufacturer's field representative and the purchaser's representative. Boxed materials are to be replaced in their original containers or properly identified as to their stored location.

C. All materials must be so stored that they will be protected against loss, corrosion, weather damage and distortion.

Motors, gauges, relays, delicate equipment, etc., must be stored in a dry building.

Parts on which the final alinement and running clearances of the turbine depend are machined to close tolerances. Consequently, adequate blocking must be provided when storing such parts to prevent distortion of their machined surfaces.

Runners, head covers, bottom rings, wearing rings, etc., must be stored with their axes vertical to maintain roundness. Shafts and runners and other attached equipment must be supported to distribute their weight uniformly and thus avoid any permanent deformation. Supports must not be placed under the bearing surfaces.

Wood supports must not be in direct contact with the shaft. The shaft must be rotated periodically through 180 degrees and lifted so that additional rust-preventive material can be applied to prevent pitting at the points of support.

D. Extreme care must be taken at all times to protect the governing equipment from damage, dirt or corrosion. Sling spreaders must be used when lifting governing equipment to prevent damage. If the equipment is received at the site before it is required, the whole shipment, as packed, should be stored in a clean, dry, well-protected place. If the weather is damp or cold, space heaters should be provided in the storage area. The installation of the equipment should be deferred as long as possible in order to prevent its being damaged or contaminated by dirt which is incidental to construction. If it must be installed some time before operation is initiated, it should be covered with a clean tarpaulin and tied shut to prevent the ingress of dust and dirt during construction.

II. Equipment and Tools

A. All tools, including precision instruments, lifting and rigging equipment, bracing, scaffolding, and all other materials which are necessary for proper installation, field tests and operation of the equipment and which are not included in the manufacturer's contract specifications are customarily furnished by the purchaser.

III. Personnel

A. Skilled and unskilled labor of various crafts are required for the proper installation, starting up, field tests and operation of the equipment and are customarily provided by the purchaser.

B. It is recommended that the services of the manufacturer's field representative(s) be employed to supervise the installation of the equipment. Such representatives have received specialized training and experience in the erection of hydraulic turbine and governor equipment. The field representative(s) will review the general program of erection as it may affect installation of the turbine and governor and will assist in setting up a coordinated procedure for the erection of this equipment. Datum requirements for leveling and alinement will be specified. Recommendations will be made on temporary bracings and supports required to maintain alinement during pouring of concrete. Instructions will be provided as the erection progresses on assembly and fitting of components, alinement checks and test requirements, operating adjustments and precautions to be observed at start-up as outlined below in further detail.

The scope of the duties of the manufacturer's field representative should be recognized. He acts in an advisory capacity on all matters pertaining to the installation of equipment as covered by the contract. He cannot control such features as schedules, workmanship and errors on the part of others or their failure to follow instructions. He will not train personnel in their respective crafts, such as welding, riveting, rigging, placement of concrete, etc. Questions relating to engineering and design should be referred directly to the manufacturer(s).

Erection procedure should be in accordance with the recommendations of the manufacturer's field representative(s) and conform to the instructions issued by the manufacturer(s), either on drawings or by other means. Such procedure is designed to result in the most satisfactory installation. Any disagreement on erection procedure, adequacy or proper functioning of the equipment should be referred to the home offices of the manufacturers involved.

IV. Turbine Erection Procedure

A. To assure proper installation in the most efficient manner, the purchaser should solicit close cooperation between his organization, all contractors and all manufacturers' field representatives. A mutual understanding with the manufacturer's field representatives as to erection procedures is advisable before beginning the erection of the equipment.

The purchaser's engineer customarily establishes the proper grade and power house centerlines to which the equipment is to be set. It is customary for this engineer to keep daily progress reports and records of all alinement figures. The manufacturer's field representative should sign all copies of these reports and records and should receive two copies of them.

Adequate space and facilities should be provided for turbine sub-assemblies to minimize conflict with the assembling of the generator and other equipment.

B. Shop assemblies of plate-steel embedded parts cannot be termed "complete" due to the fact that final alinement of plates, reaming of rivet holes, refitting of butt straps and joints, riveting and other incidental items can be done only at the job site under prevailing conditions, methods and procedures. Notwithstanding shop precautions and the bracing of various members, it is frequently found that distortions develop during transportation and handling in the field. Such conditions necessitate adjustment in the field by the purchaser as a part of the erection procedure.

C. As the final leveling and alinement of the turbine operating parts depend on the setting of the embedded parts, such parts should be braced and checked periodically throughout the erection procedure for elevation, concentricity and trueness. Subassemblies may be made before they are placed in the turbine pit, but no permanent connections should be made until all of the embedded parts are properly alined. After an assembly is fitted together, properly alined and permanently connected, it should be braced and anchored to hold it in line and shape during the pouring of concrete around it.

To insure proper installation of the embedded parts in accordance with the concreting procedure selected, it is customary for the purchaser to provide any additional bracing, spiders, jacks, blocking, supports, shims, anchor bolts and foundation materials other than those shown on the manufacturer's drawings or called for in the contract specifications.

D. For riveted parts, the manufacturer furnishes the necessary number of rivets of the correct diameters and lengths. It is customary to supply an additional 10 per cent. Care must be used in the field to select the proper rivets as specified on rivet lists and on drawings. It may be necessary to cut some rivets to suit the assembly. Since these rivets are usually large and have heads of special shape, suitable rivet-driving equipment must be used. The manufacturer furnishes an ample supply of fitting-up bolts as provided in the contract, and the plates must be drawn tightly together before riveting.

E. The publication does not specify methods or procedures for concreting around or upon embedded parts since the design and placing of all concrete is a part of the construction of the power house. However, it is important that a carefully planned sequence of concreting be set up and followed by the purchaser so that the parts will be properly embedded with a minimum of misalignment and distortion.

Some of the causes of improperly embedded parts are:

1. Attaching concrete forms to or bracing them against the parts to be embedded.
2. Contact of concrete buckets or vibrators with any of the parts to be embedded or their supporting members.
3. Severe impact of the concrete against the parts to be embedded due to the use of large vibrators or steep chutes or to the dumping of buckets from a relatively high elevation.

F. It is customary to spray cool water continually upon all internal surfaces of the embedded parts during the entire period of pouring and curing the concrete in order to dissipate excessive heat. Care must be used to prevent water from entering any of the holes provided for grouting, puddling or tamping.

G. The pouring and setting of concrete sometimes affects the correct alignment, levels and trueness of the embedded parts to such an extent that corrective measures are required in order to assure satisfactory installation and operation. Such corrective measures are a part of the normal erection procedure. The manufacturer's field representative cooperates fully in planning and supervising the needed corrections.

H. It is frequently found necessary to fill voids in the concrete adjacent to the embedded parts by grouting. The field engineer and the manufacturer's field representative should check all parts as thoroughly as possible and, if grouting is required, should cooperate to make sure it is properly done.

I. The machined surfaces of stationary parts must be cleaned of rust, paint, protective coating, burrs and nicks before assembly. Some fitting and correcting may be required if distortion has developed during transportation and handling in the field. The manufacturer's field representative may, on occasion, recommend that certain subassemblies be dismantled and checked for cleanliness, lubrication, proper functioning, etc. Proper erection procedure frequently requires the temporary placement of one or more parts, their removal and final placement and assembly. Repeated careful checking of levels and alignment is a requisite. Drilling and reaming for the installation of dowel pins in the field is a part of the erection procedure.

J. The machined surfaces of the rotating parts must be cleaned of rust, paint, protective coating, burrs and nicks before assembly. After the rotating parts of the turbine are properly assembled, set, centered, plumbed and alined, the generator is brought into proper alinement with the turbine. It is necessary to have the turbine coupling located a short distance away from its final position.

K. After the generator is properly placed, centered, plumbed and alined with the turbine, the turbine and the generator shafts are to be coupled. The work is customarily done under the supervision of the representative of the manufacturer who supplied the bolts. This involves moving the revolving element of the turbine to its final position. Sometimes the purchaser prefers to use temporary bolts for this purpose and, if so, he should have them available.

L. After the coupling has been "made up," alinement checks of the combined shaft are to be carefully made. This is customarily done by the contractor installing the generator under the joint supervision of the generator manufacturer's field representative and the turbine manufacturer's field representative. If the combined shaft proves to be true and straight, the revolving element of the entire unit is ready for final adjustment.

There are three principal requirements to be satisfactorily met:

1. The shaft should be plumb. (Level for horizontal units.)
2. The runner should be in its correct position with respect to the water surfaces of the head cover and the bottom ring.
3. The runner should be in the center of the head cover and the bottom ring.

The required plumbing and positioning is accomplished by adjusting the thrust bearing supports. These adjustments may throw the runner out of center and it may be necessary to move the entire revolving element of the unit in order to satisfy requirement 3.

Repeated careful checks must be made, and it is usually found necessary to make a number of adjustments in order to satisfy requirements 1, 2 and 3, and to secure the best possible alinement. Much skills, patience and time are required for this work.

Requirements 1, 2 and 3 must be satisfied prior to the installation of the turbine or generator guide bearing shell or shoes.

M. To secure proper clearance with the shaft, it may be necessary to adjust or to remove and scrape the turbine bearing.

V. Governor Erection Procedure

A. Before installation, the rust-preventive compounds must be removed from the control parts of the governor with a solvent and the various joints must be re-lubricated with a light machine oil. Nothing coarser than crocus cloth or oil and rouge should be used to clean off any rust which may have formed on these parts.

The inside surface of sump tanks, pressure tanks, servomotors, and piping must be inspected, and any rust or dirt must be removed. The use of wire brushes rather than rags is recommended for cleaning unfinished surfaces.

Before the hydraulic system is closed, it must be carefully checked to be sure that all extraneous matter, such as rags, tools, bolts, etc., has been removed. Do not use rags to plug pipes during erection. Cap or cover pipes with metal or wooden plates until closure is made.

B. The gate shaft for a gate shaft governor must be plumb. It should be checked, and the necessary corrections made before the governor is installed.

C. When ready for installation, the governing equipment should be placed in position in accordance with the manufacturer's instructions and installation drawings and leveled with shims. The piping connections should then be made between the various components. After the necessary minor adjustments have been made to coordinate the positioning of the equipment and after the foundation bolts, when used, have been tightened, the equipment should be grouted in if such construction is specified.

D. When flanged governor piping is furnished, it is supplied in lengths indicated on the installation drawings. Minor adjustments may be required during erection. Threaded piping and restoring conduit is not furnished cut to length and must be fitted and threaded on the job.

E. For adjustable-blade propeller turbines, the blade restoring connections and the pipes between the governor and oil head are provided with ungrounded sections adjacent to the oil head, which are insulated from the oil head and from ground. Permanent magnet generators are also insulated from their supports and from the generator shafts. After installation, the resistance of these points of insulation should be measured and must be adequate to prevent induced circulating currents from causing damage to the generator bearings.

Suitable pipe supports must be provided to prevent distortion of the oil piping during sudden surges in the lines.

F. Before grouting in a gate shaft governor, the gates should be operated through the full stroke on hand control to ascertain whether the gate operating mechanism is free and properly aligned.

G. Electrical connections must be made in accordance with the applicable wiring diagrams.

H. Extreme care should be taken to keep the interior of the oil piping, tanks and pumps perfectly clean during erection. Before filling with oil, re-inspect these components. Oil should be filtered and poured through cheese cloth when filling or adding to the hydraulic system unless a closed oil purification and filter system is provided. After the oil pressure is built up, any leaks which develop should be corrected.

VI. Preparation for Starting the Unit

A. It is imperative to carefully check all equipment including gauges, instruments, controls, valves, lubrication devices, flow indicators, filters, pumps, etc., before revolving or "starting-up" the unit. All oil lines should be flushed and oil circulated through a filter which is customarily provided by the purchaser. Oil pumps and piping should undergo a 24-hour period of operation and inspection to be sure of correct performance and the absence of leaks. The conduit, surge tank, penstock, drains, intake gate, valves, case or flume, distributor, runner, draft tube, tail race and turbine pit, including the gate operating mechanism, should be carefully inspected to be certain that all foreign matter has been removed.

All piezometer orifices and lines should be checked to be certain that they are free of obstructions and in proper condition.

All water supply lines, including strainers, should be checked to be certain of proper flow to the various parts of the unit.

B. The wicket gates shall be thoroughly checked for proper clearance and operation. The actual gate opening shall be calibrated with the servomotor stroke. This calibration is required for field performance tests.

C. Before watering the unit, the gate timing, exclusive of cushioning time, in the closing and opening directions must be set to suit the conditions of the installation. The servomotor cushioning time must be set to prevent shock on the gate mechanism.

D. Before watering the unit, the following checks and adjustments should be made:

1. Operation of the governor oil supply system
 - a. Check of unloading range.
 - b. Check of safety valve operations.
 - c. Setting of pressure failure relays.
2. Operation of gates on gate limit control.
3. Timing adjustments
 - a. Setting of wicket gate timing.
 - b. Setting of blade timing on adjustable-blade propeller turbines.
 - c. Setting of needle and/or deflector timing on impulse turbines.

4. Electrical check of operation of governor auxiliaries

- a. Split field and selsyn motors.
- b. Solenoids.
- c. Overspeed and speed switches.
- d. Limit switches.
- e. Remote indicating apparatus.
- f. Generator brake timer.

5. Setting of gate limit switches.

6. Operation and setting of gate locked after the wicket gates have been closed by governor system pressure.

E. After the turbine manufacturer's field representative is satisfied that all parts of the turbine and accessories are ready for operation, the field representatives of the generator and of the governor manufacturers are to be consulted and, if their equipment is ready, the preparations for starting may proceed.

F. Remove the draft tube gates or stop logs in accordance with the procedure required for the particular installation.

G. Fill the turbine case and penstock slowly with the wicket gates closed. If inspection discloses no troubles of any kind, operate the head gate several times through its full stroke and stop it at the 20 per cent open position if feasible. This will admit enough water for the mechanical run and should make it possible to shut off the water quickly in case of emergency. If a shut-off valve is provided, operate it through its full stroke several times and leave it in its full open position.

H. If a pressure regulator is provided, its operation and timing should be checked and it should be left in its closed position.

I. The unit is now ready for the initial "start-up."

VII. Starting the Unit

A. It is customary for the purchaser or his authorized representative to coordinate the initial start. The governor manufacturer's field representative normally supervises the initial start under the direction of the purchaser. The latter, with the cooperation of the generator and turbine manufacturers' field representatives, should specify when the unit is to be started, its speed of operation, when it is to be shut down, and all other matters relative to this operation.

Since it is customary for the purchaser's personnel to operate the equipment from the initial stages through all states to and through commercial operation, they should now operate under the direction of the purchaser and with the guidance of the various manufacturers' representatives as may be required.

The first operation should be a mechanical run, and ample opportunity should be given for checking shaft run-outs and bearing temperatures.

The speed of the unit should be increased by increments until normal speed is reached. Ample time and opportunity should be afforded to check all parts of the unit and to "run-in" the bearings.

The turbine should be shut down at the request of any of the manufacturer's field representatives. It is frequently found desirable to make adjustments during and following the mechanical run. More than one shutdown may be necessary and, in some cases, unwatering and inspecting of internal turbine parts or water passages are required. Such instances are considered normal and are to be expected.

It may be advisable again to adjust or remove and scrape the bearing.

B. After watering the unit and during the mechanical run, the following checks and adjustments should be made:

1. Adjustment for operation on governor control at normal speed with no load.
2. Operation of stop-starting mechanism or safety solenoid.
3. Operation of automatic generator brake applicator.
4. Permanent magnet generator voltage.
5. Setting of tachometer.

C. Strainers should be checked frequently and kept clean.

D. After the mechanical run and before the unit goes into commercial operation, sufficient time must be allowed to:

1. Check and adjust the governor.
2. Recheck operation at normal speed with no load.
3. Check operation of overspeed and speed switches.

VIII. On-line Operation

A. After the unit has been placed on the line:

1. Set dashpot, synchronous by-pass, if required.
2. Readjust governor for on-line performance, if necessary.
3. Make load rejection tests.
4. Readjust the servomotor cushioning time, if necessary.