

**CONSTRUCTION STANDARD**

**FOR**

**PROCESS MACHINERIES ASSEMBLING**

**AND**

**INSTALLATION**

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## **0. INTRODUCTION**

This IPS Standard specifies the minimum requirements for the mechanical installation of rotating equipment. It is intended to supplement, and in those cases where it is more stringent, to replace Manufacturer's recommendations, unless otherwise agreed by the Company.

These requirements shall form the basis for the checklists to be prepared and used by the Contractor and operating companies to ensure proper installation of rotating equipment.

Although primarily intended for new construction projects, this manual may also be useful to maintenance departments responsible for installation of rotating equipment.

For civil, instrumentation and electrical requirements on installation of rotating equipment the appropriate documents shall be consulted.

## 1. SCOPE

This Standard contains the minimum requirements for the mechanical installation of rotating equipment.

It is intended to be used in oil refineries, chemical plants, gas plants, and where applicable, in exploration and production and new ventures.

The contractor shall inform the Company on any deviations from the requirements of this Standard necessary to comply with the above.

Any deviation requires the written approval of the Company.

## 2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor/Consultant.

All publication referred to in this standard are listed below:

### IPS (IRANIAN PETROLEUM STANDARDS)

E-PM-120 "Accessibility and Safety of Machineries"

E-PM-385 "Machinery Piping"

### API (AMERICAN PETROLEUM INSTITUTE)

671 "Special-Purpose Couplings for Refinery Services"

## 3. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

## 4. GENERAL REQUIREMENTS

### 4.1 General

Whether or not hoisting facilities with associated roofs are to be provided shall be decided in accordance with the requirements of IPS-E-PM-120.

The overall lay-out of a rotating equipment installation shall be such as to allow safe access to all operating positions and to overhead lifting equipment. There shall be no unguarded floor opening around machines (specially for compressors and turbines).

Sufficient space shall be provided at the machine floor level for dismantling the machine its driver and auxiliary equipment. When two or more rotating equipment are located on the same floor, provision shall be made for a clear floor area which is adequate for the simultaneous overhaul of all equipments, their drivers and associated auxiliary equipment.

The lay-out of auxiliary equipment shall be such as to permit easy and safe access to all components for operation and maintenance by the provision of permanent steps and platforms, and adequate clear floor space.

## 4.2 Quality Control

At an early stage of the project, the Contractor and the Company shall agree on a proposal for quality control of rotating equipment covering all aspects of installation, inspection and precommissioning.

Quality control should be maintained by an independent function within the Contractor's organisation or inspection department which reports to the Contractor's management.

Each individual item of equipment shall have its own check list covering all aspects of installation, inspection and pre-commissioning.

Such a checklist shall ultimately be signed by the rotating equipment inspection department of the Company or its representative and shall act as a document in the handover procedure.

A copy of this checklist shall be added to the Equipment Record Card (including installation records, level and alignment data, run-in record, vibration data etc.).

## 4.3 Construction Tools/Special Tools

It is the Contractor's responsibility to ensure that the proper tools are available and are used for the proper installation of rotating machinery (i.e. correct-size spanners and keys, certified slings and chain hoists, torque wrenches, alignment dial gages and calibrated engineering spirit levels, V-belt tensioners, portable vibration meters, analysers etc.). Adjustable spanners shall not be used on rotating equipment.

Any defect of parts of equipment through the use of improper tools during assembly is not acceptable. At handover, equipment shall be in "as-new" condition.

At an early stage during the construction a check should be made on the availability of special tools that shall be supplied by the equipment Manufacturer.

Such special tools as provided shall be used by the Contractor as and when required. The Contractor remains responsible for the handover of these tools to the Company in as-new condition. Throughout the project, preservation of special tools should therefore be maintained.

## 4.4 Installation and Operating Manuals

Manufacturer's installation and operating manuals shall be available at site at least one month prior to installation of the equipment. The instructions contained therein shall be adhered to, unless superseded by more stringent requirements of this IPS.

Shop test inspection records and as built drawings shall be collected and made available at site when the installation commences.

The Contractor shall be responsible for supplying as-built data sheets and completed Equipment Record Cards of all equipment supplied.

At the time installation starts, completed Record Cards shall be available at site.

During installation and commissioning, the Contractor shall add any relevant information to the Equipment Record Cards until the equipment has been handed over.

Information to be indicated in data record cards shall be specified by Company and Contractor mutually according to manufacturer's recommendations.

#### 4.5 Spare Parts

The Contractor or Company should ensure that commissioning spare parts are available during the construction and commissioning period. Operating spare parts for two years shall be ordered to arrive at site prior to handover of equipment to the Company.

Spare rotors shall be furnished with proper supports, well preserved (long-term) and supplied with clear storage instructions.

For spare rotors of major equipment e.g. compressors, turbines etc., separate equipment record cards shall be prepared.

#### 4.6 Storage of Equipment Prior and After to Installation

At a (very) early stage of the project it should be certified that there will be an adequate quantity of rust preventatives at site by the time equipment is received.

If the equipment is received at site before it can be installed it shall be immediately stored in a dry location.

On receipt the equipment shall be checked against the shipping manifest and inspected for any damage.

Shop preservation shall be checked. Where necessary, damage to preservation shall be rectified without delay.

Shop-applied protection is usually sufficient for the shipment period or 6 months only. The Contractor shall take all necessary actions to restore the preservation, when the protection period expires.

Shafts shall be turned at least once per month and a check list shall be used to ensure that this is done to all rotating equipment at site. Locking devices, required for equipment transport, shall be removed and kept for any future transport.

At all times the Manufacturer's recommendations on extended storage (indoor and outdoor) shall be adhered to.

Installation procedure should be so scheduled to minimize the time elapsed before commissioning.

### 5. FOUNDATIONS

#### 5.1 General

Allowance shall be made between the rough surface of the concrete and the underside of the baseplate for grouting.

Whereas most pump units and small compressors are mounted on baseplates, some equipment may be mounted directly on the foundations. In these cases, sole plates shall be provided which are grouted on the foundation to facilitate easy removal and reinstallation of the equipment during maintenance.

Vertical close-coupled pumps shall be mounted on sole plates.

If fixed points and sliding supports have been provided for in the bed plate, they shall be sufficiently rigid and properly cast in and/or grouted to the foundation.

Misalignment and distortion of the baseplate shall be prevented during installation.

#### 5.2 Foundation Bolts

To allow for slight differences in dimensions between the holes in the frame or bed plate and the bolts in the foundation, foundation bolts shall be installed according to IPS standard drawing .....

### 5.3 Leveling

When equipment is placed on its foundation, it shall be leveled within a tolerance of  $\pm 0.05$  mm/m (or less if required by the Manufacturer). The level shall be checked with a calibrated engineer's spirit level (1 div = 0.02 mm/m).

Special leveling instructions of the Manufacturer shall be followed. For equipment which is delivered already installed on its baseplate and for which machined pads are not sufficiently accessible for proper use of a spirit level, the equipment shall be removed to facilitate leveling.

Leveling spindles, if provided by the equipment Manufacturer, shall be used for leveling base plates instead of vertical jack screws. Leveling spindles should be removed or loosened after grouting. Removal of leveling spindles after grouting is mandatory with reciprocating machinery or any other installation where impact, pounding action or appreciable vibrations are to be expected during normal operation.

For reciprocating equipment, sole plates and shims should be installed.

Jacking screws should be used whenever leveling spindles have not been provided by the equipment Manufacturer. Jacking screws shall be of a type and size according to Appendix A, and removal after grouting is not necessary. For each machine sufficient jacking screws shall be used (as a minimum one jacking screw per anchor bolt shall be installed).

All mounting pads shall be fully machined flat and level to receive the equipment. Only stainless steel shims which straddle the holding-down bolts shall be used. The total number of shims shall be minimized by using shims of adequate thickness. No more than three shims in any shim pack shall be used.

### 5.4 Grouting

Grout material (non-shrink mortar, resin base mortar, epoxy resin, high-temperature application etc.) shall comply with the equipment Manufacturer's requirements.

It shall be ensured that the foundation under the baseplate is free of dirt, dust, oil or grease and properly roughened/chipped to remove the weak upper layer of concrete, damaged concrete and any oil-soaked areas. At least 25 mm between baseplate and foundation top should be allowed for grouting.

When using leveling spindles or jack screws (as per 5.3 on leveling), the clearance shall be at least 50 mm.

For proper bonding, the bed plate shall be clean, free of rust, oil and/or grease. When using epoxy resin, the bed plate bottom side may have to be specially treated. Instructions of the resin supplier shall be followed.

Foundation bolt sleeves or pockets shall be filled prior to grouting the baseplate.

Metal parts that should not bond to the grout (like jack screws of reciprocating machinery and parts of the foundation bolts) are to be sealed with tape or grease prior to grouting.

On reciprocating machinery it is recommended to seal foundation bolts over a length of 10 times the diameter, to prevent bonding with the grout when filling sleeves or pockets, in order to retain elasticity.

When using cement-based grout, the foundation top shall be saturated with fresh water for at least 24 hours prior to grouting. Free water on the foundation top when grouting is not allowed. Necessary steps shall be taken to prevent grouting from drying too quickly as per Supplier's instructions.

After curing of the grout, foundation bolts shall be tightened and the level of the equipment rechecked. Any change in level can be a cause of rejection of the grouting, at the discretion of the Company.

The space between bed plate beams and drip pan/top plate shall be completely filled with concrete. Voids under the top plate are not allowed.

After grouting, the baseplates shall be checked for the presence of any voids. Epoxy pressure grouting techniques shall be used to fill any voids.

Grout openings and vent holes shall be sealed and/or covered where necessary, to prevent contamination of the grout by oil or other products. In chemical plants it may be necessary to protect the grout and foundation from chemicals (tiles).

## 6. PIPING ASSOCIATED WITH ROTATING EQUIPMENT

The Contractor shall ensure that the piping associated with the rotating equipment is in accordance with Manufacturer's requirements and with IPS-E-PM-385, "Machinery Piping" requirements.

After leveling and grouting the equipment is normally available for the installation of piping (including piping related with instrument and electrical connections).

During this period the equipment shall remain preserved and protected.

To prevent ingress of dirt and foreign matter it shall be ensured that all routes and openings are properly blinded off and sealed and that temporary suction strainers are correctly installed as per IPS-E-PM-385, "Machinery Piping". Dust blinds shall remain installed until final alignment.

During construction, piping should never be firmly connected to the equipment, unless pipe supports are installed.

Piping work shall never start from equipment nozzles. Piping, upstream and downstream of the machinery shall be erected from the nearest anchor away. No uncontrolled strain shall be imposed on the equipment.

Welding on pipelines connected to the equipment foundation, bed plates or the equipment, without proper direct earthing-back to the welding transformer, is not allowed.

Earth cables shall never be connected to any part (baseplate, pedestal, drive etc.) of rotating equipment, in order to prevent damage to bearings by stray currents.

All work on piping systems shall be completed before the equipment can be offered for final alignment inspection. This includes pressure tests, cleaning or air blowing, insulation installed, and installation of permanent supports (fixed, sliding and spring supports). The lock pins of any spring supports immediately adjacent to rotating equipment shall be kept in place until systems are filled with product and pressurized.

Flanges, with a pressure rating of 300 lbs and higher, should be parallel to within 0.15 mm over the flange diameter.

Flanges, with lower, pressure ratings should be parallel to within 0.2 mm over the flange diameter.

Gasket type, material and size as well as flange bolts shall be checked. Drain and vent lines, balancing lines etc. shall be connected.

## 7. SHAFT ALIGNMENT

### 7.1 General

Prior to alignment checks of rotating equipment, over and above the checks highlighted in (7.2), the following points shall be considered:

- a) Alignment shall allow for potential movements such as thermal growth, hydraulic loading, gears with rising pinions etc. Manufacturer's instructions shall be followed.
- b) Check that coupling hubs are correctly installed before starting alignment checks.
- c) Check and record the distance between shaft ends and/or distance between hubs (axial float, pre-stress etc.).

d) Confirm that the equipment has been shimmed correctly, e.g.:

- 1) No soft feet \* (max. dial movement 0.03 mm);
- 2) shims are of stainless material;
- 3) shims straddle foundation bolts are fully bearing loaded;
- 4) axial and transverse keys are properly located and secured;
- 5) level and alignment adjustment screws are loose.

**7.2 Requirements**

Final misalignment shall not exceed the Manufacturer’s recommendations or the tolerances given in Table 1, whichever are the more stringent.

**TABLE 1 - ALIGNMENT TOLERANCES**

| <b>EQUIPMENT CONDITION</b>   | <b>RADIAL (PARALLEL) MISALIGNMENT</b>           | <b>AXIAL (ANGULAR) MISALIGNMENT</b>        |
|--|---|--|
| All speeds and coupling spacer lengths ≤ 250 mm                                    | 0.05 mm T.I.R.**                                | 0.05 mm<br>(Based on a diameter of 150 mm) |
| All speeds and coupling spacer lengths ≤ 250 mm                                    | 0.02 mm T.I.R.**<br>per 100 mm of spacer length | 0.05 mm<br>(Based on a diameter of 150 mm) |
| Speed lower than 1500 rpm, low power (< 10 kW) with elastomeric flexible couplings | 0.10 mm T.I.R.**                                | 0.05 mm<br>(Based on a diameter of 150 mm) |

\* "Soft feet" are those which do not have solid flat contact with the mating support pads when the equipment is in place.

\*\* T.I.R. = Total Indicator Reading

Method of alignment shall be either the reverse periphery method which should be used whenever possible, whereby a graphical plot of the shaft position should be made, or alternatively as follows:

- |                     |   |                                   |
|---------------------|---|-----------------------------------|
| 2 axial dial gages  | } | both shafts turned simultaneously |
| 1 radial dial gages |   |                                   |

Readings shall be demonstrated to be repeatable. Dial bracket sag shall be taken into account and shall not be more than 0.05 mm which should be checked e.g. on a lathe.

Alignment checks include:

- a) A preliminary check to ensure that alignment is possible with regard to shim limitations, bolt and bolthole positions, etc.
- b) An alignment check without piping connected to the equipment.
- c) An alignment check with bearing bracket support loose.
- d) Final alignment check.

For this check the dial indicators should be on the equipment before and during the tightening of the piping and brackets, in order to highlight the cause of any distortion. The final reading shall be taken with all process piping and auxiliary piping connected with proper gaskets in place.

With the piping connected, the relative movement of shaft centre lines shall not exceed 0.025 mm. (= 0.05 mm T.I.R.).

Hot alignment checks shall be agreed with the Company on a case-to-case basis, taking into account Manufacturer's recommendations.

Final alignment data shall be recorded, filed and handed over together with the Equipment Record Card of the equipment.

### 7.3 Doweling

Doweling of equipment and its drive shall be executed when required by the Manufacturer.

Diagonal doweling is not allowed. Gearboxes shall be dowled under the high-speed pinion.

## 8. COUPLING (see also API Std. 671)

The following is a list of requirements to ensure that couplings are properly installed.

The following shall be checked:

- a) Special instructions from the Manufacturer;
- b) for couplings installed in the field, their record and file data of installations, e.g., hydraulic pressure applied, axial travel, final position, etc.;
- c) the record distance between shaft ends and/or distance between hubs (axial float, pre-stress, etc.);
- d) the correct tightening torque of the coupling bolts as applied and recorded;
- e) the axial float of spacer (measured and recorded);
- f) the luboil spray nozzles. They shall be effective in both extreme positions of the coupling spacer and shall not rub the spacer or hub;
- g) the oil pressure and flow;
- h) the correct installation of the coupling guard.

For dry-type couplings check further that the diaphragms are not distorted.

#### Note:

Grease-filled couplings shall be filled with the proper grade and quantity of grease as soon as possible after installation at site.

## 9. CLEANING OF EQUIPMENT AND ASSOCIATED PIPING

Rotating equipments and piping associated with them may need different kind of cleaning procedure.

This requirements should be considered and defined for each particular installation. The manufacturer's recommendations shall be followed in this regard.

## 10. FINAL INSPECTION AND CHECKS BEFORE START-UP

For rotating equipment the Contractor and operating Company shall mutually agree a handover procedure.

Both the Contractor and the Company shall ensure that these inspection items and checks are carried out, the Contractor being the responsible action party.

## **11. FIRST START, RUN-IN, INITIAL OPERATION**

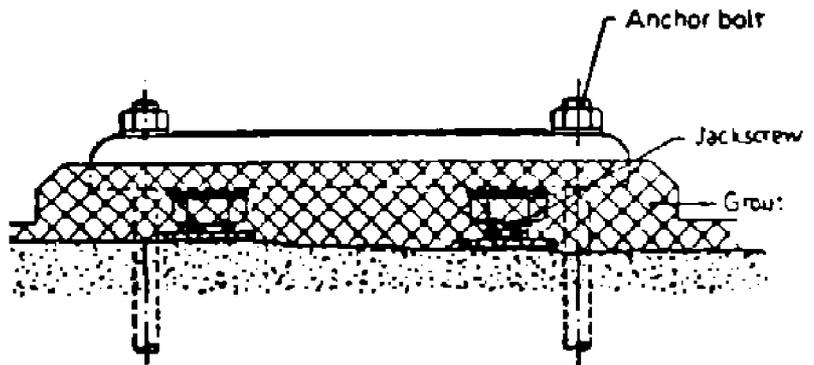
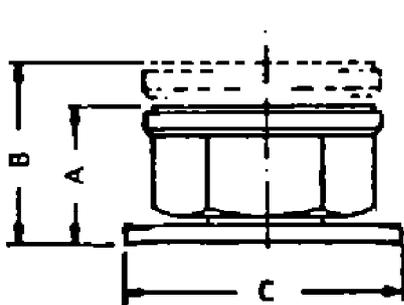
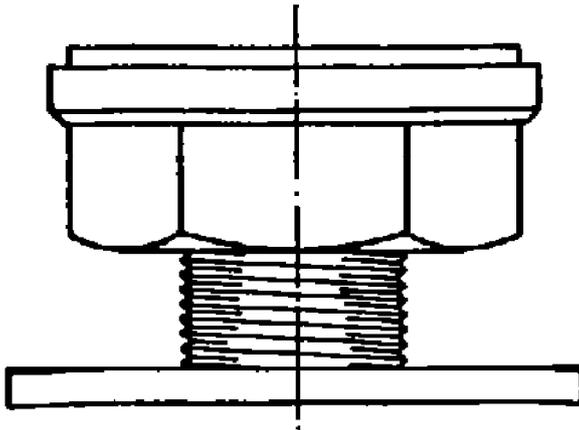
When the Contractor is required to construct and start up the equipment, it is the Contractor's responsibility to witness and record all aspects of the equipment performance, from overspeed tests to operational records, up to the agreed hand-over of the equipment.

In the event that the equipment does not comply with its specified and (contractual) agreed performance, it is the Contractor's responsibility to ensure that all necessary actions shall be taken to resolve such problems.

**APPENDICES**

**APPENDIX A**

**DIMENSIONS AND TYPICAL ARRANGEMENT OF JACKING BOLTS**



**Dimensions:**

- A = 45 mm
- B = 67 mm
- C = 80 × 80 mm

**Approx. weight: 1.05 kg**

**Maximum load: 2000 kg per jackscrew.**