

Recommended Practice for Machinery Installation and Installation Design

API RECOMMENDED PRACTICE 686
SECOND EDITION, DECEMBER 2009

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Recommended Practice for Machinery Installation and Installation Design

Chapter 1—Introduction

Downstream Segment

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Recommended Practice for Machinery Installation and Installation Design

Chapter 1—Introduction

1 Scope

1.1 Purpose

This recommended practice (RP) is intended to provide recommended procedures, practices, and checklists for the installation and precommissioning of new, existing, and reapplied machinery and to assist with the installation design of such machinery for petroleum, chemical, and gas industry services facilities. In general, this RP is intended to supplement vendor instructions and the instructions provided by the original equipment manufacturer (OEM) should be carefully followed with regard to equipment installation and checkout.

Most major topics of this RP are subdivided into sections of “Installation Design” and “Installation” with the intent being that each section can be removed and used as needed by the appropriate design or installation personnel.

1.2 Life Cycle Cost

It is the intent of this document to facilitate machinery installations that will provide the user with a reduced overall life-cycle cost of equipment ownership.

1.3 Contractual Requirements

API 686 is written such that it can be used as a contractual document between an owner company and an engineering and construction (E&C) contractor. The major benefit is that it provides a detailed scope of supply for machinery installation requirements, with acceptance criteria, and documentation requirements. There is then no ambiguity amongst multiple E&C bidders as to the requirements for project machinery installation (i.e. everyone is on an even playing field).

1.4 Equipment Classification

This RP is intended to address those installation and construction procedures associated with all machinery. Additional “special-purpose” requirements are covered at the end of each section as required.

1.5 Alternative Installation

The installation contractor or design contractor may offer alternative methods of equipment installation as mutually agreed upon by the user and equipment manufacturer.

1.6 Conflicting Requirements

Any conflicts between this RP and/or the manufacturers’ recommended procedures shall be referred to the user-designated machinery representative for resolution before proceeding.

2 Definitions

For the purposes of this document, the following definitions apply.

2.1

alignment

The process of reducing the misalignment of two adjacent shafts connected by a coupling so that the center of rotation for each shaft is as near collinear as practical during normal operation.

NOTE Most misalignment is combination misalignment. It can be resolved into a parallel offset at a given point along the fixed machine centerline and angular misalignment in both the horizontal and vertical planes. The offset is dependent on the location along the fixed machine centerline where it is measured, normally the center of the coupling spacer.

2.2

ambient offset

The practice of misaligning two shaft centerlines at ambient conditions to account for the estimated relative changes in shaft centerlines from static ambient conditions to steady state operating conditions.

2.3

angular misalignment

The angle between the shaft centerline of two adjacent shafts. This angle is normally reported in slope of millimeter of change per meter of linear distance (mils per in.) (1 mil = 0.001 in.).

2.4

baseplate

A fabricated (or cast) metal structure used to mount, support, and align, machinery and its auxiliary components. Baseplates may be directly grouted to concrete foundations (after proper leveling) or bolted to pre-grouted chockplates (see 2.9).

2.5

blowdown system

A closed system connected to a machine used to depressure and decontaminate the machine preparatory to maintenance activities; also known as a maintenance dropout system.

2.6

bolt bound

Where any hold-down bolt is not free in the bolt hole, so that the ability to move the moveable element in a machinery train horizontally or axially is constrained.

2.7

breakout spool

A short, flanged length of pipe immediately connected to the machinery piping flanges. Lengths vary with the size of the pipe but range from 15 cm (6 in.) to 1 m (3 ft). The purposes of this spool are to facilitate machinery installation, allow piping modification to reduce pipe strain, isolate the machinery, facilitate commissioning activities such as flushing or blowing lines, and allow removal of temporary inlet strainers; also known as a dropout spool.

2.8

cementitious grout

A type of grout material that is portland cement based.

2.9

chockplate

A solid steel (or alloy steel) plate with a machined top surface that is grouted to a concrete foundation to support and maintain alignment of a machinery structural steel baseplate.

2.10

combination misalignment

When the centerlines of two adjacent shafts are neither parallel nor intersect. This misalignment is normally described in both angular and offset terms.

2.11

condensing service

A gas stream that contains a vapor component that may condense to a liquid during startup, operation, or shutting-down of a compressor or blower. This may include pure vapors such as refrigerants as well as hydrocarbon gas

streams. When condensate is present in the gas stream, the term wet gas may be used. Wet gas may also be used as a synonym to condensing service.

2.12

critical service

Critical service is typically defined as those applications that are unsparred /single-train installations whereby loss of operation would result in significant loss of production, loss of primary process containment, or threat to personnel safety.

2.13

dead-leg

A length of piping with no flow.

2.14

drop point

A vertical section of oil mist distribution piping that is usually smaller in diameter than the main oil mist header. This piping rises out of a tee in the main oil mist header, turns horizontally, and extends downward to the machinery being lubricated.

2.15

elastomeric coupling

A coupling that obtains its flexibility from the flexing of an elastomeric element.

2.16

engineering designer

The person or organization charged with the project responsibility of supplying installation drawings and procedures for installing machinery in a user facility after machinery has been delivered. In general, but not always, the engineering designer specifies machinery in the user facility.

2.17

epoxy grout

A type of grout material that consists of a resin base that is mixed with a curing agent (hardener) and usually an aggregate filler.

2.18

equipment installer

The person or organization charged with providing engineering services and labor required to install machinery in a user facility after machinery has been delivered. In general, but not always, the installer is the project construction contractor.

2.19

equipment train

Two or more rotating equipment machinery elements consisting of at least one driver and one driven element joined together by a coupling.

2.20

equipment user

The person or organization charged with operation of the rotating machinery. In general, but not always, the equipment user owns and maintains the rotating machinery after the project is complete.

2.21

final alignment

The aligning of two adjacent machinery shafts after the measurement of piping-imposed strains on the machinery are verified as being within the specified tolerances.

2.22**flexible-element coupling**

A type of rotating machinery coupling that describes both disk and diaphragm couplings. A flexible-element coupling obtains its flexibility from the flexing of thin disks or diaphragm elements.

2.23**gear coupling**

A type of rotating machinery coupling that obtains its flexibility by relative rocking and sliding motion between mating, profiled gear teeth.

2.24**general-purpose**

Refers to an application that is usually spared or is in noncritical service.

2.25**general-purpose equipment trains**

Those trains that have all general-purpose elements in the train. They are usually spared, relatively small in size (power), or in noncritical service. They are intended for applications where process conditions will not exceed 48 bar gauge (700 lb/in.² gauge) pressure or 205 °C (400 °F) temperature (excluding steam turbines), or both, and where speed will not exceed 5000 revolutions per minute (rpm).

NOTE General-purpose equipment trains have all elements that are either manufacturer's standard or are covered by standards such as the following: ASME B73 pumps, small API 610 pumps, fans, API 611 steam turbines, API 672 air compressors, API 677 general-purpose gears, API 674 reciprocating pumps, API 676 rotary positive displacement pumps, API 680 reciprocating air compressors, and NEMA frame motors.

2.26**grout**

An epoxy or cementitious material used to provide a uniform foundation support and load transfer link for the installation of rotating machinery. This material is typically placed between a piece of equipment's concrete foundation and its mounting plate (see 2.32).

2.27**grout pin**

A metallic pin or dowel used to tie an epoxy grout pour to its concrete foundation to prevent delamination (or edge lifting) due to differential thermal expansion between the grout and the concrete.

2.28**head box**

A device used to funnel grout into a baseplate grout fill-hole so as to provide a static head to aid in filling all baseplate cavities with grout.

2.29**isolation block valve**

A valve used to isolate a process machine preparatory to maintenance. Also known as a block valve or isolation valve.

2.30**mechanical piping analysis**

An analysis of the piping connected to a machine to determine the stresses and deflections of the piping resulting from temperature, pressure, and dynamic loadings such as pulsating flow (mixed phased flow). Determination of the type, location, and orientation of piping supports and piping guides results from this analysis.

2.31**minimum flow bypass**

See **recycle line**.

2.32**mounting plate**

A device used to attach equipment to concrete foundations; includes baseplates, soleplates, and chockplates. A mounting plate is a base-support mechanism for the attached machinery and all individual pieces of machinery are expected to be removable from the mounting plate as a single assembly.

2.33**non-slam check valve**

A mechanically or hydraulically balanced check valve that allows closure of the valve in a controlled fashion. Wafer-style center-guided spring-loaded split-disc check valves or tilting-disc check valves are representative designs.

2.34**NPS**

Nominal pipe size (in.) (followed by the specific size designation number without an inch symbol).

2.35**oil mist**

A dispersion of oil droplets, of 1 to 3 micron size in an air stream.

2.36**oil mist application fittings**

Long path orifices that cause the small oil droplet size in the header ("dry mist") to be converted to larger size oil droplets ("wet mist") to lubricate equipment bearings. Oil mist application fittings are also known as reclassifiers.

2.37**oil mist console**

A system consisting of the oil mist generator, oil supply system, air filtering system, oil mist header outlet, and necessary controls and instrumentation. Air and oil enter the console to produce oil mist.

2.38**oil mist distributor block**

A small rectangular block that has four or more holes drilled and tapped in opposite faces. Drop points terminate in distributor blocks. An oil mist distributor block may also be described as an oil mist manifold block.

2.39**oil mist generator**

A device located inside the oil mist console that combines oil and air to make oil mist. Typical oil mist generators utilize a venturi to achieve mixing of the oil and the air.

2.40**oil mist header**

A network of piping through which the oil mist is transported from the console where it is made to the machinery bearing housing where it is used.

2.41**oil mist lubrication**

Lubrication systems that employ oil mist produced by atomization in a central unit and transported to a remote bearing housing, or casing, by compressed air. This system consists of the oil mist console, distribution piping headers and laterals, application fittings, and the lubricant supply tank and pump.

2.42**operating temperature (thermal) alignment**

A procedure to determine the actual change in relative shaft positions within a machinery train from the ambient (not running) condition and the normal operating temperature (running) condition by taking measurements from startup to normal operating temperature while the machine(s) is (are) operating, or after the shafts have been stopped but the machines are still near operating temperature.

2.43**parallel offset misalignment**

The distance between two adjacent and parallel shaft centerlines. This offset is normally described in a unit (millimeters or mils) at the flex element location.

2.44**peg test**

A test performed on optical leveling equipment to ensure that the instrument is properly adjusted and its line of sight is coincident to true earth level.

2.45**preliminary alignment**

The aligning of two adjacent machinery shafts to ensure that final alignment can be achieved without being bolt bound. This is accomplished before grouting and the measurement of piping strain on the machinery.

2.46**pulsation analysis**

An analysis of the piping system connected to a machine to determine the acoustical and mechanical effects of pulsating flow. For small machines a pulsation analysis may consist of comparison to other installations and/or use of proprietary pulsation device design charts, formulas, or graphs. For large, complicated machines a pulsation analysis may consist of a detailed digital or analog modeling of the machine and the piping. Unless otherwise specified, API 688 should be used to provide guidance for the pulsation analysis.

2.47**pure oil mist lubrication (dry sump)**

The application of oil mist to a machinery bearing housing to lubricate anti-friction bearings. The oil mist passes through the bearing elements, and oil droplets coalesce out of the air stream. All oil is drained from the machinery bearing housing and complete lubrication is provided by the mist alone.

2.48**purge oil mist lubrication (wet sump)**

The application of oil mist to a machinery bearing housing or reservoir to provide a slight positive pressure. Machinery lubrication is by conventional ring oil or submerged bearing lubrication. This prevents contamination that could be caused by infiltration of corrosive agents or condensation of ambient moisture.

2.49**recycle line**

A line from the discharge of a pump, blower, or compressor routed back to the suction system. A recycle line will usually include control elements such as meters or valves. The recycle line may connect directly into the suction line or may connect into suction vessels or liquid knock-out vessels and may include a cooler. Also known as bypass line, minimum flow bypass, or kickback line.

2.50**soleplate**

A solid steel (or alloy steel) plate with a machined top surface that is grouted to a concrete foundation to support and maintain alignment of machinery.

2.51**special-purpose application**

An application for which the equipment is designed for uninterrupted, continuous operation in critical service and for which there is usually no spare equipment.

2.52**special-purpose equipment trains**

Equipment trains with driven equipment that is usually not spared is relatively large in size (power), or is in critical service. This category is not limited by operating conditions or speed.

NOTE Special-purpose equipment trains will be defined by the user. In general, any equipment train such as an API 612 turbine, API 618 reciprocating compressor, API 613 gear, API 617 centrifugal compressor, API 619 rotary screws, or equipment with a gas turbine in the train should be considered to be special-purpose.

2.53**static piping analysis**

An analysis of the piping system connected to a machine to determine forces and moments on nozzle connections caused by various loading conditions such as pipe weight, liquid loads, and thermal expansion or contraction. These forces and moments are compared to vendor-allowable loads or national standards to ensure that nozzle loadings meet guidelines. This analysis includes specification of pipe anchors, guides, supports, and sometimes spring supports and expansion joints to control strain. Where large vertical piping displacements occur, machinery may sometimes be mounted on spring-supported baseplates to reduce nozzle loading.

2.54**suction knockout vessel**

liquid dropout vessel

A vessel located in the suction line to a compressor or blower used to separate any entrained liquid from the gas stream. It may contain a demister mat and/or centrifugal separators to aid in this separation. Usually the compressor or blower takes suction from the top of the knockout vessel.

2.55**table top foundation**

An elevated three-dimensional reinforced concrete structure that consists of large beams or a thick slab connecting the tops of the supporting columns. The mechanical equipment is supported by the large beams or the slab located at the top of the structure.

2.56**total acid number****TAN**

The quality of base (expressed in terms of milligrams of potassium hydroxide) that is required to titrate the strong acid constituents present in 1 gm of an oil sample (ASTM Method P664 or D974).

2.57**total indicated runout****TIR**

The runout of a diameter or face determined by measurement with a dial indicator (also known as total indicator reading). The indicator reading implies an out-of-squareness equal to the reading or an eccentricity equal to half the reading.

2.58**user-designated machinery representative**

The person or organization designated by the ultimate owner of the equipment to speak on his/her behalf with regard to machinery installation decisions, inspection requirements, and so forth. This representative may be an employee of the owner, a third-party inspection company, or an engineering contractor as delegated by the owner.

2.59**vendor**

supplier

The agency that, supplies the equipment.

NOTE The vendor may be the manufacturer of the equipment or the manufacturer's agent and normally is responsible for service support.

2.60**warm-up line**

A line used to purge warm or hot fluid through a process machine. The intention is to heat up or maintain the temperature of a machine to a temperature greater than the surrounding ambient temperature.

Recommended Practice for Machinery Installation and Installation Design

Chapter 2—Rigging and Lifting

Downstream Segment

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Recommended Practice for Machinery Installation and Installation Design

Chapter 2—Rigging and Lifting

1 Scope

1.1 Chapter 2 provides general guidelines for rigging and lifting of machinery from shipping trucks, railcars, and so forth, onto the foundation or platform.

NOTE Chapter 2 is intended to be used for all machinery. Even small pumps can be damaged by improper lifts. The extent of the rigging and lifting plan can be reduced when specified by the user. The lifting plan for small machinery could be in the form of a site meeting at the start of construction, if agreed to by the user. However, if not specified otherwise, this section shall be used for all machinery.

1.2 This chapter is intended to supplement the rules and regulations that the rigging and lifting subcontractor must abide by, such as state or local government inspections and permits, OSHA 1926, Subparts H and N, and ASME/ANSI B30.

2 Preplanning

2.1 The installer shall be responsible for obtaining the following as a minimum:

- a) shipping and net weights of each separate component of the machinery or machinery package; and
- b) manufacturer drawings indicating the location of lifting lugs/points, the expected load at each point, and the center of gravity;

NOTE Lifting lugs are often provided on machinery to lift individual components and are not intended to be used to lift the entire machine (that is, lifting lugs on WP-II motor air housings cannot be used to lift the entire motor).

- c) manufacturer's recommendations for the lift including the use of spreader bars, slings, and so forth.

2.2 The installer shall prepare a rigging and lifting plan of action that includes the following.

- a) A rigging plan showing the lifting points and including the load capacities of spreader bars, slings, cables, shackles, hooks, rings, and so forth. Load capacities shall be based upon a minimum safety factor of 1.5. Plans shall also be made for lifting crated equipment.

NOTE When the safety factor of 1.5 results in the selection of a more expensive crane, the selection may be reduced upon an appropriate engineering review and agreement by both the installer and the user designated representative.

- b) The selected lifting equipment and confirmation that the load and lift radius are within the capacity and range ratings of the manufacturer of the lifting equipment.

- c) Layout sketches showing the setup location for the lifting equipment in relationship to the initial pick point of the load and its final installation point. The sketch should also show the proximity to important structures, pipe racks, and overhead electrical services. OSHA 1926.550 gives clearance requirements for electrical services.

- d) Setup time for the lifting equipment and overall duration of the lift.

- e) Coordinate with the plant traffic control personnel for any roadway blockages.

- f) Check route to be taken when bringing machinery to final location. Check for overhead clearance, turn radius, road bed, high center railroad crossings, etc.

g) The installer shall check site plans for underground piping, sewers, electrical cables, or other utilities in the area of lift. Outrigger cribbing pads shall be used to eliminate any damage to roads and also to reduce the possibility of outriggers breaking through soft ground, reducing the capabilities of the crane.

NOTE Many lifts are made from unpaved areas. Point loads from crane tires and outriggers can damage underground utilities. Review potential problem areas with a civil engineer to determine if the ground cover is adequate.

2.3 The installer shall confirm that floor slabs on which the crane may sit have cured adequately. Confirm that machinery foundations have cured and grout preparations have been completed.

2.4 If the machinery will be set in a partially completed structure, or if structural members must be removed to lower the machinery into the structure, the lifting plan must be reviewed and approved by the structural engineer responsible for the design of the structure. Temporary shoring, bracing, or supports shall be reviewed and approved by the structural engineer.

2.5 The installer shall confirm that all equipment is up to date with respect to permits and inspections. Request that the rigging spreader bars, slings, cables, and so forth, are field inspected just prior to the lift being started. Refer to OSHA 1926, Subparts H and N, for inspection requirements.

2.6 The installer shall hold a prelift meeting with the user and manufacturer (if required) to ensure that the plan of action is agreed to and understood.

3 Lifting the Machinery

3.1 The installer shall verify that the cables and slings are bearing only on the intended lift points and are not transmitting any loads onto auxiliary piping, instruments, chain guards, and so forth.

3.2 Lift points for individual machinery pieces shall not be used for lifting machinery skids or packages. This can apply to lifting lugs that may be found on motors, gearboxes, casings, inspection covers, and so forth. When in doubt, consult the manufacturer. Equipment shafts shall not be used for lifting equipment.

3.3 For baseplate or skid-mounted machinery, only use lift points on the baseplate or skid. Do not use the machinery as a lift point unless approved by the manufacturer.

NOTE Care must be exercised in lifting skid-mounted equipment where part of the machinery or its auxiliaries have been removed for shipment, thus changing the center of gravity.

3.4 The installer shall keep other subcontractor and plant personnel from working under the lift and keep them a safe distance away until the machinery is secured in place on its foundation or structure.

3.5 Special-purpose machinery rotors are to be restrained to restrict axial travel prior to the lift. All restraining methods shall be externally obvious.

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Chapter 3—Jobsite Receiving and Protection

Downstream Segment

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Recommended Practice for Machinery Installation and Installation Design

Chapter 3—Jobsite Receiving and Protection

1 Scope

1.1 This recommended practice (RP) defines the minimum requirements for protecting project machinery and related components from deterioration while in field storage, after installation, and during the period prior to commissioning.

1.2 In all cases where the manufacturer's requirements or recommendations differ from the instructions provided in this document, the user-designated representative shall be consulted to determine which takes precedence.

1.3 An inspection and protective maintenance program shall be initiated and maintained by the user-designated representative for stored and installed equipment until it is turned over to the care, custody, and control of the user.

1.4 All design and installation requirements shall be ensured as being complete by completing the Machinery and Protection Checklist at the end of this chapter and submitting it to the user or his designated representative.

2 Responsibility

Overall responsibility for protecting project machinery from deterioration in the field, per this RP, rests with the construction manager and his/her designated representative until the machinery is turned over to the user.

2.1 Preplanning

2.1.1 Verify that all procurement schedules, shipping lists, manufacturer's storage recommendations, installation manuals, and drawings have been forwarded to the designated machinery representative.

2.1.2 Review weights, configuration, and method of shipping before arrival at the jobsite. Determine type of equipment required to unload the shipment, (that is, forklift, boom truck, crane, and so forth) and schedule accordingly.

NOTE See Chapter 2—Rigging and Lifting, for further details. Care must be taken to ensure that safe and appropriate rigging procedures are followed.

2.1.3 When specified, schedule the manufacturer's representative for receiving inspection. Schedule user's inspectors, where required, such as rotating equipment, instrument, and electrical engineers.

2.2 Jobsite Receiving and Inspection

Upon arrival of the machinery or portions thereof at the jobsite, follow the steps below.

a) Visually inspect components for physical damage or contamination by opening packages and crates. Hermetically sealed containers should not be opened, but visually inspected for damage and the hermetic seal maintained.

b) Verify that shipping protection has been applied and is still in effect.

c) Verify that shop inspection has been completed and that the vendor has supplied the purchase order documentation and packing lists.

d) Verify that loose components and separate packages match the packing lists.

e) Verify that special handling instructions are provided and carried out.

- f) Verify proper identification of the components.
- g) Perform visual inspection of components for compliance with project requirements.
- h) Inspect carbon steel or other ferrous flange faces for damage and coat with Type A, Type B, or Type D preservative, unless prohibited by process application (see Note 1). Reinstall protective covers. Where car seals on inspection covers or flanges have been specified, inspect the car seals for integrity (see Note 2).

NOTE 1 Preservative types are described in Annex A. Final selection of the preservative depends on the type of storage (indoor, outdoor, sheltered), weather conditions, and atmospheric corrosion potential. Equipment datasheets and manufacturer's instructions shall be reviewed to determine if there are specific preservative requirements. Refer to the notes in Annex A for additional details.

NOTE 2 Use caution with soft-gasketed flanges. Soft gaskets may absorb water and corrode carbon steel flanges.

- i) Verify that plugs and caps are in place, desiccants are unsaturated, and equipment is lubricated, as required. Nonmetallic (such as plastic) plugs and caps shall not be used.
- j) Verify that inert-gas-purged (see Annex D) equipment still has the required pressure applied. Report failures to the manufacturer and request corrective action. This equipment shall remain sealed unless otherwise instructed by the designated machinery representative.
- k) Inspect grout surfaces for proper factory blasting and coating.
- l) Tapped openings in the stuffing boxes and gland plates shall be closed and sealed with pipe plugs. Plug material shall be of the same or better than seal gland plate metallurgy. As a minimum, the plugs shall be stainless steel.
- m) When specified, impact-measuring devices shall be inspected to determine if the equipment has been exposed to any excessive shock loads. Where required, the manufacturing representative shall be present.
- n) Record all inspections (refer to Annex B and Annex C).
- o) Report any damage to the shipping company and vendor immediately. Ensure that any claim forms required by the shipper or vendor are completed.

2.3 General Instructions—Jobsite Protection

2.3.1 Manufacturer's or vendor's recommendations for storage and protective care shall be reviewed by a user-designated representative and shall be strictly followed when transmitted to the field. If the manufacturer's recommendations are not available, the information included in this RP shall be used as a minimum acceptable guide.

NOTE Failure to follow vendor's recommendation for storage and protective care may void the warranty.

2.3.1.1 Review the procurement documents to determine if the equipment had been prepared for a predetermined storage period. For example, if the equipment was procured per API standards, preparation for shipment would be "suitable for six months of outdoor storage from time of shipment, with no disassembly required before operation, except for inspection of bearings and seals. If storage for a longer period is contemplated, the purchaser will consult with the vendor regarding the recommended procedures to be followed."

NOTE It is recommended that where machines are to be partially or completely disassembled for storage preservation or inspection by the contractor or user, the vendor's service representative should be on site to ensure the accuracy of the work and the preservation of the warranty.

2.3.1.2 Protective storage requirements for specific items of equipment such as pumps, blowers, fans, compressors, and gearboxes are found in subsequent sections of this procedure.

2.3.2 Records documenting the following information are to be kept by field material control personnel using the forms referenced.

a) Conditions of equipment and materials upon arrival at the jobsite before and after unloading. Use the checklist in Annex B.

b) Maintenance and storage procedures followed, and dates maintenance was performed. See forms provided in Annex B and Annex C.

2.3.3 All equipment and material shall be stored free from direct ground contact and away from areas subject to ponding water. As a minimum, laydown areas shall be graveled.

2.3.4 For outdoor storage, even cross-cut timber with at least a 10 cm × 10 cm (4 in. × 4 in. nominal) cross section, laid flat and level, shall be used for laydown. Equipment weight shall be considered when selecting timber size. Warped timber or telephone poles are not acceptable. Timbers shall be placed perpendicular to major support structures and shall be full width of the skid or baseplate.

2.3.5 Indoor storage should be used whenever possible.

NOTE Third-party storage facilities may prove to be the most economical method for equipment requiring clean, dry, and climate-controlled conditions. On an existing site, the user may be able to provide some storage facilities.

2.3.6 Temporary protective coverings shall allow free air circulation to prevent humidity condensation and collection of water.

2.3.7 The installer shall attempt to preserve and maintain the integrity of the delivery packaging whenever possible. Replace packaging material after inspection. Review the integrity of control boxes and panels with respect to weather protection. Store indoors if required.

2.3.8 All carbon and low alloy steel shall be protected from any contact with corrosive or wet atmospheres so as to prevent rust formation.

2.3.9 Painted surfaces should not require additional protection but shall be examined periodically for signs of rusting. Touch-up, using the manufacturer's recommended methods and materials, shall be performed within a practical and reasonable period of time.

2.3.10 All items with machined surfaces should be stored so that the machined surfaces can be examined periodically (monthly) for signs of rust.

2.3.11 Any special parts and tools for construction purposes that accompany vendor shipments shall be tagged, protected, and stored per the vendor's and/or user's recommendations. All tags must be stainless steel and stainless-steel wired to the special part or tool. Paper tags are not permitted.

2.3.12 Keep the storage area and equipment clean by providing physical protection and covering when work operations such as concrete chipping, sanding, painting, and rigging are performed in the area. Stainless steel shall be protected from weld splatter and grinding dust of low alloy steel.

2.3.13 Periodic rotation of equipment will be discussed in subsequent sections. In all cases, determine that all shipping blocks on rotating components have been removed and that there is adequate lubrication before rotation. Determine that any desiccant bags or protective plastics are clear of moving parts. To rotate the shaft, use a tool such as a strap wrench that will not mark machined surfaces.

2.3.14 Preservatives and/or storage lubricants can adversely affect the safety and operating life of equipment if they react with the process fluid or operating lubricant. Specific examples are:

- a) grease or oil-based products in contact with components to be installed in oxygen or chlorine service,
- b) preservatives contaminating interiors of fluorochlorohydrocarbon refrigeration compressors, and
- c) hydrocarbon flush oil contaminating synthetic oil passages.

The installer shall ensure that all preservative and storage lubricants are suitable for the specific application.

2.3.15 Unless otherwise specified, special-purpose equipment shall be stored with a positive pressure, 2 mm to 3 mm Hg (1 in. to 2 in. w.c.), dry nitrogen purge (see Note 1 below). The equipment shall have a temporary gauge to determine purge pressure. Remove the temporary gauge before start-up. The equipment shall be inspected weekly to ensure that purge integrity is maintained. If a positive pressure cannot be maintained, purge at a rate of 2 SLPM to 3 SLPM (4 SCFH to 6 SCFH).

NOTE 1 Review all nitrogen purge installations with the user's safety personnel with respect to confined space procedures, warning signs, and asphyxiation hazards before putting the purge into service.

NOTE 2 External (temporary) soft packing, held by adjustable stainless steel bands (geared clamps), can be placed against, or touching the labyrinths (or equivalent seals) of equipment rotating shafts to significantly reduce the amount of dry nitrogen purge.

2.3.16 All equipment cavities, cooling passages, mechanical seals, positive displacement pump plunger cavities, and so forth, shall be drained of all water to prevent damage due to freezing temperature.

2.3.17 Unless stated differently in subsequent sections on specific equipment, the following shall apply.

a) Oil-lubricated bearing housings, seal housings, stuffing boxes, hydraulic equipment, and gear cases shall be fogged and approximately one-fourth filled with a manufacturer-approved oil. All openings shall then be closed and sealed tightly.

b) When specified by the user, every other month the condition of the preservative oil shall be checked by measuring the total acid number (TAN) of the oil. If the TAN is greater than 0.2 mg KOH/gm oil, the preservation oil shall be replaced with fresh oil. The date when checked and the TAN shall be recorded in the inspection records. Check with the oil supplier to determine if it needs to be heated for replacement.

c) All externally exposed, bare carbon steel or cast iron surfaces including shafts and couplings (except elastomeric components) shall be coated with Type A, Type B, or Type D preservative. All machined surfaces shall be coated with Type A, Type B, or Type D preservative. All exposed machined surfaces shall also be wrapped with waxed cloth (see Note below).

NOTE Moisture can be held under waxed cloth if not tightly sealed. Periodic inspections under the cloth may be warranted.

d) Verify that grease-lubricated bearings have been greased by the manufacturer with the specified grease. Some greases are not compatible when mixed.

2.3.18 When an oil mist preservation system is specified by the user (see Note), it shall be as follows.

NOTE Oil mist systems are typically specified on large projects where more than ten pieces of equipment will be stored longer than six months or when dust or dampness is excessive.

a) Oil mist shall be used to protect the bearings, bearing housings, seal areas and process ends of the equipment.

- 1) Oil mist lubrication connections on equipment purchased for permanent oil mist lubrication shall be used.

- 2) Equipment purchaser shall have specified to equipment vendor that oil mist preservation will be utilized on the equipment.
 - 3) Cavities not normally mist lubricated during permanent operation will need to be fitted with supply and vent connections (typically NPS 1/4).
- b) The oil mist system shall be designed and sized for preservation service.
- 1) As a minimum the mist generator shall be equipped with the following instrumentation: air pressure regulator, pressure relief valve, level gauge, and mist pressure gauge.
 - 2) The mist header system shall be NPS 2 minimum galvanized schedule 40 pipe properly supported and sloped.
 - 3) Mist flow to each application point can be less than that required for lubrication during normal operation.
 - 4) Plastic tubing (temporary use only) can be used to connect from the mist header to the application point.
- c) The oil used in the mist system shall be a good quality, paraffin-free turbine oil. A temperature sensitive, vapor emitting oil should not be used in the oil mist system. Equipment preservative oils shall be compatible with the system elastomers and the oil used in the oil mist system to eliminate the need to disassemble and remove the preservative oil.
- d) All machinery shall be connected to the system immediately upon arrival on site.
- e) Equipment is maintained in the storage yard by rotating shafts and periodically draining condensed oil from the housing.
- NOTE Oil shall not be drained to ground.
- f) For equipment that will be permanently oil mist lubricated, the movement of equipment from the storage yard to permanent locations shall be coordinated so that the maximum outage of mist preservation is minimized.

2.4 Lubricants and Preservatives

2.4.1 The table and notes in Annex A describe some of the physical characteristics, application methods, and life expectancies of preservative Type A, Type B, Type C, and Type D that are referred to in this practice. Final selection types shall be approved by the equipment manufacturer and user. Other methods of preservation not listed on the table include: vapor corrosion inhibitor (VCI), nitrogen purge, and desiccants.

2.4.2 Care shall be taken to ensure the compatibility of the preservative with elastomeric parts, seals, gaskets, and so forth.

2.4.3 All lubricant and preservative material safety datasheets (MSDSs) shall be available, and associated hazards reviewed with all personnel handling and using these materials.

2.4.4 The term desiccant shall mean silica gel or any other approved water absorbing material. All desiccants shall have prior approval from the manufacturer or the user-designated representative. Check desiccant monthly. Replacements shall be approved by the user.

2.4.5 Preservatives shall not be used on surfaces where prohibited by process application.

2.4.6 In succeeding sections, references are made to removing preservatives before the machinery is placed in service. This is always true for Type D preservative. However, with the proper selection of Type A, Type B, and Type C, removal can be eliminated. The preservative would need to be compatible with the permanent lubricating fluid, the process fluid, and materials of construction, that is, elastomers. The preservative shall also be inspected to be sure that it has not absorbed any abrasive dust or contaminants.

2.4.7 VCIs provide a self healing barrier between the metal surface and moisture. All VCI's shall have prior approval from the manufacturer or the user-designated representative. Note that some VCIs may contain nitrites which attack copper and bronze.

2.4.8 Nitrogen purging provides protection by removing the moisture laden oxygenated atmosphere. Care should be taken when working with nitrogen to prevent asphyxiation.

2.5 Bolts

2.5.1 All loose assembly bolts, nuts, and fasteners shall be packaged, identified, and stored in a sheltered area.

2.5.2 Type B or Type C preservative shall be applied to the threaded portion of all anchor bolts, washers, and nuts that are not galvanized or plated.

2.6 Spare Parts, Special Tools, and Miscellaneous Loose Items

2.6.1 Items purchased as spare parts shall be tagged and handed over to the user-designated machinery representative upon receipt and completion of jobsite receiving inspection per 2.2.

2.6.2 Storage and protective maintenance of miscellaneous loose items shall be as directed by the manufacturer.

2.6.3 Extra drawings and manuals shipped with the equipment shall be saved and handed over to the user.

NOTE Formal distribution of these types of documents should have occurred before shipment per 2.1.1.

2.6.4 Special tools shall be kept by the installer until work has been completed, then turned over to the user-designated machinery representative.

2.7 Auxiliary Components for Rotating Equipment

The following applies to auxiliary piping that is shipped loose for field assembly.

2.7.1 Pipe Components

Carbon steel pipe components that will require long-term storage outdoors during the construction period shall be coated externally and internally with thinned Type B or a Type C preservative, unless prohibited by process application.

2.7.2 Coating and Sealing

2.7.2.1 Stainless steel pipe components that will require long-term storage outdoors in a salt water atmosphere during the construction period shall be coated externally and internally with thinned Type B or a Type C preservative, unless prohibited by process.

2.7.2.2 Contamination of dry gas seals may occur if Type B or Type C preservatives are used in gas seal supply piping. A VCI that can be removed prior to operation, may be an acceptable alternative.

2.7.3 Flanges

2.7.3.1 Flanges received bolted face-to-face need not be separated for inspection; however, the face-to-face crevice shall be coated with Type A, Type B, or Type D preservative prior to outdoor storage.

2.7.3.2 After inspection of loose flanges, flange gasket surfaces shall be coated with Type A, Type B, or Type D preservative prior to outdoor storage. Flanges for prefabricated piping and lube oil systems shall be gasketed and

covered with metal covers $\frac{3}{16}$ in. thick for flanges 10 in. NPS and larger and $\frac{1}{8}$ in. thick for flanges less than 10 in. NPS.

NOTE Temporary gaskets can usually be made from service sheet-gasket material.

2.7.3.3 Care shall be taken to protect gasket surfaces of loose flanges from damage during handling and storage.

2.7.3.4 Flanges to be stored outdoors for periods exceeding six months or in corrosive atmospheres (saltwater air, industrial, and so forth) shall be coated externally and internally with thinned Type B preservative.

2.7.3.5 Preservatives shall be removed from all surfaces with a suitable solvent prior to installation of the components.

2.7.4 Valves

2.7.4.1 Whenever possible, valves shall be stored indoors or under cover.

2.7.4.2 All machined surfaces such as valve stems (including threads), packing glands, and bonnet bolts shall receive a heavy coat of appropriate grease or equivalent for atmospheric corrosion protection.

2.7.4.3 Valve flange gasket surfaces shall be coated with Type A, Type B, or Type D preservative prior to reinstalling protective covers after internal inspection.

2.7.4.4 Protective covers shall be made of a weatherproof material and of such construction to provide a weather-tight seal. Plastic plugs and flange covers are not permitted.

2.7.4.5 All ball valve internals shall be coated prior to reinstalling protective covers after internal inspection.

2.7.4.6 All ball valves shall be protected and stored in the open position.

2.7.4.7 Multiple turn, metal-seated valves shall be stored in the closed position to minimize the length of stem exposed. Multiple turn, soft-seated valves shall be stored one turn from the closed position. Valves shall be stored with valve openings horizontal to prevent water accumulation.

2.7.4.8 All valves shall be stored on their sides above grade on a well-drained, hard surface.

2.7.4.9 Periodic (at least once per month) checks shall be made to ensure that protective procedures are effective. If deterioration is observed, the user shall be notified so that appropriate corrective action can be initiated.

2.7.4.10 Packing inhibitors are usually effective for only six months. Valves with packing that are stored for longer periods shall be checked and protected against stem corrosion if necessary.

2.7.4.11 Preservatives shall be removed with solvent from all surfaces prior to installation of valves.

2.7.4.12 All ring joint flanges shall be examined when received and the condition recorded. Spot checks for corrosion shall be made monthly while in storage.

2.7.5 Vendor-supplied Associated Components

Vendor-supplied associated components that will require long-term storage outdoors during the construction period (or stainless steel in a salt water environment) shall be stored and protected per the vendor's and/or user's recommendations.

NOTE Vendor-supplied associated equipment can include inlet air filters, pulsation suppressors, silencers, etc. that are specially designed for attachment to the main equipment, but are shipped separately.

2.8 Machinery—General Short Term Criteria

2.8.1 Clean and coat all flange gasket surfaces with Type A, Type B, or Type D preservative.

2.8.2 Install weatherproof protective covers of such construction to provide a watertight seal on all openings. Plastic plugs and flange covers are not permitted.

2.8.3 Consult the manufacturer to determine if additional intermediate rotor shaft supports are required. Provide the supports as necessary.

2.8.4 Spare rotating elements shall be stored per manufacturer's specific instructions.

NOTE Rotating elements should be stored in a controlled environment room or nitrogen purged containers. Vertical storage and/or a shipping container may be required.

2.8.5 Preservatives for oxygen, ethylene and refrigeration compressors must be approved by the equipment manufacturer.

2.9 Reciprocating Compressors

NOTE Also see 2.8 for general criteria.

2.9.1 Coat exposed rods, eccentrics, plungers, and machined surfaces with Type A, Type B, or Type D preservative. If the valves have been shipped loose, tag and store per manufacturer's recommendations.

2.9.2 Compressors with non-lubricated cylinders and packing shall not be contaminated with oil. Such machines, if not already shop protected, shall be sealed, purged of air, and kept pressurized with nitrogen at 2 mm to 3 mm Hg (1 in. to 2 in. w.c.).

Install a temporary pressure indicator to indicate nitrogen pressure. Remove the temporary gauge before compressor initial run-in.

2.9.3 Cylinders and crankcase shall be inspected when the compressor is received on site by removal of the inspection covers. If water or dirt has entered the equipment through damaged covers, the equipment shall be cleaned out and rust preventive treatment restored.

2.9.4 If the compressor requires field assembly, remove the protective coatings from cylinder walls, valves, rods, and so forth, and clean all parts (including crankcase) with solvent. Assemble using the manufacturer's recommended preservative freely on cylinder walls, valves, rods, bearings, and rubbing parts and fill crankcase as recommended by the manufacturer.

Do not install carbon rings or rod packing until the compressor is serviced for initial operation. Fill crankcase and lubricators as recommended by the manufacturer, with Type C preservative.

NOTE Where compressors require field assembly, the factory representative should be present to confirm inspection, preservation, and assembly procedures.

2.9.5 Rotor Turning of Reciprocating Compressors

2.9.5.1 Where applicable, open the drip feed lubricator and operate the force feed lubricators weekly. If the compressor has a manual priming main oil pump, operate it for at least one minute. Turn the crank shaft $2\frac{1}{4}$ revolutions. Shaft rotation must be accomplished with a strap wrench or other non-marring device. Verify that radial

bearings have adequate lubrication before turning shaft. Check for rust spots. Close the drip feed lubricators and refill the lubricators as necessary. Record protective activity in the inspection records.

2.9.5.2 The suggested turning of the rotor 2 1/4 revolutions (810°) weekly is intended to help prevent permanent rotor sag/bow. Rotors having many stages and large bearing-span/shaft-diameter ratios are more prone to rotor sag. If a rotor is stored vertically then rotor turning is not required.

2.9.5.3 If the rotor was initially blocked for shipment, unblocking before turning and re-blocking (per the manufacturers recommendation) after turning, will be required.

2.9.5.4 When applying the rotor turning requirement, if previously applied corrosion prevention is compromised, the corrosion inhibitors will need to be reapplied.

2.9.5.5 Prior to turning the rotor, heavy rotors may need to be lifted so as to reduce the load at the supporting journals.

2.9.5.6 Rotor turning may not be practical during shipment and should commence as soon as practical after delivery to intermediate and final destination sites.

NOTE If lubricated compressor cylinders are attached to the frame and the piston and rods are installed, only rotate the crankshaft if the compressor cylinder bore and piston rod packing lubricator can be operated prior to rotation. On NL compressors, if the compressor cylinders are attached to the frame and the pistons and rods are installed, only rotate the crankshaft if it has been confirmed that all desiccants have been removed and that a positive pressure dry nitrogen purge is being maintained on the cylinders.

2.9.5.7 Large compressor frames [in excess of approximately 4 m (12 ft) in length] that are not skid mounted and that are to be stored more than a few days prior to installation should be aligned following the manufacturer's recommendations to prevent permanent distortion of the compressor frame.

2.10 Centrifugal Compressors

NOTE Also see 2.8 for general criteria.

2.10.1 Open bearing housing and verify that vendor has applied protective coating to shaft journals and thrust bearing disc and that noncontacting vibration probe target areas are not disturbed. If deficient, reapply shaft lubricant and coat inside of housing with manufacturer's approved preservative.

2.10.2 Check all lubricant fill points, sight glass connections, and piping to seals to ensure that lubricants or protective fluids do not leak from any joints.

2.10.3 Ensure that a nitrogen purge, or vapor phase inhibitors and desiccant have been applied per the manufacturer's requirements.

2.10.4 The compressor shaft must be turned 2 1/4 revolutions once per week and accomplished with a strap wrench or other non-marring device.

2.10.5 Rotor Turning of Centrifugal Compressors

2.10.5.1 Mark shaft and rotate 2 1/4 revolutions weekly. Record protective activity in the inspection records. Shaft rotation must be accomplished with a strap wrench or other non-marring device. Verify that radial bearings have adequate lubrication before turning shaft.

2.10.5.2 The suggested turning of the rotor 2 1/4 revolutions (810°) weekly is intended to help prevent permanent rotor sag/bow. Rotors having many stages and large bearing-span/shaft-diameter ratios are more prone to rotor sag. If a rotor is stored vertically then rotor turning is not required.

2.10.5.3 If the rotor was initially blocked for shipment, unblocking before turning and re-blocking (per the manufacturers recommendation) after turning, will be required.

2.10.5.4 When applying the rotor turning requirement, if previously applied corrosion prevention is compromised, the corrosion inhibitors will need to be reapplied.

2.10.5.5 Prior to turning the rotor, heavy rotors may need to be lifted so as to reduce the load at the supporting journals.

2.10.5.6 Rotor turning may not be practical during shipment and should commence as soon as practical after delivery to intermediate and final destination sites.

2.10.5.7 Open and inspect bearing housing every two months.

2.10.5.8 Type A, Type B, and Type D preservative shall be removed with solvent from all surfaces prior to final installation of compressor.

2.10.5.9 All compressors, if expected to be in the field in excess of six months, shall be purged with nitrogen. When nitrogen is not available, case openings shall be sealed. Vapor phase inhibitor and desiccant shall be used to protect internals from rusting. The equipment shall be tagged indicating the number and location of all vapor phase inhibitor and desiccant bags.

2.10.5.10 Manufacturers typically ship compressors with gas seals installed to prevent damage to them. No further attention should be required other than keeping them clean and dry. A continuous nitrogen purge is recommended to accomplish this requirement.

2.10.5.11 Equipment with magnetic thrust and journal bearings and the secondary (start-up/shutdown) thrust and journal bearings do not require lube oil.

2.11 Fans and Blowers

The following procedure shall be used for receiving and protecting fans and blowers.

NOTE Also see 2.8 for general criteria.

2.11.1 Coat exposed machined surfaces and shaft extension with Type A, Type B, or Type D preservative.

2.11.2 Fill bearing housing to bottom of shaft with the manufacturer's recommended oil.

2.11.3 Rotor Turning of Fans and Blowers

2.11.3.1 Mark shaft and rotate 2 1/4 revolutions weekly. Record protective activity in the inspection records. Shaft rotation must be accomplished with a strap wrench or other non-marring device. Verify that radial bearings have adequate lubrication before turning shaft.

2.11.3.2 The suggested turning of the rotor 2 1/4 revolutions (810°) weekly is intended to help prevent permanent rotor sag/bow. Rotors having many stages and large bearing-span/shaft-diameter ratios are more prone to rotor sag. If a rotor is stored vertically then rotor turning is not required.

2.11.3.3 If the rotor was initially blocked for shipment, unblocking before turning and re-blocking after turning (per the manufacturers recommendation) will be required.

2.11.3.4 When applying the rotor turning requirement, if previously applied corrosion prevention is compromised, the corrosion inhibitors will need to be reapplied.

2.11.3.5 Prior to turning the rotor, heavy rotors may need to be lifted so as to reduce the load at the supporting journals.

2.11.3.6 Rotor turning may not be practical during shipment and should commence as soon as practical after delivery to intermediate and final destination sites.

2.11.4 Preservatives shall be removed with solvent from all surfaces prior to installation of fans and blowers.

2.11.5 Install weatherproof protective covers of such construction to provide a watertight seal on all openings. Plastic plugs and flange covers are not permitted.

2.12 Gearboxes

The following procedure shall be used for receiving and protecting gearboxes at the jobsite.

NOTE Also see 2.8 for general criteria.

2.12.1 Determine if gearbox oil level is correct. Add the manufacturer's recommended oil if gear case contains less than the required amount. Check bearing housing oil level; fill as necessary.

2.12.2 Coat exposed machined surfaces and shaft extension with Type A, Type B, or Type D preservative. Type D preservative shall be removed with solvent from all surfaces prior to installation.

2.12.3 Rotor turning of gearboxes.

2.12.3.1 Mark low-speed shaft and rotate 2 1/4 revolutions weekly. Shaft rotation must be accomplished with a strap wrench or other non-marring device. Verify that radial bearings have adequate lubrication before turning shaft.

2.12.3.2 The suggested turning of the rotor 2 1/4 revolutions (810°) weekly is intended to help prevent permanent rotor sag/bow. Rotors having many stages and large bearing-span/shaft-diameter ratios are more prone to rotor sag. If a rotor is stored vertically then rotor turning is not required.

2.12.3.3 If the rotor was initially blocked for shipment, unblocking before turning and re-blocking (per the manufacturers recommendation) after turning, will be required.

2.12.3.4 When applying the rotor turning requirement, if previously applied corrosion prevention is compromised, the corrosion inhibitors will need to be reapplied.

2.12.3.5 Prior to turning the rotor, heavy rotors may need to be lifted so as to reduce the load at the supporting journals.

2.12.3.6 Rotor turning may not be practical during shipment and should commence as soon as practical after delivery to intermediate and final destination sites.

2.12.4 Purge gear case with nitrogen if required by the manufacturer's instructions or if deemed prudent by the user for the climatic conditions at the site. Purge per 2.3.15.

2.12.5 Record protective activity in the inspection records.

2.13 Pumps—General

The following procedure shall be used for receiving and protecting pumps during the storage and installation period at the jobsite.

NOTE Also see 2.8 for general criteria.

2.13.1 Coat coupling parts, except elastomeric parts and flexible stainless steel discs, with Type A, Type B, or Type D preservative.

2.13.2 Shipping covers shall be removed, flange gasket surfaces inspected, and internals checked for cleanliness. Coat flange surfaces with Type A, Type B, or Type D preservative.

2.13.3 Tag all loosely shipped items (such as couplings, oilers, and seal system components, if loose) with the pump identification number and store in a covered area.

2.14 Centrifugal Pumps

2.14.1 Install weatherproof protective covers of such construction to provide a watertight seal on all openings. Plastic plugs and flange covers are not permitted.

2.14.2 Fill bearing housings to the bottom of shaft with the manufacturer's recommended oil for pumps with oil lubricated bearings. Put oil mist on the bearing housings of pumps that are oil mist lubricated (if possible at this time or as soon as possible). An external note should be clearly visible that the oil housings are full of oil. Fill all barrier fluid piping and components with the manufacturer's recommended fluid.

2.14.3 For cast iron, carbon steel, and low alloy pumps, fill the pump casing with Type C preservative and rotate to coat the internals.

2.14.4 Rotor Turning of Centrifugal Pumps

2.14.4.1 Mark shaft and rotate 2 1/4 revolutions weekly in the correct direction of rotation. Record protective activity in the inspection records. Shaft rotation must be accomplished with a strap wrench or other non-marring device. Verify that the radial bearings have adequate lubrication before rotating the shaft

2.14.4.2 The suggested turning of the rotor 2 1/4 revolutions (810°) weekly is intended to help prevent permanent rotor sag/bow. Rotors having many stages and large bearing-span/shaft-diameter ratios are more prone to rotor sag. If a rotor is stored vertically then rotor turning is not required.

2.14.4.3 If the rotor was initially blocked for shipment, unblocking before turning and re-blocking (per the manufacturers recommendation) after turning, will be required.

2.14.4.4 When applying the rotor turning requirement, if previously applied corrosion prevention is compromised, the corrosion inhibitor will need to be reapplied.

2.14.4.5 Prior to turning the rotor, heavy rotors may need to be lifted so as to reduce the load at the supporting journals.

2.14.4.6 Rotor turning may not be practical during shipment and should commence as soon as practical after delivery to intermediate and final destination sites.

2.14.5 Type D preservative shall be removed with solvent from all surfaces with solvent prior to installation of pump.

2.14.6 Fill the piping loop for the barrier fluid of a dual seal pump with a process compatible fluid if it contains any carbon steel components.

2.15 Vertically Suspended Pumps

2.15.1 Apply Type C preservative to shaft journals at sleeve bearings and to thrust bearing disc.



2.15.2 Fill bearing housings to the bottom of shaft with vendor-recommended oil.

2.15.3 Coat the bowl assembly with Type A, Type B, or Type D preservative and close both ends.

2.15.4 Coat barrel flange, discharge head flanges, stuffing box, and all other machined surfaces with Type A, Type B, or Type D preservative.

2.15.5 Install weatherproof protective covers of such construction to provide a watertight seal on all openings. Plastic plugs and flange covers are not permitted.

2.15.6 Type D preservative shall be removed with solvent from all surfaces prior to installation of pump.

2.16 Reciprocating Pumps

2.16.1 Remove pistons and rods, if recommended by the manufacturer; coat with Type A, Type B, or Type D preservative; tag each part with the equipment number; and store in covered area.

2.16.2 Remove rod packing, if recommended by the vendor; tag; and store in covered area.

2.16.3 Remove suction and discharge valves; dip in Type A, Type B, or Type D preservative; wrap in waxed cloth; tag; and store in covered area.

2.16.4 Fill crankcase with Type C preservative to the recommended level.

2.16.5 Coat cylinder wall and distance piece wall with Type C preservative.

2.16.6 Type D preservative shall be removed with solvent from all surfaces prior to installation of pump.

2.17 Steam Turbines

The following procedure shall be used for receiving and protecting turbines during the installation and storage period at the jobsite.

NOTE Also see 2.8 for general criteria.

2.17.1 Coat stuffing box and shaft in packing area with Type B or Type C preservative and replace on turbine.

2.17.2 Clean and coat all flange gasket surfaces with Type A, Type B, or Type D preservative.

2.17.3 Shipping covers shall be removed, flange gasket surfaces inspected, and internals checked for cleanliness. Plastic plugs and flange covers are not permitted.

2.17.4 Install weatherproof protective covers of such construction to provide a watertight seal on all openings.

2.17.5 Identify and tag all loosely shipped items and store in a covered area.

2.17.6 General-purpose Turbines

2.17.6.1 If carbon shaft packing rings were not removed at the factory, remove and store indoors. Apply a manufacturer approved rust preventive to the packing ring cavity after the rings are removed. Tag the turbine from which the rings have been removed. The carbon rings shall be reinstalled just prior to start-up. Removal and reinstallation shall be performed by qualified personnel.

2.17.6.2 Open bearing housings and coat shaft journals with Type C preservative.

2.17.6.3 Fill bearing housings to bottom of shaft with vendor recommended oil.

2.17.6.4 Coat shaft extension with Type A, Type B, or Type D preservative.

2.17.6.5 If a hydraulic governor is supplied, fill hydraulic governor per manufacturer's recommendation.

2.17.6.6 Rotate shaft 2 1/4 revolutions weekly. Record protective activity in the inspection records. Shaft rotation must be accomplished with a strap wrench or other non-marring device.

2.17.6.7 Type D preservative shall be removed with solvent from all surfaces prior to installation of turbine.

2.17.7 Special-purpose Turbines

2.17.7.1 Inspect and coat surfaces of valve rack, cam, and cam followers with Type A, Type B, or Type D preservative.

2.17.7.2 Open bearing housings and coat shaft journals, thrust bearing disc, and bearing housing internally with Type C preservative.

2.17.7.3 Coat shaft extension with Type A, Type B, or Type D preservative.

2.17.7.4 Special-purpose turbine casings/internals shall be protected with nitrogen purging. Purge per 2.3.15. Where this is not possible and approved by the user, spray turbine internals through openings with Type C preservative.

2.17.7.5 Rotor Turning of Steam Turbines

2.17.7.5.1 Mark shaft and rotate 2 1/4 revolutions weekly in the correct direction of rotation. Record protective activity in the inspection records. Shaft rotation must be accomplished with a strap wrench or other non-marring device. Verify that the radial bearings have adequate lubrication before rotating the shaft

2.17.7.5.2 The suggested turning of the rotor 2 1/4 revolutions (810°) weekly is intended to help prevent permanent rotor sag/bow. Rotors having many stages and large bearing-span/shaft-diameter ratios are more prone to rotor sag. If a rotor is stored vertically then rotor turning is not required.

2.17.7.5.3 If the rotor was initially blocked for shipment, unblocking before turning and re-blocking (per the manufacturers recommendation) after turning, will be required.

2.17.7.5.4 When applying the rotor turning requirement, if previously applied corrosion prevention is compromised, the corrosion inhibitors will need to be reapplied.

2.17.7.5.5 Prior to turning the rotor, heavy rotors may need to be lifted so as to reduce the load at the supporting journals.

2.17.7.5.6 Rotor turning may not be practical during shipment and should commence as soon as practical after delivery to intermediate and final destination sites.

2.17.7.5.7 Type D preservative shall be removed with solvent from all surfaces prior to installation of turbine.

2.18 Rotary Screw Compressors

NOTE Also see 2.8 for general criteria.

2.18.1 Coat exposed shafts, rods, and machined surfaces with Type A, Type B, or Type D preservative. If compressor's associated equipment, such as inlet filters, pulsation suppressors, silencers, have been shipped loose, tag and store per manufacturer's recommendations.

2.18.2 NL "dry screw" compressors with TFE or carbon rotor tip seals must not be contaminated with oil. Such machines, if not already shop protected, shall be sealed, purged of air, and kept pressurized with anhydrous nitrogen at 2 mm to 3 mm Hg (1 in. to 2 in. w.c.).

Install a temporary pressure indicator to indicate nitrogen pressure. Remove the temporary gauge before compressor initial run-in.

2.18.3 Compressor and associated compressor equipment shall be inspected when the compressor is received on site by removal of the inspection covers. If water or dirt has entered the equipment through damaged covers, the equipment shall be cleaned out and rust preventive treatment restored.

2.18.4 If the compressor and associated equipment requires field assembly, remove the protective coatings from shafts, flanges, rods, and so forth, and clean all parts (including oil sump) with solvent. Assemble using the manufacturer's recommended preservative freely on shafts, flanges, rods, bearings, and rubbing parts as recommended by the manufacturer.

Fill oil reservoir, oil piping, and pre-lubricator systems as recommended by the manufacturer, with Type C preservative.

NOTE Where compressors require field assembly, consideration should be given to bringing in the factory representative to confirm inspection, preservation, and assembly procedures.

2.18.5 Where applicable, operate the pre-lubricator pump weekly. If the compressor has a manual priming main oil pump, operate it for at least one minute. Turn the compressor shaft 2 1/4 revolutions. Shaft rotation must be accomplished with a strap wrench or other non-marring device. Check for rust spots. Refill the lubricators as necessary. Record protective activity in the inspection records.

2.18.6 On all rotary screw compressors, remove any rotor anti-rotation device or blocks prior to rotation.

2.18.7 If oil flooded compressors are being lubricated, only rotate the driveshaft if the compressor rotor bore lubrication can be operated prior to rotation.

2.18.8 On NL compressors, only rotate the driveshaft if it has been confirmed that all desiccants have been removed and that a positive pressure dry nitrogen purge is being maintained on the compressor.

2.18.9 Large compressor frames [in excess of approximately 4 m (12 ft) in length] that are not skid mounted and that are to be stored more than a few days prior to installation should be aligned following the manufacturer's recommendations to prevent permanent distortion of the compressor frame.

2.19 Motors

The following procedure shall be used for receiving and protecting electric motors during the installation period at the jobsite. Specific storage instructions are normally provided by all motor manufacturers. Failure to follow these instructions may void the warranty. The procedures that follow must be adhered to, provided they do not invalidate the manufacturer's warranty.

NOTE Also see 2.8 for general criteria.

2.19.1 Receiving Inspection of Motors

After receipt at site but prior to any motor being stored or installed, the following shall be performed.

- a) An insulation resistance-to-ground test shall be made and recorded. This log will show the dates of the test and the insulation resistance value.
- b) Oil levels shall be inspected. An inspection shall be made for any evidence of oil leakage.
- c) Shafts shall be rotated and checked for freedom of movement.

2.19.2 Storage

2.19.2.1 Fill bearing housing with recommended oil if not factory lubricated or the level is low.

2.19.2.2 Coat shaft with Type A, Type B, or Type D preservative.

2.19.2.3 Wrap shaft seal areas with waxed cloth.

2.19.2.4 Apply Type A, Type B, or Type D preservative to machined areas of baseplate and motor case feet.

2.19.2.5 Store motors indoors when possible. A motor is suitable for outdoor storage if the enclosure Type is TEFC or explosion proof. Motors without space heaters shall not be stored outdoors without user's approval unless provisions are made by the installer to supply an adequate source of heat to the motor to protect it from moisture. If unable to store indoors, motors shall be stored in their operating position on a well-drained hard surface.

2.19.2.6 Vertical motors with ball bearings may be stored horizontally if they are oriented such that the drains are located at the low points to prevent any accumulation of water. Recommended storage position for vertical motors with sleeve type bearings is in the vertical position.

2.19.2.7 When a space heater is provided by the manufacturer, it shall be connected, energized, and operated continuously until the motor becomes operational. Proper warning signs must be installed to prevent injury or electrical shock to personnel.

2.19.2.8 Preservatives shall be removed with solvent from all surfaces prior to installation of motor, using caution to not have solvent contact the windings.

2.19.3 Rotor Turning of Motors

2.19.3.1 Rotate the shaft manually until the lubricant is evenly distributed to wearing surfaces. Rotate 2 1/4 revolutions weekly thereafter in the correct direction of rotation. Shaft rotation must be accomplished with a strap wrench or other non-marring device.

2.19.3.2 The suggested turning of the rotor 2 1/4 revolutions (810°) weekly is intended to help prevent permanent rotor sag/bow. Rotors having many stages and large bearing-span/shaft-diameter ratios are more prone to rotor sag. If a rotor is stored vertically then rotor turning is not required.

2.19.3.3 If the rotor was initially blocked for shipment, unblocking before turning and re-blocking (per the manufacturers recommendation) after turning, will be required.

2.19.3.4 When applying the rotor turning requirement, if previously applied corrosion prevention is compromised, the corrosion inhibitors will need to be reapplied.

2.19.3.5 Prior to turning the rotor, heavy rotors may need to be lifted so as to reduce the load at the supporting journals.

2.19.3.6 Rotor turning may not be practical during shipment and should commence as soon as practical after delivery to intermediate and final destination sites.

2.19.4 Testing

Insulation resistance of all motors shall be tested upon receipt, just prior to installation, and just prior to start-up and shall be recorded in the inspection records. The test voltage levels and the insulation resistance shall be per the manufacturer's instructions. If the megger readings do not meet the manufacturer's requirements, winding dryout may be required. Dry out the stator per the motor manufacturer's instructions. Other methods may be harmful to the windings.

2.20 Instrumentation on Packaged Machinery

2.20.1 All instruments shall be inspected by qualified personnel for compliance to purchase specifications, arrival at site clean, dry, and with proper protection at all openings, proper tagging, and inspected for shipping damage.

2.20.2 After inspection, instruments are to be replaced in their original factory boxes, properly tagged, and stored on shelves in a dry enclosed area.

2.20.3 For instruments or control panels that have been premounted on the machinery package that cannot be stored in a dry, enclosed area, the user and manufacturer shall be consulted.

NOTE Removal and indoor storage of premounted instruments and control panels may be required if such devices cannot be protected from rain, humidity, temperature, or dusty conditions. Explosion-proof enclosures are not necessarily weatherproof enclosures. Open conduit connections can allow entrance of moisture. This subject should have been addressed during the procurement or shop inspection stage, but is sometimes overlooked.

2.20.4 Electronic Instruments

2.20.4.1 Electronic instruments shall be stored in a dust-free room between 8 °C and 45 °C (45 °F through 110 °F).

2.20.4.2 If humidity is excessive, seal and store the instruments in plastic wrap, place in a box with desiccant outside the plastic wrapping, and store indoors. Take care that the desiccant does not contact any wiring, terminals, or electronic parts.

NOTE The avoidance of dust and excessive humidity may not be needed except for non weatherproof instruments.

2.20.4.3 The manufacturer's recommendations shall be reviewed to determine if climate-controlled storage facilities are required.

2.20.5 Pneumatic Instruments

Storage in a dry enclosed area is sufficient for pneumatic instruments.

2.20.6 Instrument Cases

2.20.6.1 Instrument cases with electronic parts, relays, and so forth, shall always be opened and checked by qualified personnel, unless shop inspections have been made and documented.

2.20.6.2 If the instrument case is in a weatherproof housing, reseal and store the instrument in a room between 8 °C and 45 °C (45 °F through 110 °F).

2.20.6.3 If in an explosion-proof housing, store in boxes with desiccant.

2.20.6.4 If covers need to remain open and unsealed, place the boxes in an indoor storage environment.

2.20.7 Local Control Panels

2.20.7.1 Open packaging enough to identify the control panel, reseal, and place in a dry enclosed area between 8 °C and 45 °C (45 °F through 110 °F).

2.20.7.2 When in a high-humidity area, put desiccant inside packaging before resealing.

2.20.8 Dial Thermometers, Pressure Gauges, Gauge Glasses

Protect against physical damage from construction activities, or remove, tag, and store in a dry enclosed area. Process connections shall be capped or plugged with metal caps/plugs until the instruments are reinstalled.

Annex A (informative)

Characteristics of Conventional Storage Preservatives

Storage Condition and/or Severity	Outdoor Storage, General Exposure to Elements	Indoor Storage Under Severe Conditions or Outdoor Storage (Partial Shelter) Under Moderate Conditions, or Outdoor Storage with Exposure to Elements for Short Term Only	Indoor Storage Under Moderate Conditions	Outdoor Storage with Exposure to Elements Under the Most Severe Conditions
	Type A	Type B	Type C	Type D
Product and typical characteristics	Firm coating, resistant to abrasion	Soft coating (self-healing)	Thin oily film	Asphaltic film, needs removal before part is used
Density kg/m ³ at 15.6 °C lb/gal 60 °F	868.5 7.25	923.7 7.71	876.9 7.32	922.5 7.70
Viscosity				
cSt at 40 °C	—	—	14	149
cSt at 100 °C	24.8	33.1	3.3	—
SSU at 100 °F	—	—	79	800
SSU at 210 °F	123	162	37.4	—
Flash Point				
°C	279	260	166	38
°F	535	500	330	100
Melting or pour point				
°C	73	66	−4	—
°F	164	151	+25	—
Unworked penetration				
At 25 °C (77 °F)	75	245	—	—
Film thickness, mil	1.6	1.6	0.9	3.0
Approximate coverage				
m ² /liter	26	6	44	11
ft ² /gal	1000	1000	1800	450
Nonvolatiles, %	99	99	—	55
Methods of application/ temperature, °C	dip/85 brush swab/60–71	dip/77 swab/18-27	roller coat, brush, mist	spray, dip, or brush/ ambient
Maximum time until inspection and possible reapplication under condition				
Mild	Extended	Extended	6 to 12 Months	Extended
Moderate	1 to 3 Years	1 to 3 Years	1 to 6 Months	1 to 3 Years
Severe	6 to 12 Months	6 to 12 Months	Not recommended	6 to 12 Months

NOTE Extracted from proceedings of the Fourteenth Turbomachinery Symposium, Texas A&M University, Table I, Page 36, "Storage Preservation of Machinery" by Heinz P. Bloch.

NOTE 1 This tabulation represents an overview of interacting factors that allows the specifying engineer to select the most appropriate preservative for a given situation. Indoor and outdoor storage protection is addressed, but lubricants or preservatives used for oil mist systems are not covered.

NOTE 2 The severity of indoor storage is a function of such factors as dampness, poor air circulation, widely fluctuating temperatures, or presence of corrosive fumes. If conditions are moderately severe, product "C" will provide an adequate oily film and some abrasion resistance. It does not contain water-displacing or fingerprint-suppressing agents.

NOTE 3 Product "B" has a greaselike consistency and leaves a thick film that will provide protection in the most severe indoor environments. If stored parts are sheltered from direct exposure to sun, rain, and snow, effective outdoor rust protection can be achieved with this product. Application of product "B" is preferably made by dipping at a temperature of 71 °C to 77 °C (160 °F to 170 °F). For parts too large to dip, application can be made by brush. This product forms a soft, thick, waxy coating on application, with the surface coating gradually drying to form a protective film or crust while the underlying material remains soft and plastic. This is an important characteristic because it affords a self-healing effect. When a minor break occurs, the softer material will slowly flow together and reseal the damaged film.

NOTE 4 The degree of protection obtained in exposed outdoor environments will depend to some extent on the thickness and durability of the barrier film provided by the rust preventive material. For relatively short-term storage, product "B" will give effective protection. For longer periods, product "A" is recommended. It provides the toughest coating for a product of this type, and is more resistant to film rupture than product "B." For dip application, product "A" should be heated to 85 °C (185 °F).

NOTE 5 Product "D" is a solvent-cutback asphaltic material. This product provides the best protection for long-term outdoor storage, but must be removed before the part is put into service. The preferred application method is by spray, although dipping and brush applications are also suitable. Product "D" dries to a thick, hard, durable, black film but may be removed with a good quality mineral spirits solvent.

NOTE 6 Although products "A" through "C" do not require removal before the part is placed in service, care should be taken to be sure that the coating has not absorbed abrasive dust.

NOTE 7 Many of the desirable attributes of premium preservatives are listed below:

- dry to a mildly tacky film that should not collect appreciable amounts of airborne particulates;
- provide freedom from oxidation in indoor and outdoor storage for extended periods of time;
- due to their polar nature, remove water from the pores of the metal, replacing the water with the rust preventive coating;
- in the form of films, have extremely low moisture transmission characteristics, even in contact with water;
- have the ability to neutralize acid, making a suitable rust preventive for acidic atmospheres and where fingerprints may create a corrosive action on metal surface;
- are self-healing, if in film form. If the film is accidentally ruptured, it should heal over the ruptured area;
- even as film, should be readily removed with solvent or a solvent-emulsion cleaner when desired;
- are safe to apply over partially painted or conventional elastomeric parts.

NOTE 8 Desiccants (moisture absorbing material), VCI products (provides self-healing barrier between the metal surface and moisture), and nitrogen purging (displaces oxygen) may be used and requires approval from the manufacturer or the user-designated representative.

NOTE 9 VCI products that contain nitrites will attack copper and bronze materials.

Annex B (informative)

Machinery Receiving and Protection Checklist

Project No.:	Equip. Tag No.:	Report No.:
Prepared by:	Storage Location:	Date:
Equipment Description:		

Equipment No.: _____			
Section	Requirements	Name	Date
2.2	Jobsite Receiving and Inspection		
2.2 a)	Visual inspection for physical damage or contamination. Comments (before unloading): _____ _____ _____		
	Comments (after unloading): _____ _____ _____		
2.2 b)	Shipping protection intact?		
2.2 c)	Have off-site (shop) inspections been made?		
2.2 d)	Loose components/packages match packing lists?		
2.2 e)	Are special handling instructions required (and carried out)?		
2.2 f)	Components properly identified?		
2.2 g)	Do components comply with project requirements?		
2.2 h)	Flange faces undamaged and properly coated?		
2.2 i)	Plugs/caps in place, desiccants unsaturated, and equipment lubricated?		
2.2 j)	For inert gas purged equipment, is the required pressure still applied?		
2.2 k)	Grout surfaces clean and coated?		
2.2 l)	Tapped openings in stuffing boxes and gland plates sealed?		
2.2 m)	Impact measuring devices inspected (when specified)?		
2.2 n)	All inspections recorded on Annex B and Annex C?		
2.2 o)	Damage reports completed and issued to shipper/vendor?		
2.3	General Instructions—Jobsite Protection		
2.3.1	Are manufacturer's recommendations for storage and protection available and equipment protected accordingly? NOTE If so, the manufacturer's recommendations take precedence, but continue to follow this checklist for items not covered by the manufacturer.		
2.3.2	Records maintained in accordance with established procedures?		
2.3.3	Equipment/material free of ground contact? Laydown area graveled as a minimum!		
2.3.4	For outdoor storage, is equipment on timber?		

Equipment No.: _____			
Section	Requirements	Name	Date
2.3.5	Is indoor storage available at site? Is third-party storage available?		
2.3.6	Do temporary coverings allow free air circulation?		
2.3.7	Is integrity of original shipping packaging maintained?		
2.3.8	All carbon and low alloy steels protected from corrosive environments?		
2.3.9	Painted surfaces should not require additional protection but shall be examined periodically for signs of rusting. Touch-up, using the manufacturer's recommended methods and materials, shall be performed within a practical and reasonable period of time.		
2.3.10	All items with machined surfaces shall be stored so that the machined surfaces can be examined periodically (monthly) for signs of rust.		
2.3.11	Any special parts and tools for construction purposes that accompany vendor shipments shall be tagged, protected, and stored per the vendor's and/or user's recommendations. All tags must be stainless steel and stainless-steel wired to the special part or tool. Paper tags are not permitted.		
2.3.12	Equipment protected from construction operations such as chipping, sanding, painting, rigging, welding, and so forth?		
2.3.13	For periodic rotation of equipment, are shipping blocks, desiccant bags, and protective plastic clear of moving parts? Is equipment properly lubricated for rotation?		
2.3.14	Have proper preservatives been selected?		
2.3.15	Nitrogen purge in place for special-purpose equipment or where specified? Use Annex C for logging of purge inspections		
2.3.16	All cavities, cooling passages, and so forth, drained of water to prevent freezing?		
2.3.17	Unless stated differently in subsequent sections on specific equipment, the following applies.		
2.3.17 a)	Oil lubed bearing housings, seal housings, stuffing boxes, hydraulic equipment, and gear cases fogged and $\frac{1}{4}$ filled with approved oil (other acceptable methods can include the use of nitrogen purge and VCI emitters)?		
2.3.17 b)	When specified, measure and record TAN number.		
2.3.17 c)	Exposed carbon steel coated with Type A, Type B, or Type D preservative? Machined surfaces coated with Type A, Type B, or Type D and wrapped with waxed cloth?		
2.3.17 d)	Grease-lubricated bearings greased by the manufacturer?		
2.3.18	Oil mist system required and in accordance with requirements?		
2.4	Lubricants and Preservatives		
2.4.1	All desiccants have prior approval from the manufacturer or the user-designated representative and in accordance with Annex A?		
2.4.2	Are selected preservatives compatible with elastomeric parts, seals, gaskets, and so forth?		
2.4.3	MSDSs on file and hazards reviewed?		
2.4.4	Desiccants approved by the manufacturer or user-designated representative and checked monthly?		
2.4.5	Do preservatives need to be removed prior to process contact?		

Equipment No.: _____			
Section	Requirements	Name	Date
2.4.7	Do all VCIs have prior approval from the manufacturer or the user-designated representative. NOTE Some VCIs may contain nitrites which attack copper and bronze.		
2.4.8	Nitrogen asphyxiation hazards removed?		
2.5	Bolts		
2.5.1	Loose bolts, nuts, and fasteners identified and stored in sheltered area?		
2.5.2	Preservative applied to non-galvanized or plated items?		
2.6	Spare Parts		
2.6.1	Spare parts inventoried and issued to user upon receipt?		
2.6.2	Storage and protective maintenance of miscellaneous loose items as directed by the manufacturer?		
2.6.3	Extra drawings and manuals shipped with the equipment saved and handed over to the user?		
2.6.4	Special tools turned over to the user-designated machinery representative at the end of the job?		
2.7	Auxiliary Piping for Rotating Equipment		
2.7.1	Pipe components coated internally and externally prepared for storage?		
2.7.3	Flanges inspected and prepared for storage?		
2.7.4	Valves inspected and prepared for storage? Ball valves in open position? Soft-seated gate and globe valves in closed/off-seat position and stored horizontal?		
2.7.5	Vendor supplied associated components that will require long term storage outdoors during the construction period (or stainless steel in a salt water environment) stored and protected per the vendor's and/or user's recommendations?		
2.8	Machinery—General Short Term Criteria		
2.8.1	All flange gasket surfaces cleaned and properly preserved?		
2.8.2	Watertight covers on all openings?		
2.8.3	Are intermediate rotor shaft supports required?		
2.8.4	Is vertical storage of rotating elements required by the manufacturer?		
2.8.5	Preservatives and procedures for refrigeration, oxygen, and chlorine service approved by manufacturer?		
2.9	Reciprocating Compressors		
2.9.1	Exposed rods, eccentrics, plungers, and machined surfaces coated?		
2.9.2	Non-lubed compressors nitrogen purged, not contaminated with preservatives?		
2.9.3	Cover on openings in cylinders and crankcase undamaged? If damaged check for water or dirt inside.		
2.9.4	For field assembled compressors, have loose components been properly cleaned and preserved? Have carbon rings and rod packing been left out until just prior to initial operation?		
2.9.5	Crank shaft turned 2 1/4 revolutions once per week and accomplished with a strap wrench or other non-marring device.		
2.10	Centrifugal Compressors		
2.10.1	Is bearing housing properly lubricated and preserved?		
2.10.2	Have the lubricant fill points, site glass, and piping been checked for leaks?		

Equipment No.: _____			
Section	Requirements	Name	Date
2.10.3	Has a nitrogen purge, or vapor phase inhibitors and desiccant been applied?		
2.10.4	Compressor shaft turned 2 1/4 revolutions once per week and accomplished with a strap wrench or other non-marring device?		
2.11	Fans and Blowers		
2.11.1	Have all exposed low alloy surfaces and shafts been coated with preservative?		
2.11.2	Bearing housing oil level correct?		
2.11.3	Rotor shaft turned 2 1/4 revolutions once per week and accomplished with a strap wrench or other non-marring device?		
2.12	Gearboxes		
2.12.1	Is gearbox oil level correct and filled with manufacturer's recommended oil?		
2.12.2	Have machined surfaces and shafts been coated?		
2.12.3	Gearbox shaft turned 2 1/4 revolutions once per week and accomplished with a strap wrench or other non-marring device?		
2.12.4	Has a nitrogen purge been applied, when specified?		
2.13	Pumps—General		
2.13.1	Coupling parts, except elastomers and stainless steel discs, coated?		
2.13.2	Shipping covers removed and flange surfaces inspected and coated?		
2.13.3	Have loose components been tagged and properly stored?		
2.14	Centrifugal Pumps		
2.14.1	Have all openings been covered with a watertight seal?		
2.14.2 a)	Have bearing housings been filled with oil to bottom of shaft?		
2.14.2 b)	Oil mist installed where applicable?		
2.14.2 c)	All barrier piping filled with proper fluid?		
2.14.3	Have low alloy pump casings been filled with proper preservative and rotated to coat all internals?		
2.14.4	Pump shaft turned 2 1/4 revolutions once per week and accomplished with a strap wrench or other non-marring device?		
2.15	Vertical Suspended Pumps		
2.15.1	Has preservative been applied to shaft journals at sleeve bearing and thrust disc?		
2.15.2	Bearing brackets completely filled?		
2.15.4	Bowl assembly, barrel flange, discharge head flanges, stuffing box, and machined surfaces coated?		
2.15.5	Weatherproof covers installed on all openings?		
2.16	Reciprocating Pumps		
2.16.1	When recommended by manufacturer, have pistons and rods been removed, coated, tagged, and stored in covered area?		
2.16.2	Has rod packing been removed and tagged, when required?		
2.16.3	Have suction and discharge valves been removed, coated, and tagged, when required?		
2.16.4	Has crankcase been filled to the recommended level with preservative?		
2.16.5	Have cylinder and distance piece walls been coated?		
2.16.6	Exposed shaft coatings with Type D preservatives removed prior to pump installation?		

Equipment No.: _____			
Section	Requirements	Name	Date
2.17	Steam Turbines		
2.17.1	Have stuffing box, shaft in packing area, and flange gasket surfaces been coated?		
2.17.2	Are weatherproof covers on all openings?		
2.17.3	Have internals been inspected for cleanliness?		
2.17.4	Have loosely shipped components been tagged?		
2.17.6	General-purpose Turbines		
2.17.6.1	Have carbon rings been removed, tagged, and stored indoors, when required?		
2.17.6.2	Have shaft journals been lubricated?		
2.17.6.3	Have bearing housings been filled with proper lubricant?		
2.17.6.4	Have exposed shafts been coated?		
2.17.6.5	Has governor been filled with manufacturer's approved fluid?		
2.17.6.6	Turbine shaft turned 2 1/4 revolutions once per week and accomplished with a strap wrench or other non-marring device?		
2.17.6.7	Type D preservatives removed prior to installation of turbine?		
2.17.7	Special-purpose Steam Turbines		
2.17.7.1	Have valve racks, cam, and cam followers been inspected and coated?		
2.17.7.2	Have bearing housings, shaft journals, and thrust bearing discs been coated?		
2.17.7.3	Have exposed shafts been coated?		
2.17.7.4	Has the nitrogen purge been applied where possible or internals alternatively coated for preservation?		
2.18	Rotary Screw Compressors		
2.18.1	Exposed shafts and machine surfaces properly protected?		
2.18.2	"Dry" compressors maintained clean and dry with a nitrogen purge?		
2.18.3	Inspected upon shipment arrival and cleaned, preserved, and all openings covered and weather-tight?		
2.18.4	For field assembly units, clean and preserve as recommended by the manufacturer during assembly?		
2.18.5	Where applicable, pre-lube pump operated weekly? Shaft rotated 2 1/4 turns weekly with a strap wrench or other non-marring device?		
2.18.6	All anti-rotation devices removed before attempting to rotate?		
2.18.7	Ensure that rotor bores on oil flooded compressors are lubricated before rotating.		
2.18.8	Ensure that all desiccants have been removed and a nitrogen purge established on NL compressors before rotating.		
2.18.9	Large compressors aligned to prevent frame distortion?		
2.19	Motors		
2.19.1.a)	Has an insulation test been made and logged?		
2.19.1.b)	Have oil levels been checked and any leakage noted?		
2.19.1.c)	Shafts rotated and checked for freedom of movement?		
2.19.2.1	Bearing housing filled with recommended lubricant?		
2.19.2.2	Has shaft been coated with proper preservative?		
2.19.2.3	Have seal areas been covered with waxed cloth?		

Equipment No.: _____			
Section	Requirements	Name	Date
2.19.2.4	Have motor baseplate machined surfaces or feet been coated?		
2.19.2.5	Have non-weatherproof motors been stored indoors?		
2.19.2.6	Have vertical motors been stored vertically?		
2.19.2.7	Have space heaters been energized? Have warning signs been posted?		
2.19.2.8	Preservatives removed prior to installation?		
2.19.3	Shafts rotated 2 1/4 turns weekly with a strap wrench or other non-marring device?		
2.20	Instrumentation on Packaged Machinery		
2.20.1	Do instruments comply with specifications, and are they properly tagged?		
2.20.2	Are loose instruments stored in a dry enclosed area, in original factory packaging?		
2.20.3	Can premounted instruments be stored outdoors?		
2.20.4	Electronic Instruments		
2.20.4.1	Are electronic instruments stored in a dry dust-free room?		
2.20.4.2	Are instruments stored in a humidity controlled area?		
2.20.5	Pneumatic Instruments		
2.20.5	Are instrument cases and local control panels stored in a dry enclosed area?		
2.20.6	Instrument Cases		
2.20.6.1	Electronic component cases opened and inspected?		
2.20.6.2	Check sealing of weatherproof enclosures and properly stored.		
2.20.6.3	Explosion-proof housings stored indoors with desiccant?		
2.20.6.4	Covers that must remain open and unsealed stored indoors?		
2.20.7	Local Control Panels		
2.20.7.1	Packaging opened sufficiently to inspect components and then resealed for preservation.		
2.20.7.2	Desiccant bags placed in enclosures in high humidity areas?		
2.20.8	Dial Thermometers, Pressure Gauges, Gauges		
2.20.8	Are thermometers, pressure gauges, and gauge glasses protected from physical damage?		

Annex C (informative)

Machinery Receiving and Inspection Checklist

Equipment No.: _____

Periodic Services Between Time Received and Start-up (See Note)							
Item	Interval	Dates/Initials					
Visual inspection that coverings and coatings are intact	Monthly						
Inspection of painted surfaces	Monthly						
Inspection of machined surfaces	Monthly						
Inspect desiccant	Monthly						
Motor insulation resistance test	Monthly						
Inspect bearing housing; replace/ refill as necessary	2 Months						
Check TAN of preservative oil, if specified	2 Months						
Oil check	2 Weeks						
Rotation of shafts	Weekly						
Compressors— lubrication	Weekly						

NOTE For nitrogen blanketing log, see Annex D.

Inert Gas Purge Maintenance Log

(a) Interval D = Daily, W = Weekly, M = Monthly

(b) Record flow rate in SLPM (SCFH) when a continuous flow purge is used in lieu of a constant pressure blanket.

Recommended Practice for Machinery Installation and Installation Design

Chapter 4—Foundations

Downstream Segment

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