Special-purpose Rotating Equipment Repairs

API RECOMMMENDED PRACTICE 687
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Chapter 0—Rotors and Stationary Components

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1 Scope and General Recommendations

1.1 Scope

This recommended practice covers the recommendations for the inspection and repair of special purpose rotating equipment assemblies and components (rotors, bearings, couplings and stationary components) used in petroleum, chemical, and gas industry services.

This document does not cover the removal or reinstallation of the assemblies of the equipment.

This recommended practice is separated into chapters that provide recommendations to specific equipment.

— Chapter 0 provides an overview of the inspections and repairs for special purpose rotating equipment assemblies and components.

— Chapter 1 provides common information that should be used for rotor assemblies identified in Chapters 2 through 7.

— Chapters 2 through 7 should be used separately for the rotors for the specific equipment identified in Chapters 2 through 7 and in conjunction with Chapters 0 and 1.

— Chapter 8 provides recommendations for stationary component inspections and repairs.

This document covers equipment manufactured to the requirements of API 612 *Special Purpose Steam Turbines*, API 613 *Special Purpose Gears*, API 617 *Axial and Centrifugal Compressors and Expander-Compressors*, API 619 *Rotary-Type Positive Displacement Compressors*, API 671 *Special Purpose Couplings*, and *Hot Gas Expanders used in FCCU Power Recovery and Nitric Acid Services*.

1.2 General Recommendations

1.2.1 The basis of repair recommendations should be to produce safe and reliable components or equipment while:

a) returning dimensions required for spare parts interchangeability to the latest design fits and clearances;

b) maintaining interchangeability with other units;

c) using existing spare parts;

d) eliminating errors in manufacturing future spare parts that could be caused by undocumented dimensional changes; and

e) maintaining its capabilities.

NOTE The latest design fits and clearances may not be as originally designed by the original equipment manufacturer (OEM), since rerates and/or upgrades may have been incorporated into the machine design.

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1.2.2 Use of previously manufactured components and their acceptance criteria should be mutually agreed upon by all parties involved and documented in the work scope.

1.2.3 The repair shop should assume order responsibility.

1.3 Alternative Procedures

The repair shop or vendor may offer alternative procedures and designs. Any exception to this recommended practice should be clearly stated in the proposal.

1.4 Conflicting Requirements

In case of conflict between this recommended practice and the inquiry, the inquiry should govern. At the time of the order, the order should govern.

1.5 Statutory Requirements

The owner and the repair shop should determine the measures to be taken to comply with any governmental codes, regulations, ordinances, or rules that are applicable to the equipment and its packaging and preservation. Equipment installed in the European Economic Area should comply with all applicable European Union Directives.

1.6 Unit Responsibility

The repair shop who has order responsibility should assure that all vendors comply with this recommended practice and all referenced standards.

2 Normative References

2.1 This RP makes reference to American standards. Other international or national standards may be used as agreed between owner and repair shop, provided it can be shown that these other standards meet or exceed the American standards referenced.

2.2 The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Recommended Practice 571, *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry*

API Recommended Practice 582, *Welding Guidelines for the Chemical, Oil, and Gas Industries*

API Standard 612, *Steam Turbines—Special Purpose Applications*

API Standard 613, *Special Purpose Gear Units*

API Standard 617, *Axial and Centrifugal Compressors and Expander-compressors*

API Standard 619, *Rotary-Type Positive-Displacement Compressors*

API TR 684, *API Standard Paragraphs Rotodynamic Tutorial: Lateral Critical Speeds, Unbalance Response, Stability, Train Torsionals, and Rotor Balancing*

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API Standard 692, *Dry Gas Sealing Systems for Axial, Centrifugal, and Rotary Screw Compressors and Expanders*

API Standard 670, *Machinery Protection Systems*

API Standard 671, *Special Purpose Couplings for Petroleum, Chemical, and Gas Industry Services*

AGMA 9002-B04, *Bores and Keyways for Flexible Couplings*

ANSI/AGMA ISO 1328, *Cylindrical Gears—ISO System of Accuracy—Part 1: Definitions and Allowable Values of Deviations Relevant to Corresponding Flanks of Gear Teeth*

ASME B16.1, *Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250*

ASME B16.5, *Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard*

ASME B16.42, *Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300*

ASME 16.47, *Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard*

ASME B31.3, *Process Piping*

ASME Boiler and Pressure Vessel Code (BPVC), Section V: *Nondestructive Examination Articles 2, 4, 5, 6, 7, and 23*

ASME Boiler and Pressure Vessel Code (BPVC), Section VIII: *Rules for Construction of Pressure Vessels*

ASME Boiler and Pressure Vessel Code (BPVC), Section IX: *Welding, Brazing, & Fusing Qualifications*

ASTM A220, *Standard Specification for Pearlitic Malleable Iron*

ASTM A388, *Standard Practice for Ultrasonic Examination of Steel Forgings*

ASTM A435, *Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates*

ASTM A472, *Standard Specification for Heat Stability of Steam Turbine Shafts and Rotor Forgings*

ASTM A516, *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service*

ASTM A577, *Standard Specification for Ultrasonic Angle-Beam Examination of Steel Plates*

ASTM, A578, *Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications*

ASTM A609, *Standard Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof*

ASTM C633, *Standard Test Method for Adhesion or Cohesion Strength of Thermal Spray Coatings*

ASTM D2240, *Standard Test Method for Rubber Property—Durometer Hardness*

ASTM D4541, *Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers*

ASTM E94, *Standard Guide for Radiographic Examination*

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ASTM E125, *Standard Reference Photographs for Magnetic Particle Indications on Ferrous Castings*

ASTM E165/E165M, *Standard Practice for Liquid Penetrant Examination for General Industry*

ASTM E186, *Standard Reference Radiographs for Heavy-Walled 50 mm to 115 mm (2 in. to 4½ in.) Steel Castings*

ASTM E280, *Standard Reference Radiographs for Heavy-Walled 115 mm to 305 mm (4½ in. to 12 in.) Steel Castings*

ASTM E446, *Standard Reference Radiographs for Steel Castings up to 50 mm (2 in.) in Thickness*

ASTM E709, *Standard Guide for Magnetic Particle Testing*

ASTM E1316, *Standard Terminology for Nondestructive Examinations*

ASTM E1417/E1417M, *Standard Practice for Liquid Penetrant Testing*

ASTM F436/F436M, *Standard Specification for Hardened Steel Washers*

ISO 2230, *Rubber products—Guidelines for storage*

ISO 4386-1, *Plain bearings—Metallic multilayer plain bearings—Part 1: Non-destructive ultrasonic yesting of bond of thickness greater than or equal to 0,5 mm*

ISO 4386-3, *Plain bearings—Metallic multilayer plain bearings—Part 3: Non-destructive penetrant testing*

ISO 21940-12, *Mechanical vibration—Rotor balancing—Procedures and tolerances for rotors with flexible behaviour*

ISO 21940-32, *Mechanical vibration—Rotor balancing—Part 32: Shaft and fitment key convention*

MSS SP-6, *Standard Finishes for Contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings*

MSS SP-55, *Quality Standard for Steel Castings for Valves, Flanges, Fittings, and Other Piping Components—Visual Method for Evaluation of Surface Irregularities*

SAE ARP5316C, *Storage of Elastomer Seals and Seal Assemblies Which Include an Elastomer Element Prior to Hardware Assembly*

SSPC SP 1, *Solvent Cleaning*

SSPC SP 6, *Commercial Blast Cleaning*

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

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

3.1.1
accuracy
Degree to which the result of a measurement, calculation, or specification conforms to the correct value or a standard.

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3.1.2
as found
Condition in which the equipment/component arrives at the repair shop, prior to any repair work.

3.1.3
as repaired
Condition in which the equipment/component leaves the repair shop, after repair work has been performed.

3.1.4
assembly
Combination of components that have been fitted together.

3.1.5
calibration
Set of operations that establish, under specified conditions, the relationship between values indicated by a measuring instrument or measuring system or values represented by a material measure and the corresponding known values of a standard.

NOTE 1 The results of calibration permit the estimation of indication errors of the measuring system or material measure, or the assignment of values to marks on an arbitrary scale.

NOTE 2 The results of calibration can be recorded in a document sometimes called a calibration certificate. Calibration method is a defined technical procedure for performing a calibration.

3.1.6
components
One of the parts of an assembly.

3.1.7
contact verification
transfer contact verification
blue check
Inspection used to characterize the contact pattern and contact percentage between two surfaces. The inspection typically uses a soft uniform paste that is nondrying, nonhardening, transferable, and remains pliable.

NOTE This is often referred to as a “blue check” because the paste is typically blue, although the paste can be in other colors.

3.1.8
containers
Boxes, canisters, cradles, pallets, or skids used for shipping, storage, or handling to prevent damage and maintain control of the component or equipment.

3.1.9
equipment
Combination of assemblies and components that have been fitted together.

3.1.10
hydrodynamic bearings
Bearings that use the principles of hydrodynamic lubrication. The bearing surfaces are oriented so that relative motion forms an oil wedge, or wedges, to support the load without shaft-to-bearing contact.

3.1.11
indications
Response or evidence of a discontinuity that requires interpretations to determine its significance.

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3.1.12
"J" strips
Thin rotating labyrinth strips held in position by caulking or prick punching to the shaft or sleeve to provide pressure breakdown. These may also be referred to as "L" strips or "T" strips.

3.1.13
maximum continuous speed
Highest rotational speed (revolutions per minute) at which the machine, as built and tested, is capable of continuous operation with the specified fluid.

3.1.14
measurement device graduation
Graduation of a measurement system is the smallest difference between values that can be distinguished.

3.1.15
NPS
nominal pipe size
Value approximately equal to a diameter in inches.

EXAMPLE NPS 3/4

NOTE 1 Refer to ASME B 31.3.

NOTE 2 The letters NPS are followed by a value which is related to an approximate diameter of the bore, in inches, for piping up to and including 12 in. diameter. For piping over 12 in. (NPS 12), the NPS value is the nominal OD.

3.1.16
observed inspection or test
Where the owner is notified of the timing of the inspection or test and the inspection or test is performed as scheduled even if the owner or representative is not present.

3.1.17
order responsibility
Responsibility for coordinating the technical aspects of the components included in the scope of the order. The technical aspects to be considered include but are not limited to such factors as testing, material test reports, conformance to specifications, manufacturing of replacement components, and coordination with vendors.

3.1.18
owner
Final recipient of the equipment. The owner may delegate another agent as the purchaser of the inspection and repair services.

3.1.19
phase I inspection
Description of the extensiveness of an inspection of a rotor assembly. Typically, a phase I inspection does not include a partial or complete disassembly of the rotor assembly, other than the coupling hub or thrust collar.

3.1.20
phase II inspection
Description of the extensiveness of an inspection of a rotor assembly. Typically, a phase II inspection includes a partial or complete disassembly of the rotor assembly.

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3.1.21
phase-referenced
Phase is an angular measurement of the relative timing between two points (measurement point and a reference point). The phase angle (measured in degrees or radians) is the difference between the measurement point and reference point.

NOTE A phase-referenced runout (TIR) has two components: 1) the TIR, and 2) the angle between the measurement point and the high spot.

3.1.22
positive material identification
PMI
Analysis of a metallic alloy to establish composition by percentages of its constituent elements.

3.1.23
positive material identification testing
Any physical evaluation or test of a material to confirm that the material which has been or will be placed into service is consistent with the selected or specified alloy material designated by the owner. These evaluations or tests may provide either qualitative or quantitative information that is sufficient to verify the nominal alloy composition.

3.1.24
procedure qualification record
PQR
Record of the welding variables recorded during the welding of the test coupons. A PQR also contains the test results of the tested specimens. Specimens are tested in accordance with ASME Section IX, other referenced welding codes, or other applicable previously agreed-to weld testing requirements.

3.1.25
protective coatings
Coatings used for fouling release, to minimize erosion or corrosion and/or for performance enhancement.

3.1.26
repair shop
Agency that provides order responsibility for the inspection and repair services. The repair shop may or may not be the owner's shop.

3.1.27
rerate
Change in the operating performance that may or may not require hardware changes.

3.1.28
residual unbalance
Amount of unbalance remaining in a rotor after balancing.

3.1.29
special purpose application
Application for which the equipment is designed for uninterrupted, continuous operation in critical service, and for which there is usually no spare installed equipment.

3.1.30
special tool
Tool that is not a commercially available catalog item.

3.1.31
stack
Term used to describe a built-up rotor construction or a step in the assembly procedure, where a minimum of one major component is assembled on the shaft.

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3.1.32
tolerance
Allowable variation in the measured parameter(s).

3.1.33
total indicator reading
total indicator runout
TIR
Difference between the maximum and the minimum readings of a dial indicator or similar device, monitoring a face or cylindrical surface during one complete revolution of the monitored surface.

NOTE For a cylindrical surface, the indicated runout implies an eccentricity equal to half the reading. For a flat face, the indicated runout implies an out-of-squareness equal to the reading.

3.1.34
trip speed (revolutions per minute)
Speed at which the independent emergency overspeed device operates to shut down a variable-speed prime mover.

3.1.35
truth bands
Locations on the component (such as a shaft) that are used to reference concentricity and or perpendicularity of a repaired location to the original geometric centerline of the component.

3.1.36
upgrade
Improvement in the equipment design that may increase reliability but does not result in a change in the performance.

3.1.37
vendor
Agency selected for service support by the repair shop.

NOTE This recommended practice addresses the responsibilities between two parties defined as the repair shop and the owner. The repair shop may utilize vendors to repair, refurbish, or supply components.

3.1.38
verified
Having received confirmation from a repair shop that a requirement has been met.

3.1.39
welder qualification record
WQR
Written record of certification of the welder's ability to produce sound welds if using a procedure specification qualified to ASME Section IX or other applicable welding qualification specification. The welder qualification is limited by the essential variables given for each process the welder is qualified to perform.

3.1.40
welding procedure specification
WPS
Written qualified welding procedure intended to provide direction to the welder or welding operator for making welds to ASME or other applicable standard requirements. The WPS should describe all essential, nonessential, and, if required, supplementary essential variables for each welding process used in the WPS. The WPS should also reference the applicable Procedure Qualification Record(s) as directed by ASME Section IX or other applicable welding specification.

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3.1.41
witnessed inspection or test
Where the owner is notified of the timing of the inspection or test and a hold is placed on the inspection or test until the owner or representative is in attendance.

3.2 Acronyms and Abbreviations

For the purposes of this document, the following acronyms and abbreviations apply.

BPVC boiler pressure vessel code

DOT United States Department of Transportation

FCCU fluid catalytic cracking unit

GMAW gas metal arc welding

HVLF high-velocity liquid fuel

HVOF high-velocity oxygen fuel

ID inside diameter

IGV inlet guide vane

MIC microbially induced corrosion

MIG metal inert gas

MT magnetic particle inspection

MTR mill test report

NDT nondestructive testing

OD outside diameter

OEM original equipment manufacturer

pH measure of acidity and alkalinity of a solution

PMI positive material identification

PQR procedure qualification record

PT liquid penetrant inspection

PTFE polytetrafluoroethylene

PVD physical vapor deposition

PWHT postweld heat treatment

RMS root mean square

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RT radiographic inspection

RTD resistance temperature device

TFE tetrafluoroethylene

TIR total indicator runout

UT ultrasonic inspection testing

VSV variable stator vane

VT visual inspection testing

WPS welding procedural specification

WQR welder qualification record

4 Process for Inspection and Refurbishment

4.1 General

This section is intended to give the owner guidance in defining the objectives, identifying the reference information needed, and setting the parameters of responsibility needed to properly evaluate the condition of special purpose rotating equipment being considered for inspection and overhaul.

4.2 Typical Sequence of Events

A typical sequence of events for the inspections and repairs is as follows.

a) Plan outage event (Annex J);

b) Owner to:

   1) obtain information to supply to repair shop (4.3);

   2) determine if a failure analysis should be completed:

      i) determine the level of analysis needed;

      ii) preserve the equipment components for the failure analysis.

   3) determine if upgrade should be considered (4.4);

   4) determine if rerate should be considered (4.4.2, outside scope of this document).

c) Develop initial work scopes (4.5):

   1) work scope per assembly or component;

   2) preservation steps for failure analysis, if specified;

   3) include applicable upgrades (4.4);

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4) include applicable rerates (out of the scope of this document) (4.4.2);

5) for rotor, determine if Phase I or Phase II (Chapter 1, Paragraph 4.2).

d) Select repair shop (5.0);

e) Communicate with the repair shop (6.0);

f) Shipment to repair shop (7.0);

g) Perform receiving inspections (8.0);

h) Repair shop to perform detailed visual inspection prior to cleaning and disassembly (10.2);

i) Disassemble to extent necessary to complete work scope (9.1);

j) Repair shop to clean assembly/component (10.3);

k) Repair shop to perform visual inspections after cleaning (10.4);

l) Repair shop to perform dimensional inspections after cleaning (10.5);

m) Repair shop to perform NDT inspections after cleaning (11.0);

n) Review of inspection data (hold point) (10.6):

1) determination of work scopes for each assembly/component (10.6);

2) determine if Phase II for rotor is required (if not already completed).

o) Perform repairs, upgrade, rerates, modifications, and new component manufacturing per work scopes (12.0):

— Reassemble and balance for rotors (Chapter 1, Section 13).

p) Final inspection review (13.2);

q) Prepare for shipment (14);

r) Provide shipping/storage container (14.2);

s) Provide work scope proposals (15.0);

t) Repair shop to provide documentation of inspections, repairs, upgrades, rerates, or new component manufacturing (16.0);

u) Owner performs postshipment review (6.4).

4.3 Owner Supplied Information to Repair Shop

4.3.1 The owner should identify the original edition of the API standard to which the equipment was supplied and describe any exceptions or modifications.

4.3.2 The owner should review and provide to the repair shop the current operating conditions and the machine's performance. If these conditions differ significantly from the original, a rerate may be

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considered (4.4.2). In addition, the owner should provide results of condition monitoring information and the expected run time of the equipment after the completion of these repairs.

4.3.3 The owner should provide the repair shop with a brief history of the equipment's service record since its last repair. Of importance would be the inclusion of details related to any unplanned outages of the machine and how the needed repair is related to in-service events.

4.3.4 The owner should provide information from previous inspections and repairs such as materials, dimensions, or operating parameters. The date of the previous inspection/repair should be provided.

4.3.5 The owner should briefly describe the internal environmental conditions in which the equipment is operating. If these conditions differ significantly from those used to design the present equipment, the owner should so advise. It is important to identify the presence of any corrosives such as H_2S, chlorides, or reactive chemicals such as chlorine not previously specified that may adversely affect the component materials. It is important to ensure that components meet the requirements of specific standards and the internal environmental conditions. The owner should discuss any specific inspections related to these conditions with the repair shop.

4.3.6 The owner should advise the repair shop if the service for the equipment is in an oxygen service.

4.3.7 The owner should provide the repair shop with general documentation related to the equipment. Documents such as the component materials, the use of any coatings, data sheet, previous repair records, general arrangement drawings, mass elastic diagrams, and rotor assembly drawings identifying radial vibration and axial positioning proximity probe track areas are appropriate and useful. The owner of the equipment may need to supply information to the repair shop from their records, such as for legacy equipment or equipment that was repaired by another repair shop.

4.3.8 The repair shop should be so advised if the equipment serves as a spare for more than one machine.

4.3.9 The owner should indicate why the equipment needs repairing and any time constraints for the repair.

4.3.10 The owner should obtain performance and mechanical data prior to unit shutdown for post-turnaround comparison.

4.3.11 The owner should provide information to the repair shop such as:

a) equipment's nameplate;

b) manufacturer's model and serial number;

c) changes or upgrades that have been made;

d) speeds including normal, minimum, maximum continuous, and any defined overspeed (including trip);

e) operating pressures including maximum continuous working pressure;

f) operating temperatures including maximum continuous operating temperature;

g) other data as requested.

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4.4 Upgrade Alternatives

4.4.1 After reviewing the information in 4.3 and the results of the inspections in Section 10, the desirability of incorporating improvements (upgrades) into the repaired or new components should be evaluated by the owner and the repair shop (10.6.3). Once the desired improvements are identified, the owner and the repair shop can develop the scope of repair, as identified in Section 15. Typical reasons for upgrades are:

a) to improve equipment safety;

b) to improve the reliability;

c) to reduce emissions;

d) to meet current editions of API Standards;

e) to allow interchangeability with similar units and reduce spare parts inventory;

f) to provide machinery protection;

g) to correct misapplied materials.

4.4.2 Rerates are not in the scope of this document. Equipment may be rerated in order to:

a) adapt equipment to changing performance conditions;

b) improve the operating efficiency and reduce power consumption costs resulting from changed operating conditions.

4.4.3 ● If specified, coatings should be applied to the components in the product (flow) path to help prevent corrosion or erosion and/or for performance improvement. See Annex F for additional information.

4.4.4 Owner approval is required for any design change. A new data plate should be installed if design changes affect data plate information. Do not remove the original nameplate.

4.5 Developing the Scope of Repair

4.5.1 The scope of repair should be determined by the owner and the repair shop and be specific per assembly or component. The scope of repair should be based on the owner's requests, owner's supplied information in 4.3, and repair shop input, along with the recommendations of this document. The owner should determine the extensiveness of the inspections. For rotors, determine whether a Phase I or a Phase II inspection (detailed in Chapter 1, Paragraph 4.2) should be completed. Not all the assemblies or components require the same level of inspection.

4.5.2 Unless otherwise specified, all assemblies and components should be given a receiving inspection, visual before and after cleaning, and a dimensional inspection after cleaning as outlined in Chapters 0, 1, or 8. The owner should specify any additional work such as upgrades or rerates as outlined in Chapters 0, 1, or 8.

4.5.3 A root cause analysis should be considered prior to repairs of damaged areas to prevent possible reoccurrence.

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4.5.4 The repair shop should provide cost and schedule impacts for repair scope changes. The repair shop may offer alternative options for the owner's consideration, including expected technical and/or economic advantages.

4.5.5 The owner and the repair shop should define any applicable inspection processes and acceptance criteria within the scope of repair. Reference to this recommended practice, other API or industry standards, owner specifications, or repair shop standards may be applied as acceptance criteria, if approved by the owner.

4.5.6 Upgrades as identified in 4.4 should be considered.

4.5.7 Annex J provides information on the planning of an outage for rotating equipment.

5 Selection of a Repair Shop

5.1 General

5.1.1 The repair shop should be selected based on the organization's ability to perform anticipated and potential scopes of repair while meeting the expectations of the owner. The review of the repair shop and their capabilities should include items such as:

a) facilities;

b) engineering capability and support;

c) experience repairing similar equipment;

d) manufacturing of replacement components;

e) having a quality system in place including documentation.

5.1.2 Qualification of a repair shop is usually accomplished by having the repair shop complete and submit a qualification survey form (such as the one in Annex A). Initial and follow-up on-site audits should be performed by the owner to ensure the repair shop can perform the repair.

6 Communication

6.1 General

6.1.1 The success of a repair depends upon open communication. Communication is important in defining the needs and expectations of the owner to the repair shop and to vendors. Verbal instructions, recommendations, and agreements should be confirmed in writing.

6.1.2 The owner, repair shop, and vendors should each have a designated person to coordinate communication.

6.1.3 The methods of communication should be defined before any repairs are initiated. Documentation supplied by the repair shop for the proposed work scope should be per Section 15 and the final documentation should be per Section 16.

6.1.4 All written correspondence should be identified with the following information:

a) owner's corporate name;

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b) job/project number;

c) equipment item number and service name;

d) inquiry or purchase order number;

e) any other identification specified in the inquiry or purchase order;

f) repair shop's identifying proposal number, repair shop order number, serial number, or other reference to identify return correspondence completely.

6.2 Meetings

The complexity of a project or repair will usually determine how many of the following meetings should be planned. After the meetings are held, the meeting minutes should be published by the repair shop and distributed to the attendees or other relevant personnel involved in the project.

a) After each inspection phase, a meeting should be held to review the repair scope and timetable, establish points of contact, and assign responsibilities for all parties. The owner's desired service life and uninterrupted operation requirements should be discussed.

b) Follow-up meetings may be required if deviations from the initial repair scope are found during the repair process.

c) In the case of rerates, additional meetings such as a pre-award/coordination and project design audit may be required.

6.3 Electronic Drawing and Data Transmittal

The project team should utilize appropriate lines of communication to ensure that all members are kept informed.

6.4 Post-Shipments Review

Post-shipment feedback is often missed but is needed in order to verify whether requirements were met and to improve the quality of the next relationship. This review should occur within 8 weeks from shipment and may be accomplished, for example, by meeting, teleconferencing, or videoconferencing.

7 Shipment of Equipment or Components to or from Repair Shop

7.1 Preparation for shipment

7.1.1 The repair shop or owner has the authority to reject any shipment not in compliance with their rules and regulations.

7.1.2 Consult with the repair shop for:

a) shipping container or skid requirements;

b) communications when shipping is initiated;

c) photographs;

d) liquid draining;

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e) preservation;

f) warning tags;

g) necessary tooling or fixtures;

h) hold points established before shipping;

i) identification of the length of shipping or storage time;

j) additional cleaning/decontamination;

k) unique shipping identification number (for example, job number).

7.1.3 Shipping containers or skids should be per Section 14.

7.1.4 All shipments not in containers should be covered by a canvas tarp to avoid miscellaneous foreign object and moisture damage.

7.1.5 Preservation should be applied to the equipment and/or components to prevent damage during shipping and possible storage. Safety Data Sheet information should be provided for the preservative.

7.1.6 Component(s) should be adequately supported and restrained to prevent movement during shipment.

7.1.7 Rotors being returned for repair should be adequately preserved to prevent any damage or environmental deterioration. Radial vibration and axial positioning proximity probe target area (burnished areas) of the shaft should be protected during disassembly with material such as nonadhesive vinyl tape. Each area should further be easily identified with, for example, a brightly colored wrapping indicating a proximity probe target area and “PROXIMITY PROBE AREA, DO NOT CUT” wording. The rotor should be supported per the recommendations of 14.3.

7.1.8 Verify that all flange openings have been sealed using temporary metal covers with gaskets. Plug all threaded holes (metal plugs preferred).

7.1.9 Verify that decontamination and/or draining has been completed.

7.1.10 Component(s) containing hazardous or flammable material transported to an off-site location should be cleaned and decontaminated (some disassembly may be necessary) in accordance with applicable governmental codes, regulations, ordinances, directives, or rules. Safety Data Sheets should be included. A repair shop may require owner certification. The owner communicates with the repair shop of the possibility of trapped liquids or gases that may result in a safety situation or that may be affected by the use of flame torches to facilitate disassembly. Consideration should be given to differences with regulations and languages of the shipping and receiving locations.

a) The owner and the repair shop may discuss and arrange for cleaning and decontamination at the repair shop.

b) The United States DOT regulates hazmat transportation within the territory of the US.

c) Consider requirements for other countries that may be used for shipping or receiving.

d) The repair shop has the authority to reject any shipment not in compliance with their rules and regulations.

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7.1.11 The owner should identify all components with a common job-related unique number such as a purchase order number or requisition number. Material shipped separately should be identified with securely affixed corrosion-resistant metal tags indicating the unique number. Components should be shipped with duplicate packing lists, one inside and one outside of the container. The packing list should have the unique number and describe each item in the container.

7.1.12 Lifting points and lifting lugs should be clearly identified on the equipment or equipment package. The recommended lifting arrangement should be identified on boxed equipment.

7.2 Shipment

7.2.1 The equipment and/or components should be tagged with the owner's description. Equipment inside enclosed shipping containers should also have tagging attached to the equipment.

7.2.2 The vehicle, type of vehicle, and method of securing the equipment should be adequate for the load being transported.

7.2.3 Hold-down methods should not damage the equipment.

7.2.4 Tooling and fixtures for lifting, disassembly, or assembly should be provided, if requested by the repair shop.

7.2.5 Photographs of the equipment as loaded onto the vehicle should be taken for documentation.

7.2.6 Any items that the owner requests to be shipped separately, and not installed during reassembly, should be clearly identified and documented.

8 Receiving Inspection

8.1 Receiving of Components

8.1.1 The repair shop should assign personnel trained in the correct lifting procedures and equipment selection for moving the components. Equipment, containers, and vehicles that will be used for lifting and moving parts should be maintained and exhibit current certifications of inspection and rating.

8.2 Receiving Inspection

8.2.1 The repair shop should make provisions for identification, verification, segregation, storage, maintenance, and release of all owner-supplied parts, materials, or other items. The repair shop or owner has the authority to reject any shipment not in compliance with their rules and regulations.

8.2.2 The repair shop should account for all owner-supplied materials upon receipt and verify against the received bill of lading and/or packing list.

8.2.3 The repair shop should photograph the as-received condition of the shipping container, skid, box, and components.

8.2.4 Any apparent damage to the shipping container, skid, box, or components should be noted on a receiving record, photographed to clearly show details of any damaged areas, and immediately reported to the carrier, repair shop representative, and owner representative. If shipping damage is present, a jointly agreed-upon schedule should be set to proceed to as-received inspection to determine what, if any, damage occurred to the equipment or component during shipping. Any damage due to shipping or handling should be resolved prior to proceeding. The owner will notify the repair shop when work may proceed.

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8.2.5 All owner-supplied material will be clearly marked with the repair shop job number and/or owner reference number and clearly identified as owner property.

8.2.6 Owner-supplied materials and items should be stored in a location that will preserve the integrity of the material. Regular monitoring and measurements will be performed by the repair shop to detect effectiveness of storage. Any deterioration will be reported to the owner.

9 Disassembly

9.1 General

The equipment should be disassembled to the extent determined by the work scope in Section 4. The equipment disassembly may occur at the owner's site or at the repair shop. This document covers the disassembly of the assemblies of components per the work scope that should be completed at the repair shop. The repair shop may receive the entire equipment, assemblies, or components. The owner may specify hold/witness points.

9.2 Disassembly in the Repair Shop

9.2.1 Disassembly Preparation

Prior to disassembly, the following steps should be taken.

a) Obtain specific information for disassembly of the equipment such as from the OEM manual.

b) Obtain cross-sectional drawings, data sheets, seal information, and clearance information for comparison as the equipment is being disassembled. Record any differences between the actual and the drawings or data sheets.

c) Verify that all required tooling and fixtures for disassembly and assembly are available.

9.2.2 Prior to Disassembly

a) Ensure that there are no fluids or gases trapped in subassemblies or components. Consider exposure to these materials prior to disassembly.

b) Clean the equipment/component to the extent necessary at this stage of the disassembly. Cleaning should be appropriate for the equipment/component and performed per 10.3.

c) Perform a visual inspection of the equipment. Observe the components for any evidence of corrosion, leakage areas, improper assembly, or physical damage. Take photographs to document the as-received condition, including any piping arrangements.

d) For complete machines, verify that the equipment rotates freely, if applicable.

e) For complete machines, record installed coupling hub or integral flange radial runout.

f) Record the location of the coupling hub on the shaft. Record the key in the keyway of the shaft and hub such as key protruding beyond coupling hub.

g) Remove coupling hub.

h) With coupling hub removed, record radial runout of shaft end extension.

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i) For complete machines, prior to disassembling bearing housings, do a bearing lift on each end of the rotor with the indicator positioned as close as possible to the bearing housing and a rotor axial float check and record the information.

NOTE This bearing lift check may not represent the actual bearing clearance.

9.2.3 Disassembly

During disassembly:

a) Photograph the assemblies or components as they are being disassembled. A photo log should be maintained for all work performed. Clearly photograph in detail any unusual or abnormal condition. Inspections should include, as a minimum, clear photograph(s) identifying the size, location, and orientation (including a physical reference point) of any erosion, corrosion, and unusual appearances or other damage resulting in loss or displacement of material, deposits, and buildup. Standardized sketches, forms, and tabulations are desirable.

b) Take as-found samples of any remaining residues and deposits without further contaminating the sample. Return the sample to the owner, if requested, for laboratory analysis. If deposits are suspected to have caused damage such as cracks or corrosion, the repair work may be delayed until a complete analysis is performed, at the discretion of the owner.

c) Match-mark all components to assure repeatability of the assembly. Markings should be durable enough to withstand the cleaning process of the components. If the parts have previous marking that will not apply to this particular overhaul, remove them or identify these markings as not current.

d) Check for broken, rubbed, wiped, galled, or loose components. Fractured surfaces of failed components should be protected and not abrasively cleaned or otherwise modified. Broken components should not be reassembled due to potential damage to the fractured surfaces. Debris of broken parts is to be collected and kept together with the assembly. These components, pieces, and debris are to be kept by the repair shop until the owner has decided if a failure analysis should be performed. If a failure analysis is performed, it should be determined who will perform the analysis and the scope.

e) Record information for the bearings such as orientation, rotation arrows, and location of anti-rotation pins.

f) All parts and components should be kept until inspections and investigations are completed. Parts should be marked for their location within the equipment and parts that are in multiple pieces (broken or disassembled) should be kept together and bagged. Consider that some parts may be damaged during disassembly.

g) Disassembly and cleaning of the components at the repair shop may generate hazardous waste. Parts such as spent gaskets, O-rings, and other items may require special handling. The owner and the repair shop should discuss handling and disposal of the generated waste as identified in 15.2.1.

9.2.4 Disassembly of the Components

9.2.4.1 Components should be disassembled to the extent of the work scope and the inspections to be performed in 10. Chapters 0 through 8 should be used for the disassembly, inspection, and repair of these components.

9.2.4.2 The equipment should have the location of each of the radial vibration and axial position proximity probes identified so that the proximity probe’s target areas can be verified after disassembly for proper placement.

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9.2.4.3 Radial vibration and axial positioning proximity probe target area (burnished areas) of the shaft should be protected during disassembly with material such as nonadhesive vinyl tape. Each area should further be easily identified, such as with a brightly colored wrapping indicating a proximity probe area and "PROXIMITY PROBE AREA, DO NOT CUT" wording.

10 Inspections and Cleaning

10.1 General

10.1.1 The purpose of an inspection should be to allow an accurate representation of the condition of the assembly or component.

10.1.1.1 The extent of the disassembly is based on the work scope generated by the owner/repair shop and the type of component in 4.5.

10.1.1.2 The inspections of the assemblies and components include visual, dimensional, and other inspections necessary to adequately evaluate the condition.

10.1.1.3 The repair shop/vendor should supply a not-to-exceed time frame for the completion of the inspection.

10.1.1.4 If the owner has specified witness points, an inspection schedule should be included with the quotation/proposal.

10.1.1.5 The schedule should be based on a normal work week without overtime.

10.1.1.6 Sufficient detail should be provided to enable the owner to plan the project witness activities. The schedule should be strictly followed for the owner to establish completion of inspection and repair.

10.1.2 The owner should define any special inspections not included in Sections 8, 9, and 10.

10.1.3 The owner should specify witness and hold points. The repair shop should provide approximate dates of any witness and hold points.

10.1.4 Assemblies and components such as couplings, seal sleeves, thrust collars, locking nuts, turning gear, overspeed devices, or timing gears that have been removed in the field should be included for inspection. Special tools and/or instructions necessary for lifting, disassembly, or reassembly requested in 7.2.4 should be sent to the repair shop for their use if the repair shop does not already have these special tools.

10.1.5 If couplings are provided, see Chapter 1, Annex C for inspection information. The complete coupling assembly should be inspected by a qualified vendor.

10.1.5.1 The highly stressed coupling hub to shaft fit should be inspected.

10.1.5.2 The coupling hub should be removed from the shaft and the coupling hub and the shaft contact should be verified by using a contact verification inspection by the repair shop. Matching ring and plug gauges of sufficient length to include the advancement, if available, should be used. Refer to Chapter 1, Annex C for the contact verification procedure. Do not lap with the checking gauge set.

NOTE The matching ring and plug gauges are typically supplied by the owner.

10.1.5.3 Prior to the contact check, the shaft should be inspected to ensure that there is no step at the end of the coupling hub that could cause an error with the contact readings.

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10.1.5.4 If matching ring and plug gauges are not available, the hub and shaft should be cleaned, and the contact should be verified using the coupling hub. Do not lap with the coupling hub.

NOTE Using the coupling hub as the gauge provides the potential of an error as the coupling hub does not include the advancement during this contact check.

10.1.6 Thrust collars should be removed from a rotor for visual and dimensional inspection. The highly stressed thrust collar to shaft fit should be inspected if a rotor is repaired.

10.1.7 The owner may elect to include inspection of the radial and/or thrust bearings as part of the initial inspection. If bearings are provided, see Chapter 8, Annexes E and F for inspection information.

10.1.8 If dry gas seals are provided, they should be sent to the owner's designated seal repair vendor to be disassembled, inspected, and rebuilt.

10.1.8.1 An inspection report should be provided. If there are any failed components, a failure analysis should be provided; refer to 9.2.3d.

10.1.8.2 The owner-designated seal repair vendor should recommend any repairs or upgrades to meet current standards and current operating conditions.

10.1.8.3 Once the seal is reassembled, it should be tested in accordance with API 692.

10.1.9 Inspection forms and drawings should be used in recording the necessary information. The inspection forms and drawings should represent the actual assemblies and components.

10.1.10 Attention should be given to applications that may be susceptible to stress corrosion cracking, low temperature, or materials with high impact requirements.

10.1.11 Match mark components and record location and orientation to assure proper reassembly.

● **10.1.12** If specified, the chemistry and hardness of component(s) should be determined.

10.1.13 The vendor should notify the owner of any discrepancies such as noted in 10.2 and 10.4 to determine if failure analysis is necessary and/or special cleaning methods are recommended.

10.1.14 Components that exhibit deterioration such as erosion, corrosion, or failures, and the material is unknown or unclear, should receive a positive material inspection (PMI) to identify the material.

10.1.15 Prior to cleaning of the component, take as-is samples of any residues and deposits without further contamination of the sample. Return the sample to the owner, if requested, for laboratory analysis. If deposits are suspected to have caused damage such as cracks, corrosion, etc., the repair work may be delayed until a complete analysis is performed.

10.1.16 A photograph log should be maintained for all steps in the work scope. Photographs should be taken prior to cleaning the component in the as-received condition and of any unusual or abnormal condition.

10.2 Visual Inspections of Assemblies or Components (Prior to Cleaning)

10.2.1 Visual inspections should be conducted before cleaning.

10.2.2 Inspections should include, as a minimum, clear photograph(s) identifying the size, location, and orientation (including a physical reference point) of any erosion, corrosion, and unusual appearances or other damage resulting in loss or displacement of material, deposits, and buildup.

10.2.3 Standardized sketches, forms, and tabulations are desirable.

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10.3 Cleaning

10.3.1 The repair shop should clean the component to remove dirt, rust, and other foreign material using a procedure appropriate for the NDT methods, such as glass beads or a light abrasive at reduced blast pressure.

10.3.1.1 Protective coatings, used to prevent erosion or corrosion or for performance enhancement, should be cleaned with a nonabrasive medium to prevent coating damage.

10.3.1.2 The coating should not be removed for base metal inspection without owner approval.

10.3.1.3 If the coating should be removed, perform the visual inspection and measurements identified in 10.4.3 prior to removal of the coating.

10.3.2 ASTM E165, Annex A1.1 gives typical cleaning methods and precautions that are suitable for LPI and may be suitable for other NDT methods.

10.3.3 If coatings or foreign material should be removed from the component per the work scope, caution should be used if applying abrasive cleaning methods to prevent damage to the base component. The abrasives used should be glass beads or a light abrasive at reduced blast pressure.

10.4 Visual Inspections of the Assemblies or Components (After Cleaning)

10.4.1 Visual inspections should be conducted after cleaning. Inspections should include, as a minimum, clear photograph(s) in detail; note on a sketch the size, location, and orientation (including a physical reference point) of any erosion, corrosion, and unusual appearances or other damage resulting in loss or displacement of material, deposits, and buildup. Standardized sketches, forms, and tabulations are desirable.

10.4.2 Photograph the assembly or component in its cleaned condition. In addition, photographs should be taken of any unusual or abnormal condition, and a photograph log should be maintained for all work performed. Identification of all items, including equipment number and part name, should be clearly shown on all photographs.

10.4.3 Visually inspect the assembly or components to identify coating and overlays. Measure and record the depth, length, location, and type of any coatings or overlays.

NOTE 1 Some coatings or overlays are difficult to identify.

NOTE 2 Coatings or overlays are typically applied to components that are in corrosive or erosive services.

NOTE 3 Other applications of coatings include shaft coatings at locations such as bearings fits or journals, component fits, or sealing areas.

NOTE 4 Use of a nonmagnetic thickness tester or solution of copper phosphate or copper sulfate can assist in locating plating; however, this solution can be incompatible with the materials.

10.4.4 Visually inspect all visible keyways and keys for nonconformances such as identified in AGMA 9002.

10.5 Dimensional Inspections of the Assemblies or Components (After Cleaning)

10.5.1 Identify and record critical dimensions and runouts as applicable. As applicable, record from a distinct feature.

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10.5.2 Measure and record the following as received data on worksheets designed for the assembly or component. The measurement device should have graduations as follows or smaller:

a) for radial runouts, 0.002 mm (0.0001 in.);

b) for shaft fits, journals, and coupling area diameters, 0.002 mm (0.0001 in.);

c) for diameters other than b), 0.01 mm (0.001 in.);

d) for axial stack-up locations, 0.01 mm (0.001 in.);

e) for axial runouts, 0.01 mm (0.0005 in.);

f) for axial runouts of shaft shoulders, thrust collar faces, and coupling flanges, 0.002 mm (0.0001 in.).

NOTE The values in 10.5.2 a) through f) are not unit conversions. Instead, they show graduations for commercially available instruments.

10.5.2.1 If the component being measured is not defined in 10.5.2, the measuring device should have graduations not larger than 1/10th of the tolerance of the measured parameter.

10.5.2.2 The measuring device should have current calibration and be in good working order. At the owner's request, the vendor should demonstrate that all standards and tools have traceable calibration certifications.

10.5.2.3 The technician collecting measurements should be able to demonstrate repeatability when measuring against a standard.

10.5.2.4 For consistency, measurements should be done under stable and repeatable conditions such as temperature, orientation, and holding of the workpiece.

10.6 Inspection Results

10.6.1 The repair shop should notify the owner upon completion of inspections.

10.6.2 A copy of all inspection documentation and deviations should be submitted for the owner's use and records.

10.6.3 The owner and repair shop should review the information in 10.6.2 and compare to OEM configuration, previous modifications, and repair shop recommendations. Modifications, including upgrades, should be evaluated.

10.6.4 The repair shop should prepare the recommended job scope along with technical justifications for modifications.

10.6.5 A checklist of the recommendations should be used to guide the discussion.

10.6.6 The recommended job scope should be used in 15.1.

11 Inspection Methods and Testing

11.1 General

- **11.1.1** The repair shop should make the following data available prior to shipment and maintain per Annex K.4:

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a) necessary or specified certification of materials, such as mill test reports or PMI results;

b) test data including inspection and NDT results, to verify that the specification(s) has been met;

c) fully identified records of all heat treatment, whether performed in the normal course of manufacture or as part of a repair procedure;

d) results of quality control tests and inspections;

e) details of all repairs and repair maps;

f) if specified, final-assembly, maintenance, and running clearances;

g) other data specified by the owner or required by the applicable codes and regulations.

11.1.2 In addition to Annex D, the owner may specify the following:

a) parts that should be subjected to surface and subsurface examination;

b) type of examination to be used.

11.1.3 Before removal of the protective coating for a NDT inspection, the repair shop should have authorization from the owner or the representative.

NOTE Protective coatings limit inspection of the base component.

11.1.4 Components that will have a protective coating applied after repairs or manufacturing should be inspected prior to coating.

11.1.5 The application of NDT inspection criteria to components should be performed and interpreted by technicians qualified to the applicable NDT methods by the SNT TC1A guidelines to assure the reliability of the testing performed.

11.1.6 The OEM recommendations such as for acceptable runouts, clearances, and dimensions should be used. If the OEM information is not available, the information in the respective chapter and paragraphs of API RP 687 can be used.

11.2 Component Inspection and Acceptance Criteria for NDT Inspectors

11.2.1 General

11.2.1.1 NDT procedures should be used to determine the existence and location of any indications.

11.2.1.2 Record the size, location, and orientation of any indications on a sketch or appropriate form.

11.2.1.3 NDT should be performed on:

a) components identified in this document;

b) pressure boundary components that have been weld repaired or remachined, and for newly coated surfaces;

c) rotating components that have been weld repaired;

d) components specified by the owner.

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11.2.1.4 The component should be degaussed per 11.2.6.

11.2.1.5 Original equipment inspection methods and acceptance criteria, if available, should be used as a minimum for NDT of components.

11.2.1.6 Annex D identifies recommended NDT inspection methods that may exceed the original NDT, for each type of equipment and for each type of component.

11.2.1.7 The repair shop should review the design of the equipment and propose to the owner more stringent criteria than the generalized limits in 11.2.2 through 11.2.4, if necessary.

11.2.1.8 Only techniques providing quantitative results should be used.

11.2.1.9 Mill test reports (MTRs), material composition certificates, and visual stamps or markings should not be considered substitutes for PMI testing of metallic parts.

11.2.1.10 OEM certification is acceptable for nonmetallic components.

11.2.1.11 If radiographic (RT), ultrasonic (UT), magnetic particle (MT), or liquid penetrant (PT) inspections are recommended, the criteria in 11.2.2 through 11.2.4 should apply unless other corresponding procedures and criteria have been specified.

11.2.1.12 Welds, cast steel, and wrought material may be inspected in accordance with 11.2.2 through 11.2.4.

11.2.1.13 Cast iron should be inspected in accordance with 11.2.4. Alternative standards may be proposed by the repair shop for approval by the owner.

11.2.1.14 Items such as pitting, erosion, and corrosion might not show up from an NDT. Visual examination and engineering judgement are generally recommended to evaluate the acceptability of the component.

11.2.1.15 Dispositions of indications larger than those acceptable for the applicable procedures in 11.2.2 through 11.2.4 should be agreed upon between the repair shop and the owner.

11.2.1.16 Refer to ASTM E1316 for standard terminology used in NDT.

11.2.1.17 The acceptance criteria in 11.2.2 through 11.2.7 should be used by the NDT technician when examining components.

11.2.1.18 Other inspection methods and acceptance criteria may be considered with agreement between the owner and the repair shop.

11.2.2 Radiography

11.2.2.1 General

Radiography inspection should be in accordance with ASTM E94.

11.2.2.2 Radiography Acceptance Criteria

Pressure-containing stationary components should use the acceptance criteria in Chapter 8, Annex B in addition to the requirements in 11.2.2.2.1 through 11.2.2.2.3:

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11.2.2.2.1 ASTM E446, *Standard Reference Radiographs for Steel Castings Up to 50 mm (2 in.) in Thickness*.

11.2.2.2.2 ASTM E186, *Standard Reference Radiographs for Heavy-Walled 50 mm to 115 mm (2 to 4½ in.) Steel Castings.*

11.2.2.2.3 ASTM E280, *Standard Reference Radiographs for Heavy-Walled 115 mm to 305 mm (4½ to 12 in.) Steel Castings.*

11.2.3 Ultrasonic Inspection

11.2.3.1 General

11.2.3.1.1 Ultrasonic inspection should be based upon the procedures ASTM A609 (castings), ASTM A388 (forgings), or ASTM A578 (plate), and ASME, Section V, Articles 4, 5, and 23.

11.2.3.1.2 Additional inspection of the base material may be specified using ASTM A516, which has acceptance criteria. Supplemental recommendations are the following:

a) S-8 requires UT inspection per ASTM A435;

b) S-11 requires UT inspection per ASTM A577;

c) S-12 requires UT inspection per ASTM A578.

NOTE 1 Typical specifications used for material in fabrication, for example ASTM A516, do not have specific default inspection of the base material plate.

NOTE 2 ASTM A516 references ASTM A220, which only calls for visual inspection of the plate edges and allows indications up to 1 in. in length.

NOTE 3 The inspection requirements of the ASME BPVC depend on the quality factor of a casting and joint efficiency of fabrication selected for the design or the material requirements.

11.2.3.1.3 Component finish prior to examination should be 250 RMS or better.

11.2.3.2 Ultrasonic Acceptance Criteria

11.2.3.2.1 Pressure-containing stationary components should use the acceptance criteria in Chapter 8, Annex B in addition to the following.

a) Straight beam examination indications exceeding 15 % of the reference back reflection or indications resulting in a 50 % or greater loss of back reflection not due to geometry are cause for rejection.

b) Angle beam examination indication exceeding the 75 % base level from reference notch are cause for rejection. Indications over 40 % but not exceeding the 75 % reference level should be reported for information only.

c) Weld-repaired pressure-containing stationary components should be inspected by the same criteria as noted in a) and b).

11.2.3.2.2 Non-Pressure-Containing Stationary Components

11.2.3.2.2.1 Discontinuities should not exceed the following limits per ASTM A 609:

a) up to 50 mm (2 in.) (including all areas to be machined regardless of thickness)—Discontinuity Level 1;

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b) 50 mm up to 100 mm (2 in. up to 4 in.)—Discontinuity Level 2;

c) 100 mm (4 in.) and above—Discontinuity Level 3.

11.2.3.2.2.2 Castings identified with defects exceeding the limits of ASTM A609 in 11.2.3.2.2.1 should be rejected or repaired and should be re-examined by ultrasonic examination.

11.2.3.2.2.3 Weld-repaired castings should be inspected by the same criteria as 11.2.3.2.2.1.

11.2.3.2.3 Rotating Components

11.2.3.2.3.1 A straight beam should be employed in both a longitudinal and radial direction. The back reflection technique of calibration should be used.

11.2.3.2.3.2 Indications exceeding 15 % of the reference back reflection or indications resulting in a 50 % or greater loss of back reflection are cause for rejection.

11.2.3.2.3.3 Weld-repaired rotating components should be inspected using both straight and shear beam transducers. Calibration procedure and establishment of a DAC for inspection should utilize, as a minimum, 1.6 mm x 1.6 mm (1/16 in. x 1/16 in.) flat-bottom notches and 1.5 mm (1/16 in.) diameter side-drilled holes for either shear or longitudinal wave testing and for near-field testing. Any discontinuity should be evaluated in accordance with the following minimum acceptance criteria.

a) Shear wave: Any linearly disposed discontinuity not attributable to geometry that causes an indication equal to or greater than the response obtained from the 1.6 mm (1/16 in.) notch at a comparable test metal distance should be a basis for rejection.

b) Longitudinal wave: All discontinuities not attributable to geometry that cause an indication equal to or greater than 40 % of the response obtained from the 3.2 mm (1/8 in.) diameter flat-bottomed hole at a comparable test metal distance should be noted and recorded. Any indication equal to or greater than 80 % of the response from a 3.2 mm (1/8 in.) diameter flat-bottom hole should be a basis for rejection.

c) Multiple discontinuities not attributable to geometry with a response of greater than 40 % response obtained from the 1.6 mm (1/16 in.) notch at a comparable test metal distance and separated by the lesser of than 3 times the largest measured single discontinuity length should be considered as one continuous discontinuity and evaluated as rejectable.

11.2.4 Magnetic Particle and Liquid Penetrant Inspections

11.2.4.1 General

11.2.4.1.1 Wet magnetic particle inspection should be used and in accordance with ASTM E 709.

NOTE Generally, the dry method is not used due to the problems with arcing on finish machined surfaces.

11.2.4.1.2 Liquid penetrant inspection should be in accordance with Section V, Article 6, of the ASME Code. Ref. ASTM E165. The sensitivity should be Level 3 per ASTM E1417.

11.2.4.1.3 Generalized acceptance criteria used for magnetic particle and liquid penetrant inspections should be used in accordance with 11.2.4.2.

11.2.4.1.4 Original equipment acceptance criteria should be used for nondestructive examinations of components if referenced by drawings or the equipment manufacturer's documents. Refer to Chapters 2 through 8 for specific application of the criteria.

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11.2.4.2 Acceptance Criteria for Stationary Pressure-Containing Components

11.2.4.2.1 For cast or wrought components, inspection and acceptance criteria should be in accordance with API 612, 613, 617, 619, and standards unless otherwise agreed.

11.2.4.2.2 Castings should meet the minimum acceptance standards of MSS SP-55 and Chapter 8, Annex B.

11.2.4.3 Acceptance Criteria for Stationary Non-Pressure-Containing Components

11.2.4.3.1 Castings should meet the minimum acceptance standards of MSS SP-55.

11.2.4.3.2 All accessible surfaces should be magnetic particle inspected.

11.2.4.3.3 Any linear indication 12.7 mm (1/2 in.) or longer should be further investigated.

11.2.4.3.4 End-to-end indications, i.e. in line, spaced less than 10 mm (3/8 in.) apart, should be considered as one indication.

11.2.4.3.5 Areas requiring further investigation may be ground to minimum casting section thickness but not to exceed a depth of 3.2 mm (1/8 in.) and blended to the original surface. They should then be rechecked after grinding.

11.2.4.3.6 Areas failing to meet 11.2.4.3.5 after grinding should be liquid penetrant inspected.

a) Linear indications 12.7 mm (1/2 in.) or longer should be rejected.

b) End-to-end indication spaced less than 10 mm (3/8 in.) apart should be considered as one indication.

11.2.4.4 Acceptance Criteria for Stationary Weld-Repaired Non-Pressure-Containing Components

11.2.4.4.1 Acceptance criteria for critical areas on any component that has been repaired by welding should be based on information in 11.2.4.4.2 and 11.2.4.4.3.

11.2.4.4.2 Any indication with the major dimension greater than 1 mm (1/32 in.) in any direction is considered relevant and recordable.

11.2.4.4.3 Indications in 11.2.4.4.3.1 through 11.2.4.4.3.4 as defined by location are considered rejected and should be repaired or should have an engineering review.

11.2.4.4.3.1 Linear indications, i.e. those having a length greater than three times the width, that have a length greater than 1.6 mm (1/16 in.).

11.2.4.4.3.2 More than two linear indications, 1.6 mm (1/16 in.) or less in length, in any one square inch area of weld.

11.2.4.4.3.3 Rounded indication 3.2 mm (1/8 in.) or greater.

11.2.4.4.3.4 Four or more rounded defects, having a maximum dimension of at least 2.3 mm (3/32 in.), in a line, separated by 1.6 mm (1/16 in.) or less.

11.2.4.5 Acceptance Criteria for Rotating Wrought Components—Impellers, Shafts, Discs, Etc.

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Only indications with major dimensions greater than 0.8 mm (1/32 in.) are considered relevant. The following relevant indications cause the part to be rejected or repaired:

a) relevant indications of cracks of any length or linear defects 2.3 mm (3/32 in.) in length or greater;

b) rounded indications with dimensions greater than 1.6 mm (1/16 in.);

c) four or more rounded indications in a line, separated by 1.6 mm (1/16 in.) or less from edge to edge;

d) five or more indications greater than 0.8 mm (1/32 in.) in any 39 square cm (6 square in.) of area.

11.2.4.6 Acceptance Criteria for Weld-Repaired Rotating Components

The following relevant indications cause the part to be rejected or repaired:

a) indications whose major dimension is equal to or exceeds 1.5 mm (1/16 in.) the impeller bore fit area;

b) two or more relevant indications separated by 0.8 mm (1/32 in.) or less in the bore or labyrinth diameter;

c) three or more relevant indications in the labyrinth to cover radius;

d) three or more relevant indications in any 75 mm (3 in.) square area in the bore or labyrinth diameter;

e) any indication 0.8 mm (1/32 in.) in length on a finished machined corner;

f) any indication greater than 1.6 mm (1/16 in.) in a noncritical area of the impeller bore, bore face labyrinth seal diameter, face, or inside diameter;

g) any cracks or crack-like indication.

11.2.4.7 Acceptance Criteria for Weld-Repaired Compressor Shafts

Only indications with major dimensions greater than 0.8 mm (1/32 in.) should be considered relevant. The following relevant indications cause the part to be rejected or repaired:

a) relevant indications of cracks of any length or linear defects 2.43 mm (3/32 in.) in length or greater;

b) rounded indications with dimensions greater than 1.6 mm (1/16 in.);

c) four or more rounded indications in a line, separated by 1.6 mm (1/16 in.) or less from edge to edge;

d) five or more indications greater than 0.8 mm (1/32 in.) in any 39 square cm (6 square in.) of area.

11.2.4.8 Acceptance Criteria for Weld-Repaired Turbine Shafts

The following relevant indications cause the part to be rejected or repaired:

a) any linear indication greater than 1.6 mm (1/16 in.);

b) rounded indications with dimensions greater than 1.6 mm (1/16 in.);

c) four or more rounded indications in a line, separated by 1.6 mm 1/16 in.) or less edge to edge;

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d) five or more indications in any 39 square cm (6 square in.) area whose major dimensions are not more than 150 mm (6 in.) with the dimensions taken in the most favorable location relative to the indications being evaluated.

11.2.4.9 Acceptance Criteria for Blading

Wrought or cast blades should be magnetic particle or liquid penetrant inspected based on the alloy being inspected. Indications discovered with magnetic particle should be verified with liquid penetrant. OEM criteria should be reviewed and applied as applicable. The following relevant indications cause the part to be rejected or repaired:

a) transverse indications;

b) indication of a crack, lap, burst, or rupture;

c) indications on the airfoil interpreted as stringers are acceptable, provided they are no longer than 19 mm (3/4 in.) and well dispersed;

d) three well-dispersed indications 1.6 mm (1/16 in.) apart in the dovetail area, each side, is acceptable;

e) for castings of 090-478, type I indications of ASTM E125 and all indications exceeding degree I of type II, III, IV, and V.

11.2.5 Acceptance Criteria for Thermal Spray Coated Components

The acceptance criteria for critical areas on any component that has thermal spray coating should be based on the criteria in Table 1.

Table 1—Indication Acceptance Criteria

Indications	Measurement	Severity		
		A	B	C
Porosity[2]	Individual	0.8 mm (1/32 in.)	0.8 mm (1/32 in.)	1.6 mm (1/16 in.)
Scattered Porosity [1,2]	Area/sq. inch	1.6 mm (1/16 in.)	1.6 mm (1/16 in.)	3.2 mm (1/8 in.)
Cracking	Individual	None	None	None
Linear	3D (L/W)	>1.6 mm (1/16 in.)	>1.6 mm (1/16 in.)	>3.2 mm (1/8 in.)
Flaking	N/A	None	None	None
Lack of Bond	N/A	None	None	None

Severity Levels:

A. Applicable to rotating components in critical areas such as any shaft diameter, impeller, and thrust disc bores, or any area specified as a high-stress location. Sealing areas on any component should be evaluated to severity level A.

B. Applicable to rotating hardware such as sleeves and spacers, impeller labyrinth seal diameters, thrust disc ODs, or other rotating components.

C. Applicable to any non-rotating components or any area specified as noncritical.

NOTE 1 Groups of porosity or scattered porosity should be defined as more than one pore in a 2-inch-square area. Total size of the porosity should be determined by adding the individual size of pore diameters. The total should not exceed the referenced severity criteria.

NOTE 2 Areas of microporosity should be classified as scattered porosity and evaluated per the above severity chart criteria after two (2) additional cleaning cycles with the measurement of the extreme outer edge of the indications evaluated as the total diameter of the area. Final disposition of microporosity indications should have an engineering review.

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11.2.6 Residual Magnetism

The residual magnetism levels (gauss) should be taken for each major component to ensure that there are no residual magnetism problems. The residual magnetism levels should be taken on each major component after disassembly and cleaning, prior to any repairs, and after repairs. Annex E provides guidance in taking residual magnetism readings. The acceptable residual magnetism levels, as measured with a digital gauss meter and Hall-type probe, are identified in Table 2.

Table 2—Residual Magnetism Acceptable Levels

Component	Maximum Residual Free Gauss Level
Shaft and all rotating components	± 2
Bearing and seal assemblies (including all components)	± 2
Bearing Housings (without bearing and seal assemblies)	± 4
Casing and all stationary components except bearing and seal assemblies	± 4
Fastener allowable residual magnetism	± 4

11.2.7 Positive Material Identification (PMI)

Positive material identification (PMI) testing is recommended for:

a) all components to be welded to confirm materials of construction;

b) components that exhibit deterioration;

c) new alloy components.

12 Repair Processes and New Component Manufacture

12.1 General

12.1.1 Repaired or new components should deliver a safe and reliable assembly or component irrespective to the repair method. Adequate methods should be used to verify a sound repair, such as witnessing of operations, special inspections, engineering reviews, or special testing. The owner should be presented the information for the repairs or new components in the proposal as identified in 15.1 for decisions.

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12.1.1.1 Repaired or new components should be per the decisions determined in 15.2.

12.1.2 Previous upgrades or modifications may have changed dimensions or finishes. Changing dimensions as part of the current scope may affect the assembly dimensions and fits, resulting in components that do not properly fit or function. Any changes in the component's design dimensions should consider the reassembly requirements. The effect on existing spare parts should also be considered.

12.1.3 Equipment may not have been built or maintained to API standards in every respect or may have been designed based on an earlier edition of the API standard. Therefore, the current fits, clearances, or tolerances may be different than those of the latest API standard. The owner should be presented any differences in the proposal (15.2) for decisions.

12.1.4 New replacement components supplied by the repair shop that do not meet the current API standard should be identified and included on the proposed work scopes. Exceptions to the latest standards may be necessary for machines built to previous API standards or other specifications

12.1.5 Use of previously manufactured components, such as surplus parts, and their acceptance criteria should be agreed upon by all parties involved.

12.1.6 An upgrade or rerate should be in accordance with the latest applicable API standards to the extent possible. If this prevents interchangeability of existing spares, the owner should be notified.

12.1.7 Existing components may be repaired, per 12.2, or replaced, if justified, per 12.3.

12.1.8 If the damaged component(s) cannot be repaired satisfactorily, with approval from the owner the repair shop should provide replacement component(s) as outlined in 12.3. Damaged components should not be discarded until replacement components are available. The owner should review these recommended replacement components to determine if one exists.

12.1.9 New material used for the repair of existing parts or the manufacture of replacement parts should be equal to or better than the original for the intended service. Compatibility of the materials and the process in which they serve should be verified. The repair shop should consult with the owner on material selection and the owner should approve the material. Materials exposed to a sour environment as defined by NACE MR-01-75 should be in accordance with that standard.

12.1.10 If repairing or replacing components, consider:

a) modifications that may have been applied to the equipment or components since the original manufacturing and subsequent repairs;

b) upgrades as identified in 4.4.1;

c) upgrades for rerates as identified in 4.4.2;

d) alternative repair procedures and scope recommendations provided by the repair shop or vendor;

e) interchangeability of existing spare parts;

f) if the new or repaired component can meet the requirements of the latest API applicable standard and still allow usage of existing spare parts;

g) how these decisions will affect common machines, usage of existing surplus warehouse materials, effect to other components, and effect to the costs and delivery.

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NOTE 1 Small rotor to stator clearance changes can move rotor critical speeds and changes in shrink fits can adversely affect rotor dynamics.

NOTE 2 Small bearing clearance changes can move rotor critical speeds and changes in shrink fits can adversely affect rotor dynamics.

NOTE 3 Returning dimensions to the current design fit or clearance will allow the repair or new manufactured component to:

a) maintain interchangeability with other units;

b) use existing spare parts;

c) eliminate errors in manufacturing future spare parts that could be caused by undocumented dimensional changes;

d) maintain its critical speed margins and torque transmission capabilities.

12.1.11 Corrosion, erosion, pitting, and rubs:

a) Minor rubs, pitting, and corrosion may be removed by polishing after an engineering review to ensure components will still meet fit, form, and function. Consideration should be given to wall thickness, dimensional fit, clearance, and other critical geometry.

b) Minor erosion wear may be dressed by polishing.

c) Major erosion or corrosion wear should be repaired by welding per 12.2.2 and machined or blended smooth with the surrounding material.

d) Surface finish of the repaired area should match that of the surrounding area.

e) Repair methods should be determined by the repair shop and owner.

f) Refer to Annex F and G for information and guidance on coatings and overlays and restoration methods.

12.1.12 The repair shop or vendor of new or repaired parts should develop a quality assurance/control plan for the owner's approval. For rotors, the quality assurance/control plans identified in Chapter 1, Annex D, and the appropriate Chapter 2 through 7, Annex C, should be referenced for recommendations in developing the specific plan for rotors. For other equipment or components, a quality plan should be provided by the repair shop or vendor.

The owner should participate in key manufacturing and verification activities by observing or witnessing as appropriate to the importance of the equipment.

12.1.13 The owner reserves the right to purchase any new component.

12.1.14 All drawings, procedures, and processes used in the repair or manufacture of any component should be available for owner review.

12.1.15 Failure analysis and redesign should be considered prior to replacing a component that failed unexpectedly or due to undetermined cause.

12.1.16 Repaired keyways and replacement keys should comply with AGMA 9002.

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12.1.17 If specified, the repair shop should perform a reverse engineering process on the components identified by the owner. The reverse engineering should include sufficient materials, heat treatment, dimensions, and appropriate functional tolerances to produce the new component. The repair shop may find it necessary to obtain field measurements of equipment in service to verify or supplement the needed data.

12.1.18 Annex I provides recommendations for surface finishes and contact percentages.

12.2 Restoration

12.2.1 If approved by the owner, areas may be repaired using repair techniques outlined in the appropriate sections for the equipment/component. Irrespective of the repair method used, adequate methods should be used to verify a sound repair. This may include witnessing of operations, special inspections, engineering reviews, or special testing.

12.2.2 Welding repairs

12.2.2.1 Welding of piping, pressure-containing parts, rotating parts and other highly stressed parts, weld repairs, and any dissimilar-metal welds should be performed and inspected in accordance with ASME BPVC Section VIII. Refer to Annex H and API RP 582 for additional information.

12.2.2.2 The repair shop should be responsible for the review of all repair welds to ensure that they are properly heat treated and nondestructively tested for soundness and compliance with the applicable qualified procedures. Repair welds should be nondestructively tested by the same method used to detect the original flaw. Annex D provides recommendations for the minimum level of inspection after the weld repair. Nonmagnetic components should have a liquid penetrant inspection (PT), ferromagnetic components a magnetic particle inspection (MT).

12.2.2.3 Use of bills of material, material test reports, or equipment data sheets to identify materials of construction alone should not be accepted.

12.2.2.4 Accessible surfaces of weld repairs should be inspected by magnetic particle or liquid penetrant examination after back chipping or gouging and again after post-weld heat treatment.

12.2.2.5 Component should be pre-heated, if required.

12.2.2.6 Quality control of weld repairs should be made available to the owner for review before any repair is made.

12.2.2.7 All welds should be heat treated in accordance with the qualified procedure.

12.2.2.8 Post-weld heat treatment, if required, should be carried out after all welds.

12.2.2.9 PMI should be performed on all components to be welded to confirm materials of construction. Use of bills of material, material test reports, or equipment data sheets to identify materials of construction alone should not be accepted.

12.2.2.10 If it is important to know the carbon content of the base material to develop a proper welding procedure, a chemical analysis of base material should be performed.

12.2.2.11 A weld map of all weld repair locations should be part of the job documentation.

12.2.2.12 Pressure-containing or rotating components of cast, ductile, or nodular iron components should not be welded, brazed, or silver soldered. Nonpressurized components require owner approval for welding, brazing, or silver soldering.

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12.2.2.13 After the welding process is completed, the component should have a residual magnetism check performed and be within the limits of 11.2.6.

12.2.2.14 Weld filler should be verified in accordance with the applicable AWS/ASME Filler Metal Specification or Material Test Report.

12.2.3 Machining

12.2.3.1 If machining is required and the material removed is not restored to the original dimension, additional surfaces may be machined so that the resulting stack dimensions are maintained.

12.2.3.2 If machining is required, consider other surfaces that may be suggested to be machined to improve the quality of these other surfaces.

12.3 New Component Manufacture

12.3.1 New components supplied by the repair shop/vendor, whether for replacement or for upgrade, should meet 12.1.

12.3.2 The repair shop/vendor should review the owner-provided information referred to in 4.3 and determine if other data should be obtained to produce a component which will meet the requirements.

12.3.3 If OEM drawings are not available for reference, the repair shop should perform a reverse engineering process to establish the proper materials, heat treatment, dimensions, and appropriate functional tolerances to produce the new component.

The repair shop may find it necessary to obtain field measurements of equipment in service to verify or supplement the needed data.

12.3.4 The owner and repair shop should hold a design review meeting to assure the reverse engineering process has been properly conducted and documented.

12.3.5 The repair shop should have a documented quality control process to perform reverse engineering for new component manufacturing. The process should document all steps in the reverse engineering process to accurately identify critical details before fabrication.

13 Assembly

13.1 Assembly should be per the appropriate sections for the equipment/component.

13.2 Prior to shipping, the repair shop should review the assembly/component to ensure all work has been completed and been completed correctly. This information should be documented and provided in the final data pack in 16.0.

14 Shipment and Storage Containers

14.1 General

14.1.1 This section establishes basic container configuration and features for various levels of preservation and packaging for shipments, handling, and storage. The majority of components for all classes should be placed in containers with covered tops. The basic differences in these containers are the material and the design for long-term storage. The containers should be designed per different

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classes as identified in 14.2. If the components are shipped without containers with covered tops, consider either tarping or utilizing an enclosed truck/trailer.

14.1.2 The equipment should be identified per owner's requirements. Material shipped separately should be identified with securely affixed corrosion-resistant metal tags indicating the owner's requirements. In addition, equipment should be shipped with duplicate packing lists describing each item, one inside and one on the outside of the shipping container.

- **14.1.3** The owner will specify the term of storage and method of shipment (domestic or export). Unless otherwise specified, the repaired components should be preserved for six months in a non-climate-controlled indoor storage. For periods greater than six months, it is suggested that the components be stored in a climate-controlled environment or a purged container.

- **14.1.4** Containers should be designed for the specific component's weight and configuration. Annex B contains sample container drawings. The owner should designate the type and materials of construction of the container.

- **14.1.5** If specified, the container will be designed to accommodate shipping, component handling, and storage.

14.1.6 The container, whether supplied by the owner or the repair shop, should comply with the recommendations of this section and Annex B. Containers should be returned to the owner of the container.

14.1.7 The repair shop should protect component critical areas such as journals, radial vibration and axial positioning proximity probe target areas, and coupling fit area from incidental mechanical damage.

14.1.8 Labelling to include as a minimum (depending on whether the shipment is from the owner or the repair shop):

a) owner name, location, address, phone contact;

b) description of equipment or components;

c) net and gross weight of equipment or components;

d) purchase order, unique identification number;

e) container number and the total number of containers in the shipment, example: Container #1 of 4;

f) center of gravity or sling marks-location-fork location;

g) repair shop name, location, address, phone contact.

14.1.9 The container should meet the recommendations of the shipping class. Three classes of packaging are established: Class #1, Transit Only; Class #2, Commercial Indoor (up to 6 months); Class #3, Export.

14.1.10 The container should include adequate supports for the component to prevent damage to the component. The supports should be located so that direct loading to the ground is provided.

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14.2 Containers

14.2.1 General

14.2.1.1 Shipping container should be designed and constructed:

a) to resemble the equipment's mounting arrangement;

b) for the specific weight and configuration;

c) to perform the intended service of support, protection, and handling;

d) considering length of time for shipping and storage;

e) with hold-down methods that do not damage the components;

f) in proportions to reduce rollover and provide bump protection;

g) to allow for lifting with a fork truck or crane;

h) with lifting points or lifting lugs that are clearly identified on the equipment or equipment package; the recommended lifting arrangement should be identified on the container;

i) with clearance allowance for small bore piping and tubing that may be attached to equipment and connected piping;

j) with flat and level mounting areas.

14.2.1.2 In addition to 14.2.1.1, metal shipping containers should:

a) be welded construction and all load-bearing welds NDT inspected;

b) be painted or coated;

c) have all sharp corners rounded.

14.2.2 Wooden Container Boxes

All materials of construction should be of suitable grade of construction lumber and plywood strong enough to protect its contents from hazards of shipping and storage. Tops should be removable. Heavy-duty nail or staple fasteners should be used in the construction with at least two steel bands to fasten the top and strengthen the box. Wooden containers should be designed for horizontal shipment and storage. For Class 2 and Class 3 containers, consideration should be given to venting and desiccants.

NOTE Some gears and overhung rotors can be supported with the shaft in the vertical position.

14.2.3 Steel

14.2.3.1 The placement of the runners should allow for a fork truck to be able to move the container and the component while placed in the horizontal position. Additionally, lugs should be provided to allow a crane to lift the container while the component is in the container. Steel rotor shipping containers should have provisions for storage of a component in both a horizontal position and a vertical position.

- **14.2.3.2** If specified, the container should be capable of being pressurized. The container, valving, and connections should be designed for a minimum of 0.35 bar (5 psig) pressure. The purge gas should be

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specified. The pressure in the container should be maintained during storage at a minimum of 0.07 bar (1 psig).

14.3 Supports

The container should include adequate supports for the component to prevent damage of the component. The supports should be located so that direct loading to the ground is provided.

14.4 Packing

14.4.1 The component should be protected with a corrosion barrier. Critical shaft areas such as journals, end seal areas, radial vibration and axial positioning proximity probe target areas, and coupling fit areas should also be protected by a separate barrier material to protect against incidental mechanical damage.

14.4.2 Care should be taken to select a corrosion barrier that does not react with the operational fluid of the process stream.

14.4.3 Each radial vibration and axial positioning proximity probe target area should be easily identified, such as with a brightly colored wrapping indicating a proximity probe target area and "PROXIMITY PROBE AREA, DO NOT CUT" wording. Loose components should be dipped in wax or placed in plastic bags and contained by cardboard boxes. Loose boxes should be securely blocked in the shipping container.

14.4.4 Class #1 (Commercial and Air Shipments)

14.4.4.1 See Annex B, Figures B.1, B.2, and B.6 for details.

14.4.4.2 Interior plastic sheeting in wooden container boxes is not required.

14.4.5 Class #2 (Commercial Long Term—Indoor)

14.4.5.1 See Annex B, Figures B.1, B.2, and B.6 for details.

14.4.5.2 All wooden container boxes should be covered on top with plastic sheeting. Overlap plastic sheeting around top a minimum of 30 cm (12 in.) all around, double over sheeting, and clamp in place by attaching cover. A minimum of 2 cm (3/4 in.) wide banding should be used on all boxes.

14.4.6 Class #3 (Export and Commercial Long Term—Outdoor)

14.4.6.1 See Annex B, Figures B.2, B.3, B.4, and B.5 for details.

14.4.6.2 All wooden container boxes should have a plastic sheet vapor barrier securely stapled to the inside and top. Interior box walls and top to be lined with 1/8 in. hard board or 1/4 in. plywood for less than 4536 kg (10,000 pound) rotors and a minimum of 1/4 in. plywood for boxes greater than 4536 kg (10,000 pounds). Liner should wrap around and be nailed or stapled to the exterior of the box wall and top. A minimum of 3 cm (1 1/4 in.) wide banding should be used on all container boxes.

15 Proposals and Finalized Work Scopes

15.1 Proposals

15.1.1 The repair shop should forward the proposal defining the recommended job scope from 10.6 with the initial inspection reports, price, and delivery time to the owner at the address specified in the inquiry documents. The proposal should include a statement that the repair scope and all documentation will be

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in accordance with this document. If the scope and supplied data are not in strict accordance, the repair shop should include a list that details and explains each deviation. The repair shop should provide details to evaluate any proposed alternative repair procedures and scope. All correspondence should be clearly identified in accordance with 6.1.2.

15.2 Finalized Work Scope

15.2.1 Once the repair shop has completed the proposal for the inspections and documentation, the owner and the repair shop should meet to develop a finalized work scope. The finalized work scope should be provided to the owner. Additional work scope may be recommended based on discovery from inspections performed during the repair process. Repaired or new components should deliver a safe and reliable component/equipment irrespective of the repair method. The repair shop should provide proposals with options identified in Section 15. The following should be available for the meeting:

a) information identified in Sections 6 through 14;

b) all inspection results and documentation clearly indicating deviations from values in OEM or repair shop's recommendations;

c) dimensional information;

d) results of all NDT inspections and PMI;

e) engineering analysis or failure analysis that has been performed up to this point;

f) information concerning modifications, rerates, or upgrades requested by the owner or suggested by the repair shop;

g) repair shop's recommendations of components to be repaired or replaced, including repair techniques;

h) weld procedures, as applicable, for review for new and repaired components;

i) spare parts availability from the owner;

j) listing of work that should be subcontracted and proposed subcontractors;

k) inspection and test plan including observed and witnessed inspections or tests and hold points;

l) identification of the vendor for replacement parts supplied by the repair shop (owner's approved vendors list should be used);

m) pricing of repairs, modifications or upgrades, replacement components, and testing;

n) proposed schedule;

o) decision on disposition of components, such as:

    1) components or debris considered hazard waste;

    2) components damaged and not reused;

    3) serviceable components not used in the reassembly.

p) identification of storage recommendations after assembly;

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q) quality assurance plan for rotor repair (The quality assurance plan for rotors is identified in Chapter 1, Annex D and the appropriate annexes of Chapters 2 through 7. The plan should be tailored as appropriate to correspond to the scope of repair agreed upon between owner and repair shop.);

r) documentation for final report and timing.

15.2.2 The complexity of a project or repair will usually determine how many review meetings or discussions should be planned. Meeting minutes should be published by the repair shop and distributed to the attendees and/or other personnel involved in the scope of the project for review and comment. Follow-up meetings may be necessary if deviations from the initial repair scope are found during the repair process. The repair shop should submit progress reports to the purchaser at agreed-upon intervals.

16 Repair Shop's/Vendor's Data (Documentation)

16.1 General

16.1.1 The purchaser may specify the content of proposals, meeting frequency, and repair shop/vendor data content/format identified in Annex K. Annex K provides a general outline of information that may be requested by the purchaser.

16.1.2 The information in Annex K should be provided.

16.2 Nameplates

16.2.1 The original machine nameplate should be kept on the machine.

16.2.2 Nameplates should not be mounted on pressure-containing components.

16.2.3 Nameplate(s) should be attached by pins of the same material as the nameplate. Welding is not permitted.

16.2.4 Additional nameplates should be mounted near the original nameplates unless this violates 16.2.2.

16.2.5 The repair shop should add an additional new austenitic stainless-steel nameplate identifying information such as:

a) name of repair shop;

b) date of repair or upgrade;

c) repair shop job number;

d) any other information requested by the owner.

16.2.6 If information in one of the data fields of the original nameplate is changed, such as due to a rerate, an additional austenitic stainless-steel nameplate(s) should be provided by the repair shop to identify the repair shop information and all data fields from the original nameplate with the current data.

17 Owner's Data (Documentation)

17.1 The owner should update their equipment history file and bill of materials to reflect any changes to the components made during the repair.

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NOTE Failure to provide information to the OEM can affect future replacement parts.

17.2 The owner should forward a change notice, if applicable, to the OEM to document the changes that were made so that the OEM's documentation and information can be revised.

NOTE Failure to provide information to the OEM can affect future replacement parts.

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