Date of Issue: October 2002
Affected Publication: API Standard 673, Centrifugal Fans for Petroleum, Chemical and Gas Industry Services, Second Edition, January 2002.

ERRATA

Existing:

Page 36, Appendix A, Section A.5.c & d

c. If the amplification factor is greater than 3.55 and the critical response peak is below the minimum operating speed, the required separation margin (a percentage of minimum speed) is equal to the following:

$$SM = 100 - 84 + \frac{6}{AF - \sqrt{3}}$$

d. If the amplification factor is greater than 3.55 and the critical response peak is above the trip speed, the required separation (a percentage of the maximum continuous speed) is equal to the following:

$$SM = 126 - \frac{6}{AF - \sqrt{3}} - 100$$

Replace the formulae with:

REMOVE THE SQUARE ROOT SIGN FROM THE 3 IN THE DENOMINATOR (under the number 6)

For c:

$$SM = 100 - 84 + \frac{6}{AF - 3}$$

For d:

$$SM = 126 - \frac{6}{AF - 3} - 100$$

Centrifugal Fans for Petroleum, Chemical and Gas Industry Services

API STANDARD 673
SECOND EDITION, JANUARY 2002

American
Petroleum
Institute

**Helping You
Get The Job
Done Right.[SM]**

Centrifugal Fans for Petroleum, Chemical and Gas Industry Services

Downstream Segment

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Suggested revisions are invited and should be submitted to the standardization manager, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

CONTENTS

Centrifugal Fans for Petroleum, Chemical and Gas Industry Services

1 General

1.1 SCOPE

This standard covers the minimum requirements for centrifugal fans intended for continuous duty in petroleum, chemical, and gas industry services. Fan pressure rise is limited to differential from a single impeller, usually not exceeding 100 in. of water Equivalent Air Pressure (EAP). Cooling tower, aerial cooler, and ventilation fans; and positive displacement blowers are NOT covered by this standard.

● Note: A bullet (●) at the beginning of a paragraph indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on the data sheets (see Appendix A); otherwise, it should be stated in the quotation request or in the order.

1.2 ALTERNATIVE DESIGNS

The vendor may offer alternative designs. Equivalent metric dimensions, fasteners, and flanges may be substituted as mutually agreed upon by the purchaser and the vendor (see 5.2.3.g).

1.3 CONFLICTING REQUIREMENTS

In case of conflict between this standard and the inquiry or order, the information included in the order shall govern.

1.4 DEFINITION OF TERMS

Terms used in this standard are defined in 1.4.1 through 1.4.33.

1.4.1 alarm point: A preset value of a parameter at which an alarm is actuated to warn of a condition that requires corrective action.

1.4.2 axially split: Refers to casing joints that are parallel to the shaft centerline.

1.4.3 design: The use of the word design in any term (such as design power, design pressure, design temperature, or design speed) should be avoided in the purchaser's specifications. This terminology should only be used by the equipment designer and the manufacturer.

1.4.4 evase: A diffuser or a diverging discharge transition piece.

1.4.5 fan impeller: The assembly of the fan wheel and the hub(s).

1.4.6 fan plane: A flow area perpendicular to the flow of gas at the specified reference plane; that is, inlet flange or outlet flange.

1.4.7 fan rated point: Defined as (1) the highest speed necessary to meet any specified operating condition, and (2) the rated capacity required by fan designs to meet all specified operating points. (The vendor shall select this capacity point to best encompass specified operating conditions within the scope of the expected performance curve.) (See Figure 1.)

Note: This term is NOT to be confused with the AMCA Publication 802 definition of RATING point, which more nearly matches "normal point" per 1.4.21. User must add head and/or volume margins for process uncertainties, reduced performance resulting from time related "wear and tear" and other operating conditions known to exist. The API "Rated" point will be the same as the AMCA defined "MCR Test Block" (para. 3.1.13, AMCA 801-92) condition unless otherwise defined by the user in specifications or data sheets. For most applications this will coincide with "Test Block" (para. 3.1.14, AMCA 801-92).

1.4.8 fan rotor: The assembly of the fan impeller and the shaft.

1.4.9 fan wheel: The assembly comprised of the blades, center-plate (or back-plate), shroud(s), and wear plates, if used.

1.4.10 forced-draft fans: Usually have ambient inlet conditions and usually are in air service.

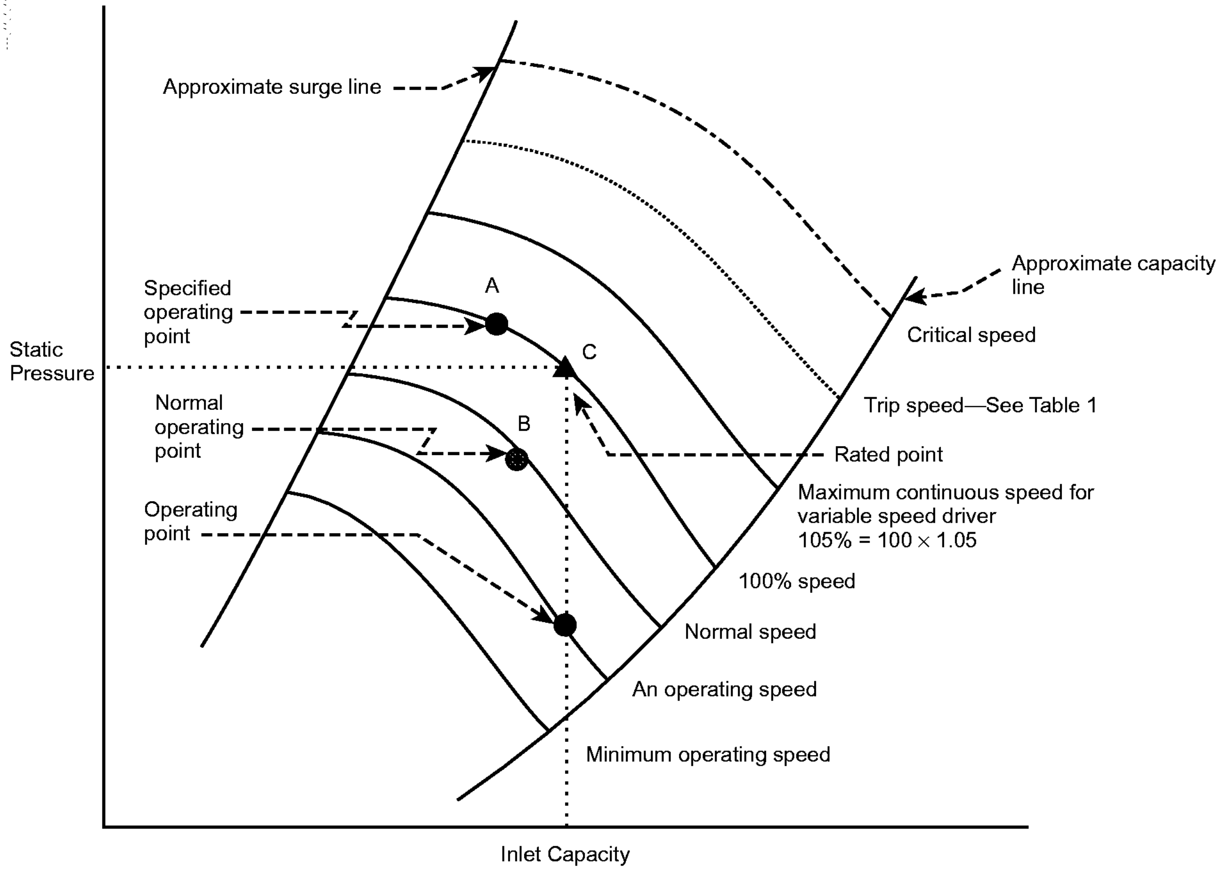
1.4.11 hydrodynamic bearings: Bearings that use the principles of hydrodynamic lubrication. Their surfaces are oriented so that relative motion forms an oil wedge to support the load without journal-to-bearing contact.

1.4.12 induced draft fans: Usually have inlet condition that are below atmospheric pressure and can be found in a wide variety of gas services. Process fans, by definition, are induced draft.

1.4.13 inlet volume: The flow rate determined at the conditions of pressure, temperature, compressibility, and gas composition (including moisture) at the fan inlet flange. Actual Volume may be used to refer to flow at a number of locations and should, therefore, NOT be used interchangeably with INLET.

1.4.14 maximum allowable speed (revolutions per minute): The highest speed at which the manufacturer's design will permit continuous operation.

1.4.15 maximum allowable temperature: The maximum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified pressure.



Notes:
1. Except where specific numerical relationships are stated, the relative values implied in this figure are assumed values for illustration only.
2. The 100% speed curve is determined from the operating point requiring the highest static pressure; point A in the illustration.
3. Refer to 1.4.7 for discussion of fan rated point.
4. Refer to 2.7 for discussion of critical speeds.

Figure 1—Fan Performance Terms

1.4.16 maximum allowable working pressure: The maximum continuous pressure for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified temperature.

1.4.17 maximum continuous speed (revolutions per minute): The speed at least equal to 105% of the highest speed required by any of the specified operating conditions.

1.4.18 maximum exhaust pressure: The highest discharge pressure at which the fan is required to operate continuously.

1.4.19 maximum sealing pressure: The highest pressure expected at the seals during any specified static or operating conditions and during start-up and shutdown.

1.4.20 minimum allowable speed (revolutions per minute): The lowest speed at which the manufacturer's design will permit continuous operation.

1.4.21 normal operating point: The point at which usual operation is expected and optimum efficiency is desired. This point is usually the point at which the vendor certifies that performance is within the tolerances stated in this standard.

1.4.22 oil mist lubrication: Lubrication systems that employ oil mist produced by atomization in a central supply unit and transported to the bearing housing by compressed air.

1.4.23 pure oil mist lubrication (dry sump): The mist both lubricates the bearing(s) and purges the housing(s).

1.4.24 purge oil mist lubrication (wet sump): The mist only purges the bearing housing. Bearing lubrication is by conventional oil bath, flinger, or oil ring.

1.4.25 radially split: Casing joints that are transverse to the shaft centerline.

1.4.26 shaft cooler (heat slinger): A fan (impeller), mounted on the shaft between the seal(s) and bearings, which reduces transfer of heat from the case to the bearings.

1.4.27 shutdown point: A preset value of a parameter at which automatic or manual shutdown of the system is required.

1.4.28 sound trunk: The silencer(s) plus transition piece(s) between silencer(s) and fan.

1.4.29 standard flow (SM^3 or SCF): The flow rate expressed in volume at "standard" pressure and temperature conditions. ISO standard flow rate is cubic meters per hour or minute (m^3/h or m^3/min.) at an absolute pressure of 1.013 Bar (14.7 lb. per square in. [psi]) and a temperature of 0°C (32°F). Customary units are standard cubic feet per minute (SCFM) or million SCF per day (MMSCFD) at an absolute pressure of 14.7 psia and a temperature of 60°F.

1.4.30 total indicated run-out (TIR): Also known as total indicator reading, is the run-out of a diameter or face determined by measurement with a dial indicator. The indicator reading implies an out-of-squareness equal to the reading or an eccentricity equal to half the reading.

1.4.31 trip speed (revolutions per minute): The speed at which the independent emergency overspeed device operates to shut down a prime mover (see Table 1).

1.4.32 turndown: The percentage of change in capacity (referred to rated capacity) between the rated capacity and surge point capacity at the rated head when the unit is operated at rated suction temperature and gas composition.

1.4.33 unit responsibility: The responsibility for coordinating the technical aspects of the equipment and all auxiliary systems included in the scope of the order. Responsibility for such factors as the power requirements, speed, rotation, general arrangement, couplings, dynamics, noise, lubrication, sealing system, material test reports, instrumentation, piping, and testing of components shall be reviewed.

Table 1—Driver Trip Speeds

Driver	Trip Speed (Percent of Rated Speed)
Steam Turbine	
NEMA Class A[a]	115
NEMA Class B, C, D[a]	110
Gas Turbine	115
Variable-speed Motor	110
Reciprocating Engine	110

[a]Indicates governor class as specified in NEMA SM 23.

1.5 REFERENCED PUBLICATIONS

1.5.1 The editions of the following standards, codes, and specifications that are in effect at the time of publication of this standard shall, to the extent specified herein, form a part of this standard. The applicability of changes in standards, codes, and specifications that occur after the inquiry shall be mutually agreed upon by the purchaser and vendor.

API

RP 500	*Classification of Locations for Electrical Installations at Petroleum Facilities*
Std 541	*Form-wound Squirrel-cage Induction Motors—250 Horsepower and Larger*
Std 546	*Brushless Synchronous Machines—500 KVA and Larger*
Std 611	*General Purpose Steam Turbines for Petroleum, Chemical and Gas Industry Service*
Std 614	*Lubrication, Shaft-sealing, and Control-oil Systems and Auxiliaries for Petroleum, Chemical, and Gas Industry Services*
Std 616	*Gas Turbines for the Petroleum, Chemical, and Gas Industry Services*
Std 670	*Vibration, Axial-positioning, and Bearing Temperature Monitoring Systems*
Std 677	*General Purpose Gear Units for Petroleum, Chemical, and Gas Industry Services*

ABMA[1]

Standard 7	*Shaft and Housing Fits for Metric Radial Ball and Roller Bearings*
Standard 8	*Ball and Roller Bearing Mounting Accessories*
Standard 9	*Load Ratings and Fatigue Life for Ball Bearings*

[1]American Bearing Manufacturers Association, 1101 Connecticut Avenue, N.W., Suite 700, Washington, D.C. 20036.

Standard 20	*Metric Ball and Roller Bearings (Except Tapered Roller Bearings) Conforming to Basic Boundary Plans: Bounder Dimensions, Tolerances, and Identification*

AGMA[2]

9002	*Bores and Keyways for Flexible Couplings (Inch Series)*

AMCA[3]

801-92	*Industrial Process/Power Generation Fans: Specifications Guidelines*
Std. 99-2404-98	*Drive Arrangements for Centrifugal Fans*
Std. 210-99	*Laboratory Methods of Testing Fans for Aerodynamic Performance Testing*
Std. 203-90	*Field Performance Measurement of Fan Systems*
Std. 802-92	*Industrial Process/Power Generation Fans: Establishing Performance Using Laboratory Models*
Std. 803-96	*Industrial Process/Power Performance Fans: Site Performance Test Standard*

ASME[4]

B 1.20.1	*Pipe Threads, General Purpose (Inch)*
B 16.1	*Cast Iron Pipe Flanges and Flanged Fittings*
B 16.5	*Pipe Flanges and Flanged Fittings (Steel)*
B 16.11	*Forged Steel Fittings, Socket-welding, and Threaded*
B 16.42	*Ductile Iron Pipe Flanges and Flanged Fittings, Class 150 and 300*
B 16.47	*Large-diameter Steel Flanges; NPS 26 through NPS 60*
B 17.1	*Keys and Keyseats*
B 31.3	*Chemical Plant and Petroleum Refinery Piping*
	Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," and Section IX, "Welding and Brazing Qualifications"

ASTM[5]

A 278	*Gray Iron Castings for Pressure-containing Parts for Temperatures up to 345°C (650°F)*
A 395	*Ferritic Ductile Iron Pressure Retaining Castings for Use at Elevated Temperatures*
A 536	*Ductile Iron Castings*
E 94	*Guide for Radiographic Testing*
E 125	*Reference Photographs for Magnetic Particle Indications on Ferrous Castings*
E 142	*Method for Controlling Quality of Radiographic Testing*
E 709	*Practice for Magnetic Particle Examination*

AWS[6]

D 1.1	*Structural Welding Code-steel*
D 14.6	*Welding of Rotating Elements of Equipment*

IEEE[7]

841	*Standard for Petroleum and Chemical Industry Severe Duty TEFC Squirrel Cage Induction Motors—Up to and Including 500HP*

ISO[8]

1940	*Mechanical Vibration-balance Quality Requirements of Rigid Rotors*
3740	*Acoustics-determination of Sound Power Levels of Noise Sources-precision Methods for Broad-band Sources in Reverberation Rooms*
3744	*Acoustics-determination of Sound Power Levels of Noise Sources-engineering Methods for Free-field Conditions Over a Reflecting Plane*
3746	*Acoustics-determination of Sound Power Levels of Noise Sources-survey Method*
7005	*Metallic Flanges*

NFPA[9]

Publication 70	*National Electric Code*, Articles 500, 501, 502, and 504

[2] American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, Virginia 22314.
[3] Air Movement and Control Association, 30 West University Drive, Arlington Heights, Illinois 60004.
[4] ASME International, 3 Park Avenue, New York, New York 10016-5990.
[5] American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959.
[6] American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33135.
[7] Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, New Jersey 08855-1331.
[8] International Organization for Standardization, ISO publications are available from the American National Standards Institute, 11 West 42nd Street, New York, New York 10036.
[9] National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269.

NACE[10]

MR-0175	*Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment*

SSPC[11]

SP 6	*Surface Preparation Method*

1.5.2 The purchaser and vendor shall mutually determine the measures that must be taken to comply with any governmental codes, regulations, ordinances, or rules that are applicable to the equipment.

1.5.3 It is the vendor's responsibility to invoke all applicable specifications to each subvendor.

1.6 UNIT CONVERSION

The factors in Chapter 15 of the API *Manual of Petroleum Measurement Standards* were used to convert from customary to SI units. The resulting exact SI units were then rounded off.

2 Basic Design

2.1 GENERAL

2.1.1 The equipment (including auxiliaries) covered by this standard shall be designed and constructed for a minimum service life of 20 years and at least 3 years of uninterrupted service. It is recognized that this is a design criterion.

2.1.2 The vendor shall assume unit responsibility for all equipment and all auxiliary systems included in the scope of the order.

● **2.1.3** The purchaser will specify the equipment's normal operating point on the data sheets.

● **2.1.4** Control of the sound pressure level (SPL) of all equipment furnished shall be a joint effort of the purchaser and the vendor. The equipment furnished by the vendor shall conform to the maximum allowable sound pressure level specified by the purchaser. The vendor will assume "free field" hemispherical radiation in predicting SPL. As installed, proximity to other equipment, structures, etc., may reflect noise and increase measured SPL.

2.1.5 Unless otherwise specified, cooling water systems shall be in accordance with 2.1.5.1.

[10]NACE International, (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, P.O. Box 218340, Houston, Texas 77218-8340.

[11]Steel Structures Painting Council, 40 24th Street, Suite 600, Pittsburgh, Pennsylvania 15222.

2.1.5.1 A cooling water system or systems shall be designed for the following conditions:

Velocity over heat exchanger surfaces	1.5 m/s – 2.5 m/s	5 ft/s – 8 ft/s
Maximum allowable working pressure	≥ 5.2 bar (2)	≥ 75 psig
Test pressure	≥ 1.5 × MAWP	
Maximum pressure drop	1 bar	15 psi
Maximum inlet temperature	32°C	90°F
Maximum outlet temperature	49°C	120°F
Maximum temperature rise	17°C	30°F
Minimum temperature rise	11°C	20°F
Fouling factor on water side	0.35-m^2k/kW	0.002 hr-ft^2-F/Btu
Shell corrosion allowance	3.2 mm	0.125 in.

Notes:
1. The vendor shall notify the purchaser if the criteria for minimum temperature rise and velocity over heat exchange surfaces result in a conflict. The criterion for velocity over heat exchange surfaces is intended to minimize waterside fouling; the criterion for minimum temperature rise is intended to minimize the use of cooling water. The purchaser will approve the final selection.
2. Gauge pressure.

Provision shall be made for complete venting and draining of the system or systems.

2.1.6 Fans shall be designed and constructed to operate satisfactorily at all specified operating conditions, maximum continuous speed, and to the trip speed setting of the driver, if applicable. The vendor shall advise or purchaser will specify the minimum operating conditions (flow, speed, etc.).

2.1.7 The arrangement of the equipment, including ducting and auxiliaries, shall be developed jointly by the purchaser and the vendor. The arrangement shall provide adequate clearance areas and safe access for operation and maintenance. See Appendix B for typical arrangements.

● **2.1.8** Motors, electrical components and electrical installations shall be designed and constructed for the area classification (class, group, and division or zone) specified by the purchaser on the data sheets and shall meet the requirements of NFPA 70, Articles 500, 501, 502, and 504 as well as local codes specified and furnished by the purchaser.

2.1.9 Oil reservoirs and housings that enclose moving lubricated parts (such as bearings, shaft seals, highly polished parts, instruments and control elements) shall be designed to minimize contamination by moisture, dust, and other foreign matter during periods of operation and idleness.

2.1.10 All equipment shall be designed to permit rapid and economical maintenance. Major parts such as machined fan components and bearing housing shall be designed (shouldered or cylindrically doweled) and manufactured to ensure accurate alignment on reassembly.

2.1.11 The machine and its driver shall perform on the test stand (when a test is specified) and on their permanent foundation(s) within the specified acceptance criteria. After installation, the performance of the combined units shall be the joint responsibility of the purchaser and the vendor who has unit responsibility.

● **2.1.12** Many factors (such as ducting loads, alignment at operating conditions, supporting structure, handling during shipment and handling and assembly at the site) may adversely affect site performance. To minimize the influence of these factors, the vendor shall review and comment on the purchaser's ducting and foundation drawings, and when specified, the vendor's representative shall observe a check of the ducting performed by parting the flanges. When specified, the vendor's representative shall check alignment at the operating temperature and shall be present during the initial alignment check.

● **2.1.13** The purchaser will specify whether the installation is indoors (heated or unheated) or outdoors (with or without a roof), as well as the weather and environmental conditions in which the equipment must operate (including maximum and minimum temperatures, unusual humidity and dusty or corrosive conditions).

2.1.14 Spare parts for the machine and all furnished auxiliaries shall meet all the criteria of this standard.

2.1.15 Fan arrangement and bearing support, whether double-width/double-inlet or single-width/single-inlet, shall be in accordance with AMCA Publication 99-86, AMCA Standard 99-2404-78, arrangement 3 or 7 (see Appendix B of this standard), with fan wheel located between bearings, the bearings mounted on independently supported pedestals, and the bearings protected from the air or gas stream when any of the following conditions exist:

a. Impeller diameter greater than 1500 mm (60 in.) for forced draft.

b. Driver rated power of 110 kW (150 horsepower) or greater.

c. Speed greater than 1800 rpm.

d. 220°C (425°F) or greater design temperature.

e. Toxic flammable, or other hazardous service.

f. Corrosive or erosive service.

g. Service subject to fouling deposits that could cause rotor unbalance.

For less arduous service, arrangements 1, 8, and 9 with bearings mounted independent of the fan housing, are acceptable with purchaser's approval.

Note: In allowing these different arrangements the following should be considered:

a. Fouling deposits which result in unbalance.

b. Reduced speed is desirable for erosive service.

c. Belt drives should be limited to the requirements of 3.3.

d. Speeds greater than 1800 rpm may be considered when speed is limited to 90% of vendor's published design, or power is less than 30 kW (40 horsepower).

e. Induced draft impellers should not exceed 760 mm (30 in.) diameter.

2.1.16 Fan performance shall be based on the static pressure rise across the fan inlet and outlet flanges. In specifying required operating conditions on the data sheet, the purchaser is responsible for accounting for inlet velocity pressure. The fan vendor is responsible for including the pressure losses attributed to all items within his scope to obtain the required S.P. rise. Refer to Figure 2 and Section 3 AMCA 801-92.

2.1.17 Unless otherwise specified, fans shall have turndown capability to 60% or less of rated flow. For parallel operations, fan performance shall have a continuously rising pressure characteristic (pressure versus flow plot) from the rated capacity to surge. Performance curves, corrected for the specified gas at the specified conditions, shall be based on performance tests of actual or prototype equipment, including evase, if any, and inlet box(es). Refer to Figure 3 for typical fan characteristic curves. Parallel operation is allowed only on the continuously increasing portion of the curve.

2.1.18 Fans shall be of "stiff shaft" design. (See 2.7.1.3.)

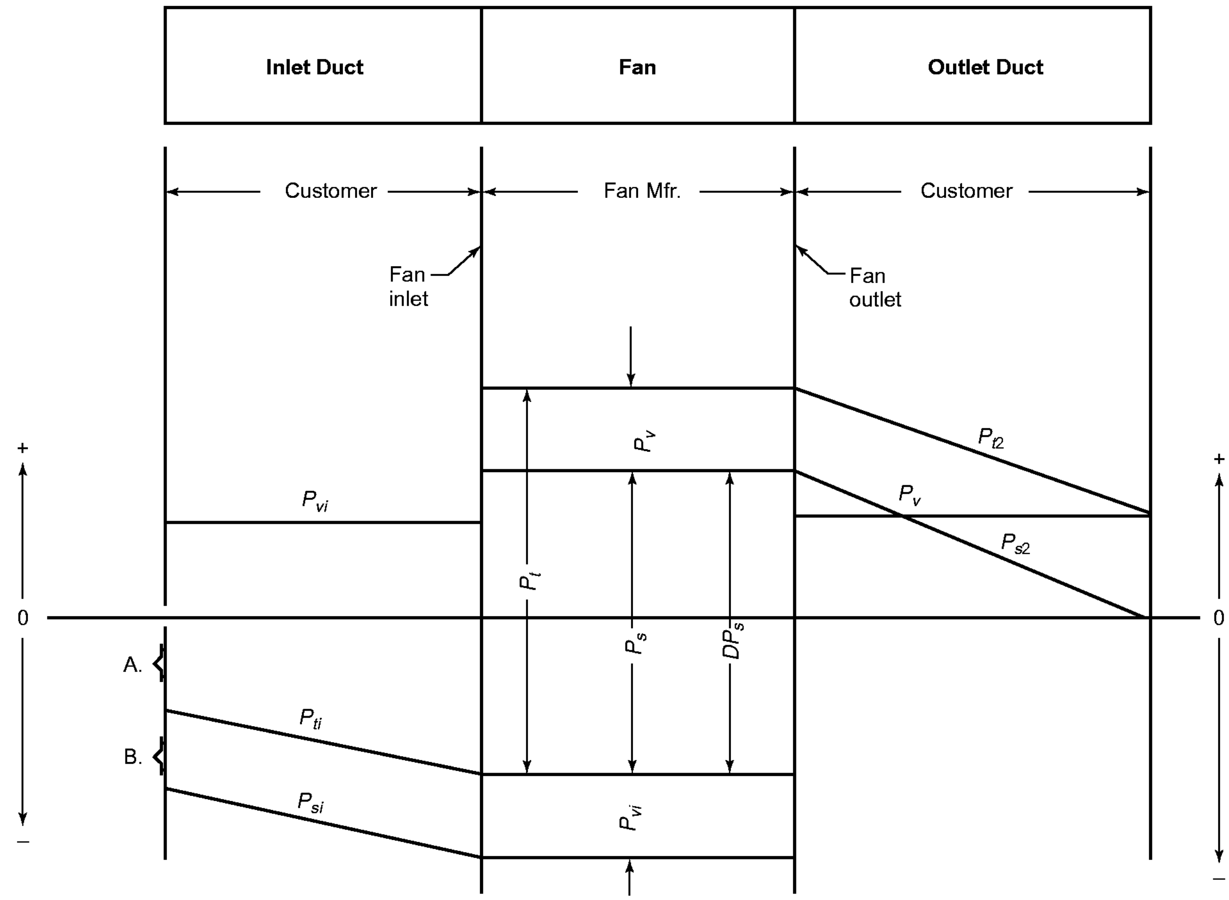
2.1.19 Induced draft fans shall be mechanically designed for operation at 55°C (100°F) above maximum specified inlet gas temperature.

2.1.20 Fan, components, and accessories shall be designed to withstand all loads and stresses during rapid load changes, such as across-the-line starting of motor drivers, failure of damper operator, and sudden opening of dampers.

2.1.21 Fan Inlets

2.1.21.1 On forced draft fans, the provision of inlet equipment and arrangements; including silencer(s) and transition piece(s), shall be coordinated between the preheat system vendor and the fan vendor. (Portions may normally be supplied by each.) Unless otherwise specified, air intake(s) shall be at least 4.5 m (15 ft) above the grade.

Note: The purchaser should evaluate air intake elevation requirements, considering the possibility of dust entering the system and causing surface fouling, the area noise limitation requirement and corresponding need for a silencer, possibility of a combustible vapor



A. Entrance Loss B. Acceleration Energy

1. Static Pressure is that portion of the air pressure which exists by virtue of the degree of compression only. It may be positive or negative relative to the ambient atmospheric pressure.

2. Velocity Pressure is that portion of the air pressure which exists by virtue of the rate of motion only. It is always positive.

3. Total Pressure is the air pressure that exists by virtue of the degree of compression and the rate of motion. It is the algebraic sum of the velocity pressure and the static pressure at a point.

4. Fan Total Pressure (P_t) is the difference between the total pressure at the fan outlet and the total pressure at the fan inlet.
$$P_t = P_{t2} - P_{t1}$$

5. Fan Velocity Pressure (P_v) is the pressure corresponding to the average velocity at the specified fan outlet area.
$$P_v = P_{v2}$$

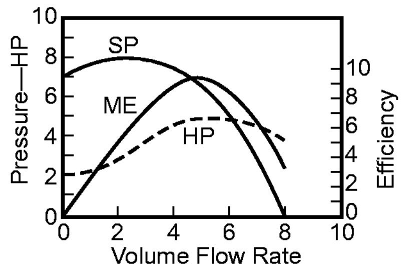
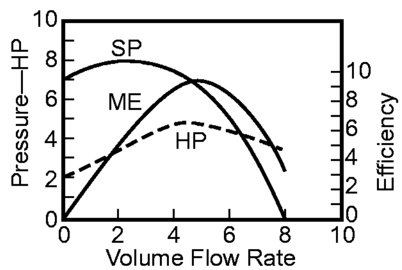
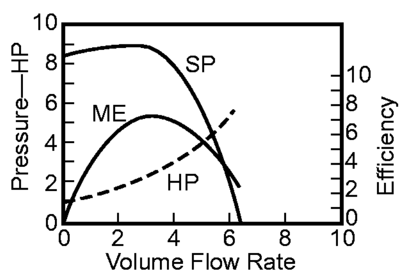
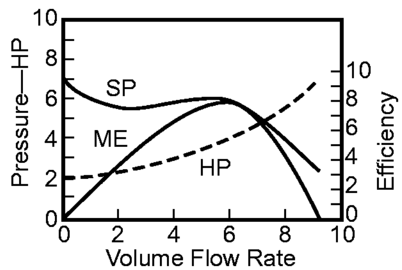
6. Fan Static Pressure (P_s) is the difference between the fan total pressure and the fan velocity pressure. Therefore, the fan static pressure is the difference between the static pressure at the fan outlet and the total pressure at the fan inlet.
$$\begin{aligned} P_s &= P_t - P_v \\ &= P_{t2} - P_{t1} - P_{v2} \\ &= (P_{s2} + P_{v2}) - P_{t1} - P_{v2} \\ &= P_{s2} - P_{t1} \end{aligned}$$

7. Fan Static Pressure Rise (ΔP_s) is the static pressure at the fan outlet minus the static pressure at the fan inlet.
$$\Delta P_s = P_{s2} - P_{s1}$$

The difference between fan static pressure and static pressure rise is the inlet velocity pressure.
$$\begin{aligned} \Delta P_s - P_s &= (P_{s2} - P_{s1}) - (P_{s2} - P_{t1}) \\ &= P_{s2} - P_{s1} - P_{s2} + P_{s1} + P_{v1} \\ &= P_{v1} \end{aligned}$$

Note: The above figure and definitions are found in AMCA Publication 801-92.

Figure 2—Fan Pressure Rise Terms

Airfoil		Highest efficiencies occur 50% to 65% of wide open volume. This is also the area of good pressure characteristics. The horsepower curve reaches a maximum near the peak efficiency area and becomes lower toward free delivery, a sell-limiting power characteristic as shown.	General heating, ventilating and air-conditioning systems. Used in large sizes for clean-air industrial applications where power savings are significant.
Backward Inclined and Curved		Operating characteristics of this fan are similar to the airfoil fan mentioned above. Peak efficiency for this fan is slightly lower than the airfoil fan. Normally unstable left of peak pressure.	Same heating, ventilating, and air-conditioning applications as the airfoil fan. Also used in some industrial applications where the airfoil blade is not acceptable because of corrosive and/or erosion environment.
Radial		Higher pressure characteristics than the above mentioned fans. Power rises continually to free delivery.	Used primarily for material-handling applications in industrial plants. Wheel can be of rugged construction and is simple to repair in the field. Wheel is sometimes coated with special material. This design also used for high-pressure industrial requirements. Not commonly found in HVAC applications.
Forward Curved		Pressure curve is less steep than that of backward-curved bladed fans. There is a dip in the pressure curve left of the peak pressure point and highest efficiency occurs to the right of peak pressure. 40 to 50% of wide open volume. Fan should be rated to the right of peak pressure. Power curve rises continually toward free delivery and this must be taken into account when motor is selected.	Used primarily in low-pressure heating, ventilating, and air-conditioning applications such as domestic furnaces, central station units, and packaged air-conditioning equipment from room air-conditioning units to roof-top units.

The above chart was extracted from ACMA Publication 201-90. The performance curves above reflect general characteristics of various types of fans commonly used. They are not intended to provide complete selection criteria for application purposes since other pertinent parameters are not defined.

Figure 3—Fan Characteristic Curves

entering the fan, and possible horsepower penalties of inlet stack and silencer configurations.

2.1.21.2 Fan inlet equipment for atmospheric air intake applications shall include intake cap or hood, trash screen, ducting and support, inlet damper or guide vanes, inlet boxes, and silencer, as required. All components shipped separately shall be flanged for assembly. The inlet equipment assembly shall be designed for the wind load shown on the fan data sheet. The minimum thickness for the above components shall be 4.75 mm ($^3/_{16}$ in.).

● **2.1.22** When specified, fans shall be designed to allow installation of fan blade cleaning systems. The fan vendor shall provide drawings showing the suggested mounting of this system. As a minimum these drawings shall include:

1. Connection size, location, and material.
2. Recommended element make, model, size, and material.
3. Recommended cleaning medium, with required pressure and temperature.
4. Recommended frequency and duration of cleaning.
5. Any other operating limitations.

Elements of the blade cleaning system inside the fan housing shall be supplied by the fan vendor and made of corrosion resistant material. The internal system shall be supported to prevent vibration damage. The purchaser will specify available cleaning media pressure and temperature.

2.2 FAN HOUSING

2.2.1 The fan scroll and housing shall be continuously welded plate construction. For corrosive, erosive, or hazardous gas service, the pressure containing joints of the fan housing shall be continuously welded inside and out. For arrangement 3 fans (see Appendix B), the housing and inlet box(es) shall be split with a bolted, flanged, and gasketed connection to allow for removal of the assembled rotor without disturbing the duct connections. Other arrangements shall be similarly constructed when rotor diameters exceed 1100 mm (42 in.). Minimum housing plate thickness shall be 4.75 mm ($^3/_{16}$ in.) for forced draft fans and 6.4 mm ($^1/_4$ in.) for induced draft fans. The housing shall be free of fan induced structural resonance(s) and limit vibration and noise. Stiffeners shall be provided when required. The inlet cone must be split, separately removable, or removable as an assembly with the rotor.

2.2.2 Bolted and gasketed access doors, minimum 600mm × 600 mm (24 in. × 24 in.) shall be provided in the scroll and inlet box(s) to access the fan internals for inspection, cleaning, rotor balancing and any internal bolting necessary for rotor removal. If fan size and construction will not permit this size access doors, the largest practical access openings shall be provided in the scroll and inlet box(es).

2.2.3 Adequate flanged sections shall be provided in the fan housing and inlet box(es) so that the rotor can be removed and installed without requiring personnel to enter the inlet box(es).

Note: Access to enclosed spaces should be limited because of the safety considerations of personnel entering a confined area. Exception to this requirement may be acceptable for specific application(s) where confined space safety considerations are properly addressed.

● **2.2.4** When specified, induced-draft fan housings shall have side and full width scroll liner(s) of abrasion-resistant material. The material shall be retained in place as agreed by the vendor and purchaser. As an option double thick scroll and side-wall of "standard" materials may be specified.

● **2.2.5** When specified, or when deemed necessary by the fan vendor, the fan housing shall be supported close to the horizontal centerline to minimize changes in housing/rotor relative position, and maintain shaft to housing seal clearances and alignment within manufacturer's limits.

Note: A fan housing is normally supported from feet mounted at the lowest point. Because the fan rotor is usually separately supported, changes in relative position between rotor and housing will result thermal expansion. It is the fan vendor's responsibility to ensure that all clearances are adequately controlled over the range of temperatures for which the fan is specified to operate.

2.2.6 Fan housing mounting surfaces shall have a machined finish of 3 μm (125 μin.) Ra or smoother. To prevent soft foot, all mounting surfaces shall be in the same plane within 50 μm (0.002 in.). Hold down or foundation bolt-holes shall be drilled perpendicular to the mounting surface(s) and castings spot faced to a diameter 3 times that of the hole. Mounting feet shall be drilled with pilot holes accessible for use in final doweling. Vertical jackscrews are required for vertical alignment shall be arranged to prevent marring of shimming surfaces.

2.3 FAN HOUSING CONNECTIONS

2.3.1 Inlet and discharge connections shall be flanged and bolted. Facings, gaskets, and bolting of all connections shall be adequate to prevent leakage. Unless otherwise specified, gaskets and bolting for the purchaser's inlet and discharge connection shall be specified by the vendor and will be provided by the purchaser.

● **2.3.1.1** When connections of different size or shape, than those covered by ASME are supplied, the vendor shall supply equipment flange details to the purchaser for the purpose of manufacturing mating parts. When specified, the mating parts shall be furnished by the vendor.

● **2.3.1.2** When specified, ASME B16.5 or B16.47 standard flanges shall be provided in toxic or flammable services.

2.3.2 Connections welded to the casing shall meet the material requirements of the casing, including impact values rather than the requirements of the connected piping (see 2.10.3).

2.3.3 Fan housing openings for pipe connections shall be at least NPS 3/4 and shall be flanged or machined and studded. Where flanged or machined and studded openings are impractical, threaded openings in sizes NPS 3/4 through 1 1/2 are permissible. The threaded openings shall be installed as specified in 2.3.3.1 through 2.3.3.7.

2.3.3.1 A pipe nipple, preferably not more than 150 mm (6 in.) long, shall be screwed into the threaded opening.

2.3.3.2 Pipe nipples shall be a minimum of Schedule 40.

2.3.3.3 The pipe nipple shall be provided with a welding-neck or socket-weld flange.

2.3.3.4 The nipple and flange materials shall meet the requirements of 2.3.2.

2.3.3.5 The threaded connection shall be seal welded; however, seal welding is not permitted on cast iron equipment, for instrument connections, or where disassembly is required for maintenance. Seal-welded joints shall be in accordance with ASME B31.3.

2.3.3.6 Tapped openings and bosses for pipe threads shall conform to ASME B16.5.

2.3.3.7 Pipe threads shall be taper threads conforming to ASME B1.20.1.

2.3.4 Openings for NPS 1 1/4, 2 1/2, 3 1/2, 5, 7, and 9 shall not be used.

2.3.5 Tapped openings not connected to piping shall be plugged with solid, round-head steel plugs furnished in accordance with ASME B16.11. As a minimum, these plugs shall meet the material requirements of the casing. Plugs that may later require removal shall be of corrosion-resistant material. A lubricant that meets the proper temperature specification shall be used on all threaded connections. Tape shall not be applied to threads of plugs inserted into oil passages. Plastic plugs are not permitted.

2.3.6 Pipe flanges shall conform to ASME B16.1, B16.5, or B16.42 as applicable.

2.3.7 All of the purchaser's connections shall be accessible for disassembly without the machine being moved.

2.3.8 Accessible flanged drain connections, NPS 2 minimum size, shall be provided at the low points of the housing and inlet boxes.

2.4 EXTERNAL FORCES AND MOMENTS

● **2.4.1** Fan housings are generally designed to accept small external forces and moments from the inlet and outlet connections. It is the purchaser's responsibility to specify the external loads to be imposed on the fan housing from the ancillary equipment (ducting, sound trunks, silencers, filters, etc.) if this equipment is not supplied by the fan vendor. The vendor shall design the housing to accept the specified loads such that:

a. Distortion resulting from imposed loads does not affect performance.
b. No internal rubs result.

2.5 ROTATING ELEMENTS

2.5.1 Materials selection shall be by joint agreement between the purchaser and vendor. The vendor shall fully detail materials, thickness, and construction details for each rotor assembly.

2.5.2 Fan wheels shall be designed for the highest efficiency consistent with the application. Blade design shall be mutually agreed upon between the purchaser and vendor.

Note 1: Forced-draft fans impellers may be provided with backward inclined or backward curved airfoil type. Induced-draft fans impellers may be radial, radial tipped, backward inclined, or backward curved airfoil type; with consideration of operation in possibly dirty gas environment.

Note 2: Design configurations listed below are available options:

a. Hollow-shaped airfoil construction of 2.5 mm (0.10 in.) minimum thickness skin material; designed and constructed to prevent the internal accumulation of condensable foulants, or corrosion products. The purchaser shall exercise care in the application of this design in corrosive and/or erosive environments such as found in some induced draft services.
b. Solid blades with airfoil shape.
c. Single thickness, 6.0 mm (1/4 in.) minimum, non-airfoil shape.

2.5.3 Welded construction of the fan wheel is required. Shrouds, back plates, and center plates shall normally be of one-piece construction, but may be fabricated if the sections are joined by full strength/penetration butt welds. Corrosiveness, erosiveness, and temperature (including excursions) of gas specified by the purchaser shall be considered during material selection.

● **2.5.4** When specified, corrosion-resistant shaft sleeves shall be provided. Sleeves shall extend 150 mm (6 in.) into the fan housing or to the impeller hub. Shaft sleeves shall be installed with an interference fit, and the fit and assembly shall take into account differential thermal expansion at the highest operating temperature. After assembly of the shaft, mechanical run out on the shaft sleeve shall not exceed 50 μm (0.002 in.) total indicated run out in the seal area.

2.5.5 Impellers shall have solid hubs, be keyed to the shaft and be secured with an interference fit. Unkeyed fits with appropriate interference are permissible with purchaser's approval. The fit shall have a minimum interference of 0.0005 mm per mm (0.0005 in. per in.) of bore diameter; however, the actual interference fit shall be shown on the data sheet and outline drawing. The impeller hub to shaft fit design shall preclude axial movement of the hub along the shaft caused by gross changes in temperature. The hub bore and shaft outside diameter shall be machined to a finish of 32 μin. arithmetic average roughness (Ra) or better in the interference fit contact area. Cast or ductile iron hubs or hollow hubs are not acceptable except in services below 150°C (300°F) or at a fan tip speed of less than 6000 m/min. (20,000 ft/min.).

● **2.5.6** The purchaser will specify on the data sheet the rate of temperature change—heating and cooling—for the rotor. The vendor shall assure that an adequate interference fit (hub to shaft) is maintained considering purchaser's defined operating conditions, including transients.

2.5.7 Shafts shall be one piece, forged steel, heat-treated after rough machining. Shafts 200 mm (8 in.) in diameter and smaller may be machined from hot rolled steel. All shafts shall be stress relieved after rough machining. Shaft diameter for arrangement 3 and 7 shall be stepped on both sides of impeller fit area to facilitate impeller removal. Fillets shall be provided at all changes in shaft diameters. Keyway fillets shall be in accordance with ASME B 17.1. Welding on the shaft is not permitted. Cold rolled steel; turned, ground, and polished, may be used for shafts not exceeding 100 mm (4 in.) finished diameter.

2.6 SHAFT SEALING OF FANS

2.6.1 Shaft seals, including labyrinth, floating bushing, close clearance annulus, felt or cloth, or honeycomb types, shall be provided to minimize leakage from or into fans over the range of specified operating conditions and during periods of idleness. Seals shall be designed to operate for process conditions that may vary during start-up and shutdown or any special operation specified by the purchaser.

2.6.2 Fans with negative pressure at the shaft seals, except forced draft fans in air service and induced draft fans exhausting to the atmosphere, shall be provided with double seals of the floating type suitable for pressurization.

● **2.6.3** When the seal is specified to be in toxic, high pressure, or flammable service, provision for a centralized buffer gas injection and/or eductor system shall be supplied to minimize leakage. System details shall be mutually agreed upon by the purchaser and the vendor.

2.6.4 Shaft sealing elements shall be replaceable without disturbing the shaft and bearings, or dismantling ductwork or the fan casing.

● **2.6.5** Shaft seal clearances and materials shall be based on the operating temperature as specified by the purchaser. Temperature excursions shall also be considered in the design.

2.7 DYNAMICS

2.7.1 Critical Speed

2.7.1.1 When the frequency of a periodic forcing phenomenon (exciting frequency) applied to a rotor-bearing support system coincides with a natural frequency of that system, the system may be in a state of resonance.

2.7.1.2 A rotor-bearing support system in resonance will have its normal vibration displacement amplified. The magnitude of amplification and the rate of phase-angle change are related to the amount of damping in the system and the mode shape taken by the rotor.

Note: The mode shapes are commonly referred to as the first-rigid (translatory or bouncing) mode, the second (conical or rocking) mode, and the (first, second, third...nth) bending mode.

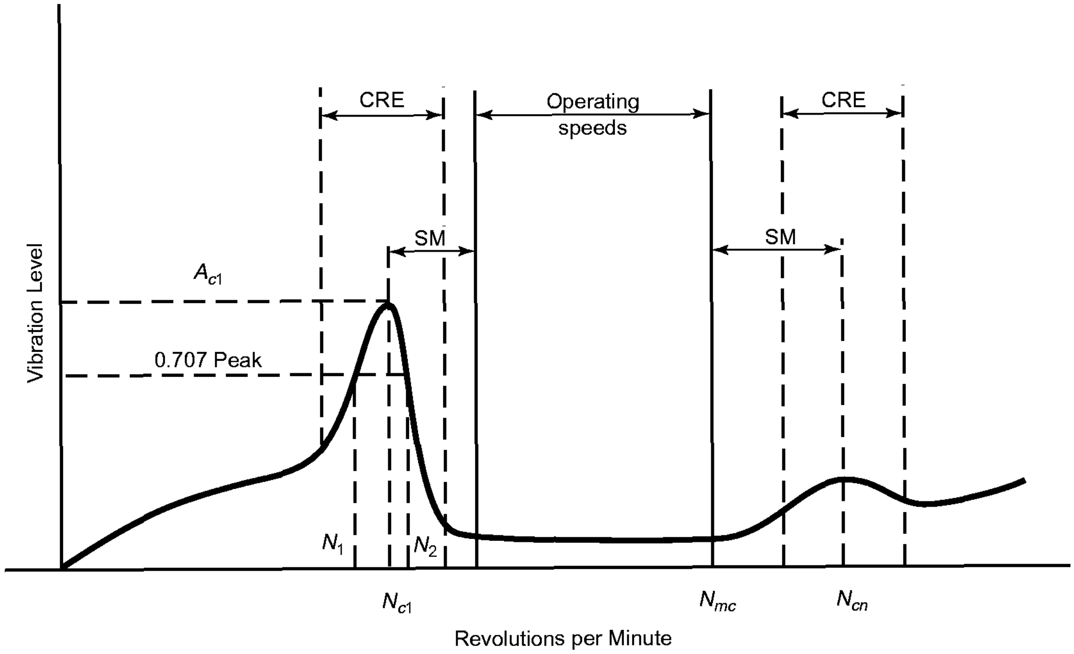
2.7.1.3 When the rotor amplification factor (see Figure 4), as measured at the shaft radial vibration probes, is greater than or equal to 2.5, the corresponding frequency is called a critical speed, and the corresponding shaft rotational frequency is also called a critical speed. For the purpose of this standard, a critically damped system is one in which the amplification factor is less than 2.5.

Note: This speed is defined in AMCA Publication 801-92 under the heading "Design Criteria" as "Design Resonant Speed."

2.7.1.4 An exciting frequency may be less than, equal to, or greater than the rotational speed of the rotor. Potential exciting frequencies that are to be considered in the design of rotor-bearing systems shall include, but are not limited to, the following sources:

a. Unbalance in the rotor system.
b. Oil-film instabilities (whirl).
c. Blade passing frequencies.
d. Gear-tooth mesh and side bands.
e. Coupling misalignment.
f. Loose rotor-system components.
g. Synchronous motor or variable frequency drive torsional transients.

2.7.1.5 Resonances of structural support systems may adversely affect the rotor vibration amplitude. Therefore, resonances of structural support systems that are within the vendors scope of supply and that affect the rotor vibration amplitude, shall not occur within the specified operating speed range or the specified separation margins (see 2.7.2. and Appendix C) unless the resonances are critically damped.



N_{c1} = Rotor 1st critical, center frequency, cycles per minute

N_{cn} = Critical speed, nth

N_{mc} = Maximum continuous speed, 105%

N_1 = Initial (lesser) speed at 0.707 × peak amplitude (critical)

N_2 = Final (greater) speed at 0.707 × peak amplitude (critical)

$N_2 - N_1$ = Peak width at the half-power point

AF = Amplification factor

$$= \frac{N_{c1}}{N_2 - N_1}$$

SM = Separation margin

CRE = Critical response envelope

A_{c1} = Amplitude @ N_{c1}

A_{cn} = Amplitude @ N_{cn}

Figure 4—Rotor Response Plot

2.7.1.6 The vendor who is specified to have unit responsibility shall determine that the drive train (turbine, gear, motor, etc.) critical speeds (rotor lateral, system torsional, blading modes, etc.) will not excite any critical speed of the machinery being supplied. The entire train shall be suitable for operation in the specified operating speed range, including any starting-speed detent (hold point) requirements of the train. A list of all undesirable speeds from zero to trip shall be submitted to the purchaser for his review and included in the instruction manual for his guidance (see Appendix F, item 33).

2.7.2 Lateral Analysis

2.7.2.1 The need for a fan rotor-lateral analysis shall be determined using the process set out in Figure 5. For this process, the following definitions apply:

a. *Identical fan*. Same size, aerodynamic design, number of stages, RPM, size and type of shaft seal, size and type of bearings, and coupling mass and overhang.

b. *Similar fan*. By agreement between purchaser and manufacturer, considering the factors listed in (a) above.

c. *Classically stiff*. First bending critical speed is above the fan's maximum allowable continuous speed by 20% (or greater). This is a Separation Margin (SM) of 20%. (See Figure 4.)

2.7.2.2 A lateral analysis, if required by 2.7.2.1, shall be carried out and the results assessed in accordance with Appendix C.

● **2.7.2.3** When specified, the effects of other equipment in the train shall be included in the damped unbalanced response analysis (that is, a train lateral analysis shall be performed)

Note: This analysis should be considered for machinery trains with long coupling spacers (more than 36 in.), rigid couplings, or both.

2.7.3 Torsional Analysis

2.7.3.1 Excitations of undamped torsional natural frequencies may come from many sources, which should be considered in the analysis. These sources may include but are not limited to the following:

a. Gear problems such as unbalance and pitch line run-out.

b. Start-up conditions such as speed detents and other torsional oscillations.

c. Torsional transients such as start-ups of synchronous electric motors.

d. Torsional excitation resulting from drivers such as electric motors and reciprocating engines.

e. Hydraulic governors.

f. Electronic feedback and control-loop resonances from variable-frequency motor drives.

g. One and two times line frequencies.

h. Running speed or speeds.

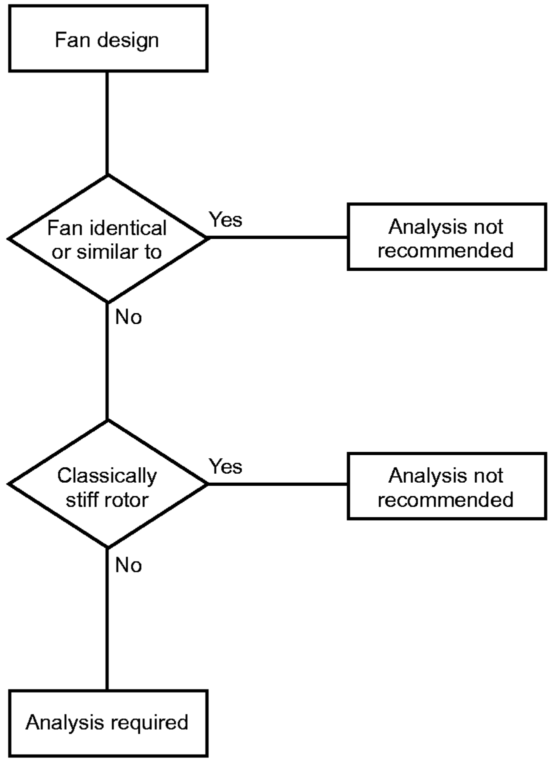


Figure 5—Lateral Analysis Decision Tree

2.7.3.2 A torsional analysis shall be performed by the manufacturer with unit responsibility when the driver is one of the following:

a. Electric motor, or turbine, through a gear rated 1500 kW (2000 HP) or higher.

b. Internal combustion engine rated 250 kW (325 HP) or higher.

c. Synchronous motor rated 500 kW (700 HP) or higher.

d. Electric motor with variable frequency control (VFD) rated 900 kW (1250 HP) or higher.

The analysis shall be for the train as a whole unless the train includes a device that has weak dynamic coupling, e.g., a hydraulic coupling or torque converter.

2.7.3.3 Excitation at the following frequencies shall be evaluated ("RPM" refers to rotor speed; "*n*" is an integer determined by the driver manufacturer);

a. Train with gear(s): one and two × RPM.

b. Engine drives: $n \times$ RPM (n = no. of cyl./cycles).

c. Synchronous motor: n x slip frequency or RPM (n = no. of poles), one and two × line frequency.

d. VFD: 1 and 2 × line frequency.

The excitation frequencies for motor drives, items c and d, include transient and steady state conditions.

2.7.3.4 The undamped torsional natural frequencies of the complete train shall be at least 10% above or 10% below any possible excitation frequency within the specified operating speed range (from minimum to maximum continuous speed).

2.7.3.5 When torsional resonances are calculated to fall within the margin specified in 2.7.3.4 (and the purchaser and the vendor have agreed that all efforts to remove the critical from within the limiting frequency range have been exhausted), a stress analysis shall be performed to demonstrate that the resonances have no adverse effect on the complete train. The acceptance criteria for this analysis shall be mutually agreed upon by the purchaser and the vendor.

2.7.4 Vibration and Balance

2.7.4.1 Prior to rotor assembly, the shaft shall be inspected for mechanical runout and concentricity at impeller mounting surface and bearing journals. Runout shall not exceed the following total indicator reading (TIR):

Shaft Diameter (At Point Measured)		Total Indicator Reading Wheel Mounting Area/Journal	
in.	millimeters	in.	micrometers
≤ 6	≤ 150	0.002/0.001	50/25
> 6, ≤ 14	> 150, ≤ 360	0.003/0.0015	75/38
> 14	> 360	0.004/0.002	100/50

A run-out recheck adjacent to the hub shall be made after rotor assembly and prior to balancing. Certified run-out reports shall be furnished by the vendor.

2.7.4.2 Balance weights, if required, shall not exceed 6 mm (1/4 in.) in thickness, or exceed the thickness of the member to which the weight is attached and shall be continuously welded onto the wheel in two or three defined balancing planes. Those balance weights required in the gas passage shall be ground to the impeller surfaces at a fillet angle not exceeding 20 degrees.

2.7.4.3 Impellers and similar major rotating components shall be dynamically balanced to ISO 1940 (International Organization for Standardization) Grade 2.5. The rotating element shall be multi-plane dynamically balanced during assembly. This shall be accomplished after the addition of no more than two major components. Balancing correction shall only be applied to the elements added. Minor correction of other components may be required during the final trim balance of the completely assembled element. When spare rotors are supplied, they shall be dynamically balanced to the same tolerance as the main rotor.

● **2.7.4.4** When specified, after the final balancing of each assembled rotating element has been completed, a residual unbalance check shall be performed and recorded in accordance with the residual unbalance work sheet (see Appendix E).

2.7.4.5 The residual unbalance shall not exceed the values for balance grade G 2.5 (see Appendix D).

● **2.7.4.6** When specified, couplings shall be mounted on the shaft after rotor balance, and then the balance shall be rechecked and corrected to meet the required tolerance.

2.7.4.7 During the shop test of the assembled machine, operating at maximum continuous speed or at any other speed within the specified operating speed range, the maximum allowable unfiltered peak amplitude of vibration in any plane measured on the bearing housing shall not exceed the value given in Table 2. At the trip speed of the driver, the vibration shall not exceed 150% of these values.

2.8 BEARINGS AND BEARING HOUSINGS

2.8.1 General

2.8.1.1 Shaft bearings shall be accessible without dismantling duct work or fan casing. Overhung impeller designs shall have provisions for supporting rotor during bearing maintenance.

2.8.1.2 Hydrodynamic radial and thrust bearings shall be required under the following conditions:

a. With fan drivers rated greater than 225 kW (300 HP), unless specific approval is obtained from the purchaser.

b. Where antifriction bearing *dmN* factors exceed the limits in Table 3.

c. When standard antifriction bearings fail to meet an L_{10} rating life (see AFBMA Standard 9) of 80,000 hours with continuous operation at normal conditions. (The rating life is the number of hours at the rated bearing load and speed that 90% of a group of identical bearings will complete or exceed before the first evidence of failure.)

d. When gas temperature exceeds 200°C (400°F).

2.8.1.3 When specified, the actual radial and thrust loads for arrangement 3 and 7 bearings (see Appendix B) shall be documented on the outline drawing.

2.8.2 Antifriction Bearings

2.8.2.1 Antifriction bearings shall be retained on the shaft and fitted into housings in accordance with the requirements of AFBMA Standard 7, except when tapered adapter sleeves are provided they shall meet the requirements of Standard 8. On units with drivers rated over 75 kW (100 HP) the device used to lock ball thrust bearings to the shaft shall be restricted by a nut with a tongue-type lock washer, e.g., Series W.

Table 2—Vibration Limits for Fans[1]

Point of Measurement	Bearing Housing		Shaft[2]	
Fan Bearings	All		Hydrodynamic(J/B)	
Units	mm/s	in./sec (true pk)	micron	mils (pk/pk)
Unfiltered	< 4.0	< 0.16	< 50	< 2.0
Filtered[3]	< 2.5	< 0.10	< 40	< 1.6

Notes:

1. At any flow within the specified operating envelope.
2. Applies when optional API 670 proximity type probes are purchased and installed adjacent to hydrodynamic bearings.
3. At discrete frequencies.

Table 3—Anti-friction Bearing Limiting *dmN* Factors

Bearing Type	Static Oil (Splash Lubricated)	Circulating Oil or Oil Mist	Grease Lubricated
Radial: Single row ball bearings Cylindrical roller bearings (see note)	450,000	500,000	380,000
Radial: Tapered roller bearings Spherical roller bearings Double row ball bearings	300,000	350,000	200,000
Thrust: Single row ball bearings	200,000	240,000	130,000
Thrust: Double row angular contact	300,000	360,000	220,000
Thrust: Tapered roller bearings	230,000	270,000	57,000

Where: dm = mean bearing diameter $(d + D)/2$, in mm.
N = rotative speed, in revolutions per minute.

Note: Limits for cylindrical roller bearings with machined cages. Pressed cage bearing limits are 20% lower.

2.8.2.2 Except for the angular contact type, antifriction bearings shall have a loose internal clearance fit equivalent to AFBMA Symbol 3, as defined in AFBMA Standard 20. Single or double-row bearings shall be of the Conrad type (no filling slots).

2.8.2.3 The bearings shall be self-aligning and shall not exceed the *dmN* limits in Table 3.

2.8.3 Hydrodynamic Radial Bearings

2.8.3.1 Hydrodynamic radial bearings shall be split for ease of assembly, precision bored, and of the sleeve type, with steel-backed, babbitted replaceable liners, or shells. These bearings shall be equipped with anti-rotation pins and shall be positively secured in the axial direction.

2.8.3.2 The bearing design shall suppress hydrodynamic instabilities and provide sufficient damping over the entire range of allowable bearing clearances to limit rotor vibration to the maximum specified amplitudes (see 2.7.4.7) while the equipment is operating at specified operating speeds, including operation at any critical frequency.

2.8.3.3 The liners or shells shall be in horizontally split housings and shall be replaceable without the removal of the casing, inlet box, pedestal, or coupling hub.

2.8.3.4 Sleeve bearings shall be self-aligning, supported on rigid pedestal(s) independent of the fan housing so as to be unaffected by vibration, differential expansion, or other forces from the fan housing.

2.8.4 Thrust Bearings

2.8.4.1 General

2.8.4.1.1 Thrust bearings shall be sized for continuous operation under the most adverse specified operating conditions. Calculation of the thrust force shall include but shall not be limited to the following factors:

a. Fouling and variation in seal clearances up to twice the design internal clearances.

b. Variation in inlet and exhaust pressure.

c. External loads from the driven equipment, as described in 2.8.4.1 through 2.8.4.1.3.

d. Operation of double-inlet fans with one inlet 100% blocked.

2.8.4.1.2 For gear-type couplings, the external thrust force shall be calculated from the following formula:

In SI units

$$F = \frac{(0.25)(95{,}540)Pr}{(NrD)}$$

In U.S. Customary units

$$F = \frac{(0.25)(63{,}000)Pr}{(NrD)}$$

where

F = external force, in kilonewtons (lb.),

Pr = rated power, in kilowatts (horsepower),

Nr = rated speed, in revolutions per minute,

D = shaft diameter at the coupling, in mm (in.).

Note: Shaft diameter is an approximation of the coupling pitch radius.

2.8.4.1.3 Thrust forces for flexible-element couplings shall be calculated on the basis of the maximum allowable deflection permitted by the coupling manufacturer.

2.8.4.2 Hydrodynamic Thrust Bearings

2.8.4.2.1 Hydrodynamic thrust bearings shall be of the babbitted multiple-segment type, designed for equal thrust capacity in both directions and arranged for lubrication to each side. The thrust bearings shall be self-aligning.

2.8.4.2.2 Replaceable thrust collars shall be furnished and positively locked to the shaft to prevent fretting unless integral thrust collars are specified by the purchaser.

2.8.4.2.3 Both faces of thrust collars for hydrodynamic thrust bearings shall have a surface finish of not more than 0.8 μm (32 μin.) Ra, and the axial total indicated run-out of either face shall not exceed 25 μm (0.001 in.) after the collar is mounted on the shaft.

2.8.4.2.4 Hydrodynamic thrust bearings shall be selected at no more than 50% of the bearing manufacturer's maximum allowable load rating for all specified operating conditions. This may be increased to 80% when considering one inlet completely closed on arrangement 3 and 7 fans, and start-up conditions for high temperature fans.

2.8.5 Bearing Housings

• **2.8.5.1** Bearing housings for non-circulating oil-lubricated bearings shall be provided with tapped and plugged fill and drain openings at least NPS $^{1}/_{2}$, except antifriction bearing housings may have smaller openings. The housings shall be equipped with constant-level sight-feed oilers at least 0.25 l (8 oz.) in size, with a positive level positioner (not a setscrew). Heat-resistant glass containers (not subject to sunlight or heat-induced opacity or deterioration and protected by wire cages) shall be provided. When specified, the oilers shall meet the purchaser's preference. A permanent indication of the proper running oil level shall be accurately located and clearly marked on the outside of the bearing housing with permanent metal tags, marks inscribed in the castings, or another durable means.

2.8.5.2 Housings for ring-oil-lubricated bearings shall be provided with plugged ports positioned to allow visual inspection of the oil rings while the equipment is running.

2.8.5.3 Bearing housings for circulating oil-lubricated hydrodynamic bearings shall be arranged to minimize foaming. The drain system shall be adequate to maintain the oil and foam level below shaft end seals. The rise in oil temperature through the bearing and housing shall not exceed 30°C (50°F) under the most adverse specified operating conditions. The bearing outlet oil temperature shall not exceed 80°C (180°F). When the inlet oil temperature exceeds 50°C (120°F), special consideration shall be given to bearing design, oil flow, and allowable temperature rise. Oil connections on bearing housings shall be in accordance with 2.3.3 through 2.3.7.

2.8.5.4 Bearing housings shall be equipped with replaceable labyrinth-type end seals and deflectors where the shaft passes through the housing; lip-type seals shall not be used. The seals and deflectors shall be made of non-sparking materials. The design of the seals and deflectors shall effectively retain oil in the housings and prevent entry of foreign material into the housing.

2.8.5.5 Axially split-bearing housings shall have a metal-to-metal split joint whose halves are located by means of cylindrical dowels.

2.8.5.6 Sufficient cooling, including an allowance for fouling, shall be provided to maintain the oil temperature below 70°C (160°F) for circulating systems and below 80°C (180°F) for ring-oiled or splash systems, based on the specified operating conditions and an ambient temperature of 40°C (110°F). Cooling may be by water or air, or by use of a heat slinger (shaft cooler). Where water cooling is required, water jackets shall be used only for hydrodynamic bearings, shall have only external connections between the upper and lower housing jackets, and shall have no gasket joints, which may allow water to leak into the oil reservoir. If cooling coils (including fittings) are used, they shall be of nonferrous material and shall have no internal pressure joints or fittings. Coils shall have a thickness of at least 19 Birmingham wire gauge (BWG) (1 mm [0.042 in.]) and shall be at least 12 mm (0.50 in.) in diameter.

2.8.5.6.1 All induced draft fans or process fans operating above 95°C (200°F) and without internal bearing cooling shall be supplied with heat slingers (with safety guards) located between the fan housing and/or inlet box(es) and the adjacent bearing(s). The design of the heat slingers and the shaft mounting arrangement shall be described in the vendor's proposal.

2.8.5.6.2 All bearing housings for induced draft fans or process fans operating above 150°C (300°F) shall have provisions for water cooling.

2.8.5.7 The requirements of 2.8.5.7.1 through 2.8.5.7.5 apply when oil mist lubrication is specified.

2.8.5.7.1 An oil mist inlet connection, 1/4 in. nominal pipe size shall be provided in the top half of the bearing housing. The pure- or purge-oil mist fitting connections shall be located so that oil mist will flow through the antifriction bearings. There shall be no internal passages to short-circuit oil mist from inlet to vent. If bearings are of the sleeve type, the connections for the condensing-oil mist fittings shall be located over the bearings so that makeup oil will drip into the bearings.

2.8.5.7.2 A vent connection NPS 1/4 shall be provided on the housing or end cover for each of the spaces between the antifriction bearings and the housing shaft closures. Housings with only sleeve-type bearings shall have the vent located near the end of the housing.

2.8.5.7.3 When pure- or purge-oil mist lubrication is specified, shielded or sealed bearings shall not be used.

2.8.5.7.4 When pure-oil mist lubrication is specified, oil rings or flingers (if any) and constant-level oilers shall not be provided, and a mark indicating the oil level is not required. When purge- or condensing-oil mist lubrication is specified, these items shall be provided and the oiler shall be piped so that it is maintained at the internal pressure of the bearing housing.

2.8.5.7.5 The oil mist supply and drain fittings will be provided by the purchaser.

2.8.5.8 Access shall be provided so that shaft vibration measurements can be taken with a hand-held sensor adjacent to each journal bearing.

● **2.8.5.9** When specified, a non-contacting speed measurement probe or a mechanical type speed activated switch shall be provided on the outboard bearing. If a mechanical type device is provided, it shall be supported from the fan bearing pedestal.

Note: This speed sensor or switch may be used to monitor speed on variable speed drives, start the backup drive on dual-drive applications, or shut down on overspeed.

● **2.8.5.10** When specified, thrust bearings and radial bearings shall be fitted with bearing-metal temperature sensors installed in accordance with API 670.

● **2.8.5.11** When specified, bearing oil temperature indicators shall be provided.

● **2.8.5.12** When specified, bearing housings shall have a threaded connection(s) for permanently mounting vibration transducers in accordance with API 670. When metric fasteners are supplied, the threads shall be M8.

● **2.8.5.13** When specified, a flat surface at least 25 mm (1 in.) in diameter shall be supplied for the location of magnetic-based vibration measuring equipment.

● **2.8.5.14** When specified, hydrodynamic bearing housings shall have provisions for mounting two radial vibration probes in each bearing housing and a one-event-per-revolution probe. The probe installation shall be as specified in API 670.

2.8.5.15 Bearing housing mounting surfaces shall be machined in a continuous plane parallel to the bearing bore.

2.8.5.16 Bearing housings shall be drilled with pilot holes for use in final doweling.

2.9 LUBRICATION

2.9.1 Unless otherwise specified, hydrodynamic bearings and bearing housings shall be arranged for disc- or ring-oil lubrication using hydrocarbon oil in accordance with bearing manufacturer's recommendations.

2.9.2 Antifriction bearings may be either static oil, circulating oil, oil mist, or grease lubricated, depending on the application. In order to select the proper lubrication method the vendor shall perform a thermal analysis of the bearings taking into account the heat conducted by the shaft in hot gas applications and the maximum specified ambient temperature. The lubrication method will be reviewed and approved by the purchaser. The requirements of 2.9.2.1 through 2.9.2.3 shall apply.

2.9.2.1 For static oil or grease lubrication the calculated maximum bearing housing temperature shall not exceed 80°C (180°F).

2.9.2.2 Grease lubricated bearings shall not exceed the bearing supplier's published maximum allowable speed for grease lubrication.

2.9.2.3 The vendor shall provide in the service manual a lubricant specification, a recommended re-lubrication interval and a recommended clean and repack interval for the specific application.

2.9.3 The fan bearing oil may be supplied from a pressure or circulating oil lubrication system when required by a gear and/or driver. The purchaser will specify the supplier of the complete lubrication system.

● **2.9.4** Where oil is supplied from a common system to two or more machines (such as a fan, a gear, and a motor), the oil's characteristics will be specified on the data sheets by the purchaser on the basis of mutual agreement with all vendors supplying equipment served by the common oil system.

2.9.5 As a minimum, pressure lubrication systems other than those described in API 614 shall consist of an oil pump with a suction strainer, a supply and return system, an oil cooler (when required), a full-flow filter, a low lube-oil pressure shutdown switch, and other necessary instruments. The requirements specified in 2.9.5.1 through 2.9.5.9 shall apply.

2.9.5.1 Oil-containing pressure components shall be steel.

2.9.5.2 A main oil pump driven by the shaft shall be provided unless another source of pressurized oil is provided.

2.9.5.3 Oil return lines shall be sized to run no more than half full and arranged to ensure good drainage (recognizing the possibility of foaming conditions). Horizontal runs shall slope continuously, 40 mm per m ($^1/_2$ in. per ft) minimum, toward the reservoir. Laterals (not more than one in any transverse plane) should, if possible, enter drain headers at 45° angle in the direction of the flow.

● **2.9.5.4** A separately driven, automatically controlled standby pump will be specified by the purchaser for equipment that will operate at idling speeds or will require rapid starting.

2.9.5.5 Standby pumps that are enclosed in a reservoir may have cast iron cases.

2.9.5.6 An oil cooler shall be provided to maintain the oil supply temperature at or below 50°C (120°F). The cooler shall be of a water-cooled, shell-and-tube type or of a suitable air-cooled type, as specified. Shell-and-tube coolers shall have water on the tube side. A removable-bundle design is required for coolers with more than 0.45 m^2 (5 ft^2) of surface, unless otherwise specified. Removable-bundle coolers shall be in accordance with TEMA Class C and shall be constructed with a removable channel cover. Tubes shall not have an outside diameter of less than 15 mm ($^5/_8$ in.), and the tube wall shall not have a thickness of less than 18 BWG (1.25 mm [0.050 in.]). Unless otherwise specified, cooler shells, channels, and covers shall be of steel; tube sheets shall be of brass; and tubes shall be of inhibited admiralty.

U-bend tubes are not permitted. To prevent the oil from being contaminated if the cooler fails, the oil-side operating pressure shall be higher than the water-side operating pressure. The cooler shall be equipped with vent and drain connections on the oil and water-sides. The vendor shall include in the proposal complete details of any proposed air-cooled cooler. Internal oil coolers are not acceptable. A three-port, flanged, steel oil temperature control valve with a manual override or bypass shall be provided in the oil circuit to maintain a constant oil temperature to the equipment.

2.9.5.7 A full-flow filter with replaceable elements and filtration of 25 microns nominal or finer shall be supplied. Filtration of 10 microns nominal or finer shall be supplied for aluminum or micro-babbitted hydrodynamic bearings. The filter shall be located downstream of the cooler. For turbine-driven centrifugal oil pumps, the filter case and head shall be suitable for operation at the maximum discharge pressure at the driver's trip speed. For positive displacement pumps, the filter case and head shall be suitable for operation at a pressure not less than the relief valve setting. Filters that have covers weighing more than 15 kg (35 lb.) shall have cover lifters. Filters shall not be equipped with a relief valve or an automatic bypass. Filter cartridge materials shall be corrosion resistant. Metal-mesh or sintered-metal filter elements are not acceptable. Flow shall be from the outside toward the center of the filter cartridge. When the filter design requires cartridges stacked two or more high, a center post and a cap for the top cartridge shall be used to secure the cartridges to the bottom of the filter housing. If the cartridge-to-cartridge joint is not self-aligning, a collar shall be used between the stacked cartridges to ensure alignment. The pressure drop for clean filter elements shall not exceed 15% of the total allowable dirty pressure drop, or 0.30 bar (5 psi) at an operating temperature of 40°C (100°F) and normal flow. Cartridges shall have a minimum collapsing differential pressure of 5.0 bar (70 psi). The filter shall be equipped with a valved vent and clean-side and dirty-side valved drain connections. The dirty-side connections shall be located lower in the housing than the filter element or cartridge support base. Where a specific filter element is desired, the purchaser will specify the make and model number of the element.

Note: Micron particle size implies the shape of a spherical bead; thus, a 10-micron particle is a sphere with a diameter of 10 microns. Within the element's recommended maximum pressure drop, 10 microns nominal implies that the efficiency of the filter on particles that are 10 microns or larger in diameter will be no less than 90% for the life of the element. Absolute micron particle ratings are different. A micron-absolute filter rating implies that no particles of the rating size or larger will pass; for example, a filter rating may be 10 microns nominal and 15 microns absolute.

● **2.9.5.8** When specified, a removable steam-heating element external to the oil reservoir or a thermostatically controlled electric immersion heater with a sheath of AISI Standard Type 300 stainless steel shall be provided for heating the charge capacity of oil before start-up in cold weather. The heating device shall have sufficient capacity to heat the oil in the reservoir from the specified minimum site ambient temperature to the manufacturer's required start-up temperature within 12 hours. If an electric immersion heater is used, the watt density shall not exceed 2.0 watts/cm^2 (15 watts/$in.^2$).

2.9.5.9 When an external reservoir is supplied, it shall be made of austenitic stainless steel with the following characteristics and appendages:

a. The capacity to avoid frequent refilling, to provide adequate allowance for system rundown, and to provide a retention time of at least 3 minutes to settle moisture and foreign matter adequately.

b. Provisions to eliminate air and to minimize flotation of foreign matter to the pump suction.

c. Fill connections, an armored gauge glass, a level indicator, and breathers suitable for outdoor use.

d. Sloped bottoms and connections for complete drainage.
e. Cleanout openings as large as is practical.

● **2.9.6** When specified, pressurized oil systems shall conform to the requirements of API 614.

2.9.7 Oil flinger discs or oil rings shall have an operating submergence of 3.0 – 6.0 mm (1/8 – 1/4 in.) above the lower edge of a flinger or above the lower edge of the bore of an oil ring. Oil flingers shall have mounting hubs to maintain concentricity and shall be positively secured to the shaft.

2.9.8 The vendor shall state in the operating manual the amount of and the specifications for the lubricating oil required.

2.9.9 Where specified for ring or disc lubricated bearings, thermostatically controlled heating devices shall be provided in the bearing housings. The heating devices shall have sufficient capacity to heat the oil in the bearing housing from the specified minimum site ambient temperature to the vendor's minimum required temperature in 4 hours. Refer to 2.9.5.8 for heat density limitations.

2.9.10 Damper and inlet guide vane linkages, shaft fittings, and bearings preferably will be permanently lubricated. Components requiring periodic lubrication shall be furnished with lubrication fittings that are accessible while the fan is in operation, or shall have suitable extension lines to permit access during operation.

2.10 MATERIALS

2.10.1 General

2.10.1.1 Materials of construction shall be the manufacturer's standard for the specified operating conditions, except as required or prohibited by the data sheets or this standard (see 3.5 for requirements for auxiliary piping materials). The metallurgy of all major components shall be clearly stated in the vendor's proposal. The corrosion allowance of carbon steel plate shall be 3 mm (1/8 in.).

2.10.1.2 Materials shall be identified in the proposal with their applicable ASTM, AISI, ASME, or SAE numbers, including the material grade. When no such designation is available, the vendor's material specification, giving physical properties, chemical composition, and test requirements shall be included in the proposal.

2.10.1.3 The vendor shall specify the ASTM optional tests and inspection procedures that may be necessary to ensure that materials are satisfactory for the service. Such tests and inspections shall be listed in the proposal. The purchaser may consider specifying additional tests and inspections, especially for materials used in critical components.

2.10.1.4 External parts that are subject to rotary or sliding motions (such as control linkage joints and adjusting mechanisms) shall be of corrosion-resistant materials suitable for the site environment.

2.10.1.5 Minor parts that are not identified (such as nuts, springs, washers, gaskets, and keys) shall have corrosion resistance at least equal to that of specified parts in the same environment.

● **2.10.1.6** The purchaser will specify any corrosive agents present in the motive and process fluids and in the environment, including constituents that may cause stress corrosion cracking.

2.10.1.7 If parts exposed to conditions that promote intergranular corrosion are to be fabricated, hard faced, overlaid, or repaired by welding, they shall be made of low-carbon or stabilized grades of austenitic stainless steel.

Note: Overlays or hard surfaces that contain more than 0.10% carbon can sensitize both low-carbon and stabilized grades of austenitic stainless steel unless a buffer layer that is not sensitive to intergranular corrosion is applied.

2.10.1.8 Where mating parts such as studs and nuts of AISI Standard Type 300 stainless steel or materials with similar galling tendencies are used, they shall be lubricated with an anti-seize compound of the proper temperature specification and compatible with the specified gas. It is preferable to use materials that do not have similar galling tendencies.

Note: Torque loading values will differ considerably with and without an anti-seize compound.

2.10.1.9 Materials exposed to a sour environment, (wet H_2S), as defined by NACE MR-0175 shall be in accordance with the requirements of the standard. Ferrous materials not covered by NACE MR-0175 shall be limited to a yield strength not exceeding 6200 bar (90,000 psi) and a hardness not exceeding Rockwell C22.

Note: It is the responsibility of the purchaser to determine the amount of H_2S that may be present. Considering normal operation, start-up, shutdown, idle standby, upsets, or unusual operating conditions such as catalyst regeneration.

In many applications small amounts of H_2S are sufficient to require NACE materials. When there are trace quantities of H_2S known to be present or if there is any uncertainty about the amount of H_2S that may be present, the purchaser should automatically note on the data sheets that NACE materials are required. Components that are fabricated by welding shall be stress relieved, if required, so that both the welds and the heat-affected zones meet the yield strength and hardness requirements. The purchaser will specify the presence of such agents in the media.

2.10.1.10 When dissimilar materials with significantly different electrical potentials are placed in contact in the presence of an electrolytic solution, galvanic couples that can result in serious corrosion of the less noble material may be created. If such conditions exist, the purchaser and the vendor should select materials in accordance with the NACE Corrosion Engineer's Reference Book.

2.10.1.11 Materials and casting factors shall be equal to those required by Section VIII, Division 1 of the ASME Code. The manufacturer's data report forms, as specified in the code, are not required.

2.10.1.12 The use of ASTM A 515 steel is prohibited. Low-carbon steels can be notch sensitive and susceptible to brittle fracture at ambient or low temperatures.

2.10.2 Castings

2.10.2.1 Castings shall be sound and free from porosity, hot tears, shrink holes, blow holes, cracks, scale, blisters, and similar injurious defects. Surfaces of castings shall be cleaned by sand or shot blasting, chemical cleaning, or any other standard method. Mold-parting fins and remains of gates and risers shall be chipped, filed, or ground flush.

2.10.2.2 Ferrous castings shall not be repaired by welding, peening, plugging, burning in, or impregnating, except as specified in 2.10.2.2.1 and 2.10.2.2.2.

2.10.2.2.1 Weldable grades of steel castings may be weld repaired, using a qualified welding procedure specified in 2.10.3.1.

2.10.2.2.2 Cast gray or nodular iron may be repaired by plugging within the limits specified in ASTM A 278, A 395, or A 536. The holes drilled for plugs shall be carefully examined, using liquid penetrant, to ensure that all defective material has been removed. All repairs that are not covered by ASTM specifications shall be subject to the purchaser's approval.

2.10.2.3 Fully enclosed cored voids, including voids closed by plugging, are prohibited.

2.10.2.4 Nodular iron castings shall be produced in accordance with ASTM A 395.

2.10.3 Welding

2.10.3.1 All welding, including weld repairs, shall be performed by welders, welder operators and procedures qualified in accordance with the specifications of American Welding Society (AWS) D1.1 for housings and structural components and AWS D14.6 for rotating components.

2.10.3.2 The vendor shall be responsible for the review of all repairs and repair welds to ensure that they are properly heat treated and nondestructively examined for soundness and compliance with AWS D14.6 Section 7 (also, see 2.10.1.9).

2.10.3.3 Repair of welding defects shall be performed in accordance with AWS D14.6 Section 8.

2.10.3.4 All butt welds on rotating elements shall be continuous, full strength, and full penetration welds.

2.10.3.5 Accessible surfaces of fan wheel welds shall be inspected by magnetic particle or liquid penetrant examination after back chipping.

2.10.4 Impact Test Requirements

2.10.4.1 To avoid brittle fracture during operation, maintenance, transportation, erection, and testing, good design practice shall be followed in the selection of fabrication methods, welding procedures, and materials for vendor furnished steel pressure retaining parts and rotating elements that may be subject to a temperature below the ductile-brittle transition point.

Note: The published design-allowable stresses for many materials in the ASME Code and ANSI Standards are based on minimum tensile properties. The ASME Code and ANSI Standards do not differentiate between rimmed, semi-killed, fully killed, hot-rolled, and normalized material, nor do they take into account whether materials were produced under fine- or course-grain practices. The vendor shall exercise caution in the selection of materials intended for services between –30°C (–20°F) and 40°C (100°F).

2.10.4.2 All pressure containing components including nozzles, flanges, weldments, and rotating elements shall be impact tested in accordance with the requirements of Section VIII, Division 1, Sections UCS-65 through 68, of the ASME Code. High-alloy steels shall be tested in accordance with Section VIII, Division 1, Section UHA-51, of the ASME Code.

Impact testing is not required if the requirements of Section VIII, Division 1, Section UG-20f, of the ASME Code are met. Nominal thickness for castings as defined in Section VIII, Division 1, Paragraph UCS-66 (2), of the ASME Code shall exclude structural support sections such as feet or lifting lugs.

The results of the impact testing shall meet the minimum impact energy requirements of Section VIII, Division 1, Section UG-84, of the ASME Code.

● **2.10.4.3** The purchaser will specify the minimum design metal temperature used to establish impact test requirements.

Note: Normally this will be the lower of the minimum surrounding ambient temperature or minimum process gas temperature; however, the purchaser may specify a minimum metal temperature based on gas properties such as auto-refrigeration at reduced pressures.

2.11 NAMEPLATES AND ROTATION ARROWS

2.11.1 A nameplate shall be securely attached at a readily visible location on the equipment and on any other major piece of auxiliary equipment.

2.11.2 Rotation arrows shall be cast in or attached to each major item of rotating equipment at a readily visible location. Nameplates and rotation arrows (if attached) shall be of AISI Standard Type 300 stainless steel or of nickel-copper alloy (Monel or equivalent). Attachment pins shall be of the same material. Welding is not permitted.

2.11.3 The rated conditions and other data below, as a minimum, shall be clearly stamped on the nameplate. The contract or data sheets shall specify SI, U.S. Customary or other units.

1. Vendor.
2. Model number.
3. Serial number.
4. Size.
5. Type.
6. Purchaser's equipment item number (may be listed on separate nameplate if space is insufficient).
7. Volume, inlet, in m^3/h ($ft^3/min.$).
8. Static pressure differential, in mm H_2O (in. H_2O).
9. Temperature, inlet, in degrees C (F).
10. Speed, rated, in revolutions per minute.
11. Speed, maximum allowable (at maximum allowable temperature), in revolutions per minute.
12. First critical speed, in revolutions per minute.
13. Power, rated in kW (bhp.)
14. WK^2.
15. Rotor weight, in kg (lb.).

3 Accessories

3.1 DRIVERS

• **3.1.1** The type of driver will be specified. The driver shall be sized to meet the maximum specified operating conditions, including external gear and/or coupling losses, and shall be in accordance with applicable specifications, as stated in the inquiry and order. The driver shall operate under the utility and site conditions specified by the purchaser.

• **3.1.2** Anticipated process variations that may affect the sizing of the driver (such as changes in the pressure, temperature, or properties of the fluid handled, as well as special plant start-up conditions) will be specified.

Note: Consideration should be given to sizing forced draft fan motor drivers for undampered fan performance at minimum ambient temperature. Induced draft fan driver considerations include possible variations in operating temperature and gas density from start-up through normal operation.

• **3.1.3** The starting conditions for the driven equipment will be specified, and the starting method shall be mutually agreed upon by the purchaser and the vendor. Driver starting torque capabilities shall exceed the speed torque requirements of the driven equipment.

3.1.4 Motor drives shall conform to API 541 or 546 as applicable. Motors that are below the power scope of 541 or 546 shall be in accordance with IEEE 841. Equipment driven by induction motors shall be rated at the actual motor speed available for the rated load specified. Motor drives shall have power ratings, including service factor (if any) at least equal to the percentages of power at fan rated conditions given in Table 4. The power at rated conditions shall not exceed motor nameplate without SF. Where it appears this will lead to uneconomical oversizing of the drive, an alternative proposal shall be submitted for the purchaser's approval. The motor nameplate rating (exclusive of the service factor) shall be at least 110% of the maximum power required (including applicable gear, belt, and coupling losses) for any of the specified operating conditions.

• **3.1.5** The purchaser will specify the type of motor and its characteristics and accessories, including the following:

a. Electrical characteristics.
b. Starting conditions (including the expected voltage drop on starting).
c. The type of enclosure.
d. The sound pressure level.
e. The area classification, based on API 500.
f. The type of insulation.
g. The required service factor.
h. The ambient temperature and elevation above sea level.
i. Transmission losses.
j. Temperature detectors, vibration sensors, and heaters, if required.
k. Auxiliaries (such as motor-generator sets, ventilation blowers, and instrumentation).
l. Vibration acceptance criteria.
m. Applicability of API 541 or IEEE 841.

• **3.1.6** The motor's starting-torque requirements shall be met at a specified reduced voltage and the motor shall accelerate to full speed within a period of time agreed upon by the purchaser and the vendor.

Note: For most applications, the starting voltage is typically 80% of the normal voltage, and the time required to accelerate to full speed is generally less than 30 seconds.

3.1.7 Steam turbine drivers shall conform to API 611. Steam turbine drivers shall be sized to deliver continuously 110% of maximum power required for the purchaser's specified conditions while operating at a corresponding speed with the specified steam conditions.

• **3.1.8** Gas turbine drivers shall conform to API 616 and shall be sized as mutually agreed upon by the purchaser and the vendor.

• **3.1.9** Gears shall conform to API 677. Epicyclic gears may be used with purchaser's approval.

Table 4—Power Ratings for Motor Drives

Motor Nameplate Rating		Percent of Rated Fan Power
Horsepower	Kilowatts	
≤ 25	≤ 18.5	125
30 – 75	22 – 55	115
≥ 100	≥ 75	110

3.1.10 Drivers that weigh more than 250 kg (500 lb.) shall be provided with vertical jackscrews in the mounting feet or at each corner.

3.2 COUPLINGS AND GUARDS

● **3.2.1** Unless otherwise specified, flexible couplings and guards between drivers and driven equipment shall be supplied by the fan vendor. The coupling make, type, and mounting arrangement shall be agreed upon by the driver and driven equipment vendors, and the purchaser.

Note: Dual drives may require overrunning clutches which must also be mutually agreed between purchaser, and fan vendor with appropriate driver vendor input for "standby" lockout devices, overhanging load, etc.

3.2.2 Couplings will have the following characteristics:

a. Hubs shall be steel and keyed in place with keys, keyways and fits conforming to AGMA 9002. Where servicing of the shaft seal requires removal of the hub, the hub shall be mounted with a taper fit and furnished with tapped puller holes at least 10 mm ($^3/_8$ in.) in diameter.
b. Spacer of sufficient length to permit removal of coupling, bearings, and shaft seals; and rotor, without disturbing the driver(s) or suction and discharge ductwork.
c. Flexible disc types shall have discs of corrosion resistant material.

3.2.3 Information on shafts, keyway dimensions (if any), and shaft end movements resulting from end play and/or thermal effects shall be furnished to the vendor supplying the coupling.

3.3 BELT DRIVES

3.3.1 Belt drives shall only be used for equipment of 150 kW (200 BHP) or less; and, unless otherwise specified, shall employ banded multi-V belts. If more than one banded multi-V belt is required, the vendor shall furnish matched belt lengths. All belts shall be oil resistant (that is, they shall have a core of Neoprene or an equivalent material) and shall be of the static-conducting type. The drive service factor shall not be less than 1.75 times the driver nameplate power rating.

3.3.2 The vendor shall provide a positive belt-tensioning device on all drives. This device shall incorporate a lateral adjustable base with guides and hold-down bolts, two belt-tensioning screws, and locking bolts.

3.3.3 The fan vendor shall inform the driver manufacturer when a belt drive is to be used. The driver manufacturer shall be provided with the belt drive's radial-load. These loads shall be included for bearing selection purposes. Antifriction bearings in the drive systems shall be selected to give a minimum L_{10} rating life of 75000 hours in continuous operation at fan rated conditions.

3.3.4 Belt drives shall meet the requirements of 3.3.4.1 through 3.3.4.7.

3.3.4.1 The distance between the centers of the sheaves shall not be less than 1.5 times the diameter of the large sheave.

3.3.4.2 The belt wrap (contact) angle on the small sheave shall not be less than 140 degrees.

3.3.4.3 The shaft length on which the sheave hub is fitted shall be greater than or equal to the width of the sheave hub.

3.3.4.4 The length of a shaft key used to mount a sheave shall not be less than the length of the sheave bore.

3.3.4.5 The sheave shall be mounted on a tapered adapter bushing.

3.3.4.6 To reduce bearing moment loading (belt tension), the sheave overhang distance from the sheave-to-shaft bearing shall be minimized.

3.3.4.7 Sheaves shall meet the balance requirements of ANSI S2.19, Grade 6.3.

3.4 MOUNTING PLATES

3.4.1 General

● **3.4.1.1** The equipment shall be furnished with soleplates or baseplates, as specified on the data sheets.

3.4.1.2 In 3.4.1.2.1 through 3.4.1.2.11, the term mounting plate refers to both baseplates and soleplates.

3.4.1.2.1 The mounting surfaces of fan bearing pedestals and mounting plates shall be machined flat and parallel after fabrication. The maximum surface roughness shall be 3 μm (125 μin.) Ra.

3.4.1.2.2 All machinery mounting surfaces on mounting plates shall extend at least 25 mm (1 in.) beyond the outer three sides of the equipment feet. All mounts shall be in the same plane within 50 μm (0.002 in.) to prevent a soft foot. (See Appendix B Base mounting pad arrangement.)

3.4.1.2.3 Mounting plate(s) which support equipment weighing more than 225 kg (500 lb.) shall be furnished with axial and lateral jackscrews the same size or larger than the mounting foot vertical jackscrews. The lugs holding these jackscrews shall be attached to the mounting plates so the lugs do not interfere with the removal or installation of the equipment, jackscrews, or shims. If the equipment is too heavy to use jackscrews for alignment, other means shall be provided.

● **3.4.1.2.4** When epoxy grout is specified, the vendor shall commercially sandblast, in accordance with SSPC SP6, all the grouting surfaces of the base or mounting plates and shall precoat these surfaces with a catalyzed epoxy primer. The epoxy primer shall be compatible with the installer's epoxy grout. The vendor shall submit to the purchaser instructions for field preparation of the epoxy primer.

Note: Epoxy primers have a limited life after application. The grout manufacturer should be consulted to ensure proper field preparation of the mounting plate for satisfactory bonding of the grout.

3.4.1.2.5 Anchor bolts shall not be used to fasten machinery to the mounting plates.

3.4.1.2.6 Mounting plates shall not be drilled for equipment to be mounted by others. Mounting plates shall be supplied with leveling screws. Mounting plates that are to be grouted shall have 50-mm-radiused (2-in.-radiused) outside corners (in the plan view). Mounting surfaces that are not to be grouted shall be coated with a rust preventive material immediately after machining.

3.4.1.2.7 The vendor of the mounting plates shall furnish stainless steel (AISI Standard Type 300) shim packs 3 mm to 15 mm ($^1/_8$ in. – $^1/_2$ in.) thick between the equipment feet and the mounting plates. All shim packs shall straddle the hold-down bolts and vertical jackscrews; and be at least 5 mm ($^1/_4$ in.) larger on all sides than the footprint of the equipment.

3.4.1.2.8 Anchor bolts will be furnished by the purchaser.

3.4.1.2.9 Fasteners for attaching the components to the mounting plates, and jackscrews for leveling the pedestal soleplates, shall be supplied by the vendor.

● **3.4.1.2.10** When specified, the base of the bearing pedestals shall be drilled with pilot holes for use in final dowelling

3.4.2 Baseplate

● **3.4.2.1** When a baseplate (subbase in AMCA terminology) is specified, the purchaser will indicate the major equipment to be mounted on it. A baseplate shall be a single fabricated steel unit, unless the purchaser and the vendor mutually agree that it may be fabricated in multiple sections. Multiple-section baseplates shall have machined and doweled mating surfaces to ensure accurate field reassembly.

3.4.2.2 Unless otherwise specified, the baseplate shall extend under the drivetrain components so that any leakage from these components is contained within the baseplate.

● **3.4.2.3** When specified, the baseplate shall be suitable for column mounting (that is, of sufficient rigidity to be supported at specified points) without continuous grouting under structural members. The baseplate design shall be mutually agreed upon by the purchaser and the vendor.

3.4.2.4 The baseplate shall be provided with lifting lugs for a minimum four-point lift. Lifting the baseplate complete with all equipment mounted shall not permanently distort or otherwise damage the baseplate or the machinery mounted on it.

3.4.2.5 The bottom of the baseplate between structural members shall be open. When the baseplate is installed on a concrete foundation, it shall be provided with at least one grout hole having a clear area of at least 0.01 m^2 (20 $in.^2$) and no dimension less than 75 mm (3 in.) in each bulkhead section. These holes shall be located to permit grouting under all load-carrying structural members. Where practical, the holes shall be accessible for grouting with the equipment installed. The holes shall have 15 mm ($^1/_2$ in.) raised-lip edges. If located in an area where liquids could impinge on the exposed grout, metallic covers with a minimum thickness of 16 gauge shall be provided. Vent holes at least 15 mm ($^1/_2$ in.) in size shall be provided at the highest point in each bulkhead section of the baseplate.

3.4.2.6 Unless otherwise specified, nonskid metal decking covering all walk and work areas shall be provided on the top of the baseplate.

3.4.2.7 The baseplate mounting pads shall be machined after the baseplate is fabricated.

3.5 CONTROLS AND INSTRUMENTATION

3.5.1 General

3.5.1.1 Unless otherwise specified, instrumentation and installation shall conform to the requirements of API 614.

● **3.5.1.2** Controls and instrumentation shall meet requirements for installation in the environment and area class indicated on the data sheets.

3.5.1.3 When vibration or bearing temperature instrumentation is specified, it shall be furnished and installed in accordance with API 670.

3.5.2 Control Systems

● **3.5.2.1** The fan control parameter may be inlet pressure, discharge pressure, flow, or some combination thereof. This may be accomplished by suction throttling (by a damper or variable inlet guide vanes), or discharge blowoff (when a constant speed drive is used). Variable fan speed may also be used. The control system may be mechanical, pneumatic, hydraulic, electrical, or any combination thereof. The system may be manual or it may be automatic with a manual override. The purchaser will specify the source of the control signal, its sensitivity and range, and the equipment to be furnished by the vendor.

3.5.2.2 For constant speed drives, the control signal shall actuate an operator that positions an inlet and/or outlet damper or adjustable inlet guide vanes. (Also called radial inlet damper, variable inlet vanes, vortex dampers.)

3.5.2.3 For variable speed drives, the control signal shall act to adjust the set point of the driver's speed control system. Unless otherwise specified, the control and operating speed range shall be from the maximum continuous speed to 95% of the minimum speed required for any specified operating case or 70% of maximum continuous speed, whichever is lower.

3.5.2.4 The full range of the specified control signal will correspond to the required operating range of the driven equipment. Unless otherwise specified, the maximum control signal shall correspond to the maximum continuous speed or the maximum flow.

● **3.5.2.5** Facilities shall be provided to automatically open or close (as specified) the dampers/guide vanes on loss of control signal and to automatically lock or brake the dampers or vanes in last position on loss of motive force (air supply, electric power, etc.).

Note: This is a specific system consideration and the associated controls should be arranged to avoid creating hazardous or other undesirable conditions.

3.5.2.6 The fan vendor shall furnish and locate the operators, actuator linkages, and operating shafts for remote control of the dampers/guide vanes. Operator output shall be adequate for the complete range of damper or guide vane positions. The proposed location of operators, linkages, and shafts shall be reviewed with the purchaser for consideration of maintenance access and safety.

3.5.2.7 External position indicators shall be provided for all dampers/inlet guide vanes.

3.5.3 Dampers or Inlet Guide Vanes

3.5.3.1 Frames for inlet dampers (unless integral with the inlet box) and outlet dampers shall be flanged and drilled air tight steel, using tight fitting bolting to connect the fan or duct work. Dampers shall be of either the parallel or opposed blade type, as appropriate to the specified control requirements. Damper blades shall be supported continuously by the shafts and not extend beyond the frame in the full open position. Stub shafts are not allowed. Damper shafts shall be sealed or packed to limit leakage (except for atmospheric air fan inlets).

● **3.5.3.2** When specified, the vendor shall state the maximum expected leakage through closed damper/vanes at purchaser's specified operating temperature and pressure. Leakage shall be stated with the fan operating.

3.5.3.3 The damper/vane mechanisms shall be interconnected to a single operator. The operating mechanism shall be designed so the dampers/vanes can be manually secured in any position.

3.5.3.4 Inlet variable guide vane operating mechanisms shall be located outside the flowing gas stream. The mechanism shall be readily accessible for inplace inspection and maintenance, and be of bolted attachment construction to permit removal if necessary. Provision shall be furnished for lubrication of the mechanism during operation.

3.5.3.5 Inlet dampers/vanes shall be continuously welded to the spindle or intermittently welded on the backside of the blade with full slot welds along the full length of the front side.

3.6 PIPING

3.6.1 General

3.6.1.1 Auxiliary system piping design and joint fabrication, examination, and inspection shall be in accordance with ASME B31.3.

3.6.1.2 Auxiliary systems are defined as piping systems that are in the following services:

a. Group I:
   1. Sealing fluid.
   2. Buffer gas.
   3. Fuel gas or oil.
   4. Drains and vents.
   5. Starting gas.
b. Group II:
   1. Sealing steam.
   2. Steam injection.
   3. Water injection.
   4. Starting air.
   5. Instruments and control air.
   6. Drains and vents.
c. Group III:
   1. Cooling water.
   2. Liquid wash.
   3. Drains and vents.
d. Group IV:
   1. Lubricating oil.
   2. Control oil.
   3. Drains and vents.

Auxiliary systems shall comply with the requirements of Table 5.

● **3.6.1.3** The vendor shall furnish all piping systems, including mounted appurtenances, located within the confines of the main unit's base area, any oil console base area, or any auxiliary base area. The piping shall terminate with flanged connections at the edge of the base. When soleplates are specified for the equipment train, the extent of the piping system at the equipment train shall be defined by the purchaser. The purchaser will furnish only interconnecting piping between equipment groupings and offbase facilities.

3.6.1.4 The design of piping systems shall achieve the following:

a. Proper support and protection to prevent damage from vibration or from shipment, operation, and maintenance.

b. Proper flexibility and normal accessibility for operation, maintenance, and thorough cleaning.

c. Installation in a neat and orderly arrangement adapted to the contour of the machine without obstructing access openings.

d. Elimination of air pockets by the use of valved vents or nonaccumulating piping arrangements.

e. Complete drainage through low points without disassembly of piping.

3.6.1.5 Piping systems shall include piping, isolating valves, control valves, relief valves, pressure reducers, orifices, temperature gauges and thermowells, pressure gauges, sight flow indicators, and all related vents and drains.

3.6.1.6 Piping shall preferably be fabricated by bending and welding to minimize the use of flanges and fittings. Welded flanges are permitted only at equipment connections, at the edge of any base, and for ease of maintenance. The use of flanges at other points is permitted only with the purchaser's specific approval. Other than tees and reducers, welded fittings are permitted only to facilitate pipe layout in congested areas. Threaded connections shall be held to a minimum. Pipe bushings shall not be used.

3.6.1.7 Pipe threads shall be taper threads in accordance with ASME B1.20.1 Alternately, pipe threads in accordance with 228 Part 1 are acceptable when required for compliance with local standards. Flanges shall be in accordance with ISO 7005 (ASME B16.5). Slipon flanges are permitted only with the purchaser's specific approval. For socket-welded construction, a 1.5 mm ($^1/_{16}$ in.) gap shall be left between the pipe end and the bottom of the socket.

3.6.1.8 Connections, piping, valves, and fittings that are 30 mm (1$^1/_4$ in.), 65 mm (2$^1/_2$ in.), 90 mm (3$^1/_2$ in.), 125 mm (5 in.), 175 mm (7 in.), or 225 mm (9 in.) in size shall not be used.

3.6.1.9 Where space does not permit the use of NPS $^1/_2$, $^3/_4$, or 1 pipe, seamless tubing may be furnished in accordance with Table 5.

3.6.1.10 The minimum size of any connection shall be NPS $^1/_2$.

3.6.1.11 Piping systems furnished by the vendor shall be fabricated, installed in the shop, and properly supported. Bolt holes for flanged connections shall straddle lines parallel to the main horizontal or vertical centerline of the equipment.

3.6.1.12 Welding shall be performed by operators and procedures qualified in accordance with Section IX of the ASME Code.

3.6.1.13 Pipe plugs shall be in accordance with 2.3.5.

3.6.2 Oil Piping

3.6.2.1 Oil drains shall be sized to run no more than one-half full when flowing at a velocity of 0.3 m/sec (1 ft/sec) and shall be arranged to ensure good drainage (recognizing the possibility of foaming conditions). Drains shall slope continuously, at least 40 mm per m ($^1/_2$ in. per ft) horizontal run, toward the reservoir. If possible, laterals (not more than one in any transverse plane) should enter drain headers at 45-degree angles in the direction of the flow.

3.6.2.2 Nonconsumable backup rings and sleeve-type joints shall not be used. Pressure piping downstream of oil filters shall be free from internal obstructions that could accumulate dirt. Socket-welded fittings shall not be used in pressure piping downstream of oil filters. (See Table 5.)

3.6.2.3 Unless otherwise specified, oil-supply piping and tubing, including fittings (excluding slip-on flanges), shall be stainless steel. (See Table 5.)

3.6.2.4 Provision shall be made for bypassing the bearings (and seals if applicable) of equipment during oil system flushing operations.

3.6.3 Process/Instrument Piping

● **3.6.3.1** The extent of, and requirements for, process piping to be supplied by the vendor will be specified by the purchaser.

3.6.3.2 Connections on equipment and piping for pressure instruments and test points shall conform to 3.6.1.3. Beyond the initial $^3/_4$-in. isolating valve, NPS $^1/_2$ piping valves and fittings may be used. Where convenient, a common connection may be used for remotely mounted instruments that measure the same pressure. Separate secondary $^1/_2$-in. isolating valves are required for each instrument on a common connection. Where a pressure gauge is to be used for testing pressure alarm or shutdown switches, common connections are required for the pressure gauge and switches.

Table 5—Minimum Piping Materials

	Group I, Auxiliary Process Fluids		Group II, Steam		Group III, Cooling Water		Group IV, Lubricating and Control Oil	
System	Nonflammable/ Nontoxic	Flammable/Toxic	≤ 75 psig	> 75 psig	Stnadard (≤ NPS 1)	Optional	≤ NPS 1	≥ NPS 1 1/2
Pipe	Seamless[a]	Seamless[a]	Seamless[a]	Seamless[a]	Seamless[a]	ASTM A 53 Type F Schedule 40, Galvanized to ASTM A 153	ASTM A 312, Type 304 or 316 Stainless Steel[b]	ASTM A 312, Type 304 or 316 Stainless Steel[b]
Tubing	ASTM A 269 Seamless Type 316 Stainless Steel[c]	ASTM A 269 Seamless Type 316 Stainless Steel[c]	ASTM A 269 Seamless Type 304 or 316 StainlessSteel[c]	ASTM A 269 Seamless Type 304 or 316 Stainless Steel[c]	ASTM A 269 Seamless Type 304 or 316 Stainless Steel[c]	ASTM A 269 Seamless Type 304 or 316 Stainless Steel[c]	ASTM A 269 Seamless Type 304 or 316 Stainless Steel[c]	—
All Valves	Class 800	Class 800	Carbon Steel, Class 800	Carbon Steel, Class 800	Bronze, Class 200	Bronze, Class 200	Carbon Steel, Class 800	Carbon Steel, Class 800
Gate and Globe Valves	Bolted Bonnet and Gland	Bolted Bonnet and Gland	Bolted Bonnet and Gland	Bolted Bonnet and Gland	—	—	Bolted Bonnet and Gland	Bolted Bonnet and Gland
Pipe Fittings and Unions	Forged Class 3000	Forged Class 3000	Forged Class 3000	Forged Class 3000	ASTM A 338 and A 197, Class 150 Malleable Iron, Galvanized to ASTM A 153	ASTM A 338 and A 197, Class 150 Malleable Iron, Galvanized to ASTM A 153	Stainless Steel	Stainless Steel
Tube Fittings	Manufacturer's Standard (With Purchaser's Approval)	Manufacturer's Standard (With Purchaser's Approval)	Manufacturer's Standard (With Purchaser's Approval)	Manufacturer's Standard (With Purchaser's Approval)	Manufacturer's Standard (With Purchaser's Approval)	—	Manufacturer's Standard (with purchaser's approval)	—
Fabricated Joints ≤ 1 1/2 in.	Threaded	Socket Welded	Threaded	Socket Welded	Threaded	—	—	Carbon Steel Slip-on Flange
Fabricated Joints ≥ 2 in.	—	—	—	—	Purchaser to Specify	Purchaser to Specify	—	Carbon Steel Slip-on Flange
Gaskets	Type 304 or 316 Stainless Steel, Spiral Wound	Type 304 or 316 Stainless Steel, Spiral Wound	Type 304 or 316 Stainless Steel, Spiral Wound	Type 304 or 316 sTainless Steel, Spiral Wound	—	—	—	Type 304 or 316 Stainless Steel, Spiral Wound
Flange Bolting	ASTM A 193, Grade B7 ASTM A 194, Grade 2H	ASTM A 193, Grade B7 ASTM A 194, Grade 2H	ASTM A 193, Grade B7 ASTM A 194, Grade 2H	ASTM A 193, Grade B7 ASTM A 194, Grade 2H	—	—	—	ASTM A 193, Grade B7 ASTM A 194, Grade 2H

Notes:
Carbon steel piping shall conform to ASTM A 106, Grade B; ASTM A 524; or API Specification 5L, Grade A or B. Carbon steel fittings, valves and flanged components shall conform to ASTM A 105 and A 181. Stainless steel piping shall conform to ASTM A 312.
[a]Schedule 80 for diameters from 1/2 in. to 1 1/2 in.; Schedule 40 for diameters 2 in. and larger.
[b]Schedule 40 for a diameter of 1 1/2 in.; Schedule 10 for diameters 2 in. and larger.
[c]1/2-in. diameter × 0.065-in. wall, 3/4-in. diameter × 0.095-in. wall, or 1-in. diameter × 0.109-in.wall.

3.7 INLET TRASH SCREENS

● **3.7.1** When specified, the vendor shall furnish inlet trash screen(s) for forced draft fans to prevent entry of debris. The screen shall be fabricated from 3.5 mm (0.135 in.) minimum diameter wire, with a mesh of 15 mm ($^1/_2$ in.) maximum opening. The screen shall be supported by cross members. All construction material shall be galvanized steel or other corrosion resistant metal as specified by the purchaser. When specified, the vendor shall furnish rain hood(s). Rain hood material shall be specified by the purchaser.

3.8 SILENCERS

● **3.8.1** When specified, fan inlet or exhaust silencers shall be provided and include the features in 3.8.2. The differential pressure through each silencer shall not exceed 25.4 mm (1.0 in.) water at rated conditions.

3.8.2 Full details of the proposed silencer(s) shall be submitted with the proposal for purchaser's approval. Silencers shall be designed to prevent damage to any components resulting from acoustic or mechanical resonances. Carbon steel construction shall be 5 mm ($^3/_{16}$ in.) minimum thickness plate. Corrosion allowance or alternative materials may be specified by the purchaser. Main connections shall be flanged.

3.9 INSULATION AND JACKETING

● **3.9.1** When specified, the vendor shall weld clips or studs on the outside surface of fan housings and their inlet box(es) and discharge connections to permit field installation of insulation by the purchaser (for thermal conservation, noise abatement, personnel protection, or to maintain the enclosure temperature above the gas dew point). The clips or studs shall allow for the installation of insulation having a thickness of 50 mm (2 in.) or greater.

3.9.2 The vendor shall include in the proposal the recommended insulation material and thickness where the above specified minimum is not sufficient for personnel protection/sound attenuation.

● **3.9.3** The insulation/jacketing shall extend over all portions of the fan housing, inlet box(es), and discharge connections that may reach normal operating temperature of 75°C (165°F) or higher. Insulation shall not interfere with damper/vanes or other operating mechanisms. When specified, this material will be provided by the fan vendor.

3.9.4 Insulation/jackets shall maintain a surface temperature of 75°C (165°F) or less under normal operation. They shall be designed to minimize damage during removal or replacement.

3.10 TURNING GEAR

● **3.10.1** When specified, or recommended by the vendor, a turning gear shall be provided.

3.10.2 The device shall be manually or automatically engaged and shall automatically disengage when the fan is placed into service.

● **3.10.3** The turning gear will be driven as specified (steam, hydraulic, electric, or pneumatic). Provision to start from rest will be agreed between purchaser and vendor.

3.11 INSTRUMENT AND CONTROL PANELS

● **3.11.1** When specified, a panel shall be provided and shall include all panel-mounted instruments for the driven equipment and the driver. Such panels shall be designed and fabricated in accordance with the purchaser's description. The purchaser will specify whether the panel is to be freestanding, located on the base of the unit, or in another location. The instruments on the panel shall be clearly visible to the operator from the driver control point. A lamp test push button shall be provided. The instruments to be mounted on the panel will be specified on the data sheets.

3.11.2 Panels shall be completely assembled, requiring only connection to the purchaser's external piping and wiring circuits. When more than one wiring point is required on a unit for control or instrumentation, the wiring to each switch or instrument shall be provided from a single terminal box with terminal posts mounted on the unit (or its base, if any). Wiring shall be installed in metal conduits or enclosures. All leads and posts on terminal strips, switches, and instruments shall be tagged for identification.

4 Inspection, Testing, and Preparation for Shipment

4.1 GENERAL

4.1.1 After advance notification by the vendor to the purchaser, the purchaser's representative shall have entry to all vendor and subvendor plants where manufacturing, testing, or inspection of the equipment is in progress.

4.1.2 The vendor shall provide sufficient advance notice to the purchaser before conducting any inspection or test that the purchaser has specified to be witnessed or observed.

4.1.3 The vendor shall notify subvendors of the purchaser's inspection and testing requirements.

● **4.1.4** The purchaser will specify the extent of participation in the inspection and testing and the amount of advance notification required.

4.1.4.1 When shop inspection and testing have been specified by the purchaser, the purchaser and the vendor shall meet to coordinate manufacturing hold points and inspectors' visits.

4.1.4.2 Witnessed means that a hold shall be applied to the production schedule and the inspection or test shall be carried out with the purchaser or his representative in attendance. For mechanical running or performance tests, this requires written notification of a successful preliminary test.

4.1.4.3 Observed means that the purchaser shall be notified of the timing of the inspection or test; however, the inspection or test shall be performed as scheduled, and if the purchaser or his representative is not present, the vendor shall proceed to the next step.

4.1.5 Equipment for the specified inspections and tests shall be provided by the vendor.

4.1.6 The purchaser's representative shall have access to the vendor's quality program for review.

4.2 INSPECTION

4.2.1 General

● **4.2.1.1** The vendor shall keep the following data available for at least 20 years for examination or reproduction by the purchaser or his representative upon request:

a. Necessary certification of materials, such as mill test reports.
b. Test data to verify that the requirements of the specification have been met.
c. Results of documented tests and inspections, including fully identified records of all heat treatment and radiography.
d. When specified, final assembly, maintenance and running clearances with runouts.

4.2.1.2 Pressure-containing parts shall not be painted until the specified inspection of the parts is completed.

● **4.2.1.3** In addition to the requirements of 2.10.1.2, the purchaser may specify the following:

a. Parts that shall be subjected to surface and subsurface examination.
b. The type of examination required, such as magnetic particle, liquid penetrant, radiographic, and ultrasonic examination.

4.2.2 Material Inspection

● 4.2.2.1 General

When radiographic, ultrasonic, magnetic particle, or liquid penetrant inspection of welds or materials is required or specified, the criteria in 4.2.2.2 through 4.2.2.5 shall apply unless other criteria are specified by the purchaser. Cast iron may be inspected in accordance with 4.2.2.4 and 4.2.2.5. Welds, cast steel, and wrought materials may be inspected in accordance with 4.2.2.2 through 4.2.2.5.

Note: User may want to review the severity of fan service in order to determine the necessity of specifying level of material inspections.

4.2.2.2 Radiography

4.2.2.2.1 Radiography shall be in accordance with ASTM E 94 and ASTM E 142.

4.2.2.2.2 The acceptance standard used for welded fabrications shall be Section VIII, Division 1, UW-51 (100%) UW-52 (spot), of the ASME Code. The acceptance standard used for castings shall be Section VIII, Division 1, Appendix 7, of the ASME Code.

4.2.2.3 Ultrasonic Inspection

4.2.2.3.1 Ultrasonic inspection shall be in accordance with Section V, Article 5 and 23, of the ASME Code.

4.2.2.3.2 The acceptance standard used for welded fabrications shall be Section VIII, Division 1, Appendix 12, of the ASME Code. The acceptance standard used for castings shall be Section VIII, Division 1, Appendix 7, of the ASME Code.

4.2.2.4 Magnetic Particle Inspection

4.2.2.4.1 Both wet and dry methods of magnetic particle inspection shall be in accordance with ASTM E 709.

4.2.2.4.2 The acceptance standard used for welded fabrications shall be Section VIII, Division 1, Appendix 6, and Section V, Article 25, of the ASME Code. The acceptability of defects in castings shall be based on a comparison with the photographs in ASTM E 125. For each type of defect, the degree of severity shall not exceed the limits specified in Table 6.

4.2.2.5 Liquid Penetrant Inspection

4.2.2.5.1 Liquid penetrant inspection shall be in accordance with Section V, Article 6, of the ASME Code.

4.2.2.5.2 The acceptance standard used for welded fabrications shall be Section VIII, Division 1, Appendix 8 and Section V, Article 24, of the ASME Code. The acceptance standard used for castings shall be Section VIII, Division 1, Appendix 7, of the ASME Code.

Note: Regardless of the generalized limits in 4.2.2, it shall be the vendor's responsibility to review the design limits of the equipment in the event that more stringent requirements are necessary. Defects that exceed the limits imposed in 4.2.2 shall be removed to meet the quality standards cited, as determined by the inspection method specified.

4.2.3 Mechanical Inspection

● **4.2.3.1** Centrifugal fans shall be shop assembled prior to shipment. When specified, drivers (if provided) and other auxiliaries shall be included in the shop assembly. If disassembly is required for shipment, all mating parts shall be suitably match-marked and tagged for field assembly. All equipment shall be furnished completely assembled to the maximum extent possible limited only by the requirements of shipping.

4.2.3.2 During assembly of the equipment and before testing, each component (including cast-in passages of these components) and all piping and appurtenances shall be cleaned chemically or by another appropriate method to remove foreign materials, corrosion products, and mill scale.

4.2.3.3 Circulating oil systems furnished shall meet the cleanliness requirements of 4.2.3.3.1 and 4.2.3.3.2.

4.2.3.3.1 After 1 hour of oil circulation at the design flow rate and a temperature of 150°F – 160°F (66°C – 71°C) or lower, as component design dictates, screens placed at all discharge terminations from the console or the packages and at other strategic points mutually agreed upon by the purchaser and the vendor shall be within the particle count limits listed in Table 7. The screen mesh shall be No. 100 plain-weave, stainless steel wire with a diameter of 0.004 in. (0.1 mm) and a 0.0059-in. (0.15-mm) opening. The particles' greatest dimension shall not exceed 0.010 in. (0.25 mm), and the particles shall be randomly distributed on the screen. Piping, coolers, and valves shall be hammered frequently during the test.

4.2.3.3.2 To further verify cleanliness, the system shall be visually inspected at two to six points selected by the inspector. The system shall be considered clean when such foreign matter as scale, rust, metal shavings, and sand are not visible to the eye and grittiness is not detectable to the touch

● **4.2.3.4** When specified, the purchaser may inspect for cleanliness of the equipment and all piping and appurtenances furnished by or through the vendor before final assembly.

● **4.2.3.5** When specified, the hardness of parts, welds, and heat-affected zones shall be verified as being within the allowable values by testing of the parts, welds, or heat affected zones. The method, extent, documentation, and witnessing of the testing shall be mutually agreed upon by the purchaser and the vendor.

Table 6—Maximum Severity of Defects in Castings

Type	Defect	Severity Level
I	Linear discontinuities	1
II	Shrinkage	2
III	Inclusions	2
IV	Chills and chaplets	1

Table 7—Maximum Number of Particles

Nominal Pipe Size (in.)	Schedule 40 or Less	Schedule 80	Schedule 160	Double Extra-strong
< 1	6	5	4	—
1 – 1$^1/_2$	15	10	10	5
2	20	20	15	10
3	45	40	35	25
4	80	70	60	50
6	180	160	130	115

4.3 TESTING

4.3.1 General

4.3.1.1 Equipment shall be tested in accordance with 4.3.2 and 4.3.3. Other tests that may be specified by the purchaser are described in 4.3.4.

4.3.1.2 At least 6 weeks before the first scheduled running test, the vendor shall submit to the purchaser, for his review and comment, detailed procedures for the mechanical running test and all specified running optional tests, including acceptance criteria for all monitored parameters.

4.3.1.3 The vendor shall notify the purchaser not less than 5 working days before the date the equipment will be ready for testing.

4.3.1.4 Acceptance of shop tests does not constitute a waiver of requirements to meet field performance under specified operating conditions, nor does inspection relieve the vendor's responsibilities.

4.3.2 Hydrostatic Test

4.3.2.1 Pressure-containing parts other than fan housing, but including auxiliaries, shall be tested hydrostatically with liquid at a minimum of 1$^1/_2$ times the maximum allowable working pressure but not less than gauge pressure of 1.5 bar (20 psig). The test liquid shall be at a higher temperature than the nilductility transition temperature of the material being tested.

4.3.2.2 Where applicable, tests shall be in accordance with the ASME Code. In the event that a discrepancy exists between the code test pressure and the test pressure in this standard, the higher pressure shall govern.

4.3.2.3 The chloride content of liquids used to test austenitic stainless steel materials shall not exceed 50 parts per million. To prevent deposition of chlorides as a result of evaporative drying, all residual liquid shall be removed from tested parts at the conclusion of the test.

4.3.2.4 Tests shall be maintained for a sufficient period of time to permit complete examination of parts under pressure. The hydrostatic test shall be considered satisfactory when neither leaks nor seepage through the casing or casing joint is observed for a minimum of 30 minutes. Large, heavy castings may require a longer testing period to be agreed upon by the purchaser and the vendor.

4.3.3 Mechanical Tests

4.3.3.1 Mechanical tests shall include the following:

a. The fan shall be operated from 0 – 115% of rated speed for VARIABLE SPEED drives and at 100% of rated speed for CONSTANT SPEED drives. Operation shall be for an uninterrupted period of at least two hours, after all measurements have stabilized, to check bearing performance and vibration.
b. All warning, protective and control devices used during the test shall be checked, and adjustments shall be made as required.
c. During the mechanical running test, the mechanical operation of all equipment being tested and the operation of the test instrumentation shall be satisfactory. The measured vibration shall not exceed the limits of 2.7.4.7 and shall be recorded throughout the operating speed range.
d. Hydrodynamic bearings shall be removed, inspected and, when applicable, reassembled after the mechanical running test is completed. See 4.2.3.1 for further details.

Note: Some fan manufacturers do not have the capability to perform shop mechanical run tests except on the smaller units.

4.3.3.2 Bearings used in oil mist lubrication systems shall be prelubricated.

4.3.3.3 All oil pressures, viscosities, and temperatures shall be within the range of operating values recommended in the vendor's operating instructions for the specific unit being tested. For pressure lubrication systems, oil flow rates for each bearing housing shall be measured.

4.3.4 Optional Tests

4.3.4.1 Performance Tests

• **4.3.4.1.1** When specified, a performance test shall be run. The details and extent of the shop or field test shall be developed jointly by the purchaser and the vendor.

Note: Typical testing procedures are contained in AMCA Standards 210-99 and 802-92 for shop testing and AMCA Publications 203-90 and 803-96 for field testing.

• **4.3.4.1.2** The fan performance shall meet all operating conditions specified on the data sheet and shall be within the tolerances listed in items 1 and 2 at the rated operating conditions.

1. For variable-speed fans, the static pressure and capacity shall be met at fan rated point and the horsepower at this point shall not exceed 104% of the specified value. Where changes in speeds are needed to meet static pressure rise requirements, the vendor shall adjust operating range.
2. For constant-speed fans, the specified capacity shall be met with the understanding that the static pressure rise shall be within plus five percent and negative zero percent of that specified; the horsepower shall not exceed 104% of the specified value.

4.3.4.2 Complete-unit Test

• **4.3.4.2.1** When specified, such components as fans, gears, drivers, and auxiliaries that make up a complete unit shall be tested together during the mechanical running tests. When specified, torsional vibration measurements shall be made to verify the vendor's analysis. The complete-unit test shall be performed in place of or in addition to separate tests of individual components specified by the purchaser.

4.3.4.3 Pressure Test

4.3.4.3.1 The casing (with or without end seals installed) shall be pressurized with air to the MAWP and held at this pressure for a minimum of 30 minutes, and subjected to a soap-bubble test or another approved test to check for gas leaks. The test shall be considered satisfactory when no casing or casing joint leaks are observed.

4.3.4.4 Sound Level Test

4.3.4.4.1 When specified, a sound level test shall be performed in accordance with ISO 3740, 3744, and 3746. The purchaser and supplier shall mutually agree on the criteria to be used for the test.

4.4 PREPARATION FOR SHIPMENT

4.4.1 Equipment shall be suitably prepared for the type of shipment specified, including blocking of the rotor when necessary. Blocked rotors shall be identified by means of corrosion-resistant tags attached with stainless steel wire. The preparation shall make the equipment suitable for 6 months of outdoor storage from the time of shipment, with no disassembly required before operation, except for inspection of bearings and seals. If storage for a longer period is contemplated, the purchaser will consult with the vendor regarding the recommended procedures to be followed.

4.4.2 The vendor shall provide the purchaser with the instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and prior to start-up.

4.4.3 The equipment shall be prepared for shipment after all testing and inspection have been completed and the equipment has been released by the purchaser. The preparation shall include that specified in 4.4.3.1 through 4.4.3.11.

4.4.3.1 Exterior surfaces, except for machined surfaces, shall be given at least one coat of the manufacturer's standard paint. The paint shall not contain lead or chromates.

4.4.3.2 Exterior machined surfaces except for corrosive resistant material shall be coated with a suitable rust preventive.

4.4.3.3 The interior of the equipment shall be clean; free from scale, welding spatter, and foreign objects; and sprayed or flushed with a suitable rust preventive that can be removed with solvent. As an alternative, purchaser may specify a permanent suitable coating.

4.4.3.4 Internal steel areas of bearing housings and carbon steel oil systems' auxiliary equipment such as reservoirs, vessels, and piping shall be coated with a suitable oil-soluble rust preventive.

4.4.3.5 Flanged openings for auxiliary piping connections shall be provided with metal closures at least 5 mm (3/16 in.) thick, with elastomer gaskets and at least four full-diameter bolts. For studded openings, all nuts needed for the intended service shall be used to secure closures. Each opening shall be car sealed so that the protective cover cannot be removed without the seal being broken.

4.4.3.6 Threaded openings shall be provided with steel caps or round head steel plugs. In no case shall nonmetallic (such as plastic) plugs or caps be used.

Note: These are shipping plugs. Permanent plugs are covered in 2.3.5.

4.4.3.7 Inlet and discharge duct connections on fans shipped assembled shall be provided with wood or metal covers to prevent entrance of foreign materials and damage to the duct connection. The vendor's proposal shall state how duct connections are to be protected.

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

4.4.3.9 The equipment shall be identified with item and serial numbers. Material shipped separately shall be identified with securely affixed, corrosion-resistant metal tags indicating the item and serial number of the equipment for which it is intended. In addition, crated equipment shall be shipped with duplicate packing lists, one inside and one on the outside of the shipping container.

4.4.3.10 When a spare rotor is purchased, the rotor shall be prepared for unheated indoor storage for a period of at least 3 years. The rotor shall be treated with a rust preventive and shall be housed in a vapor-barrier envelope with a slow-release volatile-corrosion inhibitor. The rotor shall be crated for domestic or export shipment, as specified. A resilient material 3.0 mm (1/8 in.) thick (not tetrafluoroethylene [TFE] or polytetrafluoroethylene [PTFE]) shall be used between the rotor and the cradle at the support areas. The rotor shall not be supported at journals. Vendor's proposal shall advise the material to be used.

4.4.3.11 Exposed shafts and shaft couplings shall be wrapped with waterproof, moldable waxed cloth or vapor phase volatile-corrosion inhibitor paper. The seams shall be sealed with oilproof adhesive tape.

4.4.4 Auxiliary piping connections furnished on the purchased equipment shall be impression stamped or permanently tagged to agree with the vendor's connection table or general arrangement drawing. Service and connection designations shall be indicated. Connections on auxiliary piping removed for shipment shall be match marked for ease of reassembly.

4.4.5 One copy of the manufacturer's standard installation instructions shall be packed and shipped with the equipment.

5 Vendor Data

5.1 GENERAL

● **5.1.1** The information to be furnished by the vendor is specified in 5.2 and 5.3. Purchaser shall complete Vendor Drawing and Data Requirements form (see Appendix F) clearly showing all information and drawings required for both proposals and contract data. Purchaser shall include any optional requirements that may be specific to this equipment. The vendor shall complete and forward the Vendor Drawing and Data Requirements form (see Appendix F) with his proposal. This form shall detail the schedule for transmission of drawings, curves, and data as agreed to at the time of the order, as well as the number and type of copies required by the purchaser.

5.1.2 The data shall be identified on transmittal (cover) letters and in title blocks or title pages with the following information:

a. The purchaser/user's corporate name.
b. The job/project number.
c. The equipment item number and service name.
d. The inquiry or purchase order number.
e. Any other identification specified in the inquiry or purchase order.
f. The vendor's identifying proposal number, shop order number, serial number, or other reference required to identify return correspondence completely.

● **5.1.3** When specified, a coordination meeting shall be held, preferably at the vendor's plant, within 4 – 6 weeks after the purchase commitment. Unless otherwise specified, the vendor shall prepare and distribute an agenda prior to this meeting, which, as a minimum, shall include review of the following items:

a. The purchase order, scope of supply, unit responsibility, and subvendor items.
b. The data sheets.
c. Applicable specifications and previously agreed upon exceptions.
d. Schedules for transmittal of data, production, and testing.
e. The quality assurance program and procedures.
f. Inspection, expediting, and testing.
g. Schematics and bills of material for auxiliary systems.
h. The physical orientation of the equipment, piping, and auxiliary systems.
i. Coupling selections.
j. Thrust-bearing sizing and estimated loadings.
k. The rotor dynamics analysis.
l. Other technical items.

5.2 PROPOSALS

5.2.1 General

The vendor shall forward the original proposal and the specified number of copies to the addressee specified in the inquiry documents. As a minimum, the proposal shall include the data specified in 5.2.2 through 5.2.4, as well as a specific statement that the system and all its components are in strict accordance with this standard. If the system and components are not in strict accordance, the vendor shall include a list that details and explains each deviation. The vendor shall provide details to enable the purchaser to evaluate any proposed alternative designs. All correspondence shall be clearly identified in accordance with 5.1.2.

5.2.2 Drawings

5.2.2.1 The drawings indicated on the Vendor Drawing and Data Requirements Form (see Appendix F) shall be included in the proposal. As a minimum, the following data shall be furnished:

a. A general arrangement or outline drawing for each major skid or system, showing overall dimensions, maintenance clearance dimensions, overall weights, erection weights, and maximum maintenance weights (indicated for each piece). The direction of rotation and the size and location of major purchaser connections shall also be indicated.
b. Cross-sectional drawings showing the details of the proposed equipment.
c. Schematics of all auxiliary systems, including lube-oil, control, and electrical systems. Bills of material shall be included.
d. Sketches that show methods of lifting the assembled machine or machines and major components. (This information may be included on the drawings specified in item a above.)

5.2.2.2 If typical drawings, schematics, and bills of material are used, they shall be marked up to show the correct weight and dimension data and to reflect the actual equipment and scope proposed.

5.2.3 Technical Data

The following data shall be included in the proposal:

a. The purchaser's data sheets, with complete vendor's information entered thereon and literature to fully describe details of the offering.
b. The purchaser's noise data sheet.
c. The Vendor Drawing and Data Requirements Form (see Appendix F), indicating the schedule according to which the vendor agrees to transmit all the data specified as part of the contract.
d. A schedule for shipment of the equipment, in weeks after receipt of the order.
e. A list of major wearing components, showing interchangeability with the purchaser's other units.
f. A list of spare parts recommended for start-up and normal maintenance purposes.
g. A list of the special tools furnished for maintenance. The vendor shall identify any metric items included in the offering.
h. A statement of any special weather protection and winterization required for start-up, operation, and periods of idleness under the site conditions specified on the data sheets. The list shall show the protection to be furnished by the purchaser, as well as that included in the vendor's scope of supply.
i. A complete tabulation of utility requirements, such as those for steam, water, electricity, air, gas, and lube oil, including the quantity of lube oil required and the supply pressure, the heat load to be removed by the oil, and the nameplate power rating and operating power requirements of auxiliary drivers. (Approximate data shall be defined and clearly identified as such.)
j. A description of the tests and inspection procedures for materials, as required by 2.10.1.3.
k. A description of any special requirements specified in the purchaser's inquiry and as outlined in 2.9.2.3, 2.9.5.6, 2.10.1.1, 2.10.1.2, 3.5.6.3, and 4.4.3.7.
l. A list of similar machines installed and operating under conditions analogous to those specified in the proposal.
m. Any start-up, shutdown, or operating restrictions required to protect the integrity of the equipment.
n. For constant speed units, the vendor shall outline the procedure that can be followed to reduce power consumption, in the event that excess pressure or flow is developed.

5.2.4 Curves

5.2.4.1 The vendor shall provide complete performance curves to encompass the map of operation, with any limitations indicated thereon. Any special inlet or outlet duct design required to meet performance shall be fully described.

5.2.4.2 The vendor shall provide sufficient fan performance data to enable the purchaser to properly design a control system for start-up and for all specified operating conditions. When requested by the purchaser, the vendor shall review the purchaser's overall fan control system for compatibility with vendor-furnished control equipment.

5.2.5 Options

The vendor shall furnish a list of the procedures for any special or optional tests that have been specified by the purchaser or proposed by the vendor.

5.3 CONTRACT DATA

5.3.1 General

5.3.1.1 The contract data to be furnished by the vendor is specified in Appendix F. Each drawing, bill of material, and data sheet shall have a title block in its lower right-hand corner that shows the date of certification, a reference to all identification data specified in 5.1.2, the revision number and date, and the title.

5.3.1.2 The purchaser will promptly review the vendor's data when received; however, this review shall not constitute permission to deviate from any requirements in the order unless specifically agreed upon in writing. After the data has been reviewed, the vendor shall furnish certified copies in the quantity specified.

5.3.1.3 A complete list of vendor data shall be included with the first issue of the major drawings. This list shall contain titles, drawing numbers, and a schedule for transmission of all the data the vendor will furnish (see Appendix F).

5.3.2 Drawings

5.3.2.1 The drawings furnished shall contain sufficient information so that with the drawings and the manuals specified in 5.3.6, the purchaser can properly install, operate, and maintain the ordered equipment. Drawings shall be clearly legible, shall be identified in accordance with 5.3.1.1, and shall be in accordance with ANSI Y14.2M. As a minimum, each drawing shall include the details for that drawing listed in Appendix F.

5.3.3 Technical Data

The data shall be submitted in accordance with Appendix F and identified in accordance with 5.3.1.1. Any comments on the drawings or revisions of specifications which necessitate a change in the data shall be noted by the vendor. These notations will result in the purchaser's issue of completed, corrected data sheets as part of the order specifications.

5.3.4 Progress Reports

The vendor shall submit progress reports to the purchaser at the intervals specified on the Vendor Drawing and Data Requirements Form (see Appendix F).

5.3.5 Parts Lists and Recommended Spares

5.3.5.1 The vendor shall submit complete parts lists for all equipment and accessories supplied. The lists shall include manufacturer's unique part numbers, materials of construction, and delivery times. Materials shall be identified as specified in 2.10.1.2. Each part shall be completely identified and shown on cross-sectional or assembly-type drawings so that the purchaser may determine the interchangeability of the part with other equipment. Parts that have been modified from standard dimensions and/or finish to satisfy specific performance requirements shall be uniquely identified by part number for interchangeability and future duplication purposes. Standard purchased items shall be identified by the original manufacturer's name and part number.

5.3.5.2 The vendor shall indicate on the above parts lists which parts are recommended spares for start-up and which parts are recommended for normal maintenance (see item f of 5.2.3). The vendor shall forward the lists to the purchaser promptly after receipt of the reviewed drawings and in time to permit order and delivery of the parts before field start-up. The transmittal letter shall be identified with the data specified in 5.1.2.

5.3.6 Installation, Operation, Maintenance, and Technical Data Manuals

5.3.6.1 General

The vendor shall provide sufficient written instructions and a list of all drawings to enable the purchaser to correctly install, operate, and maintain all of the equipment ordered. This information shall be compiled in a manual or manuals with a cover sheet that contains all reference-identifying data specified in 5.1.2, an index sheet that contains section titles, and a complete list of referenced and enclosed drawings by title and drawing number. The manual shall be prepared for the specified installation; a typical manual is not acceptable.

5.3.6.2 Installation Manual

Any special information required for proper installation design that is not on the drawings shall be compiled in a manual that is separate from the operating and maintenance instructions. This manual shall be forwarded when it is mutually agreed upon in the order but not later than the final issue of prints. The manual shall contain information such as special alignment and grouting procedures, utility specifications (including quantities), and all other installation design data, including the drawings and data specified in 5.2.2 and 5.2.3. The manual shall also include sketches that show the location of the center of gravity and rigging provisions to permit the removal of the top half of the casings, rotors, and any subassemblies that weigh more than 135 kg (300 lb.).

5.3.6.3 Operating and Maintenance Manual

The manual containing operating and maintenance data shall be forwarded no more than 2 weeks after all of the specified tests have been successfully completed. This manual shall include a section that provides special instructions for operation at specified extreme environmental conditions, such as temperatures. As a minimum, the manual shall also include all of the data listed in Appendix F.

5.3.6.4 Technical Data Manual

When specified, the vendor shall provide the purchaser with a technical data manual within 30 days of completion of shop testing (see Appendix F for detailed requirements).

APPENDIX A—LATERAL ANALYSIS FOR SPECIAL PURPOSE FANS

A.1 The vendor shall provide a damped unbalanced response analysis for each machine to ensure acceptable amplitudes of vibration at any speed from zero to trip.

A.2 The damped unbalanced response analysis shall include, but shall not be limited to, the following considerations:

a. Support (base, frame, and bearing-housing) stiffness, mass and damping characteristics, including effects of rotational speed variation. The vendor shall state the assumed support system values and the basis for these values (for example, tests of identical rotor support systems, assumed values)

b. Bearing lubrication-film stiffness and damping changes due to speed, load, preload, oil temperature, accumulated assembly tolerances, and maximum to minimum clearances.

c. Rotational speed, including the various starting-speed detents, operating speed and load ranges (including agreed-upon test conditions if different from those specified, trip speed, and coast-down conditions).

d. Rotor masses, including the mass moment of coupling halves, stiffness, and damping effects (for example, accumulated fit tolerances, fluid stiffening and damping, and frame and casing effects).

e. Asymmetrical loading (for example, partial arc emission, gear forces, side streams, and eccentric clearances).

f. The influence, over the operating range, of the calculated values for hydrodynamic stiffness and damping generated by the casing end seals.

● **A.3** When specified, the effects of other equipment in the train shall be included in the damped unbalanced response analysis (that is, a train lateral analysis shall be performed).

Note: This analysis should be considered for machinery trains with coupling spacers greater than 1 m (36 in.), rigid couplings, or both.

A.4 As a minimum, the damped unbalanced response analysis shall include the following:

a. A plot and identification of the mode shape at each resonant speed (critically damped or not) from zero to trip, as well as the next mode occurring above trip speed.

b. Frequency, phase, and response amplitude data (Bode plots) at the vibration probe locations through the range of each critical speed, using the arrangement of unbalance in Equation 2 for the particular mode. This unbalance shall be sufficient to raise the displacement of the rotor at the probe locations to the vibration limit defined by Equation 1:

In SI units

$$L_v = 25.4\sqrt{\frac{12,000}{N}} \quad (1)$$

In U.S. Customary units,

$$L_v = \sqrt{\frac{12,000}{N}} \quad (1)$$

where

L_v = vibration limit (amplitude of unfiltered vibration), in µm (mils) peak to peak,

N = operating speed nearest the critical of concern, in revolutions per minute.

This balance shall be no less than two times the unbalance defined by Equation 2:

In SI units

$$U_{max} = 6350\ W/N \quad (2)$$

In U.S. Customary units,

$$U_{max} = 4\ W/N \quad (2)$$

where

U = input unbalance from the rotor dynamic response analysis in gram-mm (oz.-in.),

W = journal static weight load, in kg (lb.); or for bending modes where the maximum deflection occurs at the shaft ends, the overhung weight load (that is, the weight outboard of the bearing), in kg (lb.),

N = operating speed nearest the critical of concern, in revolutions per minute.

The unbalance weight or weights shall be placed at the locations that have been analytically determined to affect the particular mode most adversely. For translatory modes, the unbalance shall be based on both journal static weights and shall be applied at the locations of maximum displacement. For conical modes, each unbalance shall be based on the journal weight and shall be applied at the location of maximum displacement of the mode nearest the journal used for the unbalance calculation, 180 degrees out of phase.

c. Modal diagrams for each response in A.4, item b, shall indicate the phase and major-axis amplitude at each coupling engagement plane, the centerlines of the bearings, the locations of the vibration probes, and each seal area throughout the machine. The minimum design diameter running clearance of the seals shall be indicated.

d. To establish the validity of the analytical model, a verification test of the rotor unbalance is required at the completion of the mechanical running test. Therefore, additional plots based on the actual unbalance to be used during the test shall be provided. For machines that meet the requirements of A.5, item b, the location of the test unbalance shall be determined by the vendor. The amount of unbalance shall be sufficient to raise the vibration levels, as measured at the vibration probes, to those specified in A.4, item b. In all cases, the unbalance plots shall include the effects of any test-stand conditions (including the effects of test seals) that may be used during the verification test of the rotor unbalance.

● e. Unless otherwise specified, a stiffness map shall be provided of the undamped rotor response from which the damped unbalanced response analysis was derived. This plot shall show frequency versus support system stiffness, with the calculated support system stiffness curves superimposed.

f. For machines whose bearing support system stiffness values are less than or equal to 3.5 times the bearing stiffness values, use either the calculated frequency-dependent support stiffness and damping values (impedances) or the values derived from modal testing. The results of the damped unbalanced response analysis shall include Bode plots that compare absolute shaft motion with shaft motion relative to the bearing housing.

A.5 The damped unbalance response analysis shall indicate that the machine in the unbalanced condition described in A.4, item b, will meet the following acceptance criteria (see Figure A-1):

a. If the amplification factor is less than 2.5, the response is considered critically damped and no separation is required.

b. If the amplification factor is 2.5 – 3.55, a separation margin of 15% above the maximum continuous speed and 5% below the minimum operating speed is required.

c. If the amplification factor is greater than 3.55 and the critical response peak is below the minimum operating speed, the required separation margin (a percentage of minimum speed) is equal to the following:

$$SM = 100 - 84 + \frac{6}{AF - \sqrt{3}} \tag{3}$$

where

SM = separation margin,

AF = amplification factor.

d. If the amplification factor is greater than 3.55 and the critical response peak is above the trip speed, the required separation (a percentage of the maximum continuous speed) is equal to the following:

$$SM = 126 - \frac{6}{AF - \sqrt{3}} - 100 \tag{4}$$

where

SM = separation margin,

AF = amplification factor.

A.6 The calculated unbalanced peak-to-peak rotor amplitudes (see A.4, item b) at any speed from zero to trip shall not exceed 75% of the minimum design diametral running clearances throughout the machine (with the exception of floating-ring seal locations).

A.7 If, after the purchaser and vendor have agreed that all practical design efforts have been exhausted, the analysis indicates that the separation margins still cannot be met or that a critical response peak falls within the operating speed range, acceptable amplitudes shall be mutually agreed upon by the purchaser and the vendor, subject to the requirements of A.6.

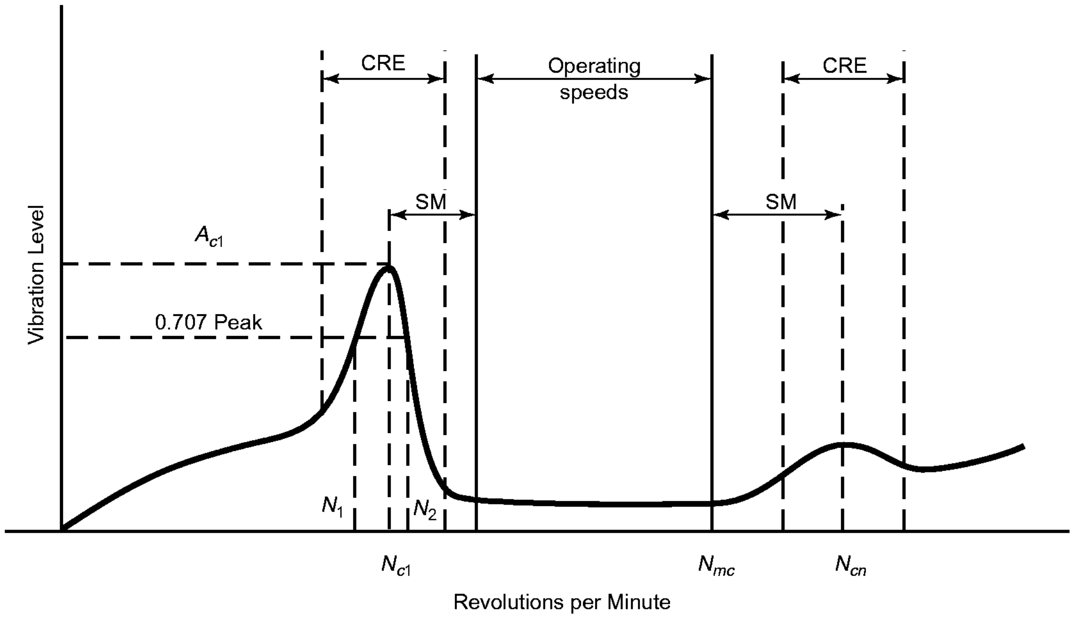
A.8 Shop Verification Of Unbalanced Response Analysis

A.8.1 A demonstration of rotor response at future unbalanced conditions is necessary because a well-balanced rotor may not be representative of future operating conditions (see A.4.d). This test shall be performed as part of the mechanical running test and the results shall be used to verify the analytical model. Unless otherwise specified, the verification test of the rotor unbalance shall be performed only on the first rotor (normally the spare rotor if two rotors are purchased). The actual response of the rotor on the test stand to the same unbalance weights as was used to develop the Bode plots specified in A.4 shall be the criterion for determining the validity of the damped unbalanced response analysis. To accomplish this, the following procedure shall be followed:

a. During the mechanical running test, the amplitudes and phase angle of the indicated vibration at the speed nearest the critical or criticals of concern shall be determined.

b. A trial weight, not more than one-half the amount calculated in A.4, item b; shall be added to the rotor at the location specified in A.4, item d; 90 degrees away from the phase of the indicated vibration at the speed or speeds closest to the critical or criticals of concern.

c. The machine shall then be brought up to the operating speed nearest the critical of concern, and the indicated vibration amplitudes and phase shall be measured. The results of this test and the corresponding indicated vibration data from A.8.1, item a, shall be vectorially added to determine the



N_{c1} = Rotor 1st critical, center frequency, cycles per minute

N_{cn} = Critical speed, nth

N_{mc} = Maximum continuous speed, 105%

N_1 = Initial (lesser) speed at 0.707 × peak amplitude (critical)

N_2 = Final (greater) speed at 0.707 × peak amplitude (critical)

$N_2 - N_1$ = Peak width at the half-power point

AF = Amplification factor

$$= \frac{N_{c1}}{N_2 - N_1}$$

SM = Separation margin

CRE = Critical response envelope

A_{c1} = Amplitude @ N_{c1}

A_{cn} = Amplitude @ N_{cn}

Figure A-1—Rotor Response Plot

magnitude and phase location of the final test weight required to produce the required test vibration amplitudes.

d. The final test weight described in A.8.1, item c, shall be added to the rotor and the machine brought up to the operating speed nearest the critical of concern. When more than one critical of concern exists, additional test runs shall be run for each, using the highest speed for the initial test run.

Note: The dynamic response of the machine on the test stand will be a function of the agreed upon test conditions and, unless the test-stand results are obtained at the conditions of pressure, temperature, speed, and load expected in the field, they may not be the same as the results expected in the field.

A.8.2 The parameters to be measured during the test shall be speed and shaft synchronous (1X) vibration amplitudes with the corresponding phase. The vibration amplitudes and phase from each pair of *x–y* vibration probes shall be vectorially summed at each response peak to determine the maximum amount of vibration. The major-axis amplitude of each response peak shall not exceed the limits specified in A.6 (more than one application of the unbalance weight and test run may be required to satisfy these criteria).

The gain of the recording instruments used shall be predetermined and preset before the test so that the highest response peak is within 60% – 100% of the recorder's full scale on the test-unit coast-down (deceleration). The major-axis amplitudes at the operating speed nearest the critical or criticals of concern shall not exceed the values predicted in accordance with A.6, before coastdown through the critical of concern.

A.8.3 Vectorial addition of slow-roll (300 rpm – 600 rpm) electrical and mechanical runout is required to determine the actual vibration amplitudes and phase during the verification tests. Vectorial addition of bearing housing motion is required for machines having flexible rotor supports (see A.4, item f).

Note 1: The phase on each vibration signal, x or y, is the angular measure, in degrees, of the phase difference (lag) between a phase reference signal (from a phase transducer sensing a once-per-revolution mark on the rotor, as described in API 670) and the next positive peak, in time, of the synchronous (1X) vibration signal. (A phase change will occur through a critical or a change in a rotor's balance condition occurs because of shifting or looseness in the assembly).

Note 2: The major-axis amplitude is properly determined from a lissajous (orbit) display on an oscilloscope, or equivalent instrument. When the phase angle between the x and y signals is not 90 degrees, the major axis amplitude can be approximated by $(x^2 + y^2)^{1/2}$. When the phase angle between the x and y signals is 90 degrees, the major-axis value is the greater of the two vibration signals.

A.8.4 The results of the verification test shall be compared with those from the original analytical model. The vendor shall correct the model if it fails to meet any of the following criteria:

a. The actual critical speeds shall not deviate from the predicted speeds by more than ± 5%.

b. The predicted amplification factors shall not deviate from the actual test-stand values by more that ± 0%.

c. The actual response peak amplitudes, including those that are critically damped, shall be within ± 50% of the predicted amplitudes.

A.8.5 Additional testing is required if, from the test data described or from the damped, corrected unbalanced response analysis (see A.8.4), it appears that either of the following conditions exists:

a. Any critical response will fail to meet the separation margin requirements (see A.5) or will fall within the operating speed range.

b. The requirements of A.6 have not been met.

A.8.6 Rotors requiring additional testing per A.8.5 shall receive additional testing as follows: Unbalance weights shall be placed as described in A.4, item b; this may require disassembly of the machine. Unbalance magnitudes shall be achieved by adjusting the indicated unbalance that exists in the rotor from the initial run to raise the displacement of the rotor at the probe locations to the vibration limit defined by Equation 2 (see A.4, item b) at the maximum continuous speed. However, the unbalance used shall be no less than twice the unbalance limit specified in A.8.2. The measurements from this test, taken in accordance with A.8.2, shall meet the following criteria:

a. At no speed outside the operating speed range, including the separation margins, shall the shaft deflections exceed 90% of the minimum design running clearances.

b. At no speed within the operating speed range, including the separation margins, shall the shaft deflections exceed 55% of the minimum design running clearances or 150% of the allowable vibration limit at the probes (see A.4, item b).

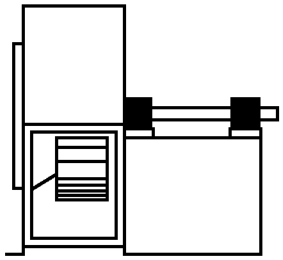
The internal deflection limits specified in this section, items a and b, shall be based on the calculated displacement ratios between the probe locations and the areas of concern identified in A.4, item c. Actual internal displacements for these tests shall be calculated by multiplying these rations by the peak readings from the probes. Acceptance will be based on these calculated displacements or inspections of seals if the machine is opened. Damage to any portions of the machine as a result of this testing shall constitute failure of the test. Minor internal seal rubs that do not cause clearance changes outside the vendor's new-part tolerance do not constitute damage.

APPENDIX B—DRIVE ARRANGEMENTS FOR FANS

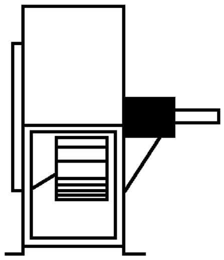
SW – Single Width **DW** – Double Width

SI – Single Inlet **DI** – Double Inlet

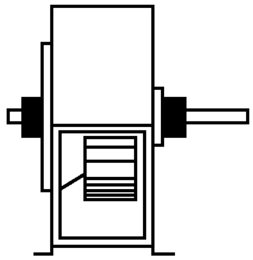
Arrangements 1, 3, 7, and 8 are also available with bearings mounted on pedestals or base set independent of the fan housing.



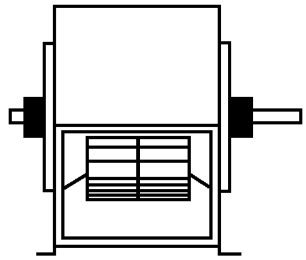
Arr. 1 SWSI For belt drive or direct connection. Impeller overhung. Two bearings on base.



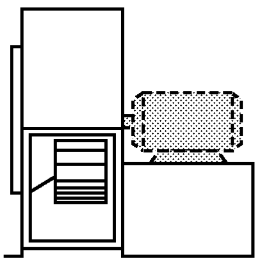
Arr. 2 SWSI For belt drive or direct connection. Impeller overhung. Bearings in bracket supported by fan housing.



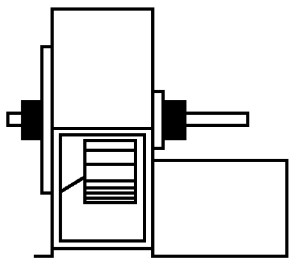
Arr. 3 SWSI For belt drive or direct connection. One bearing on each side and supported by fan housing.



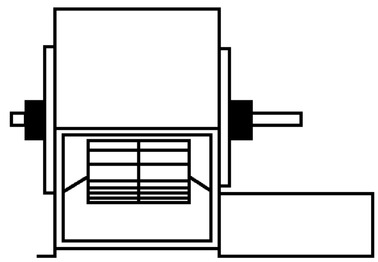
Arr. 3 DWDI For belt drive or direct connection. One bearing on each side and supported by fan housing.



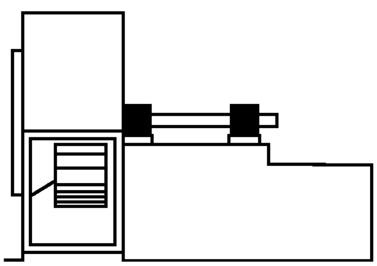
Arr. 4 SWSI For direct drive. Impeller overhung on prime mover shaft. No bearings on fan. Prime mover base mounted or integrally directly connected.



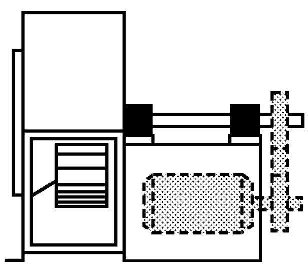
Arr. 7 SWSI For belt drive or direct connection. Arrangement 3 plus base for prime mover.



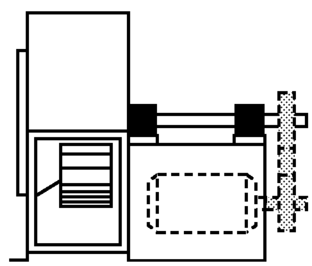
Arr. 7 DWDI For belt drive or direct connection. Arrangement 3 plus base for prime mover.



Arr. 8 SWSI For belt drive or direct connection. Arrangement 1 plus extended base for prime mover.



Arr. 9 SWSI For belt drive. Impeller overhung, two bearings, with prime mover outside base.

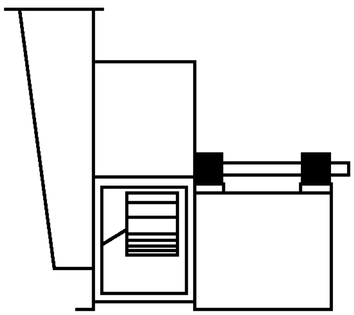


Arr. 10 SWSI For belt drive. Impeller overhung, two bearings, with prime mover inside base.

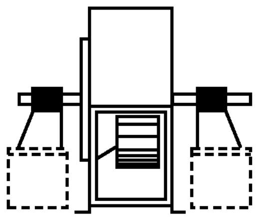
The above arrangements are obtained from ACMA Publication 201-90.

Figure B-1—Drive Arrangements for Centrifugal Fans (Page 1 of 2)

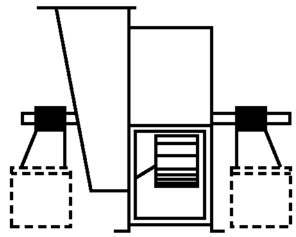
SW – Single Width **DW** – Double Width
SI – Single Inlet **DI** – Double Inlet



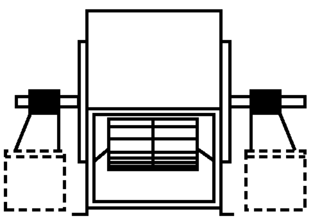
Arr. 1 SWSI with Inlet Box: For belt drive or direct connection. Impeller overhung, two bearings on base. Inlet box may be self-supporting.



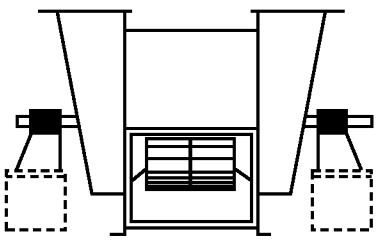
Arr. 3 SWSI with Independent Pedestal: For belt drive or direct connection fan. Housing is self-supporting. One bearing on each side supported by independent pedestals.



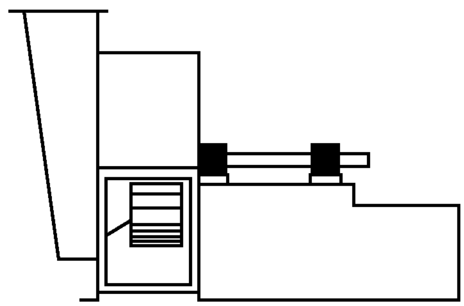
Arr. 3 SWSI with Inlet Box and Independent Pedestals: For belt drive or direct connection fan. Housing is self-supporting. One bearing on each side supported by independent pedestals with shaft extending through inlet box.



Arr. 3 DWDI with Independent Pedestal: For belt drive or direct connection fan. Housing is self-supporting. One bearing on each side supported by independent pedestals.



Arr. 3 DWDI with Inlet Box and Independent Pedestals: For belt drive or direct connection fan. Housing is self-supporting. One bearing on each side supported by independent pedestals with shaft extending through inlet box.



Arr. 8 SWSI with Inlet Box: For belt drive or direct connection. Impeller overhung, two bearings on base plus extended base for prime mover. Inlet box may be self-supporting.

The above arrangements are obtained from ACMA Publication 201-90.

Figure B-2—Drive Arrangements for Centrifugal Fans (Page 2 of 2)

APPENDIX C—TYPICAL DATA SHEETS

	JOB NO. ______ ITEM NO. ______
	PURCHASE ORDER NO. ______
	SPECIFICATION NO. ______
CENTRIFUGAL FAN (API 673-2ND. EDITION) **DATA SHEET** **U.S. CUSTOMARY UNITS**	REVISION NO. ______ DATE ______ PAGE 1 OF 10 BY ______

1 APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT — REVISION: ______
2 FOR: ______
3 SITE: ______ — UNIT: ______
4 SERVICE: ______ — NO. REQUIRED: ______
5 NOTE: ○ INDICATES INFORMATION TO BE COMPLETED BY PURCHASER ☐ BY MANUFACTURER

6 **GENERAL**

7 FAN MFR. ______ SIZE ______ TYPE/ARRANGEMENT ______ SERIAL NO. ______
8 DRIVER MFR. ______ DRIVER TYPE ______ RATED HP ______ RPM ______
9 FURNISHED BY ______ MOUNTED BY ______ PER SPECIFICATION ______ PER DATA SHEET ______
10 DRIVE SYSTEM ○ DIRECT COUPLED ○ OTHER ______ FAN ROTATION, FROM DRIVEN END ______ CW ______ CCW

11 **OPERATING CONDITIONS**

	NORMAL	RATED	OTHER CONDITIONS			
12 (ALL DATA ON PER UNIT BASIS)						
13			A	B	C	D
14 ○ OPERATING CONDITIONS/CASE						
15 ○ GAS HANDLED (See Page ____)						
16 ○ DENSITY (LB/FT_)						
17 ○ DELIVERED SCFM (14-7 PSIA & 60°F DRY)						
18 ○ WEIGHT FLOW LB/MIN (WET)						
19 **INLET CONDITIONS:**						
20 ○ TEMPERATURE (°F)						
21 ○ RELATIVE HUMIDITY (%)						
22 ○ MOLECULAR WEIGHT (MIN.)						
23 ☐ INLET VOLUME (ICFM WET)						
24 ☐ Cp/Cv (K_1) OR (K_{AVG})						
25 ☐ COMPRESSIBILITY (Z_1) OR (Z_{AVG})						
26 ○ STATIC PRESSURE @ SOUND TRUCK (IN. WG)						
27 ☐ PRESSURE LOSS ACROSS SOUND TRUCK (IN. WG)						
28 ○ STATIC PRESSURE @ INLET DAMPERS (IN. WG)						
29 ○ STATIC PRESSURE @ FAN INLET (IN. WG)						
30 **DISCHARGE CONDITIONS:**						
31 ☐ STATIC PRESSURE @ FAN OUTLET (IN. WG)						
32 ☐ STATIC PRESS. @ DISCHARGE DAMPER (IN. WG)						
33 ☐ ΔP ACROSS DISCHARGE DAMPER (IN. WG)						
34 ☐ ΔP ACROSS EVASE (IN. WG)						
35 ○ STATIC PRESSURE @ EVASE OUTLET (IN. WG)						
36 **PERFORMANCE:**						
37 ☐ BHP REQUIRED @ TEMP. (ALL LOSSES IND.)						
38 ☐ FAN SPEED (RPM)						
39 ○ GUARANTEE POINT						
40 ☐ PERFORMANCE CURVE NO.						
41 ☐ STATIC ΔP ACROSS FAN (IN. WG)						
42 ☐ INLET DAMPER/VANE POSITION						
43 ☐ DISCHARGE DAMPER POSITION						
44 ☐ FAN STATIC EFFICIENCY (%)						

45 **FAN CONTROL:**
46 ○ AIR SUPPLY ______ ○ FAN CONTROL FURNISHED BY ______
47 ○ CONTROL SIGNAL TYPE ______ SOURCE ______ SENSITIVITY ______ RANGE ______
48 ○ ARRANGEMENT DRWG NO. ______ CONTROL SIGNAL FAILURE MODE ○ CLOSE ○ OPEN ○ AUTOLOCK
49 **METHOD:** ○ INLET DAMPER ○ OUTLET DAMPER ○ INLET GUIDE VANES
50 ○ STARTING CONDITIONS ______ ○ STARTING METHOD ______
51 ○ START & STOP RESTRICTIONS ______
52 ○ VENDOR REVIEW OF CONTROL SYSTEM REQUIRED ○ OTHER ______

CENTRIFUGAL FAN (API 673-2ND. EDITION) **DATA SHEET** **U.S. CUSTOMARY UNITS**	JOB NO. ______ ITEM NO. ______ REVISION ______ DATE ______ PAGE 2 OF 10 BY ______

OPERATING CONDITIONS

GAS ANALYSIS		NORMAL	RATED	CONDITIONS				REMARKS
○ MOL% ○ ______				A	B	C	D	
	MW							
AIR	28.97							
OXYGEN	32.00							
NITROGEN	28.02							
WATER VAPOR	18.02							
CARBON MONOXIDE	28.01							
CARBON DIOXIDE	44.01							
HYDROGEN SULFIDE	34.08							
HYDROGEN CHLORIDE	36.47							
CHLORINE	70.91							
TOTAL								
AVG. MOL WT.								

CORROSIVES:

○ CORROSION/EROSION CAUSED BY ______

○ CORROSION EROSION PROTECTION ______

○ NACE MR-01-90 MATERIALS REQUIRED ______

______

LOCATION, SITE DATA

LOCATION:

○ INDOOR ○ HEATED ○ UNDER ROOF

○ OUTDOOR ○ UNHEATED ○ PARTIAL SIDES

○ GRADE ○ MEZZANINE ○ ______

○ WINTERIZATION REQ'D ○ TROPICALIZATION REQ'D

SITE DATA:

○ ELEVATION ______ FT. ○ BAR ______ PSIA/IN. Hg A

○ TEMPERATURE ______ °F SUMMER ______ °F WINTER

○ WIND LOAD ______ PSF ○ VELOCITY ______ MPH

○ MINIMUM DESIGN METAL TEMPERATURE ______ °F

UNUSUAL CONDITIONS:

○ DUST ○ FUMES

○ OTHER

______

______

______

______

______

______

______

______

ELECTRICAL AREA CLASSIFICATION:

○ CLASS ______ GROUP ______ DIVISION ______

SPECIFICATIONS

NOISE SPECIFICATIONS:

○ APPLICABLE TO MACHINE:

See Specification ______

○ APPLICABLE TO NEIGHBORHOOD

See Specification ______

ACOUSTIC HOUSING: ○ YES ○ NO

APPLICABLE SPECIFICATIONS:

PAINTING:

○ MANUFACTURER'S STD.

○ OTHER ______

SHIPMENT:

○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQ'D.

○ OUTDOOR STORAGE OVER 6 MONTHS

ERECTION:

SHIPPED ☐ ASSEMBLED ☐ PARTLY ASSEMBLED

☐ OTHER ______

☐ EXTENT OF FIELD ERECTION & ASSEMBLY ______

______ MAN HOURS ______

☐ OTHER ______

REMARKS: ______

______

JOB NO. ______ ITEM NO. ______
REVISION ______ DATE ______
PAGE 3 OF 10 BY ______

CENTRIFUGAL FAN (API 673-2ND. EDITION)
DATA SHEET
U.S. CUSTOMARY UNITS

CONSTRUCTION FEATURES

☐ **SPEEDS:**
MAX CONT. ______ RPM TRIP ______ RPM
MAX TIP SPEEDS ______ FPS @ RATED
______ FPS @ MAX. CONT.

☐ **LATERAL CRITICAL SPEEDS(2.7.2):**
FIRST CRITICAL ______ RPM ☐ DAMPED ☐ UNDAMPED
○ TRAIN LATERAL ANALYSIS REQUIRED
☐ SUBMIT X - Y PLOT (COUPLED DRIVER & FAN)

☐ **TORSIONAL CRITICAL SPEEDS(2.7.3):**
FIRST CRITICAL ______ RPM
☐ SUBMIT X - Y PLOT (COUPLED DRIVER & FAN)
☐ TORSIONAL VIBRATION ANALYSIS FOR FAN & DRIVER
☐ TRNS'NT TORS'NAL ANLYS. FOR SYNCHRNS. DRIVER UNITS
ALLOWABLE TEST LEVEL ______ MILS
(Peak To Peak)

MATERIAL ______
CONSTRUCTION ______
☐ INLET BELL ______
☐ EVASE (DETAIL IN PROPSAL)
○ INSULATION REQUIRED ○ INSULATION STUDS BY: ______
☐ INSULATION TYPE ______ THICKNESS ______ IN.
☐ FAN HOUSING NEAR-CENTERLINE SUPPORT REQUIRED(2.2.5)
☐ DRAINS: No./SIZE ______ TYPE/LOC. ______
☐ FAN INLET ACCESS: SPLIT FOR ROTOR REMOVAL
☐ MANWAYS: SIZE ______ IN. TYPE/LOC. ______
SIZE ______ IN. TYPE/LOC. ______

BEARING HOUSING:
☐ CONSTRUCTION ______ MATERIAL ______
BEARINGS
○ HYDRODYNAMIC ○ ANTI-FRICTION
MOUNTING PEDESTALS ○ YES ○ NO
SOLE PLATES ○ YES ○ NO
☐ **RADIAL BEARINGS:**

	MFG./No.	LOAD (Lbs)	LENGTH (IN.)	DIA. (IN.)
INBOARD				
OUTBOARD				

Dn FACTOR ______ L-10 ______ HRS
LOAD FACTOR ______
MAX. SPEED ______ RPM @ ______ °F
CLEARANCE ______ IN
BEARING SPAN (CL – CL) ______ IN
☐ **THRUST BEARINGS:**
TYPE (Dual Bell, Flat Land, Tapered Land, Tilt-Pad)
______
MFG./No. ______ AREA ______ IN^2
LOADING (PSI): ACTUAL ______ ALLOW ______
Dn FACTOR ______ L-0 ______ HRS
LOAD FACTOR ______
MAX. SPEED ______ RPM @ ______ °F
☐ THRUST COLLAR (On Inboard Bearing): TYPE: ______
TYPE ATTACHMENT: ______
______
○ INTEGRAL THRUST COLLAR REQUIRED(2.8.4.2.2)

ACCESSORIES:
○ TEMP DETECTORS (METAL) (OIL) ○ THRUST ○ JOURNAL
TYPE ______ MFG./NO. ______ ○ API 670
○ END SEALS ○ LABYRINTH ○ DOUBLE CONTACT
○ THERMOSTATICALLY CONTROLLED HEATERS ○ YES ○ NO
☐ TYPE ______ MFG / NO. ______
LUBRICATION: ○ CONSTANT LEVEL OILER(2.8.5.1) ○ PURE OIL MIST
○ PURGE OIL MIST ○ OTHER ______ (See Pg. 6)
COOLANT REQUIRED ☐ NONE ☐ AIR
☐ WATER ______ GPM@ ______ °F

☐ **ROTOR:**
SHAFT LENGTH (IN.) ______ DIA. @ WHEEL ______ IN.
MATERIAL ______
CONSTRUCTION ______
TIR @ SLEEVE ______ IN. DIA. @ BEARING ______ IN.

☐ **BLADES:**
No. of BLADES ______ DIAMETERS (IN.) ______
TYPE (HOLLOW OR SOLID AIRFOIL, SINGLE, THICKNESS, ETC.) ______
______
TYPE FABRICATION ______
MATERIAL ______ COATING TYPE ______
WEAR PLATES ______ MATERIAL ______
HUB: ○ SHRINK FIT ○ KEYED
MATERIAL ______ CONSTRUCTION ______
ROTOR WT. (Lbs.) ______ WR^2(Lb./Ft^2) ______
KEY WAY: No. ______ DIM ______ x ______ x ______ IN.
○ MAX. HEATING / COOLING RATE ______ / ______ °F/MIN.
MAX. ALL HEAT/COOL RATE ______ / ______ °F/MIN.

☐ **SHAFT SLEEVES:**
LENGTH (IN.) ______ DIA. (IN.) ______
SHRINK FIT ______ ☐ CORROSION RESISTANT MATL.

☐ **SHAFT SEALS:**
TYPE ______ MATERIAL ______
BUFFER OR EDUCTOR CONNECTIONS ______
DETAILS: ______

☐ **MAIN CONNECTIONS (2.3)**
INLET: No. ______ SIZE ______ x ______ AREA (FT^2) ______
☐ FLANGE SIZE ______ BOLTING ______
○ LOCATION/ORIENTATION ______
☐ EXP. JOINT REQ'D ______ FURN. BY ______
OUTLET: SIZE ______ x ______ AREA (FT^2) ______
☐ FLANGE SIZE ______ BOLTING ______
○ LOCATION/ORIENTATION ______
☐ EXP. JOINT REQ'D ______ FURN. BY ______
○ MATING FLG BY VENDOR ○ ASME B16.5 ○ ASME B16.47

☐ **OTHER CONNECTIONS (2.3):**

SERVICE	No.	SIZE	TYPE
LUBE OIL INLET			
LUBE OIL OUTLET			
COOLING WATER INLET			
COOLING WATER OUTLET			
PRESSURE GAGE			
TEMP. GAGE			
CONDENSATE DRAINS			

	JOB NO. ________ ITEM NO. ________
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1 **CONSTRUCTION FEATURES (Continued)**

NOISE ATTENUATION:	BASEPLATES & SOLEPLATES:
3 ○ MAX. ALLOW SOUND PRESS LEVEL ____ DBA@ ____ FT	○ TRI- DIRECTIONAL ADJUSTING SCREWS FOR EQUIP.
4 ☐ PREDICTED SOUND PRESS LEVEL ____ DBA@ ____ FT	○ PILOT HOLES FOR DOWELS
5 ☐ ATTENUATION METHOD ____	○ TYPE GROUT ____ TYPE PRECOAT ____
6 ____	SOLEPLATES FOR ○ BEARING PEDESTALS ○ GEAR
7 ○ FURNISHED BY ____	○ DRIVER ○ FAN HOUSING SUPPORTS
8 ☐ SILENCER MFG/MODEL No. ____	BASE PLATE:
9 ____	○ COMMON (Under Fan, Gear, Driver) ○ FAN ALONE
10 ☐ ACOUSTIC PERF ____	○ OTHER ○ DIMENSIONS ____ x ____ x ____ FT
11 ☐ AERODYNAMIC PERF ____ CFM ____ °F	DECKING ○ NON SKID ○ OPEN CONSTRUCTION
12 LOSS ____ IN WG.	○ DRIP RIM ○ OPEN DRAIN
13 ☐ ACCESSORIES ____	SUITABLE FOR ○ COLUMN or ○ PERIMETER SUPPORT
14 **FAN CLEANING SYSTEM (2.1.22):**	○ LEVELING PADS W/REMOVABLE COVER
15 ○ REQUIRED ____ CLEANING MEDIUM ____	○ SUBSOLE PLATES REQUIRED
16 ☐ MFR./MODEL ____ FURN BY ____	____
17 ○ INSTALLED BY ____	____
18 ☐ DETAILS/DWG.No. ____	____

19 **FAN ITEMS:**	○ CORROSION ALLOWANCE	☐ SIZE/THICKNESS (INCL. C.A.)	☐ MATERIAL	☐ MATERIAL SPECIFICATION
21 SHAFT				
22 BLADES				
23 HUB				
24 CENTER PLATE				
25 SHROUDS				
26 SLEEVES				
27 SEALS				
28 HOUSING				
29 DAMPERS				
30 GUIDE VANES				
31 RAIN HOODS				
32 INLET BELTS				
33 EVASE (Discharge, Diffuser)				
34 SOUND TRUCK				
35 INLET DUCT				
36 WEAR PLATES				

37 **COUPLINGS:**	DRIVER—FAN	GEAR—FAN	DRIVER—GEAR
39 ○ COUPLING & GUARD			
40 FURNISHED BY:			
41 ○ TYPE			
42 ☐ MFG.			
43 ☐ MODEL/NUMBER			
44 ○ LUBRICATION			
45 ○ MOUNT CPLG. HALVES			
46 —FAN			
47 —DRIVER			
48 —GEAR			
49 ○ SPACER LENGTH			
50 ○ LTD. END FLOAT REQ'D			
51 ○ COUPLING GUARD REQ'D			
52 ☐ SERVICE FACTOR			
53 ☐ CPLG. RATING HP/100 RPM			
54 ☐ KEYED or HYDR FIT			
55 ○ ADAPTER (Solo) PLATE			
56 ☐ MATERIALS			

CENTRIFUGAL FAN (API 673-2ND. EDITION) **DATA SHEET** **U.S. CUSTOMARY UNITS**	JOB NO. ______ ITEM NO. ______ REVISION ______ DATE ______ PAGE 5 OF 10 BY ______

CONSTRUCTION FEATURES (Continued)

☐ **ALLOWABLE EXTERNAL LOADS**

	INLET		DISCHARGE	
	FORCE LBS	MOMT. FT-LBS	FORCE LBS	MOMT. FT-LBS
AXIAL				
VERTICAL				
HORIZ. 90°				

VIBRATION DETECTORS:

○ PROVISIONS FOR VIBRATION TRANSDUCERS(THREADED CONN.)
○ FLAT SURFACES FOR MAGNETIC MOUNTED TRANSDUCERS
○ SEISMIC SENSOR COVER (S) BY ______
○ PROVISIONS FOR MOUNTING NON-CONTACTING VIB. PROBES
○ PER API 670

SPEED DETECTORS (On Outdoor Bearing):

○ NON-CONTACT PROBE ○ SPEED SWITCH
○ OTHER ______
○ TYPE ______ ☐ MODEL ______
○ MFG ______
○ LOCATION ______
☐ SCALE RANGE ______ RPM

SHOP INSPECTIONS & TESTS:	REQ'D.	OBSERV'D	WIT.
SHOP INSPECTION	○	○	○
CLEANLINESS INSPECTION	○	○	○
HARDNESS VERIFICATION	○	○	○
CHARPY IMPACT TESTING	○	○	○
SHAFT RUN OUT CHECK	○	○	○
ROTOR BALANCING	○	○	○
REBAL. AFTER MOUNTING CPLG.	○	○	○
RESIDUAL BALANCE CHECK	○	○	○
CALIBRT'N CK. OF BALNC'G EQUIP	○	○	○
NDT EXAMINATION	○	○	○
ASSEMBLY & FIT UP CHECK	○	○	○
INITIAL &/or FINAL ALIGN	○	○	○
GEAR TOOTH CNTCT. CHK. (API 677)	○	○	○
MECHANICAL RUN TEST	○	○	○
FULL UNIT MECHANICAL RUN TEST	○	○	○
VIBRATION TEST	○	○	○
SOUND LEVEL TEST	○	○	○
MAT'L CERTIFICATION	○	○	○
SURFACT & SUBSURFACE INSPCT.	○	○	○
TYPE			
PRESSURE TEST:	○	○	○
—HOUSING	○	○	○
—DUCTING	○	○	○
—LUBE OIL SYSTEM	○	○	○
RUN & CHECK LUBE CONSOLE	○	○	○
SHOP PERFORMANCE TEST	○	○	○
PRE-SHIPMENT INSPECTION	○	○	○
—DRIVER / AUX. MOUNTED	○	○	○
QUALITY CONTROL REVIEW	○	○	○
FIELD PERFORMANCE TEST	○	○	○
OTHERS: ______	○	○	○
______	○	○	○
______	○	○	○

☐ **WEIGHTS LBS:**

FAN ______ DRIVER ______ BASE ______
ROTORS FAN ______ DRIVER ______ BASE ______
GEAR UPPER CASE ______
SOUND TRUNK ______ EVASE ______
SYSTEMS: LUBE ______ CLEANING ______
CONTROL PANEL ______
MAX. FOR MAINTENANCE (Identify) ______
TOTAL SHIPPING WEIGHT ______

☐ **SPACE REQUIREMENTS (FEET & INCHES)**

	L	W	H
COMPLETE UNIT			
CONTROL PANEL			
______			

UTILITY REQUIREMENTS:

STEAM ______ WATER ______ ELECTRIC ______

MISCELLANEOUS:

○ VENDOR'S REVIEW & COMMENTS ON FOUNDATION DESIGN
○ VENDOR'S REV. & C'MNTS ON CONTRACTOR'S DUCT DESIGN
○ TORSIONAL ANALYSIS REPORT REQUIRED
○ TURNING GEAR, TYPE DRIVER ______
○ AUTO ○ MANUAL ENGAGE ○ START FROM REST
○ RAINHOOD & CAP
○ INLET AIR FILTER
○ INLET DAMPER
○ INLET GUIDE VANE
○ INLET TRASH SCREEN
○ OUTLET DAMPER
○ SOUND TRUCK (INLET BOX/ SILENCER)
○ BOLTING & GASKETS

REMARKS: ______

JOB NO. ______ ITEM NO. ______
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CENTRIFUGAL FAN (API 673-2ND. EDITION)
DATA SHEET
U.S. CUSTOMARY UNITS

LUBE OIL SYSTEM

CIRCULATING OR PRESSURIZED LUBE OIL SYSTEM BY: ______ ○ API 614 REQUIRED

PIPING MATERIALS:

	CARBON STEEL	STAINLESS STEEL
○ COMPLETE SYSTEM		
○ DOWNSTREAM OF FILTERS		
○ RETURN PIPING		

○ CARBON STEEL SLIP-ON FLANGES ON STNLESS. STEEL PIPING

SYSTEM COMPONENT SUPPLIERS:

	MANUFACTURER	MODEL
☐ MAIN PUMP		
☐ STANDBY PUMP		
☐ ELECTRIC MOTOR (S)		
☐ STEAM TURBINE (S)		
☐ OIL COOLER (S)		
☐ OIL FILTER (S)		
☐ ACCUMULATOR (S)		
☐ SUCT. STRAINER (S)		
☐ CHECK VALVE (S)		
☐ SWITCH VALVE (S)		
☐ PUMP COUPLING (S)		
☐ TEMP. INDICATORS		
☐ L.P. SHUTDOWN SWITCH		

SYSTEM PRESSURES:

☐ DESIGN ______ PSIG ☐ HYDROTEST ______ PSIG
☐ PUMP RELIEF VALVE (S) SETTINGS ______ PSIG

BASIC SYSTEM REQUIREMENTS **(NORMAL OIL FLOW)**

☐ LUBE OIL	GPM	PSIG	SSU @ 100 °F	SSU @ 210 °F
FAN				
DRIVER				
GEAR				

☐ COMMON LUBE SYSTEM ______

PUMPS:

	MAIN	STANDBY
○ HORIZONTAL		
○ VERTICAL		
○ SUBMERGED		
○ MOTOR DRIVEN		
○ TURBINE DRIVEN		
○ SHAFT DRIVEN		
○ CENTRIFUGAL		
○ GEAR/SCREW		
○ FLANGE CONNECTED		
☐ GPM (RATED)		
☐ @ PSIG		
☐ BHP @ 100 SSU		
☐ DRIVER HP		
○ CASING MATERIAL		
☐ SPEED		
○ COUPLING		
☐ GUARD		
○ MECH. SEAL		

EMERGENCY LUBE OIL PUMP:

○ AIR MOTOR DRIVEN ○ OTHER
○ SAFETY GUARD REQUIRED

STANDBY PUMP CONTROL:

○ RESET ○ MANUAL ○ AUTOMATIC
○ AUTOMATIC START
○ "ON-OFF-AUTO" SELECTOR SWITCH

RESERVOIR:

○ MATERIAL ______
RETENTION TIME ______ MIN. CAPACITY ______ GAL.
○ BASEPLATE MOUNTED ○ FABRICATED STEEL BASE
○ BAFFLE REQUIRED ○ INTERIOR COATING
FREE SURFACE AREA ______ FT^2
○ HEATER (S) ○ ELECT. ○ STREAM ○ MIN SITE ______ °F
○ FLTR./BRTHR. ○ FLANGED VNT. HEAT-UP TIME ______ Hrs.
○ PRESS. RELIEF VENT ○ INSULATION SUPPORTS
○ SPRING LOADED FILL CAP w/S.S. STRAINER

OIL COOLERS:

☐ AIR ☐ WATER ______ GPM @ ______ °F
○ SINGLE ○ SINGLE
○ W/ BYPASS & TEMP CNTRL. VALVE ○ MANUAL ○ AUTO
○ ASME CODE STAMP
○ HEATING STEAM ______ PSIG ______ °F
○ FOUL. FACTR.: SHELLSIDE ______ TUBE SIDE ______
☐ MAKE ______ ☐ TYPE ______

☐ DUTY ______ BTU/HR ☐ SURFACE ______ °F
○ CODE (S) ______
☐ DESIGN PRESS. PSIG SHELL SIDE ______ TUBE SIDE ______

☐ TUBES: O.D. ______ IN. ☐ TOTAL SURFACE AREA ______ FT^2
WALL THICKNESS (AVE) (MIN) ______ IN.
LENGTH ______ IN. NUMBER: ______
☐ MATERIALS
TUBES ______
TUBE SHEETS ______

SHELL ______
TUBE SUPPORT ______
SHELL COVER/FLANGE ______

ACCUMULATOR:

○ SINGLE ○ MULTI
○ ASME CODE DESIGN ○ ASME CODE STAMP
○ MATERIAL
☐ CORROSION ALLOWANCE (IN.) ______
☐ CAPACITY (TOTAL) GAL. ______
☐ PRE-CHARGE PRESS. (PSIG) ______
○ DIRECT CONTACT TYPE ○ BLADDER TYPE
☐ BLADDER MATERIAL ______
○ WITH SUPPLY REGULATOR ○ MANU. CHARGE VALVE

FILTERS: MFG: ______

○ SINGLE ○ TWIN
○ ASME CODE DESIGN ○ ASME CODE STAMP
○ MICRON (μ) ______
☐ FILTER MEDIUM ______
☐ DESIGN PRESS. PSIG ______

☐ ΔP CLEAN (PSI) ______
☐ ΔP COLLAPSE (PSI) ______
☐ CASING MATERIAL ______
☐ CARTRIDGE INDENT NO. ______
○ FURNISH SET OF SPARE CARTRIDGE W/ FILTERS ______

CENTRIFUGAL FAN (API 673-2ND. EDITION) **DATA SHEET** **U.S. CUSTOMARY UNITS**	JOB NO. ______ ITEM NO. ______ REVISION ______ DATE ______ PAGE 7 OF 10 BY ______

INSTRUMENTATION

○ PER API 614 ○ OTHER ______

LOCAL CONTROL PANEL:

FURNISHED BY: ☐ VENDOR ☐ PURCHASER ☐ OTHERS

☐ BASE MOUNTED ☐ FREE STANDING ☐ WEATHERPROOF ☐ TOTALLY ENCLOSED ☐ EXTRA CUTOUTS

☐ VIBRATION ISOLATORS ☐ STRIP HEATERS ☐ PURGE CONNECTIONS ☐ WITH DOORS

☐ ANNUNCIATOR WITH FIRST OUT INDICATION LOCATED ON LOCAL PANEL

☐ CUSTOMER CONNECTIONS BROUGHT OUT TO TERMINAL BOXES BY VENDOR

REMARKS: ______

INSTRUMENT SUPPLIERS:

PRESSURE GAGES	MFR.		SIZE & TYPE	
TEMPERATURE GAGES	MFR.		SIZE & TYPE	
LEVEL GAGES	MFR.		SIZE & TYPE	
DIFF. PRESSURE GAGES	MFR.		SIZE & TYPE	
PRESSURE SWITCHES	MFR.		SIZE & TYPE	
DIFF. PRESSURE SWITCHES	MFR.		SIZE & TYPE	
TEMPERATURE SWITCHES	MFR.		SIZE & TYPE	
LEVEL SWITCHES	MFR.		SIZE & TYPE	
CONTROL VALVES	MFR.		SIZE & TYPE	
PRESSURE RELIEF VALVES	MFR.		SIZE & TYPE	
SIGHT FLOW INDICATORS	MFR.		SIZE & TYPE	
VIBRATION EQUIPMENT	MFR.		SIZE & TYPE	
TACHOMETER	MFR.		RANGE &TYPE	
SOLENOID VALVES	MFR.		SIZE & TYPE	
ANNUNCIATOR	MFR.		MODEL & No. POINTS	
☐ DAMPER/VANE ACTUATOR	MFR.		MODEL	

○ FURNISHED BY ______ ☐ TYPE ______ ☐ MAX. TORQUE (FT/LBS) ______

NOTE: ☐ SUPPLIED BY VENDOR ○ SUPPLIED BY PURCHASER

PRESSURE GAGE REQUIREMENTS:

FUNCTION	LOCALLY MOUNTED	LOCAL PANEL	FUNCTION	LOCALLY MOUNTED	LOCAL PANEL
LUBE OIL PUMP DISCHARGE	☐ ○	☐ ○	FAN DISCHARGE (IN. WG.)	☐ ○	☐ ○
LUBE OIL FILTER D P	☐ ○	☐ ○	CONTROL AIR (PSIG)	☐ ○	☐ ○
LUBE OIL SUPPLY	☐ ○	☐ ○	FAN SUCTION (IN. WG.)	☐ ○	☐ ○
	☐ ○	☐ ○		☐ ○	☐ ○
	☐ ○	☐ ○		☐ ○	☐ ○

TEMP. GAGE REQUIREMENTS:

FUNCTION	LOCALLY MOUNTED	LOCAL PANEL	FUNCTION	LOCALLY MOUNTED	LOCAL PANEL
LUBE OIL TO BEARINGS	☐ ○	☐ ○	OIL COOLER INLET & OUTLET	☐ ○	☐ ○
DISCHARGE FROM EACH	☐ ○	☐ ○	FAN SUCTION	☐ ○	☐ ○
PINION JOURNAL BEARING	☐ ○	☐ ○		☐ ○	☐ ○
BULL GEAR JOURNAL BEARING	☐ ○	☐ ○		☐ ○	☐ ○
FAN THRUST BEARING	☐ ○	☐ ○		☐ ○	☐ ○
DRIVER JOURNAL BEARING	☐ ○	☐ ○		☐ ○	☐ ○
DRIVER THRUST BEARING	☐ ○	☐ ○		☐ ○	☐ ○
GEAR THRUST BEARING	☐ ○	☐ ○		☐ ○	☐ ○
FAN JOURNAL BEARING	☐ ○	☐ ○		☐ ○	☐ ○
	☐ ○	☐ ○		☐ ○	☐ ○

SWITCH CLOSURES:

ALARMCONTACTS SHALL: ☐ OPEN ☐ CLOSE TO SOUND ALARM AND BE NORMALLY ☐ ENERGIZED ☐ DE-ENERGIZED

SHUTDOWN CONTACTS SHALL: ☐ OPEN ☐ CLOSE TO TRIP AND BE NORMALLY ☐ ENERGIZED ☐ DE-ENERGIZED

NOTE: NORMAL CONDITION IS WHEN FAN IS IN OPERATION.

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INSTRUMENTATION (Continued)

MISCELLANEOUS

ALARM AND SHUTDOWN SWITCHES SHALL BE SEPARATE.

ELECTRICAL AND INSTRUMENT CONNECT'NS WITHIN THE CONFINES OF THE FAN BASE SHALL BE BROUGHT OUT TO TERMINAL BOXES.

COMMENTS REGARDING INSTRUMENTATION: ______

ALARM & SHUTDOWN SWITCHES

FUNCTION	ALARM	TRIP	FUNCTION	ALARM	TRIP
☐ ○ LOW LUBE OIL PRESSURE			☐ ○ FAN VIBRATION		
☐ ○ HI LUBE OIL FILTER ΔP			☐ ○ FAN AXIAL POSITION		
☐ ○ LOW LUBE OIL RESERVE LEVEL			☐ ○ DRIVER VIBRATION		
☐ ○ AUX. LUBE OIL PUMP START			☐ ○ DRIVER AXIAL POSITION		
☐ ○ HI INLET AIR FILTER ΔP			☐ ○ FAN MOTOR SHUTDOWN		
☐ ○			☐ ○ HI FAN THRUST BRG. TEMP.		
☐ ○			☐ ○ HI DRIVER THRUST BRG. TEMP.		
☐ ○			☐ ○		

MISCELLANEOUS INSTRUMENTATION:

☐ ○ SIGHT FLOW INDICATORS: EACH JOURNAL & THRUST BEARING OIL RETURN LINE

☐ ○ LEVEL GAGES, LUBE OIL RESERVOIR(S)

☐ ○ VIBRATION READOUT EQUIPMENT

☐ ○ VIBRATION READ OUT LOCATED ON: ☐ LOCAL PANEL ☐ OTHER ______

☐ ○ FAN SPEED PICK-UP DEVICES

☐ ○ FAN SPEED INDICATORS

☐ ○ FAN SPEED INDICATORS LOCATED ON: ☐ LOCAL PANEL ☐ OTHER ______

☐ ○ ALARM HORN & ACKNOWLEDGEMENT SWITCH

☐ ○ ______

☐ ○ ______

☐ ○ ______

REMARKS: ______

ELECTRIC MOTOR (API 673-2ND. EDITION) **DATA SHEET** **U.S. CUSTOMARY UNITS**	JOB NO. ______ ITEM NO. ______ REVISION ______ DATE ______ PAGE 9 OF 10 BY ______

1	APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT	
2	FOR ______	UNIT ______
3	SITE ______	DRIVEN EQUIP. ______
4	SERVICE ______	NO. REQUIRED ______
5	MANUFACTURER ______ MODEL ______	SERIAL NO. ______
6	NOTE: INFORMATION TO BE COMPLETED ○ BY PURCHASER	☐ BY MANUFACTURER
7	**MOTOR DESIGN DATA**	
8	**APPLICABLE SPECIFICATIONS:**	**VIBRATION:**
9	○ NEMA ______	○ NEMA STANDARD ○ ______
10	○ ______	**NOISE**
11	**SITE DATA:**	○ NEMA STANDARD ○ ______
12	AREA: ○ C.L.______ GR.______ DIV.______ ○ N-HAZARDOUS	**THRUST:**
13	○ ALTITUDE ___ FT ○ AMBIENT TEMPS: MAX ___ °F	☐ MAX. MOTOR THRUST ______ LBS.
14	UNUSUAL CONDITIONS ○ DUST ○ FUMES MIN ___ °F	**REMARKS:** ______
15	○ OTHER ______	______
16	**DRIVE SYSTEM:** ○ DIRECT CONNECTED	______
17	○ GEAR	______
18	○ OTHER ______	______
19	**TYPE MOTOR:**	______
20	○ SQUIRREL CAGE INDUCTION ○ NEMA DESIGN ______	______
21	○ SYNCHRONOUS ______	______
22	○ POWER FACTOR REQ'D ______	______
23	EXCITATION: ○ BRUSHLESS ○ SLIP RING	______
24	○ FIELD DISCHARGE RESISTOR BY MOTOR MFR.	**ACCESSORY EQUIPMENT**
25	○ WOUND ROTOR INDUCTION	○ BASEPLATE ○ SOLEPLATE ○ STATOR SHIFT
26	○ ______	○ MFR. STD. FANS ○ NONSPARKING FANS
27	**ENCLOSURE:**	○ **D.C. EXCITATION**
28	○ EXPLOSION PROOF ○ TEFC	☐ KW REQ'D. ______ VOLTS ______
29	○ TEWAC ○ TEIGF, USING ______ GAS	BY: ○ PURCHASER ○ MANUFACTURER
30	○ DOUBLE WALL CARBON STEEL TUBES	DESCRIPTION ______
31	○ WATER SUPP.: PRESS. ______ PSIG TEMP. ______ °F	○ **ENCLOSED COLLECTOR RINGS:**
32	○ WATER ALLOW. Δ P ___ PSI & TEMP RISE ______ °F	○ PURGED MEDIUM ______ PRESS ______ PSIG
33	○ WATER SIDE MIN CORR. ALLOW. ______ IN.	○ EXPLOSION-RESISTANT NONPURGED
34	AND FOUL FACTOR ______	○ FORCE VENTILATION
35	○ (AIR) (GAS) SUPPLY PRESS. ______ PSIG	☐ CFM ______ PRESS. DROP ______ IN. H_2O
36	○ ______	○ **BEARING TEMP. DEVICES:**
37	○ WEATHER PROTECTED TYPE ______	☐ LOCATION ______
38	○ FORCED VENTILATION	☐ DESCRIPTION ______
39	○ OPEN-DRIPPROOF	☐ SET @ ______ °F FOR ALARM ______ °F FOR SHUTDN.
40	○ OPEN	SPACE HEATERS:
41	______	☐ ______ KW ○ ______ VOLT ______ PHASE ______ HERTZ
42	______	○ MAX SHEATH TEMP. ______ °F
43	**BASIC DATA:**	**WINDING TEMPERATURE DETECTORS:**
44	○ ______ VOLTS ______ PHASE ______ HERTZ	○ THERMISTORS No./PHASE ______
45	☐ NAMEPLATE HP ______ SERVICE FACTOR ______	TYPE: ○ POS. TEMP. COEFF. ○ NEG. TEMP. COEFF.
46	○ SYNCHRONOUS RPM ______	TEMPERATURE SWITCH ○ YES ○ NO
47	○ INSULATION CLASS ______ TYPE ______	○ RESISTANCE TEMP. DETECTORS: No./PHASE ______
48	○ TEMP. RISE: ______ °F ABOVE ______ °F BY ______	☐ RESISTANCE MAT. ______ ☐ ______ OHM
49	**STARTING:**	SLCTR. SWITCH & INDICATOR BY: ○ PURCHR. ○ MFR.
50	○ FULL VOLTAGE ○ REDUCED VOLTAGE ______ %	☐ MAX. STATOR WINDING TEMPS:
51	○ LOADED ○ UNLOADED	______ °F FOR ALARM ______ °F FOR SHUTDOWN
52	○ VOLTAGE DIP ______ %	

		JOB NO. ___ ITEM NO. ___	
	ELECTRIC MOTOR (API 673-2ND. EDITION)	REVISION ___ DATE ___	
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1	**ACCESSORY EQUIPMENT (Cont'd)**	**MANUFACTURER'S DATA, (Cont'd)**
2	**WINDING TEMP, DETECTOR & SPACE HEATER LEADS:**	FIELD DISCHARGE RESISTOR ___ OHMS
3	○ IN SAME CONDUIT BOX	RATED EXCITATION FIELD VOLTAGE ___ D.C.
4	○ IN SEPARATE CONDUIT BOXES	RESISTANCE OF EXCITATION FIELD @ 25°C ___ OHMS
5	○ **MOTOR ARRANGED FOR DIFFERENTIAL PROTECTION:**	EXCITATION FIELD AMPS @ FULL LOAD & RATED P.F. ___
6	○ SELF-BALANCE PRIMARY-CURRENT METHOD	EXCITATION FIELD AMPS: MAX. ___ MIN. ___
7	○ C.T. DESCRIPTION ___	EXCITATION FIELD ☐ RHEOSTAT ☐ FIXED RESISTOR REQ'D
8	○ EXTENDED LOADS LENGTH ___ FT.	SUPPLIED BY ___
9	○ **SURGE CAPACITORS**	BEARINGS: TYPE ___ LUBR. ___
10	○ **LIGHTING ARRESTERS**	LUBE OIL REQUIRED: ___ GPM@ ___ PSIG
11	○ **C.T. FOR AMMETER**	TOTAL SHAFT END FLOAT ___
12	○ DESCRIPTION ___	LIMIT END FLOAT TO ___
13	**MAIN CONDUIT BOX SIZED FOR:**	MOTOR ROTOR: ☐ SOLID ☐ SPLIT
14	○ MAIN MOTOR LEADS ○ TYPE ___	MOTOR HUB ☐ SOLID ☐ SPLIT
15	○ INSULATED ○ NONINSULATED	FOR TEWAC &TEIGF MOTORS:
16	○ C.T.'S FOR DIFF. PROTECT. (MTD. BY ___)	COOLING WATER REQ'D ___ GPM
17	○ SURGE CAPACITORS (MTD. BY ___)	C.W. TEMP. RISE ___ °F PRESS. DROP ___ PSI
18	○ LIGHTNING ARRESTERS (MTD. BY ___)	(AIR) (GAS) REQ'D ___ SCFM PRESS. MAINT. ___ IN. H_2O
19	○ C.T. FOR AMMETER (MTD. BY ___)	CURVES REQ'D BASED ON MOTOR SATURATION @ RATED VOLTAGE:
20	○ SPACE FOR STRESS CONES	○ SPEED vs TORQUE (ALSO @ ___ % RATED VOLTAGE)
21	○ **AIR FILTERS**	○ SPEED vs POWER FACTOR
22	☐ MFR. ___ ☐ TYPE ___	○ SPEED vs CURRENT
23	☐ **MANUFACTURER'S DATA**	WEIGHTS (LBS):
24	MANUFACTURER ___	NET WEIGHT ___ SHIPPING WT. ___
25	FRAME No. ___ FULL LOAD RPM (Ind.) ___	ROTOR WEIGHT ___ MAX. ERECTION WT. ___
26	EFFICIENCY: F.L. ___ 3/4L ___ 1/2L ___	MAX. MAINT. WT (Identify) ___
27	PWR. FACTOR (Ind.): F.L. ___ 3/4L ___ 1/2L ___	**DIMENSIONS (FEET & INCHES):**
28	CURRENT (Rated Volt.): FULL LOAD ___ LOCKED ROTOR ___	L ___ W ___ H ___
29	LOCKED ROTOR POWER FACTOR ___	**SHOP INSPECTION AND TESTS**
30	LOCKED ROTOR WITHSTAND TIME (Cold Start) ___	REQUIRED / OBSERVED / WITNESS
31	TORQUES (FT-LBS): FULL LOAD ___	SHOP INSPECTION ○ ○ ○
32	LOCKED ROTOR ___ STARTING (Syn.) ___	TESTING PER NEMA ○ ○ ○
33	PULL-UP (Ind.) ___ PULL-IN (Syn.) ___	MFR. STD. SHOP TESTS ○ ○ ○
34	BREAKDOWN (Ind.) ___ PULL-OUT (Syn.) ___	IMMERSION TEST ○ ○ ○
35	___	SPECIAL TESTS (List Below)
36	OPEN CIRCUIT TIME CONSTANT (SEC.) ___	___ ○ ○ ○
37	SYMMETRICAL CONTRIBUTION TO 3ø TERMINAL FAULT: ___	___ ○ ○ ○
38	AT 1/2 CYCLES ___ AT 5 CYCLES ___	___ ○ ○ ○
39	REACTANCES: SUB-TRANSIENT (X''_d) ___	___ ○ ○ ○
40	TRANSIENT (X'_d) ___ SYNCHRONOUS (X_d) ___	**COUPLING:**
41	A.C. STATOR RESISTANCE ___ OHMS@ ___ °F	○ SUPPLIED BY ___
42	RATED KVA ___	○ MFR. ___ ☐ MODEL ___
43	KVA INRUSH @ FULL VOLT. & LOCKED ROTOR (SYN.) ___ %	○ MOTOR MFR. ○ FAN MFR. ○ PUCH. TO MOUNT MTR. HALF
44	KVA @ FULL VOLTAGE & 95% SPEED ___ %	**PAINTING:**
45	MAX. LINE CURR. IN STATOR ON 1st SLIP CYC. @ PULL-OUT	○ MANUFACTURER'S STANDARD
46	(SYN.) ___	○ ___
47	ACCELERATION TIME (Motor Only @ Rated Volt.) ___ SEC.	**SHIPMENT:**
48	ACCEL. TIME (Motor & Load @ 85% Rated Volt.) ___ SEC.	○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQUIRED
49	ROTOR/FIELD WR^2 @ MOTOR SHAFT (LB-FT_) ___	○ OUT DOOR STORAGE OVER 6 MONTHS
50	ROTATION FACING COUPLING END ___	○ ___
51	No. OF STARTS PER HOUR ___	
52	**REMARKS:** ___	

CENTRIFUGAL FAN (API 673-2ND. EDITION) **DATA SHEET** **SI UNITS**	JOB NO. ______ ITEM NO. ______ PURCHASE ORDER NO. ______ SPECIFICATION NO. ______ REVISION NO. ______ DATE ______ PAGE 1 OF 10 BY ______

1 APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT — REVISION: ______

2 FOR: ______

3 SITE: ______ UNIT: ______

4 SERVICE: ______ NO. REQUIRED: ______

5 NOTE: ○ INDICATES INFORMATION TO BE COMPLETED BY PURCHASER □ BY MANUFACTURER

6 **GENERAL**

7 FAN MFR. ______ SIZE ______ TYPE/ARRANGEMENT ______ SERIAL NO. ______

8 DRIVER MFR. ______ DRIVER TYPE ______ RATED kW ______ RPM ______

9 FURNISHED BY ______ MOUNTED BY ______ PER SPECIFICATION ______ PER DATA SHEET ______

10 DRIVE SYSTEM ○ DIRECT COUPLED ○ OTHER ______ FAN ROTATION, FROM DRIVEN END ______ CW ______ CCW

11 **OPERATING CONDITIONS**

		NORMAL	RATED	OTHER CONDITIONS			
12	(ALL DATA ON PER UNIT BASIS)			A	B	C	D
13							
14	○ OPERATING CONDITIONS/CASE						
15	○ GAS HANDLED (See Page ____)						
16	○ DENSITY (kg/m_)						
17	○ DELIVERED m_n^3/h (1 atm & 0°C DRY)						
18	○ WEIGHT FLOW Kg/h (WET)						
19	**INLET CONDITIONS:**						
20	○ TEMPERATURE (°C)						
21	○ RELATIVE HUMIDITY (%)						
22	○ MOLECULAR WEIGHT (MIN.)						
23	□ INLET VOLUME (m^3/s WET)						
24	□ Cp/Cv (K_1) OR (K_{AVG})						
25	□ COMPRESSIBILITY (Z_1) OR (Z_{AVG})						
26	○ STATIC PRESSURE @ SOUND TRUCK (mm WG)						
27	□ PRESSURE LOSS ACROSS SOUND TRUCK (mm WG)						
28	○ STATIC PRESSURE @ INLET DAMPERS (mm WG)						
29	○ STATIC PRESSURE @ FAN INLET (mm WG)						
30	**DISCHARGE CONDITIONS:**						
31	□ STATIC PRESSURE @ FAN OUTLET (mm WG)						
32	□ STATIC PRESS. @ DISCHARGE DAMPER (mm WG)						
33	□ ΔP ACROSS DISCHARGE DAMPER (mm WG)						
34	□ ΔP ACROSS EVASE (mm WG)						
35	○ STATIC PRESSURE @ EVASE OUTLET (mm WG)						
36	**PERFORMANCE:**						
37	□ BHP REQUIRED @ TEMP. (ALL LOSSES IND.)						
38	□ FAN SPEED (RPM)						
39	○ GUARANTEE POINT						
40	□ PERFORMANCE CURVE NO.						
41	□ STATIC ΔP ACROSS FAN (mm WG)						
42	□ INLET DAMPER/VANE POSITION						
43	□ DISCHARGE DAMPER POSITION						
44	□ FAN STATIC EFFICIENCY (%)						

45 **FAN CONTROL:**

46 ○ AIR SUPPLY ______ ○ FAN CONTROL FURNISHED BY ______

47 ○ CONTROL SIGNAL TYPE ______ SOURCE ______ SENSITIVITY ______ RANGE ______

48 ○ ARRANGEMENT DRWG NO. ______ CONTROL SIGNAL FAILURE MODE ○ CLOSE ○ OPEN ○ AUTOLOCK

49 **METHOD:** ○ INLET DAMPER ○ OUTLET DAMPER ○ INLET GUIDE VANES

50 ○ STARTING CONDITIONS ______ ○ STARTING METHOD ______

51 ○ START & STOP RESTRICTIONS ______

52 ○ VENDOR REVIEW OF CONTROL SYSTEM REQUIRED ○ OTHER ______

CENTRIFUGAL FAN (API 673-2ND. EDITION) **DATA SHEET** **SI UNITS**	JOB NO. ______ ITEM NO. ______ REVISION ______ DATE ______ PAGE 2 OF 10 BY ______

OPERATING CONDITIONS

GAS ANALYSIS O MOL% O ______	MW	NORMAL	RATED	CONDITIONS A	B	C	D	REMARKS
AIR	28.97							
OXYGEN	32.00							
NITROGEN	28.02							
WATER VAPOR	18.02							
CARBON MONOXIDE	28.01							
CARBON DIOXIDE	44.01							
HYDROGEN SULFIDE	34.08							
HYDROGEN CHLORIDE	36.47							
CHLORINE	70.91							
TOTAL								
AVG. MOL WT.								

CORROSIVES:

O CORROSION/EROSION CAUSED BY ______

O CORROSION EROSION PROTECTION ______

O NACE MR-01-90 MATERIALS REQUIRED ______

______

LOCATION, SITE DATA

LOCATION:

O INDOOR O HEATED O UNDER ROOF

O OUTDOOR O UNHEATED O PARTIAL SIDES

O GRADE O MEZZANINE O ______

O WINTERIZATION REQ'D O TROPICALIZATION REQ'D

SITE DATA:

O ELEVATION ______ m2 O BAR ______ (ABS)/mm Hg A

O TEMPERATURE ______ °C SUMMER ______ °C WINTER

O WIND LOAD ______ Kg/m2 O VELOCITY ______ KPH

O MINIMUM DESIGN METAL TEMPERATURE ______ ° C

UNUSUAL CONDITIONS:

O DUST O FUMES

O OTHER ______

ELECTRICAL AREA CLASSIFICATION:

O CLASS ______ GROUP ______ ZONE ______

SPECIFICATIONS

NOISE SPECIFICATIONS:

O APPLICABLE TO MACHINE:

See Specification ______

O APPLICABLE TO NEIGHBORHOOD

See Specification ______

ACOUSTIC HOUSING: O YES O NO

APPLICABLE SPECIFICATIONS:

PAINTING:

O MANUFACTURER'S STD.

O OTHERS ______

SHIPMENT:

O DOMESTIC O EXPORT O EXPORT BOXING REQ'D.

O OUTDOOR STORAGE OVER 6 MONTHS

ERECTION:

SHIPPED ☐ ASSEMBLED ☐ PARTLY ASSEMBLED

☐ OTHER ______

☐ EXTENT OF FIELD ERECTION & ASSEMBLY ______

______ MAN HOURS ______

☐ OTHER ______

REMARKS: ______

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CONSTRUCTION FEATURES

☐ **SPEEDS:**
MAX CONT. ______ RPM TRIP ______ RPM
MAX TIP SPEEDS ______ m/s @ RATED
______ m/s @ MAX. CONT.

☐ **LATERAL CRITICAL SPEEDS (2.7.2)**
FIRST CRITICAL ______ RPM ☐ DAMPED ☐ UNDAMPED
○ TRAIN LATERAL ANALYSIS REQUIRED
☐ SUBMIT X - Y PLOT (COUPLED DRIVER & FAN)

☐ **TORSIONAL CRITICAL SPEEDS (2.7.3):**
FIRST CRITICAL ______ RPM
☐ SUBMIT X - Y PLOT (COUPLED DRIVER & FAN)
☐ TORSIONAL VIBRATION ANALYSIS FOR FAN & DRIVER
☐ TRNS'NT TORS'NAL ANLYS. FOR SYNCHRNS. DRIVER UNITS
ALLOWABLE TEST LEVEL ______ mm
(Peak To Peak)

☐ **HOUSING:**
MATERIAL ______
CONSTRUCTION ______
☐ INLET BELL ______
☐ EVASE (DETAIL IN PROPSAL)
○ INSULATION REQUIRED ○ INSULATION STUDS BY ______
☐ INSULATION TYPE ______ THICKNESS ______ mm
☐ FAN HOUSING NEAR-CENTERLINE SUPPORT REQUIRED (2.2.5)
☐ DRAINS: No./SIZE ______ TYPE/LOC. ______
☐ FAN INLET ACCESS: SPLIT FOR ROTOR REMOVAL
☐ MANWAYS: SIZE ______ mm TYPE/LOC. ______
SIZE ______ mm TYPE/LOC. ______

BEARING HOUSING:
☐ CONSTRUCTION ______ MATERIAL ______
BEARINGS
○ HYDRODYNAMIC ○ ANTI-FRICTION
MOUNTING PEDESTALS ○ YES ○ NO
SOLE PLATES ○ YES ○ NO
☐ **RADIAL BEARINGS:**

	MFG./No.	LOAD (N)	L'NGT. (mm)	DIA. (mm)
INBOARD				
OUTBOARD				

Dn FACTOR ______ L-10 ______ HRS
LOAD FACTOR ______
MAX. SPEED ______ RPM @ ______ °C
CLEARANCE ______ mm
BEARING SPAN (CL – CL) ______ mm

☐ **THRUST BEARINGS:**
TYPE (Dual Bell, Flat Land, Tapered Land, Tilt-Pad)
______
MFG./No. ______ AREA ______ mm^2
LOADING N/m^2: ACTUAL ______ ALLOW ______
Dn FACTOR ______ L – 10 ______ HRS
LOAD FACTOR ______
MAX. SPEED ______ RPM @ ______ °C
☐ **THRUST COLLAR** (On Inboard Bearing): TYPE: ______
TYPE ATTACHMENT: ______
______
○ INTEGRAL THRUST COLLAR REQUIRED (2.8.4.2.2)

ACCESSORIES:
○ TEMP DETECTORS (METAL) (OIL) ○ THRUST ○ JOURNAL
TYPE ______ MFG./NO. ______ ○ API 670
○ END SEALS ○ LABYRINTH ○ DOUBLE CONTACT
○ THERMOSTATICALLY CONTROLLED HEATERS ○ YES ○ NO
☐ TYPE ______ MFG/NO. ______
LUBRICATION ○ CONSTANT LEVEL OILER(2.8.5.1) ○ PURE OIL MIST
○ PURGE OIL MIST ○ OTHER ______ (See Pg. 6)
COOLANT REQUIRED ☐ NONE ☐ AIR
☐ WATER ______ m^3/h@ ______ °C

☐ **ROTOR:**
SHAFT LENGTH (mm) ______ DIA. @ WHEEL ______ mm
MATERIAL ______
CONSTRUCTION ______
TIR @ SLEEVE ______ mm DIA. @ BEARING ______ mm
SHAFT END MOVEMENTS (TOLERANCE PLUS THERMAL) ______

☐ **BLADES:**
No. of BLADES ______ DIAMETERS (mm) ______
TYPE (HOLLOW OR SOLID AIRFOIL, SINGLE, THICKNESS, ETC.) ______
______
TYPE FABRICATION
MATERIAL ______ COATING TYPE ______
WEAR PLATES ______ MATERIAL ______
HUB: ○ SHRINK FIT ○ KEYED
MATERIAL ______ CONSTRUCTION ______
ROTOR WT. (Kg) ______ $WK^2(Kg/m^2)$ ______
KEY WAY: No. ______ DIM ______ x ______ x ______ mm
○ MAX. HEATING / COOLING RATE ______ / ______ °C/MIN.

☐ **SHAFT SLEEVES:**
LENGTH (mm) ______ DIA. (mm) ______
SHRINK FIT ______ ○ CORROSION RESISTANT MATL.

☐ **SHAFT SEALS:**
TYPE ______ MATERIAL ______
BUFFER OR EDUCTOR CONNECTIONS ______
DETAILS:

☐ **MAIN CONNECTIONS (2.3)** ( )
INLET: No. ______ SIZE ______ x ______ AREA (m^2) ______
☐ FLANGE SIZE ______ BOLTING ______
○ LOCATION/ORIENTATION ______
☐ EXP. JOINT REQ'D ______ FURN. BY ______
OUTLET: SIZE ______ x ______ AREA (m^2) ______
☐ FLANGE SIZE ______ BOLTING ______
○ LOCATION/ORIENTATION ______
☐ EXP. JOINT REQ'D ______ FURN. BY ______
○ MATING FLG BY VENDOR ○ ASME B16.5 ○ ASME B16.47

☐ **OTHER CONNECTIONS (2.3):**

SERVICE	No.	SIZE	TYPE
LUBE OIL INLET			
LUBE OIL OUTLET			
COOLING WATER INLET			
COOLING WATER OUTLET			
PRESSURE GAGE			
TEMP. GAGE			
CONDENSATE DRAINS			

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CONSTRUCTION FEATURES (Continued)

NOISE ATTENUATION:

○ MAX. ALLOW SOUND PRESS LEVEL ______ DBA@ ____ m
☐ PREDICTED SOUND PRESS LEVEL ______ DBA@ ____ m
☐ ATTENUATION METHOD ______
○ FURNISHED BY ______
☐ SILENCER MFG/MODEL No. ______
☐ ACOUSTIC PERF ______
☐ AERODYNAMIC PERF ______ m^3/s ______ °C
LOSS ______ mm WG.
☐ ACCESSORIES ______

FAN CLEANING SYSTEM (2.1.22):

○ REQUIRED ______ CLEANING MEDIUM ______
☐ MFR./MODEL ______ FURN BY ______
○ INSTALLED BY ______
☐ DETAILS/DWG.No. ______

BASEPLATES & SOLEPLATES:

○ TRI- DIRECTIONAL ADJUSTING SCREWS FOR EQUIP.
○ PILOT HOLES FOR DOWELS
○ TYPE GROUT ______ TYPE PRECOAT ______
SOLEPLATES FOR ○ BEARING PEDESTALS ○ GEAR
○ DRIVER ○ FAN HOUSING SUPPORTS
BASE PLATE:
○ COMMON (Under Fan, Gear, Driver) ○ FAN ALONE
○ OTHER ○ DIMENSIONS ______ x ______ x ______ m
DECKING ○ NON SKID ○ OPEN CONSTRUCTION
○ DRIP RIM ○ OPEN DRAIN
SUITABLE FOR ○ COLUMN or ○ PERIMETER SUPPORT
○ LEVELING PADS W/REMOVABLE COVER
○ SUBSOLE PLATES REQUIRED

FAN ITEMS:	○ CORROSION ALLOWANCE	☐ SIZE/THICKNESS (INCL. C.A.)	☐ MATERIAL	☐ MATERIAL SPECIFICATION
SHAFT				
BLADES				
HUB				
CENTER PLATE				
SHROUDS				
SLEEVES				
SEALS				
HOUSING				
DAMPERS				
GUIDE VANES				
RAIN HOODS				
INLET BELTS				
EVASE (Discharge, Diffuser)				
SOUND TRUCK				
INLET DUCT				
WEAR PLATES				

COUPLINGS:	DRIVER—FAN	GEAR—FAN	DRIVER—GEAR
○ COUPLING & GUARD			
FURNISHED BY:			
○ TYPE			
☐ MFG.			
☐ MODEL/NUMBER			
○ LUBRICATION			
○ MOUNT CPLG. HALVES			
—FAN			
—DRIVE			
—GEAR			
○ SPACER LENGTH			
○ LTD. END FLOAT REQ'D			
○ COUPLING GUARD REQ'D			
☐ SERVICE FACTOR			
☐ CPLG. RATING HP/100 RPM			
☐ KEYED or HYDR FIT			
○ ADAPTER (Solo) PLATE			
☐ MATERIALS			

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CONSTRUCTION FEATURES (Continued)

☐ **ALLOWABLE EXTERNAL LOADS**

	INLET		DISCHARGE	
	FORCE N	MOMT. N-m	FORCE N	MOMT. N-m
AXIAL				
VERTICAL				
HORIZ. 90°				

VIBRATION DETECTORS:

○ PROVISIONS FOR VIBRATION TRANSDUCERS(THREADED CONN.)
○ FLAT SURFACES FOR MAGNETIC MOUNTED TRANSDUCERS
○ SEISMIC SENSOR COVER(S) BY ______
○ PROVISIONS FOR MOUNTING NON-CONTACTING VIB. PROBES
○ PER API 670

SPEED DETECTORS (On Outdoor Bearing):

○ NON-CONTACT PROBE ○ SPEED SWITCH
○ OTHER ______
○ TYPE ______ ☐ MODEL ______
○ MFG ______
○ LOCATION ______
☐ SCALE RANGE ______ RPM

SHOP INSPECTIONS & TESTS:	REQ'D.	OBSERV'D	WIT.
SHOP INSPECTION	○	○	○
CLEANLINESS INSPECTION	○	○	○
HARDNESS VERIFICATION	○	○	○
CHARPY IMPACT TESTING	○	○	○
SHAFT RUN OUT CHECK	○	○	○
ROTOR BALANCING	○	○	○
REBAL. AFTER MOUNTING CPLG.	○	○	○
RESIDUAL BALANCE CHECK	○	○	○
CALIBRT'N CK. OF BALNC'G EQUIP	○	○	○
NDT EXAMINATION	○	○	○
ASSEMBLY & FIT UP CHECK	○	○	○
INITIAL &/or FINAL ALIGN	○	○	○
GEAR TOOTH CNTCT. CHK. (API 677)	○	○	○
MECHANICAL RUN TEST	○	○	○
FULL UNIT MECHANICAL RUN TEST	○	○	○
VIBRATION TEST	○	○	○
SOUND LEVEL TEST	○	○	○
MAT'L CERTIFICATION	○	○	○
SURFACT & SUBSURFACE INSPCT.	○	○	○
TYPE			
PRESSURE TEST:	○	○	○
—HOUSING	○	○	○
—DUCTING	○	○	○
—LUBE OIL SYSTEM	○	○	○
RUN & CHECK LUBE CONSOLE	○	○	○
SHOP PERFORMANCE TEST	○	○	○
PRE-SHIPMENT INSPECTION	○	○	○
—DRIVER / AUX. MOUNTED	○	○	○
QUALITY CONTROL REVIEW	○	○	○
FIELD PERFORMANCE TEST	○	○	○
OTHERS: ______	○	○	○
	○	○	○

☐ **WEIGHTS Kg:**

FAN ______ DRIVER ______ BASE ______
ROTORS FAN ______ DRIVER ______ BASE ______
GEAR UPPER CASE ______
SOUND TRUNK ______ EVASE ______
SYSTEMS: LUBE ______ CLEANING ______
CONTROL PANEL ______
MAX. FOR MAINTENANCE (Identify) ______
TOTAL SHIPPING WEIGHT ______

☐ **SPACE REQUIREMENTS (METERS):**

COMPLETE UNIT L ______ W ______ H ______
CONTROL PANEL L ______ W ______ H ______
______ L ______ W ______ H ______

UTILITY REQUIREMENTS:

STEAM ______ WATER ______ ELECTRIC ______
AIR ______ GAS ______ DRIVER RATING ______ NET LOADS ______

MISCELLANEOUS:

○ VENDOR'S REVIEW & COMMENTS ON FOUNDATION DESIGN
○ VENDOR'S REV. & C'MNTS ON CONTRACTOR'S DUCT DESIGN
○ TORSIONAL ANALYSIS REPORT REQUIRED
○ TURNING GEAR, TYPE DRIVER ______
○ AUTO ○ MANUAL ENGAGE ○ START FROM REST
○ RAINHOOD & CAP
○ INLET AIR FILTER
○ INLET DAMPER
○ INLET GUIDE VANE
○ INLET TRASH SCREEN
○ OUTLET DAMPER
○ SOUND TRUCK (INLET BOX/ SILENCER)
○ BOLTING & GASKETS

REMARKS: ______

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CIRCULATING LUBE OIL SYSTEM BY ______

PIPING MATERIALS:

	CARBON STEEL	STAINLESS STEEL
○ COMPLETE SYSTEM		
○ DOWNSTREAM OF FILTERS		
○ RETURN PIPING		

○ CARBON STEEL SLIP-ON FLANGES ON STNLESS. STEEL PIPING

SYSTEM COMPONENT SUPPLIERS:

	MANUFACTURER	MODEL
☐ MAIN PUMP		
☐ STANDBY PUMP		
☐ ELECTRIC MOTOR (S)		
☐ STEAM TURBINE (S)		
☐ OIL COOLER (S)		
☐ OIL FILTER (S)		
☐ ACCUMULATOR (S)		
☐ SUCT. STRAINER (S)		
☐ CHECK VALVE (S)		
☐ SWITCH VALVE (S)		
☐ PUMP COUPLING (S)		
☐ TEMP. INDICATORS		
☐ L.P. SHUTDOWN SWITCH		

SYSTEM PRESSURES:
☐ DESIGN ______ PSIG ☐ HYDROTEST ______ PSIG
☐ PUMP RELIEF VALVE (S) SETTINGS ______ PSIG

BASIC SYSTEM REQUIREMENTS: (NORMAL OIL FLOW)

☐ LUBE OIL	m^3/h	BAR	SSU @ 38°C	SSU @ 99°C
FAN				
DRIVER				
GEAR				

☐ COMMON LUBE SYSTEM ______

PUMPS:

	MAIN	STANDBY
○ HORIZONTAL		
○ VERTICAL		
○ SUBMERGED		
○ MOTOR DRIVEN		
○ TURBINE DRIVEN		
○ SHAFT DRIVEN		
○ CENTRIFUGAL		
○ GEAR/SCREW		
○ FLANGE CONNECTED		
☐ m^3/h (RATED)		
☐ @ BAR		
☐ BHP @ 100 SSU		
☐ DRIVER kW		
○ CASING MATERIAL		
☐ SPEED		
○ COUPLING		
☐ GUARD		
○ MECH. SEAL		

EMERGENCY LUBE OIL PUMP:
○ AIR MOTOR DRIVEN ○ OTHER ______
○ SAFETY GUARD REQUIRED

REMARKS: ______

______

LUBE OIL SYSTEM ○ **API 614 REQUIRED**

STANBY PUMP CONTROL:
○ RESET ○ MANUAL ○ AUTOMATIC
○ AUTOMATIC START
○ "ON-OFF-AUTO" SELECTOR SWITCH

RESERVOIR:
○ MATERIAL ______
RETENTION TIME ______ MIN. CAPACITY ______ m^3
○ BASEPLATE MOUNTED ○ FABRICATED STEEL BASE
○ BAFFLE REQUIRED ○ INTERIOR COATING
FREE SURFACE AREA ______ m^2
○ HEATER (S) ○ ELECT. ○ STREAM ○ MIN SITE ______ °C
○ FLTR./BRTHR. ○ FLANGED VNT. HEAT-UP TIME ______ Hrs.
○ PRESS. RELIEF VENT ○ INSULATION SUPPORTS
○ SPRING LOADED FILL CAP w/S.S. STRAINER

OIL COOLERS:
☐ AIR ☐ WATER ______ m^3/h @ ______ °C
○ SINGLE ○ SINGLE
○ W/ BYPASS & TEMP CNTRL. VALVE ○ MANUAL ○ AUTO
○ ASME CODE STAMP
○ HEATING STEAM ______ BAR ______ °C
○ FOUL. FACTR.: SHELLSIDE ______ TUBE SIDE ______
☐ MAKE ______ ☐ TYPE ______
☐ DUTY ______ W/HR ☐ SURFACE ______ °C
○ CODE (S) ______
☐ DESIGN PRESS. PSIG SHELL SIDE ______ TUBE SIDE ______
☐ TUBES: O.D. ______ mm ☐ TOTAL SURFACE AREA ______ m^2
WALL THICKNESS (AVE) (MIN) ______ mm
LENGTH ______ mm NUMBER: ______
☐ MATERIALS
TUBES ______
TUBE SHEETS ______
SHELL ______
TUBE SUPPORT ______
SHELL COVER/FLANGE ______

ACCUMULATOR:
○ SINGLE ○ MULTI
○ ASME CODE DESIGN ○ ASME CODE STAMP
○ MATERIAL
☐ CORROSION ALLOWANCE (mm) ______
☐ CAPACITY (TOTAL) m^3 ______
☐ PRE-CHARGE PRESS. (BAR) ______
○ DIRECT CONTACT TYPE ○ BLADDER TYPE
☐ BLADDER MATERIAL ______
○ WITH SUPPLY REGULATOR ○ MANU. CHARGE VALVE

FILTERS: MFG: ______
○ SINGLE ○ TWIN
○ ASME CODE DESIGN ○ ASME CODE STAMP
○ MICRON (μ) ______
☐ FILTER MEDIUM ______
☐ DESIGN PRESS. BAR ______
☐ Δ P CLEAN BAR ______
☐ Δ P COLLAPSE BAR ______
☐ CASING MATERIAL ______
☐ CARTRIDGE INDENT NO. ______
○ FURNISH SET OF SPARE CARTRIDGE W/ FILTERS ______

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INSTRUMENTATION

○ PER API 614 ○ OTHER ______

LOCAL CONTROL PANEL:

FURNISHED BY: ☐ VENDOR ☐ PURCHASER ☐ OTHERS

☐ BASE MOUNTED ☐ FREE STANDING ☐ WEATHERPROOF ☐ TOTALLY ENCLOSED ☐ EXTRA CUTOUTS

☐ VIBRATION ISOLATORS ☐ STRIP HEATERS ☐ PURGE CONNECTIONS ☐ WITH DOORS

☐ ANNUNCIATOR WITH FIRST OUT INDICATION LOCATED ON LOCAL PANEL

☐ CUSTOMER CONNECTIONS BROUGHT OUT TO TERMINAL BOXES BY VENDOR

REMARKS: ______

INSTRUMENT SUPPLIERS:

PRESSURE GAGES	MFR.	______	SIZE & TYPE	______
TEMPERATURE GAGES	MFR.	______	SIZE & TYPE	______
LEVEL GAGES	MFR.	______	SIZE & TYPE	______
DIFF. PRESSURE GAGES	MFR.	______	SIZE & TYPE	______
PRESSURE SWITCHES	MFR.	______	SIZE & TYPE	______
DIFF. PRESSURE SWITCHES	MFR.	______	SIZE & TYPE	______
TEMPERATURE SWITCHES	MFR.	______	SIZE & TYPE	______
LEVEL SWITCHES	MFR.	______	SIZE & TYPE	______
CONTROL VALVES	MFR.	______	SIZE & TYPE	______
PRESSURE RELIEF VALVES	MFR.	______	SIZE & TYPE	______
SIGHT FLOW INDICATORS	MFR.	______	SIZE & TYPE	______
VIBRATION EQUIPMENT	MFR.	______	SIZE & TYPE	______
TACHOMETER	MFR.	______	RANGE &TYPE	______
SOLENOID VALVES	MFR.	______	SIZE & TYPE	______
ANNUNCIATOR	MFR.	______	MODEL & No. POINTS	______
☐ DAMPER/VANE ACTUATOR	MFR.	______	MODEL	______

○ FURNISHED BY ______ ☐ TYPE ______ ☐ MAX. TORQUE (N-m) ______

NOTE: ☐ SUPPLIED BY VENDOR ○ SUPPLIED BY PURCHASER

PRESSURE GAGE REQUIREMENTS:

FUNCTION	LOCALLY MOUNTED	LOCAL PANEL	FUNCTION	LOCALLY MOUNTED	LOCAL PANEL
LUBE OIL PUMP DISCHARGE	☐ ○	☐ ○	FAN DISCHARGE	☐ ○	☐ ○
LUBE OIL FILTER ΔP	☐ ○	☐ ○	CONTROL AIR	☐ ○	☐ ○
LUBE OIL SUPPLY	☐ ○	☐ ○	FAN SUCTION	☐ ○	☐ ○
______	☐ ○	☐ ○	______	☐ ○	☐ ○
______	☐ ○	☐ ○	______	☐ ○	☐ ○

TEMP. GAGE REQUIREMENTS:

FUNCTION	LOCALLY MOUNTED	LOCAL PANEL	FUNCTION	LOCALLY MOUNTED	LOCAL PANEL
LUBE OIL TO BEARINGS	☐ ○	☐ ○	OIL COOLER INLET & OUTLET	☐ ○	☐ ○
DISCHARGE FROM EACH	☐ ○	☐ ○	FAN SUCTION	☐ ○	☐ ○
PINION JOURNAL BEARING	☐ ○	☐ ○	______	☐ ○	☐ ○
BULL GEAR JOURNAL BEARING	☐ ○	☐ ○	______	☐ ○	☐ ○
FAN THRUST BEARING	☐ ○	☐ ○	______	☐ ○	☐ ○
DRIVER JOURNAL BEARING	☐ ○	☐ ○	______	☐ ○	☐ ○
DRIVER THRUST BEARING	☐ ○	☐ ○	______	☐ ○	☐ ○
GEAR THRUST BEARING	☐ ○	☐ ○	______	☐ ○	☐ ○
FAN JOURNAL BEARING	☐ ○	☐ ○	______	☐ ○	☐ ○
______	☐ ○	☐ ○	______	☐ ○	☐ ○

SWITCH CLOSURES:

ALARMCONTACTS SHALL: ☐ OPEN ☐ CLOSE TO SOUND ALARM AND BE NORMALLY ☐ ENERGIZED ☐ DE-ENERGIZED

SHUTDOWN CONTACTS SHALL: ☐ OPEN ☐ CLOSE TO TRIP AND BE NORMALLY ☐ ENERGIZED ☐ DE-ENERGIZED

NOTE: NORMAL CONDITION IS WHEN FAN IS IN OPERATION.

REMARKS: ______

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INSTRUMENTATION (Continued)

MISCELLANEOUS:

ALARM AND SHUTDOWN SWITCHES SHALL BE SEPARATE.

ELECTRICAL AND INSTRUMENT CONNECTIONS WITHIN THE CONFINES OF THE FAN BASE SHALL BE BROUGHT OUT TO TERMINAL BOXES.

COMMENTS REGARDING INSTRUMENTATION: ______

______

______

ALARM & SHUTDOWN SWITCHES:

FUNCTION	ALARM	TRIP	FUNCTION	ALARM	TRIP
☐ ○ LOW LUBE OIL PRESSURE			☐ ○ FAN VIBRATION		
☐ ○ HI LUBE OIL FILTER ΔP			☐ ○ FAN AXIAL POSITION		
☐ ○ LOW LUBE OIL RESERVE LEVEL			☐ ○ DRIVER VIBRATION		
☐ ○ AUX. LUBE OIL PUMP START			☐ ○ DRIVER AXIAL POSITION		
☐ ○ HI INLET AIR FILTER ΔP			☐ ○ FAN MOTOR SHUTDOWN		
☐ ○ ______			☐ ○ HI FAN THRUST BRG. TEMP.		
☐ ○ ______			☐ ○ HI DRIVER THRUST BRG. TEMP.		
☐ ○ ______			☐ ○ ______		

MISCELLANEOUS INSTRUMENTATION:

☐ ○ SIGHT FLOW INDICATORS: EACH JOURNAL & THRUST BEARING OIL RETURN LINE

☐ ○ LEVEL GAUGES, LUBE OIL RESERVOIR (S)

☐ ○ VIBRATION READOUT EQUIPMENT

☐ ○ VIBRATION READ OUT LOCATED ON: ☐ LOCAL PANEL ☐ OTHER ______

☐ ○ FAN SPEED PICK-UP DEVICES

☐ ○ FAN SPEED INDICATORS

☐ ○ FAN SPEED INDICATORS LOCATED ON: ☐ LOCAL PANEL ☐ OTHER ______

☐ ○ ALARM HORN & ACKNOWLEDGEMENT SWITCH

☐ ○ ______

☐ ○ ______

☐ ○ ______

REMARKS: ______

	JOB NO. ______ ITEM NO. ______
ELECTRONIC MOTOR (API 673-2ND. EDITION)	REVISION ______ DATE ______
DATA SHEET	PAGE 9 OF 10 BY ______
SI UNITS	

APPLICABLE TO: PROPOSAL PURCHASE AS BUILT

FOR ______ UNIT ______

SITE ______ DRIVEN EQUIP. ______

SERVICE ______ NO. REQUIRED ______

MANUFACTURER ______ MODEL ______ SERIAL NO. ______

NOTE: INFORMATION TO BE COMPLETED BY PURCHASER BY MANUFACTURER

MOTOR DESIGN DATA

APPLICABLE SPECIFICATIONS:

NEMA ______

______

SITE DATA:

AREA: C.L. ______ GR. ______ ZN. ______ N-HAZARDOUS

ALTITUDE ______ m AMBIENT TEMPS: MAX ______ °C

UNUSUAL CONDITIONS DUST FUMES MIN ______ °C

OTHER ______

DRIVE SYSTEM: DIRECT CONNECTED

GEAR

OTHER ______

TYPE MOTOR:

SQUIRREL CAGE INDUCTION NEMA DESIGN ______

SYNCHRONOUS ______

POWER FACTOR REQ'D ______

EXCITATION: BRUSHLESS SLIP RING

FIELD DISCHARGE RESISTOR BY MOTOR MFR.

WOUND ROTOR INDUCTION

______

ENCLOSURE:

CLASS ______ GROUP ______ EXP. PROOF

TEFC

TEWAC TEIGF, USING ______ GAS

DOUBLE WALL CARBON STEEL TUBES

WATER SUPP.: PRESS. ______ BAR TEMP. ______ °C

WATER ALLOW. ΔP ______ BAR & TEMP RISE ______ °C

WATER SIDE MIN CORR. ALLOW. ______ mm

AND FOUL FACTOR ______

(AIR) (GAS) SUPPLY PRESS. ______ BAR

______

WEATHER PROTECTED TYPE ______

FORCED VENTILATION

OPEN-DRIPPROOF

OPEN

______

BASIC DATA:

______ VOLTS ______ PHASE ______ HERTZ

NAMEPLATE HP ______ SERVICE FACTOR ______

SYNCHRONOUS RPM ______

INSULATION CLASS ______ TYPE ______

TEMP. RISE: ______ °C ABOVE ______ °C BY ______

STARTING:

FULL VOLTAGE REDUCED VOLTAGE ______ %

LOADED UNLOADED

VOLTAGE DIP ______ %

VIBRATION:

NEMA STANDARD ______

NOISE

NEMA STANDARD ______

THRUST:

MAX. MOTOR THRUST ______ N

REMARKS: ______

ACCESSORY EQUIPMENT

BASEPLATE SOLEPLATE STATOR SHIFT

MFR. STD. FANS NONSPARKING FANS

D.C. EXCITATION:

KW REQ'D. ______ VOLTS ______

BY: PURCHASER MANUFACTURER

DESCRIPTION ______

ENCLOSED COLLECTOR RINGS:

PURGED MEDIUM ______ PRESS ______ BAR

EXPLOSION-RESISTANT NONPURGED

FORCE VENTILATION

CFM ______ PRESS. DROP ______ mm H_2O

BEARING TEMP. DEVICES:

LOCATION ______

DESCRIPTION ______

SET @ ______ °C FOR ALARM ______ °C FOR SHUTDN.

SPACE HEATERS:

______ KW ______ VOLT ______ PHASE ______ HERTZ

MAX SHEATH TEMP. ______ °C

WINDING TEMPERATURE DETECTORS:

THERMISTORS No./PHASE ______

TYPE: POS. TEMP. COEFF. NEG. TEMP. COEFF.

TEMPERATURE SWITCH YES NO

RESISTANCE TEMP. DETECTORS: No./PHASE ______

RESISTANCE MAT. ______ ______ OHM

SLCTR. SWITCH & INDICATOR BY: PURCHR. MFR.

MAX. STATOR WINDING TEMPS:

______ °C FOR ALARM ______ °C FOR SHUTDOWN

ELECTRONIC MOTOR (API 673-2ND. EDITION) **DATA SHEET** **SI UNITS**	JOB NO. ________ ITEM NO. ________ REVISION ________ DATE ________ PAGE 10 OF 10 BY ________

ACCESSORY EQUIPMENT, (Cont'd)

WINDING TEMP, DETECTOR & SPACE HEATER LEADS:
- O IN SAME CONDUIT BOX
- O IN SEPARATE CONDUIT BOXES

O **MOTOR ARRANGED FOR DIFFERENTIAL PROTECTION:**
- O SELF-BALANCE PRIMARY-CURRENT METHOD
- O C.T. DESCRIPTION ________
- O EXTENDED LOADS LENGTH ________ m

O **SURGE CAPACITORS**
O **LIGHTING ARRESTERS**
O **C.T. FOR AMMETER**
- O DESCRIPTION ________

MAIN CONDUIT BOX SIZED FOR:
- O MAIN MOTOR LEADS O TYPE ________
- O INSULATED O NONINSULATED
- O C.T.'S FOR DIFF. PROTECT. (MTD. BY ________)
- O SURGE CAPACITORS (MTD. BY ________)
- O LIGHTNING ARRESTERS (MTD. BY ________)
- O C.T. FOR AMMETER (MTD. BY ________)
- O SPACE FOR STRESS CONES

O **AIR FILTERS**
- ☐ MFR. ________ ☐ TYPE ________

☐ **MANUFACTURER'S DATA**

MANUFACTURER ________
FRAME No. ________ FULL LOAD RPM (Ind.) ________
EFFICIENCY: F.L. ________ 3/4L ________ 1/2L ________
PWR. FACTOR (Ind.): F.L. ________ 3/4L ________ 1/2L ________
CURRENT (Rated Volt.): FULL LOAD ________ LOCKED ROTOR ________
LOCKED ROTOR POWER FACTOR ________
LOCKED ROTOR WITHSTAND TIME (Cold Start) ________
TORQUES (FT-LBS): FULL LOAD ________
- LOCKED ROTOR ________ STARTING (Syn.) ________
- PULL-UP (Ind.) ________ PULL-IN (Syn.) ________
- BREAKDOWN (Ind.) ________ PULL-OUT (Syn.) ________

OPEN CIRCUIT TIME CONSTANT (SEC.) ________
SYMMETRICAL CONTRIBUTION TO 3ø TERMINAL FAULT: ________
AT 1/2 CYCLES ________ AT 5 CYCLES ________
REACTANCES: SUB-TRANSIENT (X"d) ________
- TRANSIENT (X'd) ________ SYNCHRONOUS (X_d) ________

A.C. STATOR RESISTANCE ________ OHMS@ ________ °C
RATED KVA ________
KVA INRUSH @ FULL VOLT. & LOCKED ROTOR (SYN.) ________ %
KVA @ FULL VOLTAGE & 95% SPEED ________ %
MAX. LINE CURR. IN STATOR ON 1st SLIP CYC. @ PULL-OUT
(SYN.) ________
ACCELERATION TIME (Motor Only @ Rated Volt.) ________ SEC.
ACCEL. TIME (Motor & Load @ 85% Rated Volt.) ________ SEC.
ROTOR/FIELD WK^2 @ MOTOR SHAFT (Kg-m_) ________
ROTATION FACING COUPLING END ________
NO. OF STARTS PER HOUR ________

MANUFACTURER'S DATA, (Cont'd)

FIELD DISCHARGE RESISTOR ________ OHMS
RATED EXCITATION FIELD VOLTAGE ________ D.C.
RESISTANCE OF EXCITATION FIELD @ 25°C ________ OHMS
EXCITATION FIELD AMPS @ FULL LOAD & RATED P.F. ________
EXCITATION FIELD AMPS: MAX. ________ MIN. ________
EXCITATION FIELD ☐ RHEOSTAT ☐ FIXED RESISTOR REQ'D
- SUPPLIED BY ________

BEARINGS: TYPE ________ LUBR. ________
LUBE OIL REQUIRED: ________ m^3/h @ ________ BAR
TOTAL SHAFT END FLOAT ________
LIMIT END FLOAT TO ________
MOTOR ROTOR: ☐ SOLID ☐ SPLIT
MOTOR HUB ☐ SOLID ☐ SPLIT
FOR TEWAC &TEIGF MOTORS:
- COOLING WATER REQ'D ________ m^3/h
- C.W. TEMP. RISE ________ °C PRESS. DROP ________ BAR
- (AIR) (GAS) REQ'D ________ m_n^3/h PRESS. MAINT. ________ mm H_2O

CURVES REQ'D BASED ON MOTOR SATURATION @ RATED VOLTAGE:
- O SPEED vs TORQUE (ALSO @ ________ % RATED VOLTAGE)
- O SPEED vs POWER FACTOR
- O SPEED vs CURRENT

WEIGHTS (Kg):
NET WEIGHT ________ SHIPPING WT. ________
ROTOR WEIGHT ________ MAX. ERECTION WT. ________
MAX. MAINT. WT (Identify) ________
DIMENSIONS (METERS):
L ________ W ________ H ________

SHOP INSPECTION AND TESTS

	REQUIRED	OBSERVED	WITNESS
SHOP INSPECTION	O	O	O
TESTING PER NEMA	O	O	O
MFR. STD. SHOP TESTS	O	O	O
IMMERSION TEST	O	O	O
SPECIAL TESTS (List Below)			
________	O	O	O
________	O	O	O
________	O	O	O
________	O	O	O

COUPLING:
- O SUPPLIED BY ________
- O MFR. ________ ☐ MODEL ________
- O MOTOR MFR. O FAN MFR. O PUCH. TO MOUNT MTR. HALF

PAINTING:
- O MANUFACTURER'S STANDARD
- O ________

SHIPMENT:
- O DOMESTIC O EXPORT O EXPORT BOXING REQUIRED
- O OUT DOOR STORAGE OVER 6 MONTHS
- O ________

REMARKS: ________

APPENDIX D—MAXIMUM RESIDUAL SPECIFIC UNBALANCE

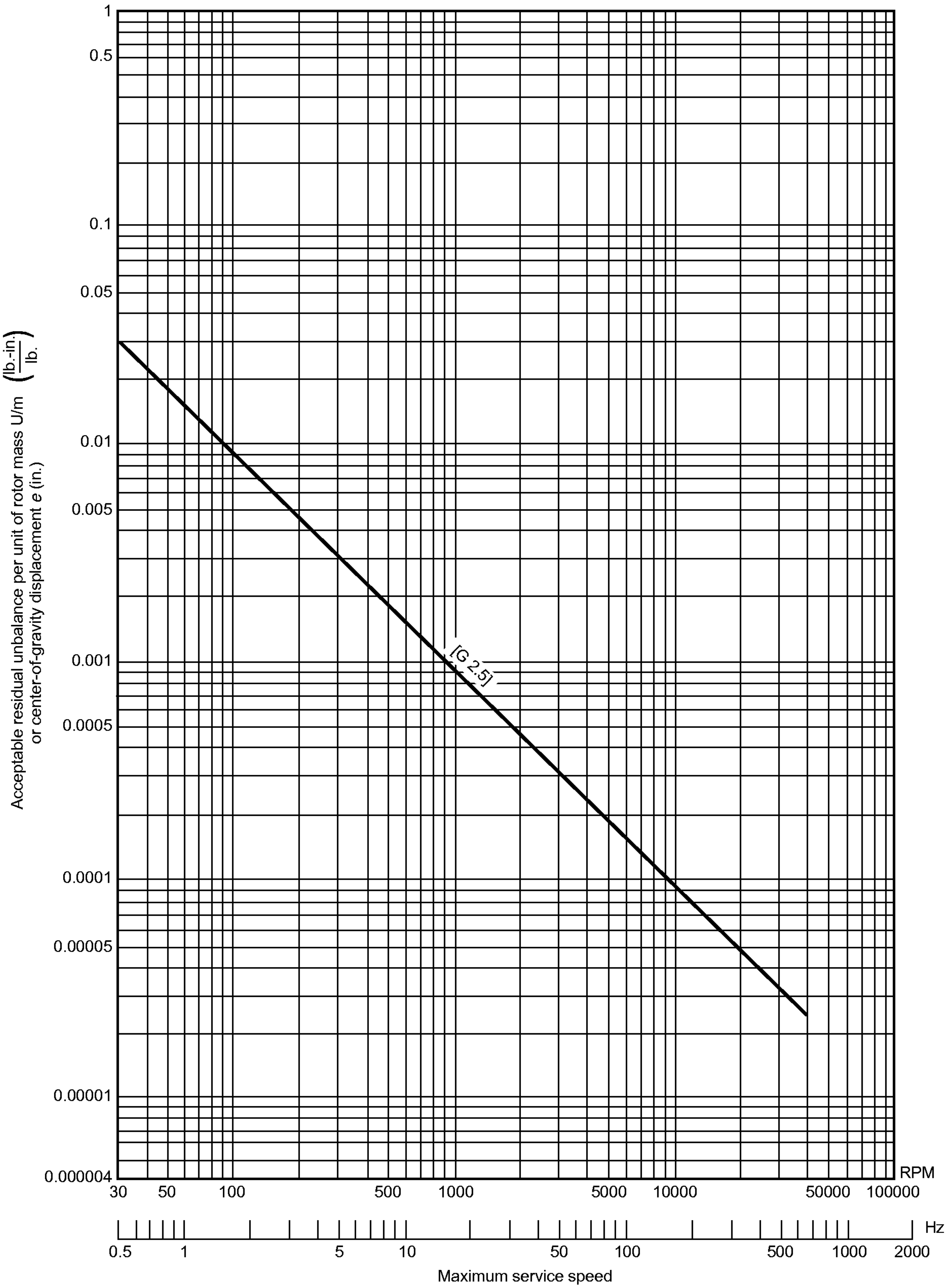


Figure D-1—Maximum Residual Specific Unbalance Corresponding to Balance Quality Grade G2.5 (ANSI S2.19) (Shown in Customary Units)

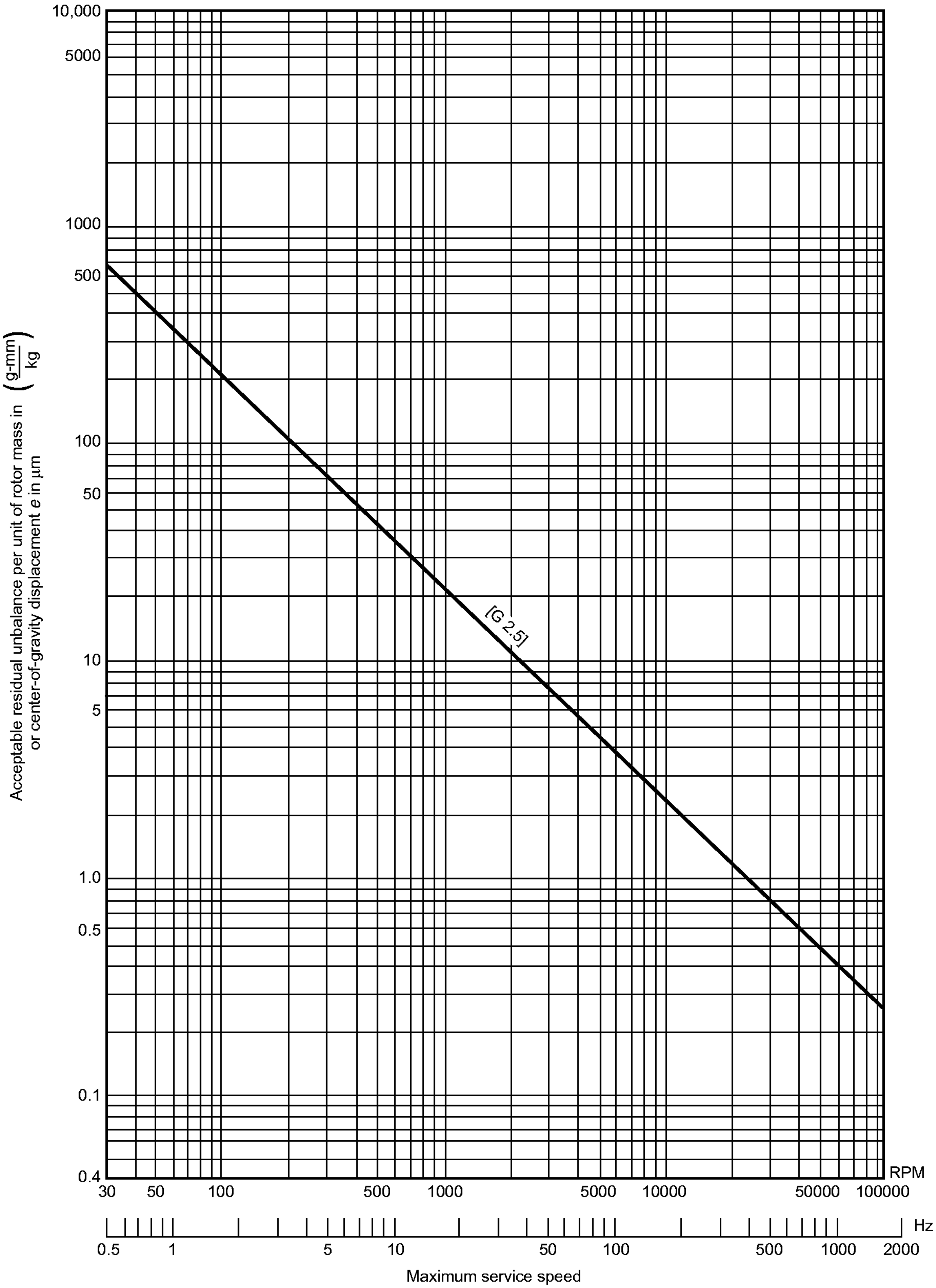


Figure D-2—Maximum Residual Specific Unbalance Corresponding to Balance Quality Grade G2.5 (ANSI S2.19) (Shown in SI Units)

APPENDIX E—PROCEDURE FOR DETERMINATION OF RESIDUAL UNBALANCE

E.1 General

This appendix describes the procedure to be used to determine residual unbalance in machine rotors. Although some balancing machines may be set up to read out the exact amount of unbalance, the calibration can be in error. The only sure method of determining is to test the rotor with a known amount of unbalance.

E.2 Residual Unbalance

Residual unbalance is the amount of unbalance remaining in a rotor after balancing. Unless otherwise specified, residual unbalance shall be expressed in g-mm (g-in).

E.3 Maximum Allowable Residual Unbalance

E.3.1 The maximum allowable residual unbalance, per plane, shall be calculated according to the paragraph from the standard to which this appendix is attached.

E.3.2 The static weight on each journal shall be determined by physical measurement. (Calculation methods may introduce errors). Do NOT simply assume that rotor weight is equally divided between the two journals. There can be great discrepancies in the journal weight to the point of being very low (even negative on over-hung rotors). In the example problem, the left plane has a journal weight of 530.7 kg (1170 lb.). The right plane has a journal weight of 571.5 kg (1260 lb.).

E.4 Residual Unbalance Check

E.4.1 GENERAL

E.4.1.1 When the balancing machine readings indicate that the rotor has been balanced within the specified tolerance, a residual unbalance check shall be performed before the rotor is removed from the balancing machine.

E.4.1.2 To check the residual unbalance, a known trial weight is attached to the rotor sequentially in six equally spaced radial positions (60 degrees apart), each at the same radius. (i.e., same moment [g-in.]). The check is run at each balance machine readout plane, and the readings in each plane are tabulated and plotted on the polar graph using the procedure specified in E.4.2.

E.4.2 PROCEDURE

E.4.2.1 Select a trial weight and radius that will be equivalent to between one and two times the maximum allowable residual unbalance (e.g., if U_{max} is 488.4 g-mm [19.2 g-in.]), the trial weight should cause 488.4 to 976.8 g-mm (19.2 to 38.4 g-in.) of unbalance]. This trial weight and radius must be sufficient so that the resulting plot in E 4.2.5 encompasses the origin of the polar plot.

E.4.2.2 Starting at a convenient reference plane (i.e., ~ last heavy spot), mark off the specified six radial positions (60-degree increments) around the rotor. Add the trial weight near the last known heavy spot for that plane. Verify that the balance machine is responding and is within the range and graph selected for taking the residual unbalance check.

E.4.2.3 Verify that the balancing machine is responding linearly (i.e., no faulty sensors or displays) sufficient display near balance and within range at largest unbalance. If the trial weight was added to the last known heavy spot, the first meter reading should be at least twice as much as the last reading taken before the trial weight was added. Little or no meter reading generally indicates that the rotor was not balanced to the correct tolerance, the balancing machine was not sensitive enough, or that a balancing machine fault exists (i.e., a faulty pickup). Proceed, if all OK.

E.4.2.4 Remove the trial weight and rotate the trial weight to the next trial position (that is, 60, 120, 180, 240, 300 and 360 degrees from the initial trial weight position). Repeat the initial position as a check for repeatability on the Residual Unbalance Worksheet. All verification shall be performed using only one sensitivity range on the balance machine.

E.4.2.5 Plot the balancing machine amplitude readout versus angular location of trial weight (NOT balancing machine phase angle) on the Residual Unbalance Worksheet and calculate the amount of residual unbalance (refer to worksheets, Figures E-3 and E-5).

Note: The maximum reading occurs when the trial weight is placed at the rotor's remaining heavy spot; the minimum reading occurs when the trial weight is placed opposite the rotor's heavy spot (light spot). The plotted readings should form an approximate circle around the origin of the polar chart. The balance machine angular location readout should approximate the location of the trial weight. The maximum deviation (highest reading) is the heavy spot (represents the plane of the residual unbalance). Blank work sheets are Figures E-1 and E-2.

E.4.2.6 Repeat the steps described in E.4.2.1 through E.4.2.5 for each balance machine readout plane. If the specified maximum allowable residual unbalance has been exceeded in any balance machine readout plane, the rotor shall be balanced more precisely and checked again. If a balance correction is made in any balance machine readout plane, then the residual unbalance check shall be repeated in all balance machine readout planes.

E.4.2.7 For stack component balanced rotors, a residual unbalance check shall be performed after the addition and balancing of the rotor after the addition of the first rotor component, and at the completion of balancing of the entire rotor, as a minimum.

Note 1: This ensures that time is not wasted and rotor components are not subjected to unnecessary material removal in attempting to balance a multiple component rotor with a faulty balancing machine.

Note 2: For large multi-stage rotors, the journal reactions may be considerably different from the case of a partially stacked to a completely stacked rotor.

Customer: ______
Job / Project Number: ______
OEM Equipment S / N: ______
Rotor Identification Number: ______
Repair Purchase Order Number: ______
Vendor Job Number: ______
Correction Plane (Left or Right)—use sketch ______ (plane)

Balancing Speed ______ (rpm)
Maximum Rotor Operating Speed (N) ______ (rpm)
Static Journal Weight Closest to This Correction Plane (W) ______ (kg) ______ (lb.)
Trial Weight Radius (R)—the radius at which the trial weight will be placed ______ (mm) ______ (in.)

Calculate Maximum Allowable Residual Unbalance (U_{max}):

Si Units:

$U_{max} = \frac{(6350) \times (W)}{(N)} = \frac{(6350) \times \square}{\square} = \square$ (g-mm)

Customary Units:

$U_{max} = \frac{(113.4) \times (W)}{(N)} = \frac{(113.4) \times \square}{\square} = \square$ (g-in.)

Calculate the trial unbalance (TU):

Trial Unbalance (TU) is between ($1 \times U_{max}$) and ($2 \times U_{max}$) (1 ×) to (2 ×) (Selected Multiplier is) ______

SI Units: ______ to ______ = ______ (g-mm)
Customary units: ______ to ______ = ______ (g-in.)

Calculate the trial weight (TW):

Trial Weight (TW) = $\frac{U_{max}}{R}$ = $\frac{\square \text{ g-mm}}{\square \text{ mm}}$ or $\frac{\square \text{ g-in.}}{\square \text{ in.}}$ = ______ (g)

Conversion Information:
1 kg = 2.2046 lb. 1 oz. = 28.345 g

Obtain the test data and complete the table:

Test Data

Position	Trial Weight Angular Location on Rotor (degrees)	Balancing Mach Readout	
		Amplitude (grams)	Phase Angle (degrees)
1	0		
2	60		
3	120		
4	180		
5	240		
6	300		
Repeat 1	0		

Sketch the rotor configuration:

Rotor Sketch

PROCEDURE:

Step 1: Plot the balancing machine amplitude versus trial weight angular location on the polar chart (Figure E-2) such that the largest and smallest values will fit.
Step 2: The points located on the Polar Chart should closely approximate a circle. If it does not, then it is probably that the recorded data it is in error and the test should be repeated.
Step 3: Determine the maximum and minimum balancing machine amplitude readings.
Step 5: Using the worksheet, (Figure E-2), determine the *Y* and *Z* values required for the residual unbalance calculation.
Step 6: Using the worksheet, (Figure E-2), calculate the residual unbalance remaining in the rotor.
Step 7: Verify that the determined residual unbalance is equal to or less than the maximum allowable residual unbalance (U_{max}).

NOTES:

1) The trial weight angular location should be referenced to a keyway or some other permanent marking on the rotor. The preferred location is the location of the once-per-revolution mark (for the phase reference transducer).
2) The balancing machine amplitude readout for the Repeat of 1 should be the same as Position 1, indicating repeatability.
3) A primary source for error is not maintaining the same radius for each trial weight location.

Balanced By: ______ Date: ______
Approved By: ______ Date: ______

Figure E-1—(Blank) Residual Unbalance Work Sheet

Customer: ______________________________

Job / Project Number: ______________________________

OEM Equipment S / N: ______________________________

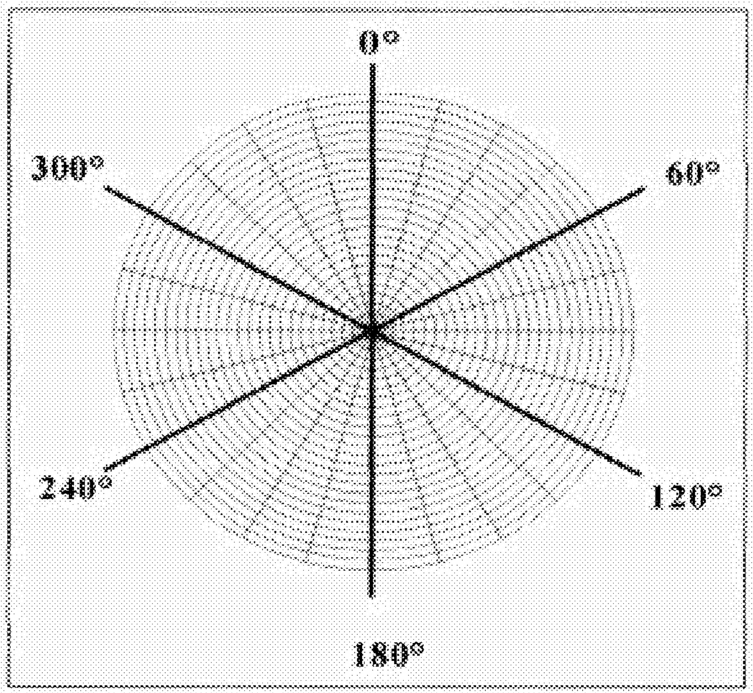
Rotor Identification Number: ______________________________

Repair Purchase Order Number: ______________________________

Vendor Job Number: ______________________________

Correction Plane (Left or Right) - use sketch ______________________________ (plane)

RESIDUAL UNBALANCE POLAR PLOT



Rotor Rotation: ☐ CCW ☐ CW   Phase is layed out: ☐ CCW ☐ CW

Calculate Y and Z values:

Maximum amplitude value is: [ ] grams   Minimum amplitude value is: [ ]

Y = (Maximum - Minimum) / 2 ([ ] − [ ]) / 2 = [ ]

Z = (Maximum + Minimum) / 2 ([ ] + [ ]) / 2 = [ ]

Residual Unbalance

Left in Rotor =	(TI)	×	(Y)	/	(Z)	=	
SI Units:	[ ]	×	[ ]	/	[ ]	=	[ ]
Customary Units:	[ ]	×	[ ]	/	[ ]	=	[ ]

Allowable Unbalance Tolerance = U_{max} = [ ] gm-mm [ ] gm-in.

RESULT: Residual unbalance left in the rotor is equal to or less than the allowable unbalance tolerance?

☐ PASS ☐ FAIL

☐ As Received ☐ Final ☐ Other: ________

Balanced By: ________ Date: ________

Approved By: ________ Date: ________

Figure E-2—(Blank) Residual Unbalance Polar Plot Work Sheet

Customer:	ABC Refining Co.
Job / Project Number:	00-1234
OEM Equipment S / N:	C-1234
Rotor Identification Number:	1234-C-4320
Repair Purchase Order Number:	PO 12345678
Vendor Job Number:	Shop-00-1234
Correction Plane (Left or Right)—use sketch	Left (plane)

Balancing Speed	800 (rpm)	
Maximum Rotor Operating Speed (N)	6900 (rpm)	
Static Journal Weight Closest to This Correction Plane (W)	530.7 (kg)	1170 (lb.)
Trial Weight Radius (R)—the radius at which the trial weight will be placed	381 (mm)	15 (in.)

Calculate Maximum Allowable Residual Unbalance (U_{max}):

SI Units:

$U_{max} = \frac{(6350) \times (W)}{(N)} = \frac{(6350) \times 530.7}{6900} = $ 488.4 (g-mm)

Customary Units:

$U_{max} = \frac{(113.4) \times (W)}{(N)} = \frac{(113.4) \times 1170}{6900} = $ 19.2 (g-in.)

Calculate the trial unbalance (TU):

Trial Unbalance (TU) is between ($1 \times U_{max}$) and ($2 \times U_{max}$) — (1 ×) to (2 ×) (Selected Multiplier is) 1.6

	(1 ×)	to	(2 ×)		
SI Units:	488.4	to	976.8	is	781.4 (g-mm)
Customary units:	19.2	to	38.5	is	30.8 (g-in.)

Calculate the trial weight (TW):

Trial Weight (TW) = $\frac{U_{max}}{R} = \frac{781 \text{ g-mm}}{381 \text{ mm}}$ or $\frac{31 \text{ g-in.}}{15 \text{ in.}}$ = 2.1 (g)

Conversion Information:

1 kg = 2.2046 lb. 1 oz. = 28.345 g

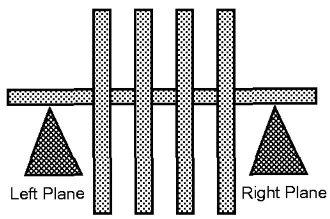
Obtain the test data and complete the table:

Test Data

Position	Trial Weight Angular Location on Rotor (degrees)	Balancing Mach Readout	
		Amplitude (grams)	Phase Angle (degrees)
1	0	1.60	358
2	60	1.11	59
3	120	1.58	123
4	180	2.21	182
5	240	3.00	241
6	300	2.30	301
Repeat 1	0	1.58	359

Sketch the rotor configuration:

Rotor Sketch



PROCEDURE:

Step 1: Plot the balancing machine amplitude versus trial weight angular location on the polar chart (Figure E-4) such that the largest and smallest values will fit.

Step 2: The points located on the Polar Chart should closely approximate a circle. If it does not, then it is probably that the recorded data it is in error and the test should be repeated.

Step 3: Determine the maximum and minimum balancing machine amplitude readings.

Step 5: Using the worksheet, (Figure E-4), determine the *Y* and *Z* values required for the residual unbalance calculation.

Step 6: Using the worksheet, (Figure E-4), calculate the residual unbalance remaining in the rotor.

Step 7: Verify that the determined residual unbalance is equal to or less than the maximum allowable residual unbalance (U_{max}).

NOTES:

1) The trial weight angular location should be referenced to a keyway or some other permanent marking on the rotor. The preferred location is the location of the once-per-revolution mark (for the phase reference transducer).

2) The balancing machine amplitude readout for the Repeat of 1 should be the same as Position 1, indicating repeatability.

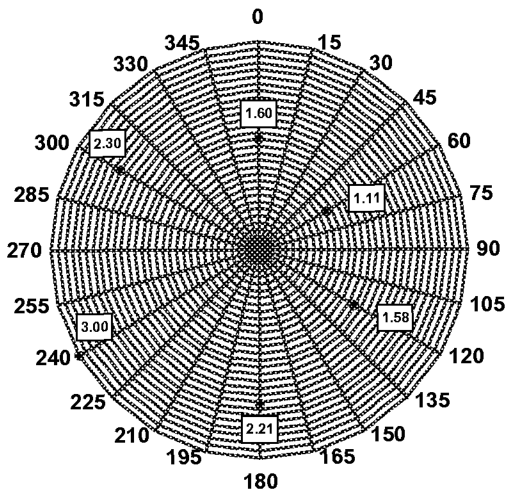
3) A primary source for error is not maintaining the same radius for each trial weight location.

Balanced By:	CJ, TR, & RC	Date:	05/24/00
Approved By:	CC	Date:	05/24/00

Figure E-3—Sample Residual Unbalance Work Sheet for Left Plane

Customer:	ABC Refining Co.
Job / Project Number:	00-1234
OEM Equipment S / N:	C-1234
Rotor Identification Number:	1234-C-4320
Repair Purchase Order Number:	PO 12345678
Vendor Job Number:	Shop-00-1234
Correction Plane (Left or Right)—use sketch	Left (plane)

RESIDUAL UNBALANCE POLAR PLOT



Rotor Rotation: ☒ CCW ☐ CW

Phase is layed out: ☐ CCW ☒ CW

Calculate *Y* and *Z* values:

Maximum amplitude value is:	3.00	grams	Minimum amplitude value is:			1.11 grams
Y = (Maximum - Minimum) / 2 (	3.00	–	1.11	) / 2	=	0.9
Z = (Maximum + Minimum) / 2 (	3.00	+	1.11	) / 2	=	2.1

Residual Unbalance Left in Rotor =	(TU)	×	(*Y*)	/	(*Z*)	=		
SI Units:	781	×	0.95	/	2.06	=	359.3	g-mm
Customary Units:	31	×	0.95	/	2.06	=	14.1	g-in

Allowable Unbalance Tolerance = U_{max} = 488.4 g-mm 19.2 g-in.

RESULT: Residual unbalance left in the rotor is equal to or less than the allowable unbalance tolerance? PASS

☐ As Received ☐ Final ☒ Other: w/o trim hardware

Balanced By:	CJ, TR & RC	Date:	05/24/00
Approved By:	CC	Date:	05/24/00

Figure E-4—Sample Residual Unbalance Polar Plot Work Sheet for Left Plane

Customer:	ABC Refining Co.	
Job / Project Number:	00-1234	
OEM Equipment S / N:	C-1234	
Rotor Identification Number:	1234-C-4320	
Repair Purchase Order Number:	PO 12345678	
Vendor Job Number:	Shop-0-1234	
Correction Plane (Left or Right)—use sketch	Right	(plane)

Balancing Speed	800	(rpm)		
Maximum Rotor Operating Speed (N)	6900	(rpm)		
Static Journal Weight Closest to This Correction Plane (W)	571.5	(kg)	1260	(lb.)
Trial Weight Radius (R)—the radius at which the trial weight will be placed	203	(mm)	8	(in.)

Calculate Maximum Allowable Residual Unbalance (U_{max}):

Si Units:

$U_{max} = \frac{(6350) \times (W)}{(N)} = \frac{(6350) \times 571.5}{6900} =$ 525.9 (g-mm)

Customary Units:

$U_{max} = \frac{(113.4) \times (W)}{(N)} = \frac{(113.4) \times 1260}{6900} =$ 20.7 (g-in.)

Calculate the trial unbalance (TU):

	(1 ×)	to	(2 ×)	(Selected Multiplier is)	1.6
Trial Unbalance (TU) is between ($1 \times U_{max}$) and ($2 \times U_{max}$)					
SI Units:	525.9	to	1051.9	is	841.5 (g-mm)
Customary units:	20.7	to	41.4	is	33.1 (g-in.)

Calculate the trial weight (TW):

Trial Weight (TW) = $\frac{U_{max}}{R} = \frac{842 \text{ g-mm}}{203 \text{ mm}}$ or $\frac{33 \text{ g-in.}}{8 \text{ in.}}$ = 4.1 (g)

Conversion Information:

1 kg = 2.2046 lb. 1 oz. = 28.345 g

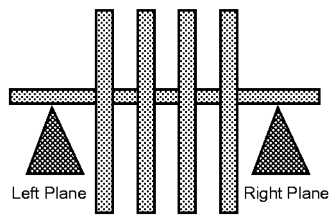
Obtain the test data and complete the table:

Test Data

Position	Trial Weight Angular Location on Rotor (degrees)	Balancing Mach Readout: Amplitude (grams)	Balancing Mach Readout: Phase Angle (degrees)
1	0	4.60	3
2	60	4.20	58
3	120	4.70	121
4	180	5.20	180
5	240	5.80	235
6	300	5.10	301
Repeat 1	0	4.60	2

Sketch the rotor configuration:

Rotor Sketch



PROCEDURE:

Step 1: Plot the balancing machine amplitude versus trial weight angular location on the polar chart (Figure E-6) such that the largest and smallest values will fit.

Step 2: The points located on the Polar Chart should closely approximate a circle. If it does not, then it is probably that the recorded data it is in error and the test should be repeated.

Step 3: Determine the maximum and minimum balancing machine amplitude readings .

Step 5: Using the worksheet, (Figure E-6), determine the *Y* and *Z* values required for the residual unbalance calculation.

Step 6: Using the worksheet, (Figure E-6), calculate the residual unbalance remaining in the rotor.

Step 7: Verify that the determined residual unbalance is equal to or less than the maximum allowable residual unbalance (U_{max}).

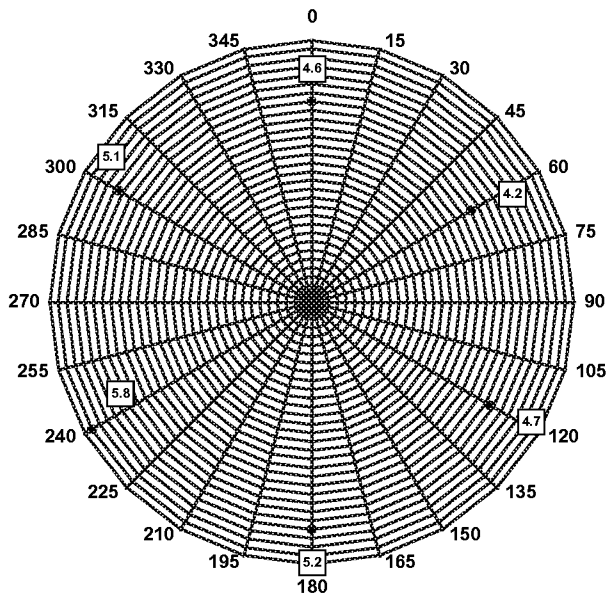
NOTES:

1) The trial weight angular location should be referenced to a keyway or some other permanent marking on the rotor. The preferred location is the location of the once-per-revolution mark (for the phase reference transducer).
2) The balancing machine amplitude readout for the Repeat of 1 should be the same as Position 1, indicating repeatability.
3) A primary source for error is not maintaining the same radius for each trial weight location.

Balanced By:	CJ, TR, & RC	Date:	05/24/00
Approved By:	CC	Date:	05/24/00

Figure E-5—Sample Residual Unbalance Work Sheet for Right Plane

Customer:	ABC Refining Co.
Job / Project Number:	00-1234
OEM Equipment S / N:	C-1234
Rotor Identification Number:	1234-C-4320
Repair Purchase Order Number:	PO 12345678
Vendor Job Number:	Shop-00-1234
Correction Plane (Left or Right)—use sketch	Right (plane)



Rotor Rotation: ☒ CCW ☐ CW Phase is layed out: ☐ CCW ☒ CW

Calculate *Y* and *Z* values:

Maximum amplitude value is:	5.80	grams	Minimum ampltude value is:			4.20	grams
Y = (Maximum - Minimum) / 2 (	5.80	–	4.20	) / 2	=	0.8	
Z = (Maximum + Minimum) / 2 (	5.80	+	4.20	) / 2	=	5.0	

Residual Unbalance

Left in Rotor =	(TU)	×	(*Y*)	/	(*Z*)			
SI Units:	842	×	0.8	/	5	=	134.6	g-mm
Customary Units:	33	×	0.8	/	5	=	5.3	g-in.

Allowable Unbalance Tolerance = U_{max} = 525.9 g-mm 20.7 g-in.

RESULT: Residual unbalance left in the rotor is equal to or less than the allowable unbalance tolerance? PASS

☐ As Received ☐ Final ☒ Other: w/o trim hardware

Balanced By:	CJ, TR & RC	Date:	05/24/00
Approved By:	CC	Date:	05/24/00

Figure E-6—Sample Residual Unbalance Polar Plot Work Sheet for Right Plane

APPENDIX F— CENTRIFUGAL FANS VENDOR DRAWING AND DATA REQUIREMENTS

This appendix consists of a sample distribution record (schedule), followed by a description of the items that are presented numerically in the schedule.

CENTRIFUGAL FAN VENDOR DRAWING AND DATA REQUIREMENTS

JOB NO. ______________________ ITEM NO. _____________
PURCHASE ORDER NO. _________ DATE ________________
REQUISITION NO. ______________ DATE ________________
INQUIRY NO. __________________ DATE ________________
PAGE _______ OF _____ BY ________________________

FOR ____
SITE ____
SERVICE ____________________________________

REVISION ____
UNIT ____
NO. REQUIRED _______________________________________

Proposal[a] Bidder shall furnish ______ copies of data for all items indicated by an X.

Review[b] Vendor shall furnish ______ copies and ______ transparencies of drawings and data indicated.

Final[b] Vendor shall furnish ______ copies and ______ transparencies of drawings and data indicated.
Vendor shall furnish ______ operating and maintenance manuals.

DISTRIBUTION RECORD

Final—Received from vendor
Final—Due from vendor[c]
Review—Returned to vendor
Review—Received from vendor
Review—Due from vendor[c]

Proposal	Review	Final	FAN	Review—Due from vendor	Review—Received from vendor	Review—Returned to vendor	Final—Due from vendor	Final—Received from vendor
			1. Certified dimensional outline drawing and list of connections					
			2. Cross-sectional drawing and bill of materials					
			3. Rotor assembly drawing and bill of materials					
			4. Thrust bearing assembly drawing and bill of materials					
			5. Journal bearing assembly drawing and bill of materials					
			6. Shaft sleeve and seal drawing and bill of materials					
			7. Shaft/coupling assembly drawing and bill of materials					
			8. Silencer(s), intake cap(s) or hood(s), trash screen(s), and transition piece(s) drawing					
			9. Inlet damper(s)/vane(s) assembly drawing(s) and bill of materials					
			10. Discharge damper assembly drawing and bill of materials					
			11. Control system drawing and bill of materials					
			12. Cleaning system drawing and bill of materials					
			13. Electrical and instrumentation schematics and bill of materials					
			14. Electrical and instrumentation arrangement drawing and list of connections					
			15. Lube/control oil schematic and bill of materials					
			16. Lube oil assembly and arrangement drawing					
			17. Lube oil component drawings and data					
			18. Performance curves					
			19. Vibration analysis data					
			20. Lateral critical speed analysis (optional)					
			21. Torsional critical speed analysis					
			22. Transient torsional analysis					
			23. Allowable flange loadings					
			24. Coupling alignment diagram					
			25. Weld procedures					
			26. Performance test log					
			27. Mechanical run test logs					
			28. Rotor balance logs					
			29. Rotor mechanical and electrical runout					
			30. "As-built" data sheets					
			31. "As-built" dimensions					
			32. Field installation instructions					
			33. Operating and maintenance manuals					
			34. Spare parts recommendation and price list					

[a]Proposal drawings and data do not have to be certified or "as-built."
[b]Purchaser will indicate in this column the time frame for submission of materials using the nomenclature given at the end of this form.
[c]Bidder shall complete these two columns to reflect his actual distribution schedule and include this form with his proposal.

CENTRIFUGAL FAN VENDOR DRAWINGS AND DATA REQUIREMENTS

JOB NO. __________________ ITEM NO. _________________
PAGE _______ OF _____ BY _________________________
DATE _______________ REV. NO. _______________________

Proposal[a] Bidder shall furnish _______ copies of data for all items indicated by an X.

Review[b] Vendor shall furnish _______ copies and _______ transparencies of drawings and data indicated.

Final[b] Vendor shall furnish _______ copies and _______ transparencies of drawings and data indicated.
Vendor shall furnish _______ operating and maintenance manuals.

DISTRIBUTION RECORD

Final—Received from vendor
Final—Due from vendor[c]
Review—Returned to vendor
Review—Received from vendor
Review—Due from vendor[c]

Proposal	Review	Final	Item	Review—Due from vendor	Review—Received from vendor	Review—Returned to vendor	Final—Due from vendor	Final—Received from vendor
			MOTOR					
			35. Certified dimensional outline drawing					
			36. Cross-sectional drawing and bill of material					
			37. "As-built" data sheet					
			38. Performance data					
			39. Certified drawings of auxiliary systems					
			40. Operating and maintenance manuals					
			41 Spare parts recommendation and price list					
			GEAR					
			42. Certified dimensional outline drawing and list of connections					
			43. Cross-sectional drawing and bill of materials					
			44. Thrust bearing assembly drawing and bill of materials					
			45. Journal bearing assembly drawing and bill of materials					
			46. "As-built" data sheets					
			47. Mechanical run test log					
			48. Gear test logs					
			49. Specified operational test data and reports					
			50. Operating and maintenance manuals					
			51. Spare parts recommendation and price list					
			GENERAL					
			52. Engineering, fabrication, and delivery schedule (progress reports)					
			53. List of drawings					
			54. Shipping list					
			55. Technical data manual					
			56. Material Safety Data Sheets					
			57. Preservation, packaging, and shipping procedures					
			58. Bearing babbitt strength versus temperature curves					

[a]Proposal drawings and data do not have to be certified or "as-built."
[b]Purchaser will indicate in this column the time frame for submission of materials using the nomenclature given at the end of this form.
[c]Bidder shall complete these two columns to reflect his actual distribution schedule and include this form with his proposal.

Notes:
1. Vendor shall not proceed with manufacture without purchaser's review of drawings if required by 6.2.1.2.
2. Send all drawings and data to ____
____
3. All drawings and data must show project, appropriation, purchase order, and item numbers in addition to the plant location and unit. One set of the drawings/instructions necessary for field installation must be forwarded with shipment in addition to copies specified above.
4. See expanded description below of specified items.
5. All of the requested information indicated above shall be received before final payment will be made.

Nomenclature:
_________ S—number of weeks prior to shipment.
_________ F—number of weeks after firm order.
_________ D—number of weeks after receipt of approved drawings.

Vendor ____
Date __________________________ Vendor Reference _____________________________
Signature ____
(Signature acknowledges receipt of all instructions)

DESCRIPTION

1. Certified dimensional outline drawing including:
   a. The size, rating, and location of all customer connections.
   b. Approximate overall handling weights.
   c. Overall dimensions.
   d. Shaft centerline height.
   e. Dimensions of baseplates (if furnished) complete with diameter, number, and locations of bolt holes and thickness of metal through which the bolts must pass, recommended clearances, center of gravity, and details for foundation design.
   f. Direction of rotation.

2. Cross-sectional drawings and bill of materials including:
   a. Journal bearing clearances and tolerance.
   b. Rotor float (axial).
   c. Seal clearances and tolerance.
   d. Outside diameter of wheel at blade tip.
   e. Axial overlap of the inlet cone and impeller.
   f. Radial clearance between the inlet cone and impeller.

3. Rotor assembly drawing including:
   a. Axial position from a thrust collar face to:
      1. The impeller (each inlet side).
      2. Each radial probe.
      3. Each journal bearing centerline.
      4. The phase angle notch.
      5. Coupling face or end of shaft.
   b. Thrust collar assembly details including:
      1. Collar-shaft fit with tolerance.
      2. Concentricity (or axial run-out) tolerance.
      3. The surface finish requirements for collar faces.
      4. The preheat method and temperature requirements for "shrunk-on" collar installation and removal.
      5. Required torque for locknut.
   c. Dimensioned shaft end(s) for coupling mounting.
   d. The bill of materials.

4. Thrust bearing assembly drawing and bill of materials.

5. Journal bearing assembly drawing and bill of materials.

6. Shaft sleeve and seal drawing and bill of materials including:
   a. Sleeve-shaft fit with tolerance.
   b. Surface finish requirements for sleeve.
   c. Seal clearances and tolerances.
   d. The preheat method and temperature requirements for "shrunk-on" sleeve installation and removal.

7. Shaft/coupling assembly drawing and bill of materials including allowable misalignment tolerances.
   a. Hydraulic mounting procedure.
   b. Shaft end gap and tolerance.
   c. Coupling guards.
   d. Thermal growth.
   e. Make, size, and serial number.
   f. Balance tolerance.

8. Silencer(s), intake cap(s) or hood(s), trash screen(s), and transition piece(s).

9. Inlet damper(s)/vane(s), assembly drawing(s), and bill of materials.

10. Discharge damper assembly drawing and bill of materials.

11. Fan control system drawing and bill of materials including:
    a. Damper positioner drawings.
    b. Damper positioner operating and maintenance manuals.

12. Fan cleaning system drawing and bill of materials including:
    a. Cleaner arrangement drawing.
    b. Cleaner controller assembly drawing.
    c. Electric wiring diagram.
    d. Operating and maintenance manual.

13. Electrical and instrumentation schematics nd bill of materials including:
    a. Vibration warning and shutdown limits.
    b. Bearing temperature warning and shutdown limits.
    c. Lube oil temperature warning and shutdown limits.

14. Electrical and instrumentation arrangement drawing and list of connections.

15. Lube oil schematic and bill of materials including:
    a. Steady state and transient oil flows and pressures at each use point.
    b. Control, alarm, and trip settings (pressure and recommended temperatures).
    c. Heat loads at each use point at maximum load.
    d. Utility requirements, including electrical, water, and air.
    e. Pipe, valve, and orifice sizes.
    f. Instrumentation, safety devices, and control schemes.
    g. Control valve sizing coefficient (*Cv*).

16. Lube oil system arrangement drawing including size, rating, and location of all customer connections.

17. Lube oil component drawings and data including:
    a. Pumps and drivers.
       1. Certified dimensional outline drawing.
       2. Cross-section and bill of materials.

3. Mechanical seal drawing and bill of materials.
4. Performance curves for centrifugal pumps.
5. Instruction and operating manuals.
6. Completed data forms for pumps and for drivers.

b. Coolers, filters, and reservoir.
   1. Fabrication drawings.
   2. Maximum, minimum, and normal liquid levels in reservoir.
   3. Completed data form for cooler(s).

c. Instrumentation.
   1. Controllers.
   2. Switches.
   3. Control valves.
   4. Gauges.

d. Priced spare parts list(s) and recommendations.

18. Performance curves including:
    a. Curves for static pressure rise and horsepower versus ICFM for all operating conditions specified on data sheet.
    b. Curve for speed versus starting torque.

19. Vibration analysis data including:
    a. The number of blades in the wheel.
    b. The number of teeth-gear type couplings.

20. Lateral critical speed analysis including:
    a. Method used.
    b. Graphic display of bearing and support stiffness and its effect on critical speeds.
    c. Graphic display of rotor response to unbalance (including damping).
    d. Graphic display of overhung moment and its effect on critical speed (including damping).
    e. Journal static loads.
    f. Stiffness and damping coefficients.
    g. Tilting pad geometry and configuration.
       1. Pad angle.
       2. Pivot clearance.
       3. Pad clearance.
       4. Preload.

21. Torsional critical speed analysis for all motor and/or gear driven units including but not limited to the following:
    a. Method used.
    b. Graphic display of the mass-elastic system.
    c. Tabulation identifying the mass moment torsional stiffness for each component in the mass elastic system.
    d. Graphic display of exciting sources (RPM).
    e. Graphic display of torsional critical speeds and deflections (mode shape diagrams).

22. Transient torsional analysis for all synchronous motor driven units.

23. Allowable flange loading(s) for all customer connections including anticipated thermal movements referenced to a defined point.

24. A coupling alignment diagram, including recommended limits during operation. Note all shaft end position changes and support growths from 15°C (60°F) or another temperature specified by the purchaser. Include the recommended alignment method and cold setting targets.

25. Weld procedures for fabrication and repair.

26. Performance test log.

27. Mechanical run test logs including but not limited to the following:
    a. Oil flows, pressures, and temperatures.
    b. Vibration, including *x–y* plot of amplitude and phase angle versus revolutions per minute during startup and shutdown.
    c. Bearing metal temperatures.

28. Rotor balance logs.

29. Rotor combined mechanical and electrical run-out.

30. "As-built" data sheets.

31. "As-built" dimensions (including design tolerances) and/or data:
    a. Shaft diameters at:
        1. Thrust collar (for separate collars).
        2. Each seal.
        3. Impeller hub.
        4. Each journal bearing.
        5. Each coupling.
    b. Each coupling bore.
    c. Each wheel bore.
    d. Thrust collar bore (for separate collars).
    e. Each journal bearing inside diameter.
    f. Thrust bearing concentricity (axial runout).
    g. Metallurgy and heat treatment for:
        1. Shaft.
        2. Impeller.
        3. Thrust collar(s).
    h. Hardness readings on parts listed under item 31.g above when corrosive agents which may cause stress corrosion cracking are in the motive or process fluid.

32. Field installation manual describing the following (see 5.3.6.2):
    a. Storage procedures.
    b. Foundation plan.
    c. Grouting details.

d. Setting equipment, rigging procedures, component weights, and lifting diagrams.
e. Coupling alignment diagram (per item 24 above).
f. Piping recommendations, including allowable flange loads.
g. Composite outline drawings for the driver/driven-equipment train including anchor-bolt locations.
h. Dismantling clearances.

33. Operating and maintenance manuals describing the following:
   a. Start-up.
   b. Normal shutdown.
   c. Emergency shutdown.
   d. Operating limits (see 2.7.1.6) other operating restrictions, and a list of undesirable speeds (see 2.7.1.6).
   e. Lube-oil recommendations and specifications.
   f. Routine operational procedures, including recommended inspection schedules and procedures.
   g. Instruction for:
      1. Disassembly and reassembly of rotor in casing.
      2. Rotor unstacking and restacking procedures.
      3. Disassembly and reassembly of journal bearings (for tilting-pad bearings, the instructions shall include “go/no-go” dimensions with tolerances for three-step plug gauges).
   h. Performance data, including:
      1. Curve showing certified shaft speed versus site rated power.
      2. Curve showing ambient temperature versus site rated power.
      3. Curve showing output-power shaft speed versus torque.
   i. Vibration analysis data, per items 19 – 22 above.
   j. As-built data, including:
      1. As-built data sheets.
      2. As-built dimensions or data, including assembly clearances.
      3. Mechanical running test logs, per item 27 above.
      4. Rotor balancing logs, per item 28 above.
      5. Rotor mechanical and electrical runout at each journal per item 29 above.
      6. Physical and chemical mill certificates for critical components.
      7. Test logs of all specified optional tests.
   k. Drawings and data, including:
      1. Certified dimensional outline drawing and list of connections.
      2. Cross-sectional drawing and bill of materials.
      3. Rotor assembly drawings and bills of materials.
      4. Thrust-bearing assembly drawing and bill of materials.
      5. Journal-bearing assembly drawings and bill of materials.
      6. Seal-component drawing and bill of materials.
      7. Lube-oil schematics and bills of materials.
      8. Lube-oil assembly drawing and list of connections.
      9. Lube-oil component drawings and data.
      10. Electrical and instrumentation schematics and bills of materials.

11. Electrical and instrumentation assembly drawings and list of connections.
12. Governor and control- and trip-system data.
13. Trip- and throttle-valve construction drawings.
14. Silencer(s), intake cap(s) or hood(s), trash screen(s), transition piece(s0 drawing.
15. Inlet damper(s) /vane(s) assembly drawing(s) and bill of materials.
16. Discharge damper assembly drawing and bill of materials.
17. Fan control system drawing and bill of materials.
18. Fan cleaning system drawing and bill of materials.

34. Spare parts recommendation and price list—see 5.3.5 in text of standard.

35. Certified dimensional outline drawing for motor and all auxiliary equipment including:
    a. The size, location, and purpose of all customer connections, including conduit, instrumentation, and any piping or ducting.
    b. ANSI rating and facing for any flanged connections.
    c. The size and location of anchor bolt holes and thickness of metal through which bolts must pass.
    d. The total weight of each item of equipment (motor and auxiliary equipment) plus loading diagrams, heaviest weight, and name of the part.
    e. Overall dimensions and all horizontal and vertical clearances necessary for dismantling purposes and the approximate location of lifting lugs.
    f. The shaft centerline height.
    g. Shaft end dimensions plus tolerances for the coupling.
    h. The direction of rotation. If suitable for rotation in both directions, the drawings shall be so marked.

36. Cross-sectional drawing and bill of materials including:
    a. Bearing clearances and tolerances.
    b. The rotor float (axial).
    c. The complete parts list.

37. “As-built” data sheets.

38. Performance data including:
    a. For induction motors 200 HP and smaller:
        1. Efficiency and power factor at one-half, three-quarter, and full load.
        2. Speed-torque curves.
    b. For induction motors 250 HP and larger, certified test reports for all tests run and guaranteed performance curves as follows:
        1. Time-current heating curve.
        2. Speed-torque curves at 70%, 80%, 90%, and 100% of rated voltage.
        3. Efficiency and power factor curves from 0 to rated service factor.
        4. Current versus load curves from 0 to rated service factor.
        5. Current versus speed curves from 0 to rated service factor.

39. Certified drawings of auxiliary systems including:
    a. Wiring diagrams for each auxiliary system supplied. The drawings shall clearly indicate the extent of the system to be supplied by the manufacturer and the extent to be supplied by others.

40. Operating and maintenance manuals shall be furnished describing installation, operation, and maintenance procedures. Each manual shall include the following sections:

    Section 1— Installation:
    a. Storage.
    b. Setting motor, rigging procedures, component weights, and lifting diagram.
    c. Piping and conduit recommendations.
    d. Composite outline drawing for motor, including anchor bolt locations.
    e. Dismantling clearances.

    Section 2 — Operation:
    a. Startup—including check prior to startup.
    b. Normal shutdown.
    c. Operating limits including number of successive starts.
    d. Lube oil recommendations.

    Section 3 — Disassembly and assembly instructions:
    a. Rotor in the motor.
    b. Journal bearings.
    c. Seals.

    Section 4 — Performance data required by item 38.

    Section 5 — "As-built" data:
    a. "As-built" data sheets.
    b. Mechanical run test logs.
    c. Rotor balance logs.
    d. Rotor mechanical and electrical run-out at each journal.

    Section 6 — Drawing and data requirements:
    a. Certified dimensional outline drawing for motor and all auxiliary equipment with list of connections.
    b. Cross-sectional drawing and bill of materials.

41. Spare parts recommendation and price list.

42. Certified dimensional outline drawings and list of connections including:
    a. The size, rating, location, and identification of all customer connections, including vents, drains, lubricating oil, conduits, and instruments.
    b. All principal dimensions, including those required for the purchaser's foundation.
    c. Overall and handling weights.
    d. Shaft centerline heights.
    e. Shaft end dimensions plus tolerances for the couplings.
    f. The direction of rotation.
    g. Location of the center of gravity of the gear unit.
    h. The size and location of anchor bolt holes and thickness of metal through which bolts must pass.
    i. Thermal and mechanical movements of casings and shafts.

43. Cross-sectional drawing and bill of materials including:
    a. Thrust and journal bearing clearances and tolerances.
    b. Gear and pinion float (axial).
    c. Complete parts list.

44. Thrust bearing assembly drawing and bill of materials.

45. Journal bearing assembly drawing and bill of materials.

46. "As-built" data sheets including:
    a. Data for torsional analysis (a dimensional sketch of each rotor showing diameters, lengths, weight moments of inertia, and torsional stiffness).
    b. Lateral critical speed reports.

47. Certified shop log of mechanical test run.

48. Gear manufacturer's standard test logs including gear contact test data.

49. Specified optional test data and reports as mutually agreed to by the purchaser and gear manufacturer.

50. Operating and maintenance manuals shall be furnished describing installation, operation, and maintenance procedures. Each manual shall include the following sections:

    Section 1 — Installation:
    a. Storage.
    b. Setting gear, rigging procedures, component weights, and lifting diagram.
    c. Piping recommendations.
    d. Composite outline drawing for gear, including anchor bolt hole locations.
    e. Dismantling clearances.
    f. Thermal and mechanical movements of casing and shaft.

    Section 2 — Operation:
    a. Startup—including final tests and checks.
    b. Normal shutdown.
    c. Operating limits.
    d. Routine operational procedures.
    e. Lube oil recommendations.

    Section 3 — Disassembly and assembly instructions:
    a. Rotors in casing.
    b. Journal bearings.
    c. Thrust bearings.
    d. Thrust collars.
    e. Seals.

    Section 4 — "As-built" data:
    a. "As-built" data sheets.
    b. Lateral critical speed report.

c. Mechanical run test logs.
d. Standard test logs.
e. Specified optional test data and reports.

Section 5 — Drawing and data requirements:
a. Certified dimensional outline drawing and list of connections.
b. Cross-sectional drawing and bill of materials.
c. Thrust bearing assembly drawing and bill of materials.
d. Journal bearing assembly drawing and bill of materials.

51. Spare parts recommendation price list.

52. Progress reports and delivery schedule, including vendor buy-out and milestones. The reports shall include engineering, purchasing, manufacturing, and testing schedules for all major components. Planned and actual dates and the percentage completed shall be indicated for each milestone in the schedule.

53. List of drawings, including latest revision numbers and dates.

54. Shipping list, including all major components that will ship separately.

55. Technical data manual, including the following:
a. "As-built" purchaser data sheets, per item 30 above.
b. Certified performance curves, per item 18 above.
c. Drawings in accordance with 5.3.2.
d. "As-built" assembly clearances.
e. Spare parts list, in accordance with 5.3.5.
f. Vibration data, per item 19 above.
g. Report, per items 20, 21, 22, 24, 26, 27, 28, and 29 above.
h. API data sheets.

56. Material safety data sheets (OSHA form 20).

57. Preservation, packaging, and shipping procedures.

58. Bearing Babbitt strength versus temperature curves.

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Quantity	Product Number	Title	SO★	Unit Price	Total
	C61008	Std 610, *Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services*		$ 132.00	
	C68201	Std 682, *Shaft Sealing Systems for Centrifugal and Rotary Pumps*		$ 116.00	
	C68601	RP 686, *Machinery Installation and Installation Design*		$ 83.00	
	C68401	Publ 684, *Tutorial on the API Standard Paragraphs Covering Rotor Dynamics and Balance (An Introduction to Lateral Critical and Train Torsional Analysis and Rotor Balancing*		$ 116.00	
	C61804	Std 618, *Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services*		$ 127.00	
	C67203	Std 672, *Packaged, Integrally Geared Centrifugal Air Compressors for Petroleum, Chemical, and Gas Industry Services*		$ 110.00	
	C61903	Std 619, *Rotary-Type Positive Displacement Compressors for Petroleum, Chemical, and Gas Industry Services*		$ 127.00	

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