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## 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



**Helping You  
Get The Job  
Done Right.<sup>SM</sup>**



# Centrifugal Fans for Petroleum, Chemical and Gas Industry Services

**Downstream Segment**

API STANDARD 673  
SECOND EDITION, JANUARY 2002



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Done Right.<sup>SM</sup>**

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# 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.

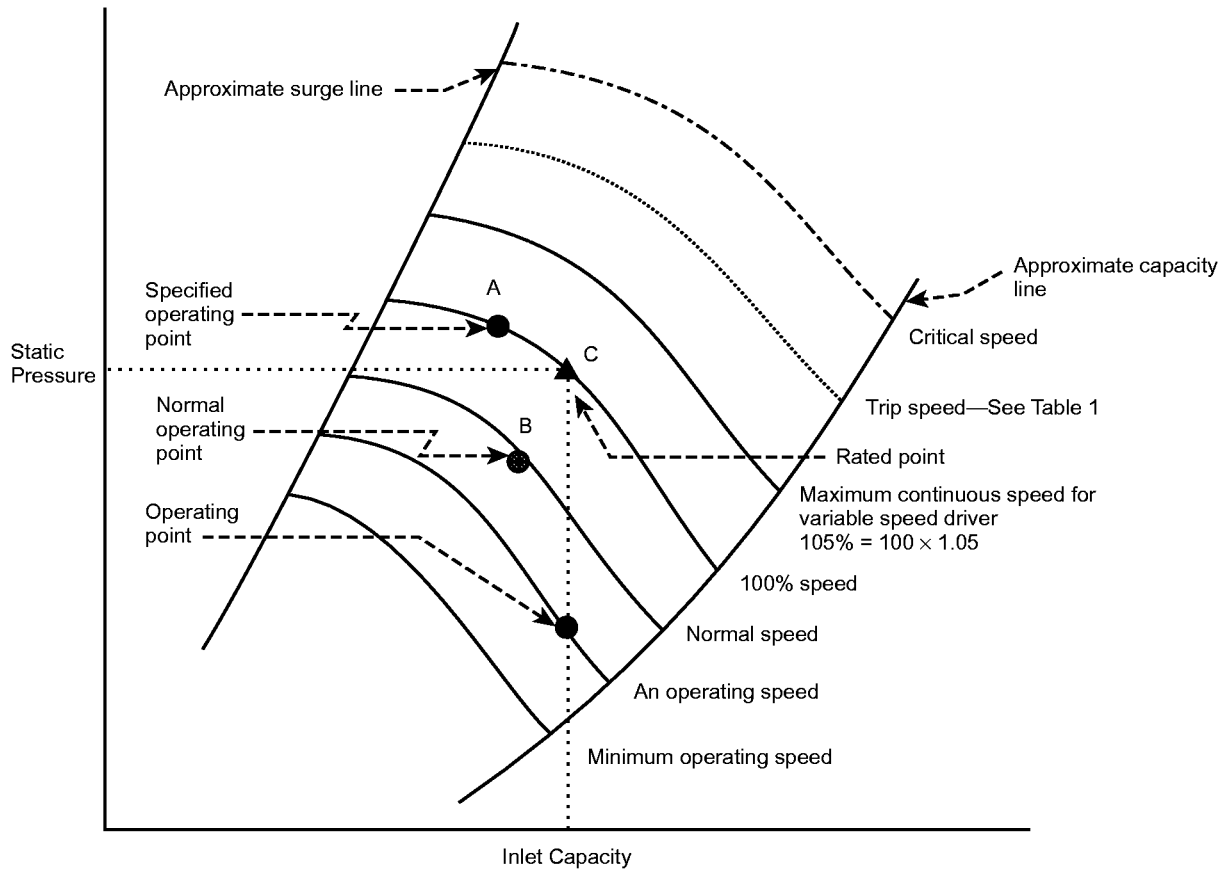
**1.4.11 hydrodynamic bearings:** Bearings that use the principles of hydrodynamic lubrication. Their surfaces are oriented so that relative motion forms an oil wedge to support the load without journal-to-bearing contact.

**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<sup>3</sup> 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<sup>3</sup>/h or m<sup>3</sup>/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 <sup>a</sup>	115
NEMA Class B, C, D <sup>a</sup>	110
Gas Turbine	115
Variable-speed Motor	110
Reciprocating Engine	110

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

### ABMA<sup>1</sup>

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

<sup>1</sup>American Bearing Manufacturers Association, 1101 Connecticut Avenue, N.W., Suite 700, Washington, D.C. 20036.

Standard 20	<i>Metric Ball and Roller Bearings (Except Tapered Roller Bearings) Conforming to Basic Boundary Plans: Bounding Dimensions, Tolerances, and Identification</i>	A 395	<i>Ferritic Ductile Iron Pressure Retaining Castings for Use at Elevated Temperatures</i>
AGMA <sup>2</sup>		A 536	<i>Ductile Iron Castings</i>
9002	<i>Bores and Keyways for Flexible Couplings (Inch Series)</i>	E 94	<i>Guide for Radiographic Testing</i>
AMCA <sup>3</sup>		E 125	<i>Reference Photographs for Magnetic Particle Indications on Ferrous Castings</i>
801-92	<i>Industrial Process/Power Generation Fans: Specifications Guidelines</i>	E 142	<i>Method for Controlling Quality of Radiographic Testing</i>
Std. 99-2404-98	<i>Drive Arrangements for Centrifugal Fans</i>	E 709	<i>Practice for Magnetic Particle Examination</i>
Std. 210-99	<i>Laboratory Methods of Testing Fans for Aerodynamic Performance Testing</i>	AWS <sup>6</sup>	
Std. 203-90	<i>Field Performance Measurement of Fan Systems</i>	D 1.1	<i>Structural Welding Code-steel</i>
Std. 802-92	<i>Industrial Process/Power Generation Fans: Establishing Performance Using Laboratory Models</i>	D 14.6	<i>Welding of Rotating Elements of Equipment</i>
Std. 803-96	<i>Industrial Process/Power Performance Fans: Site Performance Test Standard</i>	IEEE <sup>7</sup>	
ASME <sup>4</sup>		841	<i>Standard for Petroleum and Chemical Industry Severe Duty TEFC Squirrel Cage Induction Motors—Up to and Including 500HP</i>
B 1.20.1	<i>Pipe Threads, General Purpose (Inch)</i>	ISO <sup>8</sup>	
B 16.1	<i>Cast Iron Pipe Flanges and Flanged Fittings</i>	1940	<i>Mechanical Vibration-balance Quality Requirements of Rigid Rotors</i>
B 16.5	<i>Pipe Flanges and Flanged Fittings (Steel)</i>	3740	<i>Acoustics-determination of Sound Power Levels of Noise Sources-precision Methods for Broad-band Sources in Reverberation Rooms</i>
B 16.11	<i>Forged Steel Fittings, Socket-welding, and Threaded</i>	3744	<i>Acoustics-determination of Sound Power Levels of Noise Sources-engineering Methods for Free-field Conditions Over a Reflecting Plane</i>
B 16.42	<i>Ductile Iron Pipe Flanges and Flanged Fittings, Class 150 and 300</i>	3746	<i>Acoustics-determination of Sound Power Levels of Noise Sources-survey Method</i>
B 16.47	<i>Large-diameter Steel Flanges; NPS 26 through NPS 60</i>	7005	<i>Metallic Flanges</i>
B 17.1	<i>Keys and Keyseats</i>	NFPA <sup>9</sup>	
B 31.3	<i>Chemical Plant and Petroleum Refinery Piping</i>	Publication 70	<i>National Electric Code, Articles 500, 501, 502, and 504</i>
	<i>Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," and Section IX, "Welding and Brazing Qualifications"</i>		
ASTM <sup>5</sup>			
A 278	<i>Gray Iron Castings for Pressure-containing Parts for Temperatures up to 345°C (650°F)</i>		

<sup>2</sup> American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, Virginia 22314.

<sup>3</sup> Air Movement and Control Association, 30 West University Drive, Arlington Heights, Illinois 60004.

<sup>4</sup> ASME International, 3 Park Avenue, New York, New York 10016-5990.

<sup>5</sup> American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959.

<sup>6</sup> American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33135.

<sup>7</sup> Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, New Jersey 08855-1331.

<sup>8</sup> International Organization for Standardization, ISO publications are available from the American National Standards Institute, 11 West 42nd Street, New York, New York 10036.

<sup>9</sup> National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269.

NACE<sup>10</sup>MR-0175 *Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment*SSPC<sup>11</sup>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.

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

<sup>11</sup>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 <sup>2</sup> k/kW	0.002 hr-ft <sup>2</sup> -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 turn-down 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.)

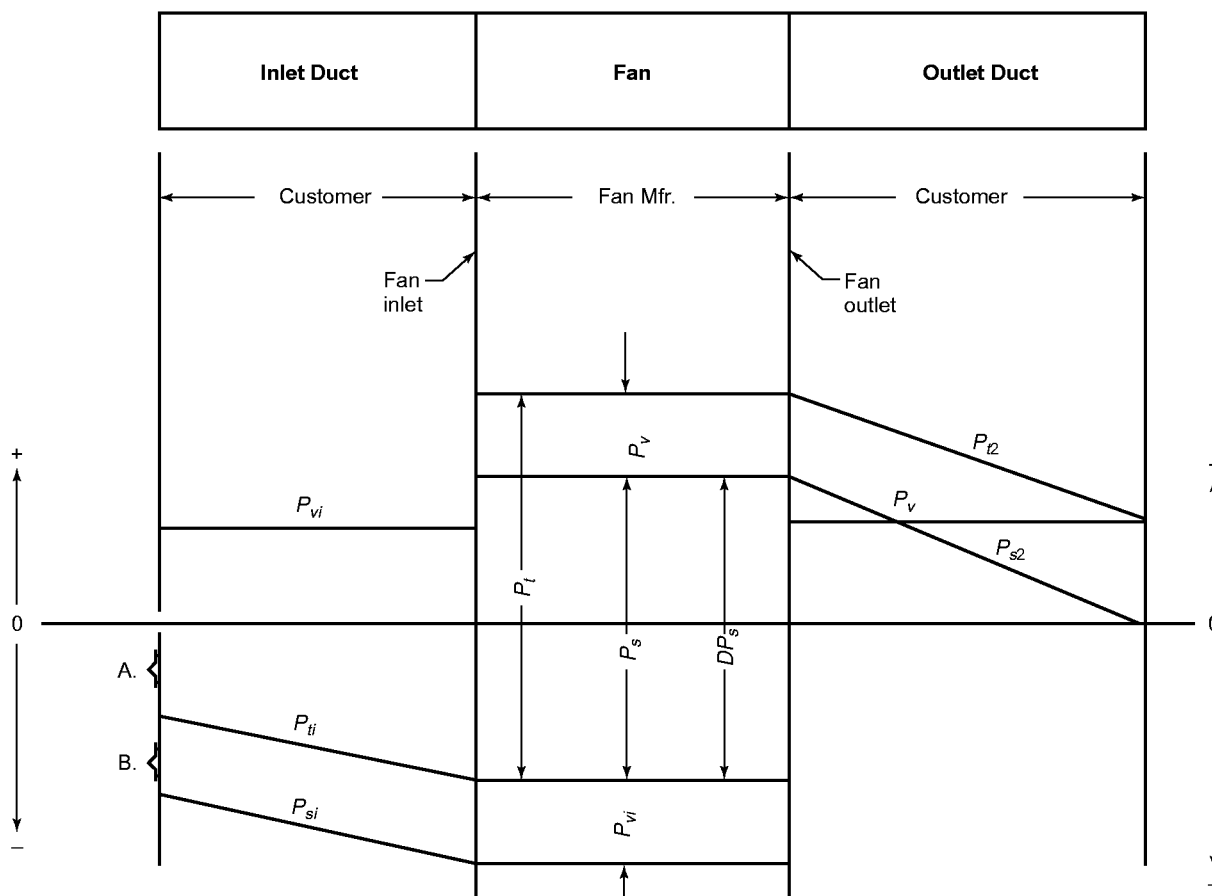
**2.1.19** Induced draft fans shall be mechanically designed for operation at 55°C (100°F) above maximum specified inlet gas temperature.

**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 ( $\Delta P_s$ ) is the static pressure at the fan outlet minus the static pressure at the fan inlet.

$$\Delta P_s = P_{s2} - P_{s1}$$

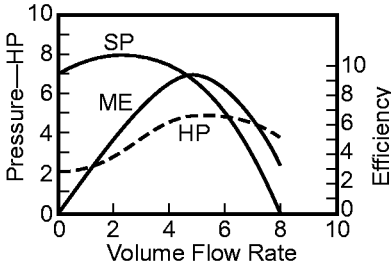
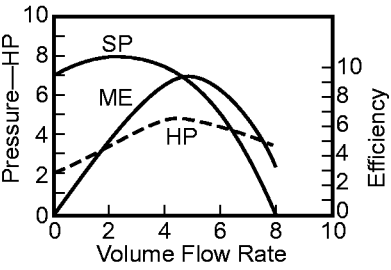
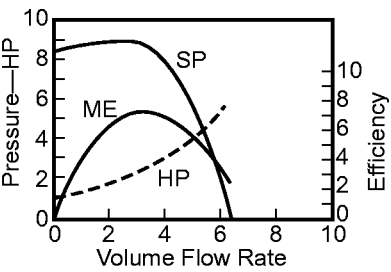
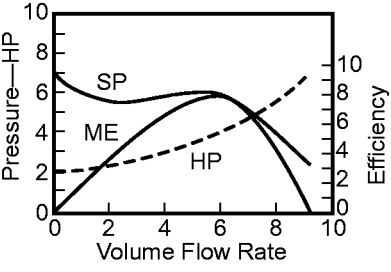
The difference between fan static pressure and static pressure rise is the inlet velocity pressure.

$$\begin{aligned} \Delta P_s - P_s &= (P_{s2} - P_{s1}) - (P_{s2} - P_{t1}) \\ &= P_{s2} - P_{s1} - P_{s2} + P_{s1} + P_{v1} \\ &= P_{v1} \end{aligned}$$

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

Figure 2—Fan Pressure Rise Terms



<b>Airfoil</b>	 <p>The graph for an Airfoil fan shows three curves: Static Pressure (SP), Mechanical Efficiency (ME), and Horsepower (HP). The SP curve starts at approximately 7.5 at zero flow and drops to zero at a flow rate of about 8.5. The ME curve starts at 0, peaks at approximately 7.5 at a flow rate of 4, and then declines. The HP curve starts at 0 and rises to a peak of about 5 at a flow rate of 6, before declining. The Efficiency curve (dashed line) starts at 0, peaks at approximately 6.5 at a flow rate of 4, and then declines.</p>	<p>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 self-limiting power characteristic as shown.</p>	<p>General heating, ventilating and air-conditioning systems. Used in large sizes for clean-air industrial applications where power savings are significant.</p>
<b>Backward Inclined and Curved</b>	 <p>The graph for a Backward Inclined and Curved fan shows three curves: Static Pressure (SP), Mechanical Efficiency (ME), and Horsepower (HP). The SP curve starts at approximately 8 at zero flow and drops to zero at a flow rate of about 8.5. The ME curve starts at 0, peaks at approximately 7 at a flow rate of 4, and then declines. The HP curve starts at 0 and rises to a peak of about 4.5 at a flow rate of 6, before declining. The Efficiency curve (dashed line) starts at 0, peaks at approximately 5 at a flow rate of 4, and then declines.</p>	<p>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.</p>	<p>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.</p>
<b>Radial</b>	 <p>The graph for a Radial fan shows three curves: Static Pressure (SP), Mechanical Efficiency (ME), and Horsepower (HP). The SP curve starts at approximately 8.5 at zero flow and drops to zero at a flow rate of about 6.5. The ME curve starts at 0, peaks at approximately 5.5 at a flow rate of 3, and then declines. The HP curve starts at 0 and rises to a peak of about 6 at a flow rate of 6, before declining. The Efficiency curve (dashed line) starts at 0 and rises to a peak of about 5.5 at a flow rate of 6, before declining.</p>	<p>Higher pressure characteristics than the above mentioned fans. Power rises continually to free delivery.</p>	<p>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.</p>
<b>Forward Curved</b>	 <p>The graph for a Forward Curved fan shows three curves: Static Pressure (SP), Mechanical Efficiency (ME), and Horsepower (HP). The SP curve starts at approximately 6.5 at zero flow, has a slight dip at a flow rate of 2, and then drops to zero at a flow rate of about 9. The ME curve starts at 0, peaks at approximately 6 at a flow rate of 6, and then declines. The HP curve starts at 0 and rises to a peak of about 6 at a flow rate of 6, before declining. The Efficiency curve (dashed line) starts at 0, peaks at approximately 6 at a flow rate of 6, and then declines.</p>	<p>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.</p>	<p>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.</p>

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  $\mu$ m (125  $\mu$ in.) Ra or smoother. To prevent soft foot, all mounting surfaces shall be in the same plane within 50  $\mu$ m (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  $1\frac{1}{2}$  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  $1\frac{1}{4}$ ,  $2\frac{1}{2}$ ,  $3\frac{1}{2}$ , 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, mechani-

cal run out on the shaft sleeve shall not exceed 50  $\mu\text{m}$  (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  $\mu\text{in.}$  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.

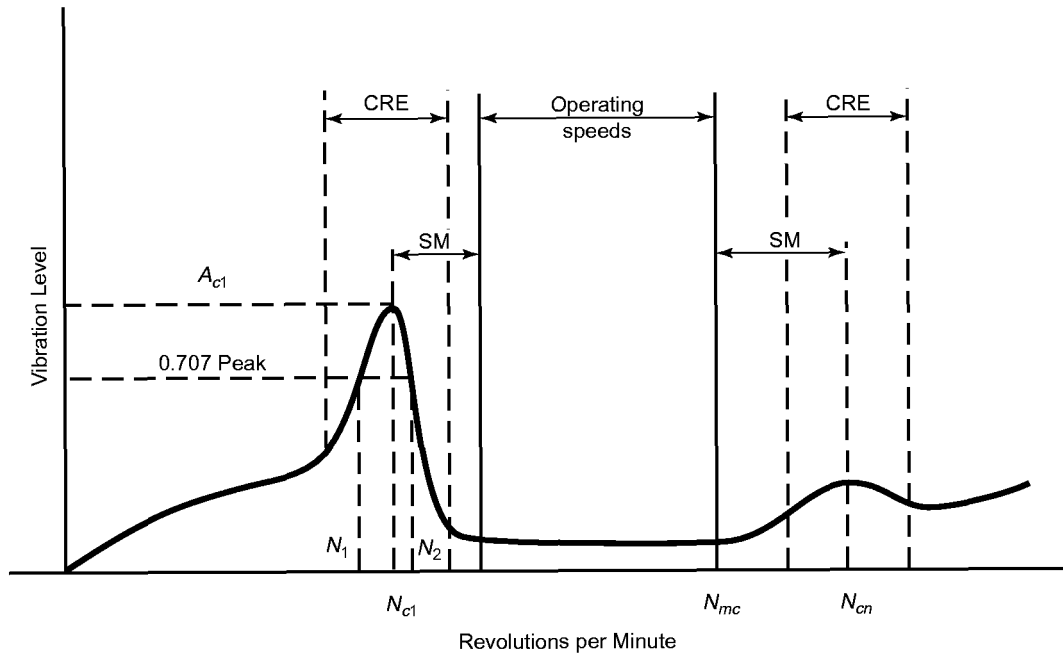
**2.7.1.3** When the rotor amplification factor (see Figure 4), as measured at the shaft radial vibration probes, is greater than or equal to 2.5, the corresponding frequency is called a critical speed, and the corresponding shaft rotational frequency is also called a critical speed. For the purpose 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  $0.707 \times$  peak amplitude (critical)

$N_2$  = Final (greater) speed at  $0.707 \times$  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:

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

- Gear problems such as unbalance and pitch line run-out.
- Start-up conditions such as speed detents and other torsional oscillations.
- Torsional transients such as start-ups of synchronous electric motors.
- Torsional excitation resulting from drivers such as electric motors and reciprocating engines.
- Hydraulic governors.
- Electronic feedback and control-loop resonances from variable-frequency motor drives.
- One and two times line frequencies.
- Running speed or speeds.

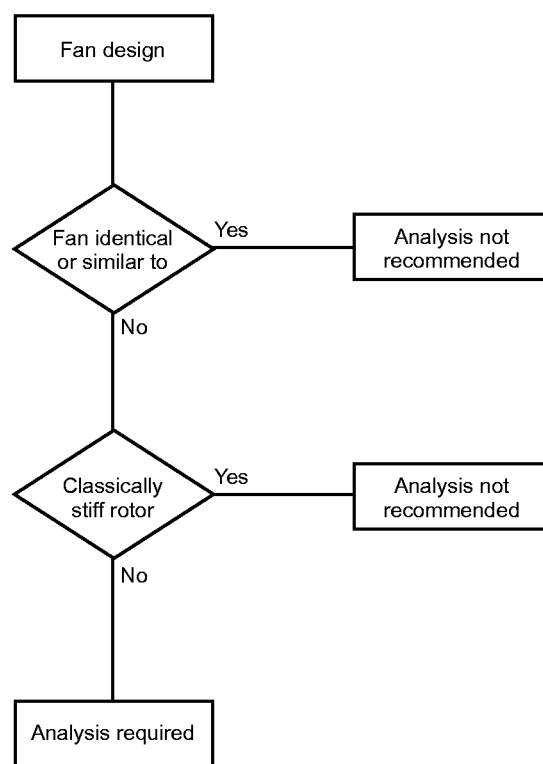


Figure 5—Lateral Analysis Decision Tree

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

- Electric motor, or turbine, through a gear rated 1500 kW (2000 HP) or higher.
- Internal combustion engine rated 250 kW (325 HP) or higher.
- Synchronous motor rated 500 kW (700 HP) or higher.
- 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);

- Train with gear(s): one and two  $\times$  RPM.
- Engine drives:  $n \times$  RPM ( $n$  = no. of cyl./cycles).
- Synchronous motor:  $n \times$  slip frequency or RPM ( $n$  = no. of poles), one and two  $\times$  line frequency.
- VFD: 1 and 2  $\times$  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 resid-

ual 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:

- With fan drivers rated greater than 225 kW (300 HP), unless specific approval is obtained from the purchaser.
- Where antifriction bearing  $dmN$  factors exceed the limits in Table 3.
- 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.)
- 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<sup>1</sup>

Point of Measurement	Bearing Housing		Shaft <sup>2</sup>	
	All		Hydrodynamic(J/B)	
Fan Bearings	mm/s	in./sec (true pk)	micron	mils (pk/pk)
Unfiltered	< 4.0	< 0.16	< 50	< 2.0
Filtered <sup>3</sup>	< 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:

- Fouling and variation in seal clearances up to twice the design internal clearances.
- Variation in inlet and exhaust pressure.
- External loads from the driven equipment, as described in 2.8.4.1 through 2.8.4.1.3.
- 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  $0.8 \mu\text{m}$  ( $32 \mu\text{in.}$ ) Ra, and the axial total indicated run-out of either face shall not exceed  $25 \mu\text{m}$  ( $0.001 \text{ in.}$ ) 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  $30^\circ\text{C}$  ( $50^\circ\text{F}$ ) under the most adverse specified operating conditions. The bearing outlet oil temperature shall not exceed  $80^\circ\text{C}$  ( $180^\circ\text{F}$ ). When the inlet oil temperature exceeds  $50^\circ\text{C}$  ( $120^\circ\text{F}$ ), 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  $70^\circ\text{C}$  ( $160^\circ\text{F}$ ) for circulating systems and below  $80^\circ\text{C}$  ( $180^\circ\text{F}$ ) for ring-oiled or splash systems, based on the specified operating conditions and an ambient temperature of  $40^\circ\text{C}$  ( $110^\circ\text{F}$ ). 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) ( $1 \text{ mm}$  [ $0.042 \text{ in.}$ ]) and shall be at least  $12 \text{ mm}$  ( $0.50 \text{ in.}$ ) in diameter.

**2.8.5.6.1** All induced draft fans or process fans operating above  $95^\circ\text{C}$  ( $200^\circ\text{F}$ ) 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  $150^\circ\text{C}$  ( $300^\circ\text{F}$ ) 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 pres-

sure 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<sup>2</sup> (5 ft<sup>2</sup>) 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 pres-

sure 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<sup>2</sup> (15 watts/in.<sup>2</sup>).

**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 mecha-

nisms) 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  $-30^{\circ}\text{C}$  ( $-20^{\circ}\text{F}$ ) and  $40^{\circ}\text{C}$  ( $100^{\circ}\text{F}$ ).

**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<sup>3</sup>/h (ft<sup>3</sup>/min.).
8. Static pressure differential, in mm H<sub>2</sub>O (in. H<sub>2</sub>O).
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<sup>2</sup>.
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 undamped 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:

- 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 (<sup>3</sup>/<sub>8</sub> in.) in diameter.
- 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.
- 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<sub>10</sub> 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<sup>2</sup> (20 in.<sup>2</sup>) 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 sig-



nal, 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 in-place 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 spec-

ified 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 ( $1\frac{1}{4}$  in.), 65 mm ( $2\frac{1}{2}$  in.), 90 mm ( $3\frac{1}{2}$  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

System	Group I, Auxiliary Process Fluids		Group II, Steam		Group III, Cooling Water		Group IV, Lubricating and Control Oil	
	Nonflammable/ Nontoxic	Flammable/Toxic	≤ 75 psig	> 75 psig	Standard (≤ NPS 1)	Optional	≤ NPS 1	≥ NPS 1 <sup>1/2</sup>
Pipe	Seamless <sup>a</sup>	Seamless <sup>a</sup>	Seamless <sup>a</sup>	Seamless <sup>a</sup>	Seamless <sup>a</sup>	ASTM A 53 Type F Schedule 40, Galvanized to ASTM A 153	ASTM A 312, Type 304 or 316 Stainless Steel <sup>b</sup>	ASTM A 312, Type 304 or 316 Stainless Steel <sup>b</sup>
Tubing	ASTM A 269 Seamless Type 316 Stainless Steel <sup>c</sup>	ASTM A 269 Seamless Type 316 Stainless Steel <sup>c</sup>	ASTM A 269 Seamless Type 304 or 316 Stainless Steel <sup>c</sup>	ASTM A 269 Seamless Type 304 or 316 Stainless Steel <sup>c</sup>	ASTM A 269 Seamless Type 304 or 316 Stainless Steel <sup>c</sup>	ASTM A 269 Seamless Type 304 or 316 Stainless Steel <sup>c</sup>	ASTM A 269 Seamless Type 304 or 316 Stainless Steel <sup>c</sup>	—
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.

<sup>a</sup>Schedule 80 for diameters from 1/2 in. to 1 1/2 in.; Schedule 40 for diameters 2 in. and larger.

<sup>b</sup>Schedule 40 for a diameter of 1 1/2 in.; Schedule 10 for diameters 2 in. and larger.

<sup>c</sup>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.

## 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

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 – 1½	15	10	10	5
2	20	20	15	10
3	45	40	35	25
4	80	70	60	50
6	180	160	130	115

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 1½ 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 ven-



dor 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 informa-

tion 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 mutu-

ally 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 spec-

ified 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:

- 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)
- Bearing lubrication-film stiffness and damping changes due to speed, load, preload, oil temperature, accumulated assembly tolerances, and maximum to minimum clearances.
- 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).
- 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).
- Asymmetrical loading (for example, partial arc emission, gear forces, side streams, and eccentric clearances).
- 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 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.
- 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  $\mu\text{m}$  (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

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

In U.S. Customary units,

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

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:

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

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:

$$SM = 126 - \frac{6}{AF - \sqrt{3}} - 100 \quad (4)$$

where

$SM$  = separation margin,

$AF$  = amplification factor.

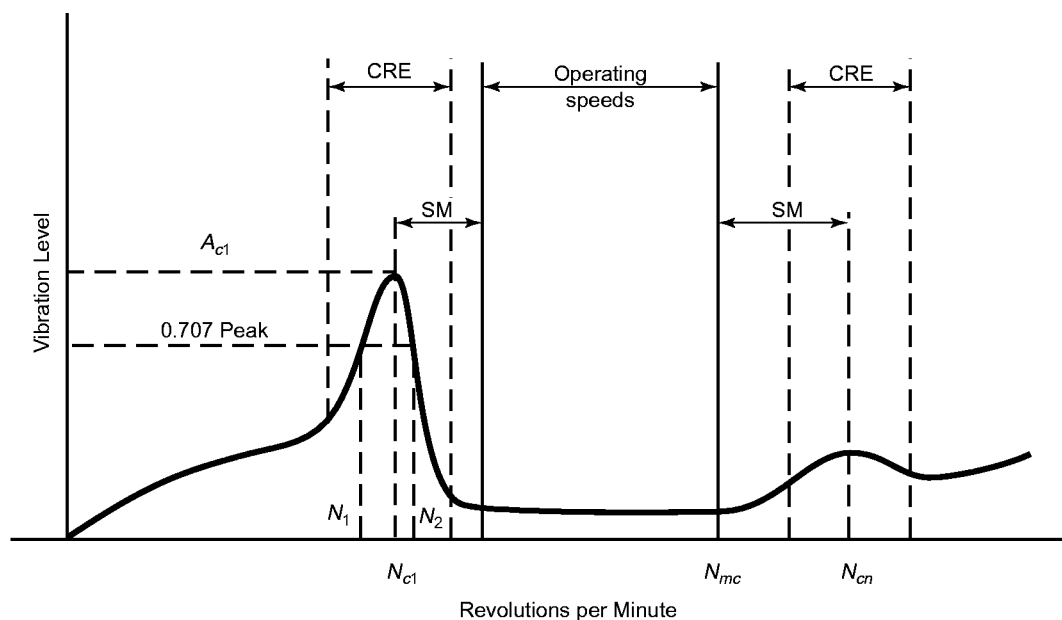
**A.6** The calculated unbalanced peak-to-peak rotor amplitudes (see A.4, item b) at any speed from zero to trip shall not exceed 75% of the minimum design diametral running clearances throughout the machine (with the exception of floating-ring seal locations).

**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  $0.707 \times$  peak amplitude (critical)  
 $N_2$  = Final (greater) speed at  $0.707 \times$  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  $\pm 5\%$ .
- b. The predicted amplification factors shall not deviate from the actual test-stand values by more than  $\pm 0\%$ .
- c. The actual response peak amplitudes, including those that are critically damped, shall be within  $\pm 50\%$  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 ratios 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.

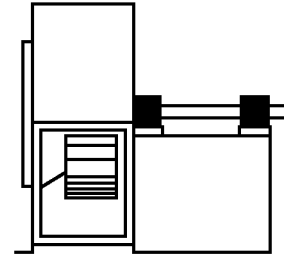
## APPENDIX B—DRIVE ARRANGEMENTS FOR FANS



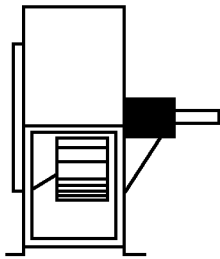
11/11/2020 10:00:00 AM

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

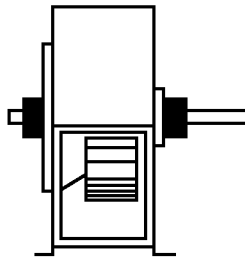
Arrangements 1, 3, 7, and 8 are also available with bearings mounted on pedestals or base set independent of the fan housing.



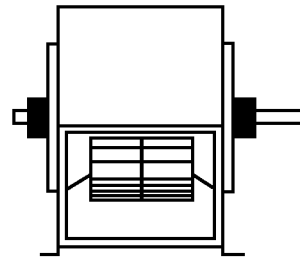
**Arr. 1 SWSI** For belt drive or direct connection. Impeller overhung. Two bearings on base.



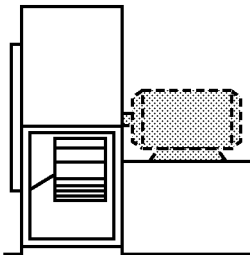
**Arr. 2 SWSI** For belt drive or direct connection. Impeller overhung. Bearings in bracket supported by fan housing.



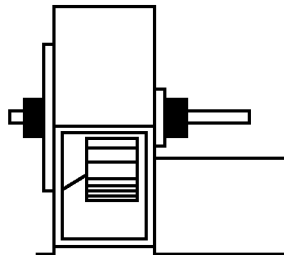
**Arr. 3 SWSI** For belt drive or direct connection. One bearing on each side and supported by fan housing.



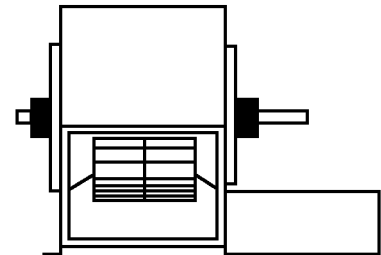
**Arr. 3 DWDI** For belt drive or direct connection. One bearing on each side and supported by fan housing.



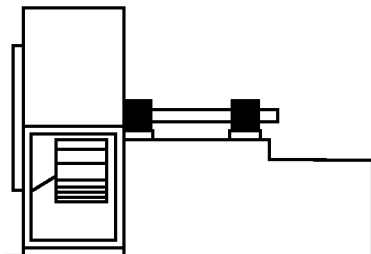
**Arr. 4 SWSI** For direct drive. Impeller overhung on prime mover shaft. No bearings on fan. Prime mover base mounted or integrally directly connected.



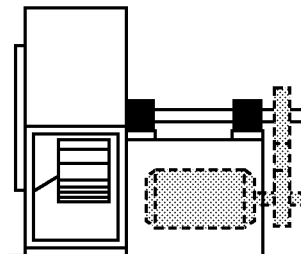
**Arr. 7 SWSI** For belt drive or direct connection. Arrangement 3 plus base for prime mover.



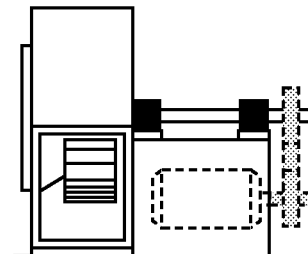
**Arr. 7 DWDI** For belt drive or direct connection. Arrangement 3 plus base for prime mover.



**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.

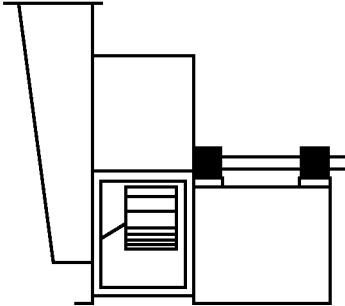


**Arr. 10 SWSI** For belt drive. Impeller overhung, two bearings, with prime mover inside base.

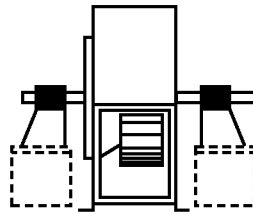
*The above arrangements are obtained from ACMA Publication 201-90.*

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

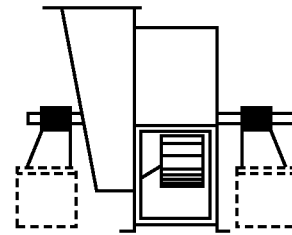
**SW** – Single Width      **DW** – Double Width  
**SI** – Single Inlet      **DI** – Double Inlet



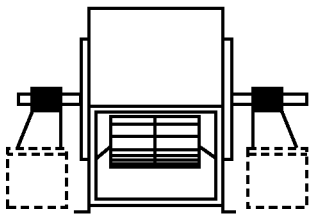
**Arr. 1 SWSI with Inlet Box:** For belt drive or direct connection. Impeller overhung, two bearings on base. Inlet box may be self-supporting.



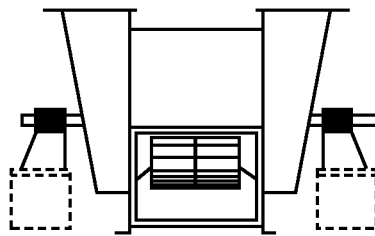
**Arr. 3 SWSI with Independent Pedestal:** For belt drive or direct connection fan. Housing is self-supporting. One bearing on each side supported by independent pedestals.



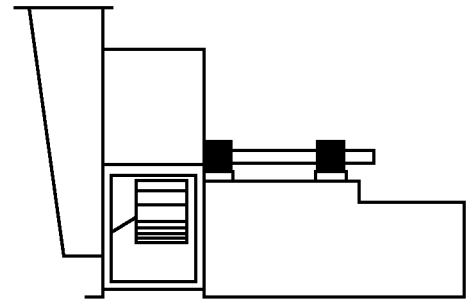
**Arr. 3 SWSI with Inlet Box and Independent Pedestals:** For belt drive or direct connection fan. Housing is self-supporting. One bearing on each side supported by independent pedestals with shaft extending through inlet box.



**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. _____
<b>CENTRIFUGAL FAN (API 673-2ND. EDITION)</b> <b>DATA SHEET</b> <b>U.S. CUSTOMARY UNITS</b>	SPECIFICATION NO. _____
	REVISION NO. _____ DATE _____
	PAGE <u>1</u> OF <u>10</u> BY _____

1 APPLICABLE TO: <input type="radio"/> PROPOSAL <input type="radio"/> PURCHASE <input type="radio"/> AS BUILT	REVISION: _____
2 FOR: _____	UNIT: _____
3 SITE: _____	NO. REQUIRED: _____
4 SERVICE: _____	
5 NOTE: <input type="radio"/> INDICATES INFORMATION TO BE COMPLETED BY PURCHASER <input type="checkbox"/> BY MANUFACTURER	

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 <input type="radio"/> DIRECT COUPLED <input type="radio"/> OTHER _____	FAN ROTATION, FROM DRIVEN END _____ CW _____ CCW _____

**OPERATING CONDITIONS**

(ALL DATA ON PER UNIT BASIS)	NORMAL	RATED	OTHER CONDITIONS			
			A	B	C	D
12						
13						
14 <input type="radio"/> OPERATING CONDITIONS/CASE						
15 <input type="radio"/> GAS HANDLED (See Page _____)						
16 <input type="radio"/> DENSITY (LB/FT <sup>3</sup> )						
17 <input type="radio"/> DELIVERED SCFM (14-7 PSIA & 60°F DRY)						
18 <input type="radio"/> WEIGHT FLOW LB/MIN (WET)						

INLET CONDITIONS:						
20 <input type="radio"/> TEMPERATURE (°F)						
21 <input type="radio"/> RELATIVE HUMIDITY (%)						
22 <input type="radio"/> MOLECULAR WEIGHT (MIN.)						
23 <input type="checkbox"/> INLET VOLUME (ICFM WET)						
24 <input type="checkbox"/> Cp/Cv (K <sub>1</sub> ) OR (K <sub>AVG</sub> )						
25 <input type="checkbox"/> COMPRESSIBILITY (Z <sub>1</sub> ) OR (Z <sub>AVG</sub> )						
26 <input type="radio"/> STATIC PRESSURE @ SOUND TRUCK (IN. WG)						
27 <input type="checkbox"/> PRESSURE LOSS ACROSS SOUND TRUCK (IN. WG)						
28 <input type="radio"/> STATIC PRESSURE @ INLET DAMPERS (IN. WG)						
29 <input type="radio"/> STATIC PRESSURE @ FAN INLET (IN. WG)						

DISCHARGE CONDITIONS:						
30 <input type="checkbox"/> STATIC PRESSURE @ FAN OUTLET (IN. WG)						
31 <input type="checkbox"/> STATIC PRESS. @ DISCHARGE DAMPER (IN. WG)						
32 <input type="checkbox"/> ΔP ACROSS DISCHARGE DAMPER (IN. WG)						
33 <input type="checkbox"/> ΔP ACROSS EVASE (IN. WG)						
34 <input type="radio"/> STATIC PRESSURE @ EVASE OUTLET (IN. WG)						

PERFORMANCE:						
35 <input type="checkbox"/> BHP REQUIRED @ TEMP. (ALL LOSSES IND.)						
36 <input type="checkbox"/> FAN SPEED (RPM)						
37 <input type="radio"/> GUARANTEE POINT						
38 <input type="checkbox"/> PERFORMANCE CURVE NO.						
39 <input type="checkbox"/> STATIC ΔP ACROSS FAN (IN. WG)						
40 <input type="checkbox"/> INLET DAMPER/VANE POSITION						
41 <input type="checkbox"/> DISCHARGE DAMPER POSITION						
42 <input type="checkbox"/> FAN STATIC EFFICIENCY (%)						

45 <b>FAN CONTROL:</b>	
46 <input type="radio"/> AIR SUPPLY _____	<input type="radio"/> FAN CONTROL FURNISHED BY _____
47 <input type="radio"/> CONTROL SIGNAL TYPE _____ SOURCE _____	SENSITIVITY _____ RANGE _____
48 <input type="radio"/> ARRANGEMENT DRWG NO. _____	CONTROL SIGNAL FAILURE MODE <input type="radio"/> CLOSE <input type="radio"/> OPEN <input type="radio"/> AUTOLOCK
49 <b>METHOD:</b> <input type="radio"/> INLET DAMPER <input type="radio"/> OUTLET DAMPER <input type="radio"/> INLET GUIDE VANES	
50 <input type="radio"/> STARTING CONDITIONS _____	<input type="radio"/> STARTING METHOD _____
51 <input type="radio"/> START & STOP RESTRICTIONS _____	
52 <input type="radio"/> VENDOR REVIEW OF CONTROL SYSTEM REQUIRED	<input type="radio"/> 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										
1	GAS ANALYSIS		NORMAL	RATED	CONDITIONS				REMARKS	
	MOL%	MOL%			A	B	C	D		
2										
3	<input type="radio"/>	<input type="radio"/>								
4		MW								
5	AIR	28.97								
6	OXYGEN	32.00								
7	NITROGEN	28.02								
8	WATER VAPOR	18.02								
9	CARBON MONOXIDE	28.01								
10	CARBON DIOXIDE	44.01								
11	HYDROGEN SULFIDE	34.08								
12	HYDROGEN CHLORIDE	36.47								
13	CHLORINE	70.91								
14										
15										
16										
17										
18	TOTAL									
19	AVG. MOL WT.									
20	<b>CORROSIVES:</b>									
21	<input type="radio"/> CORROSION/EROSION CAUSED BY _____									
22	<input type="radio"/> CORROSION EROSION PROTECTION _____									
23	<input type="radio"/> NACE MR-01-90 MATERIALS REQUIRED _____									
24	_____									
25	<b>LOCATION, SITE DATA</b>					<b>SPECIFICATIONS</b>				
26	<b>LOCATION:</b>					<b>NOISE SPECIFICATIONS:</b>				
27	<input type="radio"/> INDOOR <input type="radio"/> HEATED <input type="radio"/> UNDER ROOF					<input type="radio"/> APPLICABLE TO MACHINE:				
28	<input type="radio"/> OUTDOOR <input type="radio"/> UNHEATED <input type="radio"/> PARTIAL SIDES					See Specification _____				
29	<input type="radio"/> GRADE <input type="radio"/> MEZZANINE <input type="radio"/> _____					<input type="radio"/> APPLICABLE TO NEIGHBORHOOD				
30	<input type="radio"/> WINTERIZATION REQ'D <input type="radio"/> TROPICALIZATION REQ'D					See Specification _____				
31	<b>SITE DATA:</b>					ACOUSTIC HOUSING: <input type="radio"/> YES <input type="radio"/> NO				
32	<input type="radio"/> ELEVATION _____ FT. <input type="radio"/> BAR _____ PSIA/IN. Hg A					_____				
33	<input type="radio"/> TEMPERATURE _____ °F SUMMER      _____ °F WINTER					_____				
34	<input type="radio"/> WIND LOAD _____ PSF <input type="radio"/> VELOCITY _____ MPH					<b>APPLICABLE SPECIFICATIONS:</b>				
35	<input type="radio"/> MINIMUM DESIGN METAL TEMPERATURE _____ °F					_____				
36	<b>UNUSUAL CONDITIONS:</b>					_____				
37	<input type="radio"/> DUST <input type="radio"/> FUMES					<b>PAINTING:</b>				
38	<input type="radio"/> OTHER _____					<input type="radio"/> MANUFACTURER'S STD.				
39	_____					<input type="radio"/> OTHER _____				
40	_____					_____				
41	_____					<b>SHIPMENT:</b>				
42	_____					<input type="radio"/> DOMESTIC <input type="radio"/> EXPORT <input type="radio"/> EXPORT BOXING REQ'D.				
43	_____					<input type="radio"/> OUTDOOR STORAGE OVER 6 MONTHS				
44	_____					<b>ERECTION:</b>				
45	_____					SHIPPED <input type="checkbox"/> ASSEMBLED <input type="checkbox"/> PARTLY ASSEMBLED				
46	_____					<input type="checkbox"/> OTHER _____				
47	_____					<input type="checkbox"/> EXTENT OF FIELD ERECTION & ASSEMBLY _____				
48	<b>ELECTRICAL AREA CLASSIFICATION:</b>					_____ MAN HOURS _____				
49	<input type="radio"/> CLASS _____ GROUP _____ DIVISION _____					<input type="checkbox"/> OTHER _____				
50	<b>REMARKS:</b> _____									
51	_____									

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

JOB NO. \_\_\_\_\_ ITEM NO. \_\_\_\_\_  
 REVISION \_\_\_\_\_ DATE \_\_\_\_\_  
 PAGE 3 OF 10 BY \_\_\_\_\_

**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<sup>2</sup>  
 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<sup>2</sup>(Lb./Ft<sup>2</sup>) \_\_\_\_\_  
 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<sup>2</sup>) \_\_\_\_\_  
 FLANGE SIZE \_\_\_\_\_ BOLTING \_\_\_\_\_  
 LOCATION/ORIENTATION \_\_\_\_\_  
 EXP. JOINT REQ'D \_\_\_\_\_ FURN. BY \_\_\_\_\_  
 OUTLET: SIZE \_\_\_\_\_ x \_\_\_\_\_ AREA (FT<sup>2</sup>) \_\_\_\_\_  
 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@ \_\_\_\_\_ FT
- PREDICTED SOUND PRESS LEVEL \_\_\_\_\_ DBA@ \_\_\_\_\_ FT
- ATTENUATION METHOD \_\_\_\_\_
- \_\_\_\_\_
- FURNISHED BY \_\_\_\_\_
- SILENCER MFG/MODEL No. \_\_\_\_\_
- \_\_\_\_\_
- ACOUSTIC PERF \_\_\_\_\_
- AERODYNAMIC PERF \_\_\_\_\_ CFM \_\_\_\_\_ °F
- LOSS \_\_\_\_\_ IN WG.
- ACCESSORIES \_\_\_\_\_

**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 \_\_\_\_\_ FT
- DECKING  NON SKID  OPEN CONSTRUCTION
- DRIP RIM  OPEN DRAIN
- SUITABLE FOR  COLUMN or  PERIMETER SUPPORT
- LEVELING PADS W/REMOVABLE COVER
- SUBSOLE PLATES REQUIRED

**FAN CLEANING SYSTEM (2.1.22):**

- REQUIRED \_\_\_\_\_ CLEANING MEDIUM \_\_\_\_\_
- MFR./MODEL \_\_\_\_\_ FURN BY \_\_\_\_\_
- INSTALLED BY \_\_\_\_\_
- DETAILS/DWG.No. \_\_\_\_\_

**FAN ITEMS:**

- 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

CORROSION ALLOWANCE  SIZE/THICKNESS (INCL. C.A.)  MATERIAL  MATERIAL SPECIFICATION

**COUPLINGS:**

- COUPLING & GUARD FURNISHED BY:
- TYPE
- MFG.
- MODEL/NUMBER
- LUBRICATION
- MOUNT CPLG. HALVES
- FAN
- DRIVER
- 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

DRIVER—FAN                      GEAR—FAN                      DRIVER—GEAR

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**CONSTRUCTION FEATURES (Continued)**

	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.
24 SHOP INSPECTION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
25 CLEANLINESS INSPECTION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
26 HARDNESS VERIFICATION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
27 CHARPY IMPACT TESTING	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
28 SHAFT RUN OUT CHECK	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
29 ROTOR BALANCING	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
30 REBAL. AFTER MOUNTING CPLG.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
31 RESIDUAL BALANCE CHECK	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
32 CALIBRT'N CK. OF BALNC'G EQUIP	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
33 NDT EXAMINATION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
34 ASSEMBLY & FIT UP CHECK	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
35 INITIAL &/or FINAL ALIGN	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
36 GEAR TOOTH CNTCT. CHK. (API 677)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
37 MECHANICAL RUN TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
38 FULL UNIT MECHANICAL RUN TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
39 VIBRATION TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
40 SOUND LEVEL TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
41 MAT'L CERTIFICATION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
42 SURFACT & SUBSURFACE INSPCT.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
43 TYPE _____			
44 PRESSURE TEST:	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
45 —HOUSING	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
46 —DUCTING	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
47 —LUBE OIL SYSTEM	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
48 RUN & CHECK LUBE CONSOLE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
49 SHOP PERFORMANCE TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
50 PRE-SHIPMENT INSPECTION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
51 —DRIVER / AUX. MOUNTED	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
52 QUALITY CONTROL REVIEW	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
53 FIELD PERFORMANCE TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
54 OTHERS: _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
55 _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
56 _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**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)**

COMPLETE UNIT L \_\_\_\_\_ W \_\_\_\_\_ H \_\_\_\_\_  
 CONTROL PANEL L \_\_\_\_\_ W \_\_\_\_\_ H \_\_\_\_\_  
 \_\_\_\_\_ L \_\_\_\_\_ W \_\_\_\_\_ H \_\_\_\_\_

**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:**

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
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**LUBE OIL SYSTEM**

1 **CIRCULATING OR PRESSURIZED LUBE OIL SYSTEM BY:** \_\_\_\_\_  API 614 REQUIRED

3 **PIPING MATERIALS:** CARBON STEEL STAINLESS STEEL  
 4 \_\_\_\_\_  
 5  COMPLETE SYSTEM \_\_\_\_\_  
 6  DOWNSTREAM OF FILTERS \_\_\_\_\_  
 7  RETURN PIPING \_\_\_\_\_  
 8 \_\_\_\_\_  
 9  CARBON STEEL SLIP-ON FLANGES ON STNLESS. STEEL PIPING

**STANDBY PUMP CONTROL:**  
 RESET  MANUAL  AUTOMATIC  
 AUTOMATIC START  
 "ON-OFF-AUTO" SELECTOR SWITCH

10 **SYSTEM COMPONENT SUPPLIERS:**

	MANUFACTURER	MODEL
11 <input type="checkbox"/> MAIN PUMP	_____	_____
12 <input type="checkbox"/> STANDBY PUMP	_____	_____
13 <input type="checkbox"/> ELECTRIC MOTOR (S)	_____	_____
14 <input type="checkbox"/> STEAM TURBINE (S)	_____	_____
15 <input type="checkbox"/> OIL COOLER (S)	_____	_____
16 <input type="checkbox"/> OIL FILTER (S)	_____	_____
17 <input type="checkbox"/> ACCUMULATOR (S)	_____	_____
18 <input type="checkbox"/> SUCT. STRAINER (S)	_____	_____
19 <input type="checkbox"/> CHECK VALVE (S)	_____	_____
20 <input type="checkbox"/> SWITCH VALVE (S)	_____	_____
21 <input type="checkbox"/> PUMP COUPLING (S)	_____	_____
22 <input type="checkbox"/> TEMP. INDICATORS	_____	_____
23 <input type="checkbox"/> L.P. SHUTDOWN SWITCH	_____	_____

**RESERVOIR:**  
 MATERIAL \_\_\_\_\_  
 RETENTION TIME \_\_\_\_\_ MIN. CAPACITY \_\_\_\_\_ GAL.  
 BASEPLATE MOUNTED  FABRICATED STEEL BASE  
 BAFFLE REQUIRED  INTERIOR COATING  
 FREE SURFACE AREA \_\_\_\_\_ FT<sup>2</sup>  
 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

25 **SYSTEM PRESSURES:**  
 26  DESIGN \_\_\_\_\_ PSIG  HYDROTEST \_\_\_\_\_ PSIG  
 27  PUMP RELIEF VALVE (S) SETTINGS \_\_\_\_\_ PSIG

**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 \_\_\_\_\_

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

	GPM	PSIG	SSU @ 100 °F	SSU @ 210 °F
30 <input type="checkbox"/> LUBE OIL	_____	_____	_____	_____
31 FAN	_____	_____	_____	_____
32 DRIVER	_____	_____	_____	_____
33 GEAR	_____	_____	_____	_____
34 <input type="checkbox"/> COMMON LUBE SYSTEM	_____	_____	_____	_____

DUTY \_\_\_\_\_ BTU/HR  SURFACE \_\_\_\_\_ °F  
 CODE (S) \_\_\_\_\_  
 DESIGN PRESS. PSIG SHELL SIDE \_\_\_\_\_ TUBE SIDE \_\_\_\_\_  
 TUBES: O.D. \_\_\_\_\_ IN.  TOTAL SURFACE AREA \_\_\_\_\_ FT<sup>2</sup>  
 WALL THICKNESS (AVE) (MIN) \_\_\_\_\_ IN.  
 LENGTH \_\_\_\_\_ IN. NUMBER: \_\_\_\_\_

36 **PUMPS:** MAIN STANDBY

37 <input type="radio"/> HORIZONTAL	_____	_____
38 <input type="radio"/> VERTICAL	_____	_____
39 _____	_____	_____
40 <input type="radio"/> SUBMERGED	_____	_____
41 <input type="radio"/> MOTOR DRIVEN	_____	_____
42 <input type="radio"/> TURBINE DRIVEN	_____	_____
43 <input type="radio"/> SHAFT DRIVEN	_____	_____
44 <input type="radio"/> CENTRIFUGAL	_____	_____
45 <input type="radio"/> GEAR/SCREW	_____	_____
46 <input type="radio"/> FLANGE CONNECTED	_____	_____
47 <input type="checkbox"/> GPM (RATED)	_____	_____
48 <input type="checkbox"/> @ PSIG	_____	_____
49 <input type="checkbox"/> BHP @ 100 SSU	_____	_____
50 <input type="checkbox"/> DRIVER HP	_____	_____
51 <input type="radio"/> CASING MATERIAL	_____	_____
52 <input type="checkbox"/> SPEED	_____	_____
53 <input type="radio"/> COUPLING	_____	_____
54 <input type="checkbox"/> GUARD	_____	_____
55 <input type="radio"/> MECH. SEAL	_____	_____

MATERIALS  
 TUBES \_\_\_\_\_  
 TUBE SHEETS \_\_\_\_\_  
 SHELL \_\_\_\_\_  
 TUBE SUPPORT \_\_\_\_\_  
 SHELL COVER/FLANGE \_\_\_\_\_

56 **EMERGENCY LUBE OIL PUMP:**  
 57  AIR MOTOR DRIVEN  OTHER  
 58  SAFETY GUARD REQUIRED

**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 \_\_\_\_\_

Δ P CLEAN (PSI) \_\_\_\_\_  
 Δ P COLLAPSE (PSI) \_\_\_\_\_  
 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:**

12	PRESSURE GAGES	MFR. _____	SIZE & TYPE _____
13	TEMPERATURE GAGES	MFR. _____	SIZE & TYPE _____
14	LEVEL GAGES	MFR. _____	SIZE & TYPE _____
15	DIFF. PRESSURE GAGES	MFR. _____	SIZE & TYPE _____
16	PRESSURE SWITCHES	MFR. _____	SIZE & TYPE _____
17	DIFF. PRESSURE SWITCHES	MFR. _____	SIZE & TYPE _____
18	TEMPERATURE SWITCHES	MFR. _____	SIZE & TYPE _____
19	LEVEL SWITCHES	MFR. _____	SIZE & TYPE _____
20	CONTROL VALVES	MFR. _____	SIZE & TYPE _____
21	PRESSURE RELIEF VALVES	MFR. _____	SIZE & TYPE _____
22	SIGHT FLOW INDICATORS	MFR. _____	SIZE & TYPE _____
23	VIBRATION EQUIPMENT	MFR. _____	SIZE & TYPE _____
24	TACHOMETER	MFR. _____	RANGE & TYPE _____
25	SOLENOID VALVES	MFR. _____	SIZE & TYPE _____
26	ANNUNCIATOR	MFR. _____	MODEL & No. POINTS _____
27	<input type="checkbox"/> DAMPER/VANE ACTUATOR	MFR. _____	MODEL _____
28	<input type="radio"/> FURNISHED BY _____	<input type="checkbox"/> TYPE _____	<input type="checkbox"/> MAX. TORQUE (FT/LBS) _____

NOTE:     SUPPLIED BY VENDOR       SUPPLIED BY PURCHASER

**PRESSURE GAGE REQUIREMENTS:**

30 FUNCTION	LOCALLY MOUNTED		LOCAL PANEL		31 FUNCTION	LOCALLY MOUNTED		LOCAL PANEL	
	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>		<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
32 LUBE OIL PUMP DISCHARGE	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	FAN DISCHARGE (IN. WG.)	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
33 LUBE OIL FILTER DP	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	CONTROL AIR (PSIG)	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
34 LUBE OIL SUPPLY	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	FAN SUCTION (IN. WG.)	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
35 _____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
36 _____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>

**TEMP. GAGE REQUIREMENTS:**

37 FUNCTION	LOCALLY MOUNTED		LOCAL PANEL		38 FUNCTION	LOCALLY MOUNTED		LOCAL PANEL	
	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>		<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
39 LUBE OIL TO BEARINGS	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	OIL COOLER INLET & OUTLET	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
40 DISCHARGE FROM EACH	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	FAN SUCTION	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
41 PINION JOURNAL BEARING	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
42 BULL GEAR JOURNAL BEARING	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
43 FAN THRUST BEARING	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
44 DRIVER JOURNAL BEARING	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
45 DRIVER THRUST BEARING	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
46 GEAR THRUST BEARING	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
47 FAN JOURNAL BEARING	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
48 _____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>

**SWITCH CLOSURES:**

ALARM CONTACTS 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.

<b>CENTRIFUGAL FAN (API 673-2ND. EDITION)</b> <b>DATA SHEET</b> <b>U.S. CUSTOMARY UNITS</b>	JOB NO. _____ ITEM NO. _____ REVISION _____ DATE _____ PAGE <u>8</u> OF <u>10</u> BY _____
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1	<b>INSTRUMENTATION (Continued)</b>
2	<b>MISCELLANEOUS</b>
3	ALARM AND SHUTDOWN SWITCHES SHALL BE SEPARATE.
4	ELECTRICAL AND INSTRUMENT CONNECTIONS WITHIN THE CONFINES OF THE FAN BASE SHALL BE BROUGHT OUT TO TERMINAL BOXES.
5	COMMENTS REGARDING INSTRUMENTATION: _____
6	_____
7	_____

8 <b>ALARM &amp; SHUTDOWN SWITCHES</b>		ALARM	TRIP	FUNCTION		ALARM	TRIP
9	FUNCTION			FUNCTION			
10	<input type="checkbox"/> <input type="radio"/> LOW LUBE OIL PRESSURE	_____	_____	<input type="checkbox"/> <input type="radio"/> FAN VIBRATION	_____	_____	_____
11	<input type="checkbox"/> <input type="radio"/> HI LUBE OIL FILTER ΔP	_____	_____	<input type="checkbox"/> <input type="radio"/> FAN AXIAL POSITION	_____	_____	_____
12	<input type="checkbox"/> <input type="radio"/> LOW LUBE OIL RESERVE LEVEL	_____	_____	<input type="checkbox"/> <input type="radio"/> DRIVER VIBRATION	_____	_____	_____
13	<input type="checkbox"/> <input type="radio"/> AUX. LUBE OIL PUMP START	_____	_____	<input type="checkbox"/> <input type="radio"/> DRIVER AXIAL POSITION	_____	_____	_____
14	<input type="checkbox"/> <input type="radio"/> HI INLET AIR FILTER ΔP	_____	_____	<input type="checkbox"/> <input type="radio"/> FAN MOTOR SHUTDOWN	_____	_____	_____
15	<input type="checkbox"/> <input type="radio"/> _____	_____	_____	<input type="checkbox"/> <input type="radio"/> HI FAN THRUST BRG. TEMP.	_____	_____	_____
16	<input type="checkbox"/> <input type="radio"/> _____	_____	_____	<input type="checkbox"/> <input type="radio"/> HI DRIVER THRUST BRG. TEMP.	_____	_____	_____
17	<input type="checkbox"/> <input type="radio"/> _____	_____	_____	<input type="checkbox"/> <input type="radio"/> _____	_____	_____	_____

18	<b>MISCELLANEOUS INSTRUMENTATION:</b>
19	<input type="checkbox"/> <input type="radio"/> SIGHT FLOW INDICATORS: EACH JOURNAL & THRUST BEARING OIL RETURN LINE
20	<input type="checkbox"/> <input type="radio"/> LEVEL GAGES, LUBE OIL RESERVOIR(S)
21	<input type="checkbox"/> <input type="radio"/> VIBRATION READOUT EQUIPMENT
22	<input type="checkbox"/> <input type="radio"/> VIBRATION READ OUT LOCATED ON: <input type="checkbox"/> LOCAL PANEL <input type="checkbox"/> OTHER _____
23	<input type="checkbox"/> <input type="radio"/> FAN SPEED PICK-UP DEVICES
24	<input type="checkbox"/> <input type="radio"/> FAN SPEED INDICATORS
25	<input type="checkbox"/> <input type="radio"/> FAN SPEED INDICATORS LOCATED ON: <input type="checkbox"/> LOCAL PANEL <input type="checkbox"/> OTHER _____
26	<input type="checkbox"/> <input type="radio"/> ALARM HORN & ACKNOWLEDGEMENT SWITCH
27	<input type="checkbox"/> <input type="radio"/> _____
28	<input type="checkbox"/> <input type="radio"/> _____
29	<input type="checkbox"/> <input type="radio"/> _____

30	<b>REMARKS:</b> _____
31	_____
32	_____
33	_____
34	_____
35	_____
36	_____
37	_____
38	_____
39	_____
40	_____
41	_____
42	_____
43	_____
44	_____
45	_____
46	_____
47	_____
48	_____
49	_____
50	_____
51	_____

**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

**MOTOR DESIGN DATA**

8 **APPLICABLE SPECIFICATIONS:**  
9  NEMA \_\_\_\_\_  
10  \_\_\_\_\_  
11 **SITE DATA:**  
12 AREA:  C.L. \_\_\_\_\_ GR. \_\_\_\_\_ DIV. \_\_\_\_\_  N-HAZARDOUS  
13  ALTITUDE \_\_\_\_\_ FT  AMBIENT TEMPS: MAX \_\_\_\_\_ °F  
14 UNUSUAL CONDITIONS  DUST  FUMES MIN \_\_\_\_\_ °F  
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.  
25  WOUND ROTOR INDUCTION  
26  \_\_\_\_\_

**VIBRATION:**  
 NEMA STANDARD  \_\_\_\_\_  
**NOISE**  
 NEMA STANDARD  \_\_\_\_\_  
**THRUST:**  
 MAX. MOTOR THRUST \_\_\_\_\_ LBS.  
**REMARKS:**  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

27 **ENCLOSURE:**  
28  EXPLOSION PROOF  TEFC  
29  TEWAC  TEIGF, USING \_\_\_\_\_ GAS  
30  DOUBLE WALL CARBON STEEL TUBES  
31  WATER SUPP.: PRESS. \_\_\_\_\_ PSIG TEMP. \_\_\_\_\_ °F  
32  WATER ALLOW. ΔP \_\_\_\_\_ PSI & TEMP RISE \_\_\_\_\_ °F  
33  WATER SIDE MIN CORR. ALLOW. \_\_\_\_\_ IN.  
34 AND FOUL FACTOR \_\_\_\_\_  
35  (AIR) (GAS) SUPPLY PRESS. \_\_\_\_\_ PSIG  
36  \_\_\_\_\_  
37  WEATHER PROTECTED TYPE  
38  FORCED VENTILATION  
39  OPEN-DRIPPROOF  
40  OPEN  
41 \_\_\_\_\_  
42 \_\_\_\_\_

**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 \_\_\_\_\_ PSIG  
 EXPLOSION-RESISTANT NONPURGED  
 FORCE VENTILATION  
 CFM \_\_\_\_\_ PRESS. DROP \_\_\_\_\_ IN. H<sub>2</sub>O  
 **BEARING TEMP. DEVICES:**  
 LOCATION \_\_\_\_\_  
 DESCRIPTION \_\_\_\_\_  
 SET @ \_\_\_\_\_ °F FOR ALARM \_\_\_\_\_ °F FOR SHUTDN.  
SPACE HEATERS:  
 \_\_\_\_\_ KW  \_\_\_\_\_ VOLT \_\_\_\_\_ PHASE \_\_\_\_\_ HERTZ  
 MAX SHEATH TEMP. \_\_\_\_\_ °F

43 **BASIC DATA:**  
44  \_\_\_\_\_ VOLTS \_\_\_\_\_ PHASE \_\_\_\_\_ HERTZ  
45  NAMEPLATE HP \_\_\_\_\_ SERVICE FACTOR \_\_\_\_\_  
46  SYNCHRONOUS RPM \_\_\_\_\_  
47  INSULATION CLASS \_\_\_\_\_ TYPE \_\_\_\_\_  
48  TEMP. RISE: \_\_\_\_\_ °F ABOVE \_\_\_\_\_ °F BY \_\_\_\_\_  
49 **STARTING:**  
50  FULL VOLTAGE  REDUCED VOLTAGE \_\_\_\_\_ %  
51  LOADED  UNLOADED  
52  VOLTAGE DIP \_\_\_\_\_ %

**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:  
\_\_\_\_\_ °F FOR ALARM \_\_\_\_\_ °F FOR SHUTDOWN

<b>ELECTRIC MOTOR (API 673-2ND. EDITION) DATA SHEET U.S. CUSTOMARY UNITS</b>		JOB NO. _____ ITEM NO. _____ REVISION _____ DATE _____ PAGE 10 OF 10 BY _____																																									
<b>ACCESSORY EQUIPMENT (Cont'd)</b>		<b>MANUFACTURER'S DATA, (Cont'd)</b>																																									
1																																											
2	<b>WINDING TEMP, DETECTOR &amp; SPACE HEATER LEADS:</b>	23																																									
3	<input type="radio"/> IN SAME CONDUIT BOX	24	FIELD DISCHARGE RESISTOR _____ OHMS																																								
4	<input type="radio"/> IN SEPARATE CONDUIT BOXES	25	RATED EXCITATION FIELD VOLTAGE _____ D.C.																																								
5	<input type="radio"/> <b>MOTOR ARRANGED FOR DIFFERENTIAL PROTECTION:</b>	26	RESISTANCE OF EXCITATION FIELD @ 25°C _____ OHMS																																								
6	<input type="radio"/> SELF-BALANCE PRIMARY-CURRENT METHOD	27	EXCITATION FIELD AMPS @ FULL LOAD & RATED P.F. _____																																								
7	<input type="radio"/> C.T. DESCRIPTION _____	28	EXCITATION FIELD AMPS: MAX. _____ MIN. _____																																								
8	<input type="radio"/> EXTENDED LOADS LENGTH _____ FT.	29	EXCITATION FIELD <input type="checkbox"/> RHEOSTAT <input type="checkbox"/> FIXED RESISTOR REQ'D																																								
9	<input type="radio"/> <b>SURGE CAPACITORS</b>	30	SUPPLIED BY _____																																								
10	<input type="radio"/> <b>LIGHTING ARRESTERS</b>	31	BEARINGS: TYPE _____ LUBR. _____																																								
11	<input type="radio"/> <b>C.T. FOR AMMETER</b>	32	LUBE OIL REQUIRED: _____ GPM@ _____ PSIG																																								
12	<input type="radio"/> DESCRIPTION _____	33	TOTAL SHAFT END FLOAT _____																																								
13	<b>MAIN CONDUIT BOX SIZED FOR:</b>	34	LIMIT END FLOAT TO _____																																								
14	<input type="radio"/> MAIN MOTOR LEADS <input type="radio"/> TYPE _____	35	MOTOR ROTOR: <input type="checkbox"/> SOLID <input type="checkbox"/> SPLIT																																								
15	<input type="radio"/> INSULATED <input type="radio"/> NONINSULATED	36	MOTOR HUB <input type="checkbox"/> SOLID <input type="checkbox"/> SPLIT																																								
16	<input type="radio"/> C.T.'S FOR DIFF. PROTECT. (MTD. BY _____)	37	FOR TEWAC & TEIGF MOTORS:																																								
17	<input type="radio"/> SURGE CAPACITORS (MTD. BY _____)	38	COOLING WATER REQ'D _____ GPM																																								
18	<input type="radio"/> LIGHTNING ARRESTERS (MTD. BY _____)	39	C.W. TEMP. RISE _____ °F PRESS. DROP _____ PSI																																								
19	<input type="radio"/> C.T. FOR AMMETER (MTD. BY _____)	40	(AIR) (GAS) REQ'D _____ SCFM PRESS. MAINT. _____ IN. H <sub>2</sub> O																																								
20	<input type="radio"/> SPACE FOR STRESS CONES	41	CURVES REQ'D BASED ON MOTOR SATURATION @ RATED VOLTAGE:																																								
21	<input type="radio"/> <b>AIR FILTERS</b>	42	<input type="radio"/> SPEED vs TORQUE (ALSO @ _____ % RATED VOLTAGE)																																								
22	<input type="checkbox"/> MFR. _____ <input type="checkbox"/> TYPE _____	43	<input type="radio"/> SPEED vs POWER FACTOR																																								
23	<input type="checkbox"/> <b>MANUFACTURER'S DATA</b>	44	<input type="radio"/> SPEED vs CURRENT																																								
24	MANUFACTURER _____	45	WEIGHTS (LBS):																																								
25	FRAME No. _____ FULL LOAD RPM (Ind.) _____	46	NET WEIGHT _____ SHIPPING WT. _____																																								
26	EFFICIENCY: F.L. _____ <sup>3/4</sup> L _____ <sup>1/2</sup> L _____	47	ROTOR WEIGHT _____ MAX. ERECTION WT. _____																																								
27	PWR. FACTOR (Ind.): F.L. _____ <sup>3/4</sup> L _____ <sup>1/2</sup> L _____	48	MAX. MAINT. WT (Identify) _____																																								
28	CURRENT (Rated Volt.): FULL LOAD _____ LOCKED ROTOR _____	49	<b>DIMENSIONS (FEET &amp; INCHES):</b>																																								
29	LOCKED ROTOR POWER FACTOR _____	50	L _____ W _____ H _____																																								
30	LOCKED ROTOR WITHSTAND TIME (Cold Start) _____	51																																									
31	TORQUES (FT-LBS): FULL LOAD _____	52																																									
32	LOCKED ROTOR _____ STARTING (Syn.) _____	<b>SHOP INSPECTION AND TESTS</b>																																									
33	PULL-UP (Ind.) _____ PULL-IN (Syn.) _____		<table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">REQUIRED</th> <th style="text-align: center;">OBSERVED</th> <th style="text-align: center;">WITNESS</th> </tr> </thead> <tbody> <tr> <td>SHOP INSPECTION</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>TESTING PER NEMA</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>MFR. STD. SHOP TESTS</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>IMMERSION TEST</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>SPECIAL TESTS (List Below)</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>_____</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>_____</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>_____</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>_____</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> </tbody> </table>		REQUIRED	OBSERVED	WITNESS	SHOP INSPECTION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	TESTING PER NEMA	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	MFR. STD. SHOP TESTS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	IMMERSION TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	SPECIAL TESTS (List Below)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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_____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>																																								
34	BREAKDOWN (Ind.) _____ PULL-OUT (Syn.) _____	<b>COUPLING:</b>																																									
35	_____	<input type="radio"/> SUPPLIED BY _____																																									
36	OPEN CIRCUIT TIME CONSTANT (SEC.) _____	<input type="radio"/> MFR. _____ <input type="checkbox"/> MODEL _____																																									
37	SYMMETRICAL CONTRIBUTION TO 3 $\phi$ TERMINAL FAULT:	<input type="radio"/> MOTOR MFR. <input type="radio"/> FAN MFR. <input type="radio"/> PUCH. TO MOUNT MTR. HALF																																									
38	AT <sup>1</sup> / <sub>2</sub> CYCLES _____ AT 5 CYCLES _____	<b>PAINTING:</b>																																									
39	REACTANCES: SUB-TRANSIENT (X'' <sub>d</sub> ) _____	<input type="radio"/> MANUFACTURER'S STANDARD																																									
40	TRANSIENT (X' <sub>d</sub> ) _____ SYNCHRONOUS (X <sub>d</sub> ) _____	<input type="radio"/>																																									
41	A.C. STATOR RESISTANCE _____ OHMS@ _____ °F	<b>SHIPMENT:</b>																																									
42	RATED KVA _____	<input type="radio"/> DOMESTIC <input type="radio"/> EXPORT <input type="radio"/> EXPORT BOXING REQUIRED																																									
43	KVA INRUSH @ FULL VOLT. & LOCKED ROTOR (SYN.) _____ %	<input type="radio"/> OUT DOOR STORAGE OVER 6 MONTHS																																									
44	KVA @ FULL VOLTAGE & 95% SPEED _____ %	<input type="radio"/>																																									
45	MAX. LINE CURR. IN STATOR ON 1st SLIP CYC. @ PULL-OUT																																										
46	(SYN.) _____																																										
47	ACCELERATION TIME (Motor Only @ Rated Volt.) _____ SEC.																																										
48	ACCEL. TIME (Motor & Load @ 85% Rated Volt.) _____ SEC.																																										
49	ROTOR/FIELD WR <sup>2</sup> @ MOTOR SHAFT (LB-FT.) _____																																										
50	ROTATION FACING COUPLING END _____																																										
51	No. OF STARTS PER HOUR _____																																										
52	<b>REMARKS:</b> _____																																										

<b>CENTRIFUGAL FAN (API 673-2ND. EDITION) DATA SHEET SI UNITS</b>	JOB NO. _____ ITEM NO. _____ PURCHASE ORDER NO. _____ SPECIFICATION NO. _____ REVISION NO. _____ DATE _____ PAGE <u>1</u> OF <u>10</u> BY _____
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1 APPLICABLE TO: <input type="radio"/> PROPOSAL <input type="radio"/> PURCHASE <input type="radio"/> AS BUILT 2 FOR: _____ 3 SITE: _____ 4 SERVICE: _____ 5 NOTE: <input type="radio"/> INDICATES INFORMATION TO BE COMPLETED BY PURCHASER <input type="checkbox"/> BY MANUFACTURER	REVISION: _____ UNIT: _____ NO. REQUIRED: _____
---	---

<b>GENERAL</b>			
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 <input type="radio"/> DIRECT COUPLED <input type="radio"/> OTHER _____	FAN ROTATION, FROM DRIVEN END _____		CW _____    CCW _____

<b>OPERATING CONDITIONS</b>			
-----------------------------	--	--	--

(ALL DATA ON PER UNIT BASIS)	NORMAL	RATED	OTHER CONDITIONS			
			A	B	C	D
14 <input type="radio"/> OPERATING CONDITIONS/CASE						
15 <input type="radio"/> GAS HANDLED (See Page _____)						
16 <input type="radio"/> DENSITY (kg/m <sup>3</sup> )						
17 <input type="radio"/> DELIVERED m <sup>3</sup> /h (1 atm & 0°C DRY)						
18 <input type="radio"/> WEIGHT FLOW Kg/h (WET)						
<b>INLET CONDITIONS:</b>						
20 <input type="radio"/> TEMPERATURE ( °C)						
21 <input type="radio"/> RELATIVE HUMIDITY (%)						
22 <input type="radio"/> MOLECULAR WEIGHT (MIN.)						
23 <input type="checkbox"/> INLET VOLUME (m <sup>3</sup> /s WET)						
24 <input type="checkbox"/> Cp/Cv (K <sub>1</sub> ) OR (K <sub>AVG</sub> )						
25 <input type="checkbox"/> COMPRESSIBILITY (Z <sub>1</sub> ) OR (Z <sub>AVG</sub> )						
26 <input type="radio"/> STATIC PRESSURE @ SOUND TRUCK (mm WG)						
27 <input type="checkbox"/> PRESSURE LOSS ACROSS SOUND TRUCK (mm WG)						
28 <input type="radio"/> STATIC PRESSURE @ INLET DAMPERS (mm WG)						
29 <input type="radio"/> STATIC PRESSURE @ FAN INLET (mm WG)						
<b>DISCHARGE CONDITIONS:</b>						
31 <input type="checkbox"/> STATIC PRESSURE @ FAN OUTLET (mm WG)						
32 <input type="checkbox"/> STATIC PRESS. @ DISCHARGE DAMPER (mm WG)						
33 <input type="checkbox"/> ΔP ACROSS DISCHARGE DAMPER (mm WG)						
34 <input type="checkbox"/> ΔP ACROSS EVASE (mm WG)						
35 <input type="radio"/> STATIC PRESSURE @ EVASE OUTLET (mm WG)						
<b>PERFORMANCE:</b>						
37 <input type="checkbox"/> BHP REQUIRED @ TEMP. (ALL LOSSES IND.)						
38 <input type="checkbox"/> FAN SPEED (RPM)						
39 <input type="radio"/> GUARANTEE POINT						
40 <input type="checkbox"/> PERFORMANCE CURVE NO.						
41 <input type="checkbox"/> STATIC ΔP ACROSS FAN (mm WG)						
42 <input type="checkbox"/> INLET DAMPER/VANE POSITION						
43 <input type="checkbox"/> DISCHARGE DAMPER POSITION						
44 <input type="checkbox"/> FAN STATIC EFFICIENCY (%)						

<b>FAN CONTROL:</b>			
46 <input type="radio"/> AIR SUPPLY _____	<input type="radio"/> FAN CONTROL FURNISHED BY _____		
47 <input type="radio"/> CONTROL SIGNAL TYPE _____	SOURCE _____	SENSITIVITY _____	RANGE _____
48 <input type="radio"/> ARRANGEMENT DRWG NO. _____	CONTROL SIGNAL FAILURE MODE		<input type="radio"/> CLOSE <input type="radio"/> OPEN <input type="radio"/> AUTOLOCK
49 <b>METHOD:</b> <input type="radio"/> INLET DAMPER <input type="radio"/> OUTLET DAMPER <input type="radio"/> INLET GUIDE VANES			
50 <input type="radio"/> STARTING CONDITIONS _____	<input type="radio"/> STARTING METHOD _____		
51 <input type="radio"/> START & STOP RESTRICTIONS _____			
52 <input type="radio"/> VENDOR REVIEW OF CONTROL SYSTEM REQUIRED		<input type="radio"/> OTHER _____	



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**OPERATING CONDITIONS**

1 2 3	GAS ANALYSIS MOL%	NORMAL	RATED	CONDITIONS				REMARKS
				A	B	C	D	
4	MW							
5	AIR	28.97						
6	OXYGEN	32.00						
7	NITROGEN	28.02						
8	WATER VAPOR	18.02						
9	CARBON MONOXIDE	28.01						
10	CARBON DIOXIDE	44.01						
11	HYDROGEN SULFIDE	34.08						
12	HYDROGEN CHLORIDE	36.47						
13	CHLORINE	70.91						
14								
15								
16								
17								
18	TOTAL							
19	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 \_\_\_\_\_ m<sup>2</sup>       BAR \_\_\_\_\_ (ABS)/mm Hg A
- TEMPERATURE \_\_\_\_\_ °C SUMMER      \_\_\_\_\_ °C WINTER
- WIND LOAD \_\_\_\_\_ Kg/m<sup>2</sup>       VELOCITY \_\_\_\_\_ KPH
- MINIMUM DESIGN METAL TEMPERATURE \_\_\_\_\_ °C

**UNUSUAL CONDITIONS:**

- DUST       FUMES
- OTHER \_\_\_\_\_

**SPECIFICATIONS**

**NOISE SPECIFICATIONS:**

- APPLICABLE TO MACHINE:  
See Specification \_\_\_\_\_
- APPLICABLE TO NEIGHBORHOOD  
See Specification \_\_\_\_\_
- ACOUSTIC HOUSING:**       YES       NO

**APPLICABLE SPECIFICATIONS:**

**PAINTING:**

- MANUFACTURER'S STD.
- OTHERS \_\_\_\_\_

**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 \_\_\_\_\_

**ELECTRICAL AREA CLASSIFICATION:**

- CLASS \_\_\_\_\_ GROUP \_\_\_\_\_ ZONE \_\_\_\_\_

**REMARKS:**

50 \_\_\_\_\_  
51 \_\_\_\_\_

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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<sup>2</sup>  
 LOADING N/m<sup>2</sup>: 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 (See Pg. 6)  
 PURGE OIL MIST  OTHER \_\_\_\_\_  
 COOLANT REQUIRED  NONE  AIR \_\_\_\_\_  
 WATER \_\_\_\_\_ m<sup>3</sup>/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<sup>2</sup>(Kg/m<sup>2</sup>) \_\_\_\_\_  
 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<sup>2</sup>) \_\_\_\_\_  
 FLANGE SIZE \_\_\_\_\_ BOLTING \_\_\_\_\_  
 LOCATION/ORIENTATION \_\_\_\_\_  
 EXP. JOINT REQ'D \_\_\_\_\_ FURN. BY \_\_\_\_\_

OUTLET: SIZE \_\_\_\_\_ x \_\_\_\_\_ AREA (m<sup>2</sup>) \_\_\_\_\_  
 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<sup>3</sup>/s \_\_\_\_\_ °C
- LOSS \_\_\_\_\_ mm WG.
- ACCESSORIES \_\_\_\_\_

**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 CLEANING SYSTEM (2.1.22):**

- REQUIRED \_\_\_\_\_ CLEANING MEDIUM \_\_\_\_\_
- MFR./MODEL \_\_\_\_\_ FURN BY \_\_\_\_\_
- INSTALLED BY \_\_\_\_\_
- DETAILS/DWG.No. \_\_\_\_\_

**FAN ITEMS:**

- 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

- CORROSION ALLOWANCE
- SIZE/THICKNESS (INCL. C.A.)
- MATERIAL
- MATERIAL SPECIFICATION

**COUPLINGS:**

- 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

- DRIVER—FAN
- GEAR—FAN
- DRIVER—GEAR

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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°				

**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 \_\_\_\_\_

- 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

**SPACE REQUIREMENTS (METERS):**

COMPLETE UNIT L \_\_\_\_\_ W \_\_\_\_\_ H \_\_\_\_\_  
 CONTROL PANEL L \_\_\_\_\_ W \_\_\_\_\_ H \_\_\_\_\_  
 \_\_\_\_\_ L \_\_\_\_\_ W \_\_\_\_\_ H \_\_\_\_\_

- SPEED DETECTORS (On Outdoor Bearing):**
- NON-CONTACT PROBE  SPEED SWITCH  
 OTHER \_\_\_\_\_  
 TYPE \_\_\_\_\_  MODEL \_\_\_\_\_  
 MFG \_\_\_\_\_  
 LOCATION \_\_\_\_\_  
 SCALE RANGE \_\_\_\_\_ RPM

**UTILITY REQUIREMENTS:**

STEAM \_\_\_\_\_ WATER \_\_\_\_\_ ELECTRIC \_\_\_\_\_  
 AIR \_\_\_\_\_ GAS \_\_\_\_\_ DRIVER RATING \_\_\_\_\_ NET LOADS \_\_\_\_\_

**SHOP INSPECTIONS & TESTS:**

	REQ'D.	OBSERV'D	WIT.
24 SHOP INSPECTION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
25 CLEANLINESS INSPECTION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
26 HARDNESS VERIFICATION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
27 CHARPY IMPACT TESTING	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
28 SHAFT RUN OUT CHECK	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
29 ROTOR BALANCING	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
30 REBAL. AFTER MOUNTING CPLG.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
31 RESIDUAL BALANCE CHECK	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
32 CALIBRT'N CK. OF BALNC'G EQUIP	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
33 NDT EXAMINATION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
34 ASSEMBLY & FIT UP CHECK	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
35 INITIAL &/or FINAL ALIGN	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
36 GEAR TOOTH CNTCT. CHK. (API 677)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
37 MECHANICAL RUN TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
38 FULL UNIT MECHANICAL RUN TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
39 VIBRATION TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
40 SOUND LEVEL TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
41 MAT'L CERTIFICATION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
42 SURFACT & SUBSURFACE INSPCT.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
43 TYPE _____			
44 PRESSURE TEST:	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
45 —HOUSING	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
46 —DUCTING	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
47 —LUBE OIL SYSTEM	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
48 RUN & CHECK LUBE CONSOLE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
49 SHOP PERFORMANCE TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
50 PRE-SHIPMENT INSPECTION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
51 —DRIVER / AUX. MOUNTED	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
52 QUALITY CONTROL REVIEW	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
53 FIELD PERFORMANCE TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
54 OTHERS: _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
55	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- 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**

**LUBE OIL SYSTEM**  **API 614 REQUIRED**

**PIPING MATERIALS:**

	CARBON STEEL	STAINLESS STEEL
<input type="radio"/> COMPLETE SYSTEM	_____	_____
<input type="radio"/> DOWNSTREAM OF FILTERS	_____	_____
<input type="radio"/> RETURN PIPING	_____	_____
<input type="radio"/> CARBON STEEL SLIP-ON FLANGES ON STNLESS. STEEL PIPING	_____	_____

**STANBY PUMP CONTROL:**

RESET       MANUAL       AUTOMATIC

AUTOMATIC START

"ON-OFF-AUTO" SELECTOR SWITCH

**SYSTEM COMPONENT SUPPLIERS:**

	MANUFACTURER	MODEL
<input type="checkbox"/> MAIN PUMP	_____	_____
<input type="checkbox"/> STANDBY PUMP	_____	_____
<input type="checkbox"/> ELECTRIC MOTOR (S)	_____	_____
<input type="checkbox"/> STEAM TURBINE (S)	_____	_____
<input type="checkbox"/> OIL COOLER (S)	_____	_____
<input type="checkbox"/> OIL FILTER (S)	_____	_____
<input type="checkbox"/> ACCUMULATOR (S)	_____	_____
<input type="checkbox"/> SUCT. STRAINER (S)	_____	_____
<input type="checkbox"/> CHECK VALVE (S)	_____	_____
<input type="checkbox"/> SWITCH VALVE (S)	_____	_____
<input type="checkbox"/> PUMP COUPLING (S)	_____	_____
<input type="checkbox"/> TEMP. INDICATORS	_____	_____
<input type="checkbox"/> L.P. SHUTDOWN SWITCH	_____	_____

**RESERVOIR:**

MATERIAL \_\_\_\_\_

RETENTION TIME \_\_\_\_\_ MIN. CAPACITY \_\_\_\_\_ m<sup>3</sup>

BASEPLATE MOUNTED       FABRICATED STEEL BASE

BAFFLE REQUIRED       INTERIOR COATING

FREE SURFACE AREA \_\_\_\_\_ m<sup>2</sup>

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

**SYSTEM PRESSURES:**

DESIGN \_\_\_\_\_ PSIG       HYDROTEST \_\_\_\_\_ PSIG

PUMP RELIEF VALVE (S) SETTINGS \_\_\_\_\_ PSIG

**OIL COOLERS:**

AIR       WATER \_\_\_\_\_ m<sup>3</sup>/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<sup>2</sup>

WALL THICKNESS (AVE) (MIN) \_\_\_\_\_ mm

LENGTH \_\_\_\_\_ mm NUMBER: \_\_\_\_\_

MATERIALS

TUBES \_\_\_\_\_

TUBE SHEETS \_\_\_\_\_

SHELL \_\_\_\_\_

TUBE SUPPORT \_\_\_\_\_

SHELL COVER/FLANGE \_\_\_\_\_

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

	m <sup>3</sup> /h	BAR	SSU @ 38°C	SSU @ 99°C
<input type="checkbox"/> LUBE OIL	_____	_____	_____	_____
<input type="checkbox"/> FAN	_____	_____	_____	_____
<input type="checkbox"/> DRIVER	_____	_____	_____	_____
<input type="checkbox"/> GEAR	_____	_____	_____	_____

COMMON LUBE SYSTEM \_\_\_\_\_

**PUMPS:**

	MAIN	STANDBY
<input type="radio"/> HORIZONTAL	_____	_____
<input type="radio"/> VERTICAL	_____	_____
<input type="radio"/> SUBMERGED	_____	_____
<input type="radio"/> MOTOR DRIVEN	_____	_____
<input type="radio"/> TURBINE DRIVEN	_____	_____
<input type="radio"/> SHAFT DRIVEN	_____	_____
<input type="radio"/> CENTRIFUGAL	_____	_____
<input type="radio"/> GEAR/SCREW	_____	_____
<input type="radio"/> FLANGE CONNECTED	_____	_____
<input type="checkbox"/> m <sup>3</sup> /h (RATED)	_____	_____
<input type="checkbox"/> @ BAR	_____	_____
<input type="checkbox"/> BHP @ 100 SSU	_____	_____
<input type="checkbox"/> DRIVER kW	_____	_____
<input type="radio"/> CASING MATERIAL	_____	_____
<input type="checkbox"/> SPEED	_____	_____
<input type="radio"/> COUPLING	_____	_____
<input type="checkbox"/> GUARD	_____	_____
<input type="radio"/> MECH. SEAL	_____	_____

**ACCUMULATOR:**

SINGLE       MULTI

ASME CODE DESIGN       ASME CODE STAMP

MATERIAL \_\_\_\_\_

CORROSION ALLOWANCE (mm) \_\_\_\_\_

CAPACITY (TOTAL) m<sup>3</sup> \_\_\_\_\_

PRE-CHARGE PRESS. (BAR) \_\_\_\_\_

DIRECT CONTACT TYPE       BLADDER TYPE

BLADDER MATERIAL \_\_\_\_\_

WITH SUPPLY REGULATOR       MANU. CHARGE VALVE

**EMERGENCY LUBE OIL PUMP:**

AIR MOTOR DRIVEN       OTHER \_\_\_\_\_

SAFETY GUARD REQUIRED \_\_\_\_\_

**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 \_\_\_\_\_

**REMARKS:**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**CENTRIFUGAL FAN (API 673-2ND. EDITION)  
DATA SHEET  
SI UNITS**

JOB NO. \_\_\_\_\_ ITEM NO. \_\_\_\_\_  
 REVISION \_\_\_\_\_ DATE \_\_\_\_\_  
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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:**

12	PRESSURE GAGES	MFR.	_____	SIZE & TYPE	_____
13	TEMPERATURE GAGES	MFR.	_____	SIZE & TYPE	_____
14	LEVEL GAGES	MFR.	_____	SIZE & TYPE	_____
15	DIFF. PRESSURE GAGES	MFR.	_____	SIZE & TYPE	_____
16	PRESSURE SWITCHES	MFR.	_____	SIZE & TYPE	_____
17	DIFF. PRESSURE SWITCHES	MFR.	_____	SIZE & TYPE	_____
18	TEMPERATURE SWITCHES	MFR.	_____	SIZE & TYPE	_____
19	LEVEL SWITCHES	MFR.	_____	SIZE & TYPE	_____
20	CONTROL VALVES	MFR.	_____	SIZE & TYPE	_____
21	PRESSURE RELIEF VALVES	MFR.	_____	SIZE & TYPE	_____
22	SIGHT FLOW INDICATORS	MFR.	_____	SIZE & TYPE	_____
23	VIBRATION EQUIPMENT	MFR.	_____	SIZE & TYPE	_____
24	TACHOMETER	MFR.	_____	RANGE & TYPE	_____
25	SOLENOID VALVES	MFR.	_____	SIZE & TYPE	_____
26	ANNUNCIATOR	MFR.	_____	MODEL & No. POINTS	_____
27	<input type="checkbox"/> DAMPER/VANE ACTUATOR	MFR.	_____	MODEL	_____
28	<input type="radio"/> FURNISHED BY _____	<input type="checkbox"/> TYPE _____	<input type="checkbox"/> MAX. TORQUE (N-m) _____		

NOTE:     SUPPLIED BY VENDOR       SUPPLIED BY PURCHASER

**PRESSURE GAGE REQUIREMENTS:**

FUNCTION	LOCALLY MOUNTED		LOCAL PANEL		FUNCTION	LOCALLY MOUNTED		LOCAL PANEL		
	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>		<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	
32	LUBE OIL PUMP DISCHARGE	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	FAN DISCHARGE	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
33	LUBE OIL FILTER ΔP	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	CONTROL AIR	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
34	LUBE OIL SUPPLY	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	FAN SUCTION	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
35	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
36	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>

**TEMP. GAGE REQUIREMENTS:**

FUNCTION	LOCALLY MOUNTED		LOCAL PANEL		FUNCTION	LOCALLY MOUNTED		LOCAL PANEL		
	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>		<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	
39	LUBE OIL TO BEARINGS	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	OIL COOLER INLET & OUTLET	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
40	DISCHARGE FROM EACH	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	FAN SUCTION	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
41	PINION JOURNAL BEARING	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
42	BULL GEAR JOURNAL BEARING	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
43	FAN THRUST BEARING	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
44	DRIVER JOURNAL BEARING	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
45	DRIVER THRUST BEARING	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
46	GEAR THRUST BEARING	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
47	FAN JOURNAL BEARING	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>
48	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>	_____	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="radio"/>

**SWITCH CLOSURES:**

- ALARM CONTACTS 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: \_\_\_\_\_



**ELECTRONIC MOTOR (API 673-2ND. EDITION)  
DATA SHEET  
SI 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

**MOTOR DESIGN DATA**

8 **APPLICABLE SPECIFICATIONS:**  
 9  NEMA \_\_\_\_\_  
 10  \_\_\_\_\_  
 11 **SITE DATA:**  
 12 AREA:  C.L. \_\_\_\_\_ GR. \_\_\_\_\_ ZN. \_\_\_\_\_  N-HAZARDOUS  
 13  ALTITUDE \_\_\_\_\_ m  AMBIENT TEMPS: MAX \_\_\_\_\_ °C  
 14 UNUSUAL CONDITIONS  DUST  FUMES MIN \_\_\_\_\_ °C  
 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.  
 25  WOUND ROTOR INDUCTION  
 26  \_\_\_\_\_

27 **ENCLOSURE:**  
 28  CLASS \_\_\_\_\_ GROUP \_\_\_\_\_ EXP. PROOF \_\_\_\_\_  
 29  TEFC  
 30  TEWAC  TEIGF, USING \_\_\_\_\_ GAS  
 31  DOUBLE WALL CARBON STEEL TUBES  
 32  WATER SUPP.: PRESS. \_\_\_\_\_ BAR TEMP. \_\_\_\_\_ °C  
 33  WATER ALLOW. ΔP \_\_\_\_\_ BAR & TEMP RISE \_\_\_\_\_ °C  
 34  WATER SIDE MIN CORR. ALLOW. \_\_\_\_\_ mm  
 35 AND FOUL FACTOR \_\_\_\_\_  
 36  (AIR) (GAS) SUPPLY PRESS. \_\_\_\_\_ BAR  
 37  \_\_\_\_\_  
 38  WEATHER PROTECTED TYPE \_\_\_\_\_  
 39  FORCED VENTILATION  
 40  OPEN-DRIPPROOF  
 41  OPEN  
 42  \_\_\_\_\_

43 **BASIC DATA:**  
 44  \_\_\_\_\_ VOLTS \_\_\_\_\_ PHASE \_\_\_\_\_ HERTZ  
 45  NAMEPLATE HP \_\_\_\_\_ SERVICE FACTOR \_\_\_\_\_  
 46  SYNCHRONOUS RPM \_\_\_\_\_  
 47  INSULATION CLASS \_\_\_\_\_ TYPE \_\_\_\_\_  
 48  TEMP. RISE: \_\_\_\_\_ °C ABOVE \_\_\_\_\_ °C BY \_\_\_\_\_  
 49 **STARTING:**  
 50  FULL VOLTAGE  REDUCED VOLTAGE \_\_\_\_\_ %  
 51  LOADED  UNLOADED  
 52  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<sub>2</sub>O  
**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



<b>ELECTRONIC MOTOR (API 673-2ND. EDITION) DATA SHEET SI UNITS</b>		JOB NO. _____ ITEM NO. _____ REVISION _____ DATE _____ PAGE 10 OF 10 BY _____																																							
<p><b>ACCESSORY EQUIPMENT, (Cont'd)</b></p> <p>2 <b>WINDING TEMP, DETECTOR &amp; SPACE HEATER LEADS:</b></p> <p>3 <input type="radio"/> IN SAME CONDUIT BOX</p> <p>4 <input type="radio"/> IN SEPARATE CONDUIT BOXES</p> <p>5 <input checked="" type="radio"/> <b>MOTOR ARRANGED FOR DIFFERENTIAL PROTECTION:</b></p> <p>6 <input type="radio"/> SELF-BALANCE PRIMARY-CURRENT METHOD</p> <p>7 <input type="radio"/> C.T. DESCRIPTION _____</p> <p>8 <input type="radio"/> EXTENDED LOADS LENGTH _____ m</p> <p>9 <input type="radio"/> <b>SURGE CAPACITORS</b></p> <p>10 <input type="radio"/> <b>LIGHTING ARRESTERS</b></p> <p>11 <input type="radio"/> <b>C.T. FOR AMMETER</b></p> <p>12 <input type="radio"/> DESCRIPTION _____</p> <p>13 <b>MAIN CONDUIT BOX SIZED FOR:</b></p> <p>14 <input type="radio"/> MAIN MOTOR LEADS <input type="radio"/> TYPE _____</p> <p>15 <input type="radio"/> INSULATED <input type="radio"/> NONINSULATED</p> <p>16 <input type="radio"/> C.T.'S FOR DIFF. PROTECT. (MTD. BY _____)</p> <p>17 <input type="radio"/> SURGE CAPACITORS (MTD. BY _____)</p> <p>18 <input type="radio"/> LIGHTNING ARRESTERS (MTD. BY _____)</p> <p>19 <input type="radio"/> C.T. FOR AMMETER (MTD. BY _____)</p> <p>20 <input type="radio"/> SPACE FOR STRESS CONES</p> <p>21 <input type="radio"/> <b>AIR FILTERS</b></p> <p>22 <input type="checkbox"/> MFR. _____ <input type="checkbox"/> TYPE _____</p> <p>23 <input type="checkbox"/> <b>MANUFACTURER'S DATA</b></p> <p>24 MANUFACTURER _____</p> <p>25 FRAME No. _____ FULL LOAD RPM (Ind.) _____</p> <p>26 EFFICIENCY: F.L. _____ <sup>3/4</sup>L _____ <sup>1/2</sup>L _____</p> <p>27 PWR. FACTOR (Ind.): F.L. _____ <sup>3/4</sup>L _____ <sup>1/2</sup>L _____</p> <p>28 CURRENT (Rated Volt.): FULL LOAD _____ LOCKED ROTOR _____</p> <p>29 LOCKED ROTOR POWER FACTOR _____</p> <p>30 LOCKED ROTOR WITHSTAND TIME (Cold Start) _____</p> <p>31 TORQUES (FT-LBS): FULL LOAD _____</p> <p>32 LOCKED ROTOR _____ STARTING (Syn.) _____</p> <p>33 PULL-UP (Ind.) _____ PULL-IN (Syn.) _____</p> <p>34 BREAKDOWN (Ind.) _____ PULL-OUT (Syn.) _____</p> <p>35 _____</p> <p>36 OPEN CIRCUIT TIME CONSTANT (SEC.) _____</p> <p>37 SYMMETRICAL CONTRIBUTION TO 3<math>\phi</math> TERMINAL FAULT: _____</p> <p>38 AT <sup>1</sup>/<sub>2</sub> CYCLES _____ AT 5 CYCLES _____</p> <p>39 REACTANCES: SUB-TRANSIENT (X'd) _____</p> <p>40 TRANSIENT (X'd) _____ SYNCHRONOUS (X<sub>d</sub>) _____</p> <p>41 A.C. STATOR RESISTANCE _____ OHMS@ _____ °C</p> <p>42 RATED KVA _____</p> <p>43 KVA INRUSH @ FULL VOLT. &amp; LOCKED ROTOR (SYN.) _____ %</p> <p>44 KVA @ FULL VOLTAGE &amp; 95% SPEED _____ %</p> <p>45 MAX. LINE CURR. IN STATOR ON 1st SLIP CYC. @ PULL-OUT _____</p> <p>46 (SYN.) _____</p> <p>47 ACCELERATION TIME (Motor Only @ Rated Volt.) _____ SEC.</p> <p>48 ACCEL. TIME (Motor &amp; Load @ 85% Rated Volt.) _____ SEC.</p> <p>49 ROTOR/FIELD WK<sup>2</sup> @ MOTOR SHAFT (Kg-m_) _____</p> <p>50 ROTATION FACING COUPLING END _____</p> <p>51 NO. OF STARTS PER HOUR _____</p> <p>52 REMARKS: _____</p>	<p><b>MANUFACTURER'S DATA, (Cont'd)</b></p> <p>FIELD DISCHARGE RESISTOR _____ OHMS</p> <p>RATED EXCITATION FIELD VOLTAGE _____ D.C.</p> <p>RESISTANCE OF EXCITATION FIELD @ 25°C _____ OHMS</p> <p>EXCITATION FIELD AMPS @ FULL LOAD &amp; RATED P.F. _____</p> <p>EXCITATION FIELD AMPS: MAX. _____ MIN. _____</p> <p>EXCITATION FIELD <input type="checkbox"/> RHEOSTAT <input type="checkbox"/> FIXED RESISTOR REQ'D</p> <p>SUPPLIED BY _____</p> <p>BEARINGS: TYPE _____ LUBR. _____</p> <p>LUBE OIL REQUIRED: _____ m<sup>3</sup>/h @ _____ BAR</p> <p>TOTAL SHAFT END FLOAT _____</p> <p>LIMIT END FLOAT TO _____</p> <p>MOTOR ROTOR: <input type="checkbox"/> SOLID <input type="checkbox"/> SPLIT</p> <p>MOTOR HUB <input type="checkbox"/> SOLID <input type="checkbox"/> SPLIT</p> <p>FOR TEWAC &amp; TEIGF MOTORS:</p> <p>COOLING WATER REQ'D _____ m<sup>3</sup>/h</p> <p>C.W. TEMP. RISE _____ °C PRESS. DROP _____ BAR</p> <p>(AIR) (GAS) REQ'D _____ m<sup>3</sup>/h PRESS. MAINT. _____ mm H<sub>2</sub>O</p> <p>CURVES REQ'D BASED ON MOTOR SATURATION @ RATED VOLTAGE:</p> <p><input type="radio"/> SPEED vs TORQUE (ALSO @ _____ % RATED VOLTAGE)</p> <p><input type="radio"/> SPEED vs POWER FACTOR</p> <p><input type="radio"/> SPEED vs CURRENT</p> <p>WEIGHTS (Kg):</p> <p>NET WEIGHT _____ SHIPPING WT. _____</p> <p>ROTOR WEIGHT _____ MAX. ERECTION WT. _____</p> <p>MAX. MAINT. WT (Identify) _____</p> <p><b>DIMENSIONS (METERS):</b></p> <p>L _____ W _____ H _____</p> <p style="text-align: center;"><b>SHOP INSPECTION AND TESTS</b></p> <table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">REQUIRED</th> <th style="text-align: center;">OBSERVED</th> <th style="text-align: center;">WITNESS</th> </tr> </thead> <tbody> <tr> <td>SHOP INSPECTION</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>TESTING PER NEMA</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>MFR. STD. SHOP TESTS</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>IMMERSION TEST</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>SPECIAL TESTS (List Below)</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>_____</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>_____</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>_____</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> <tr> <td>_____</td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> <td style="text-align: center;"><input type="radio"/></td> </tr> </tbody> </table> <p><b>COUPLING:</b></p> <p><input type="radio"/> SUPPLIED BY _____</p> <p><input type="radio"/> MFR. _____ <input type="checkbox"/> MODEL _____</p> <p><input type="radio"/> MOTOR MFR. <input type="radio"/> FAN MFR. <input type="radio"/> PUCH. TO MOUNT MTR. HALF</p> <p><b>PAINTING:</b></p> <p><input type="radio"/> MANUFACTURER'S STANDARD</p> <p><input type="radio"/> _____</p> <p><b>SHIPMENT:</b></p> <p><input type="radio"/> DOMESTIC <input type="radio"/> EXPORT <input type="radio"/> EXPORT BOXING REQUIRED</p> <p><input type="radio"/> OUT DOOR STORAGE OVER 6 MONTHS</p> <p><input type="radio"/> _____</p>		REQUIRED	OBSERVED	WITNESS	SHOP INSPECTION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	TESTING PER NEMA	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	MFR. STD. SHOP TESTS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	IMMERSION TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	SPECIAL TESTS (List Below)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	REQUIRED	OBSERVED	WITNESS																																						
SHOP INSPECTION	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>																																						
TESTING PER NEMA	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>																																						
MFR. STD. SHOP TESTS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>																																						
IMMERSION TEST	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>																																						
SPECIAL TESTS (List Below)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>																																						
_____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>																																						
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## APPENDIX D—MAXIMUM RESIDUAL SPECIFIC UNBALANCE



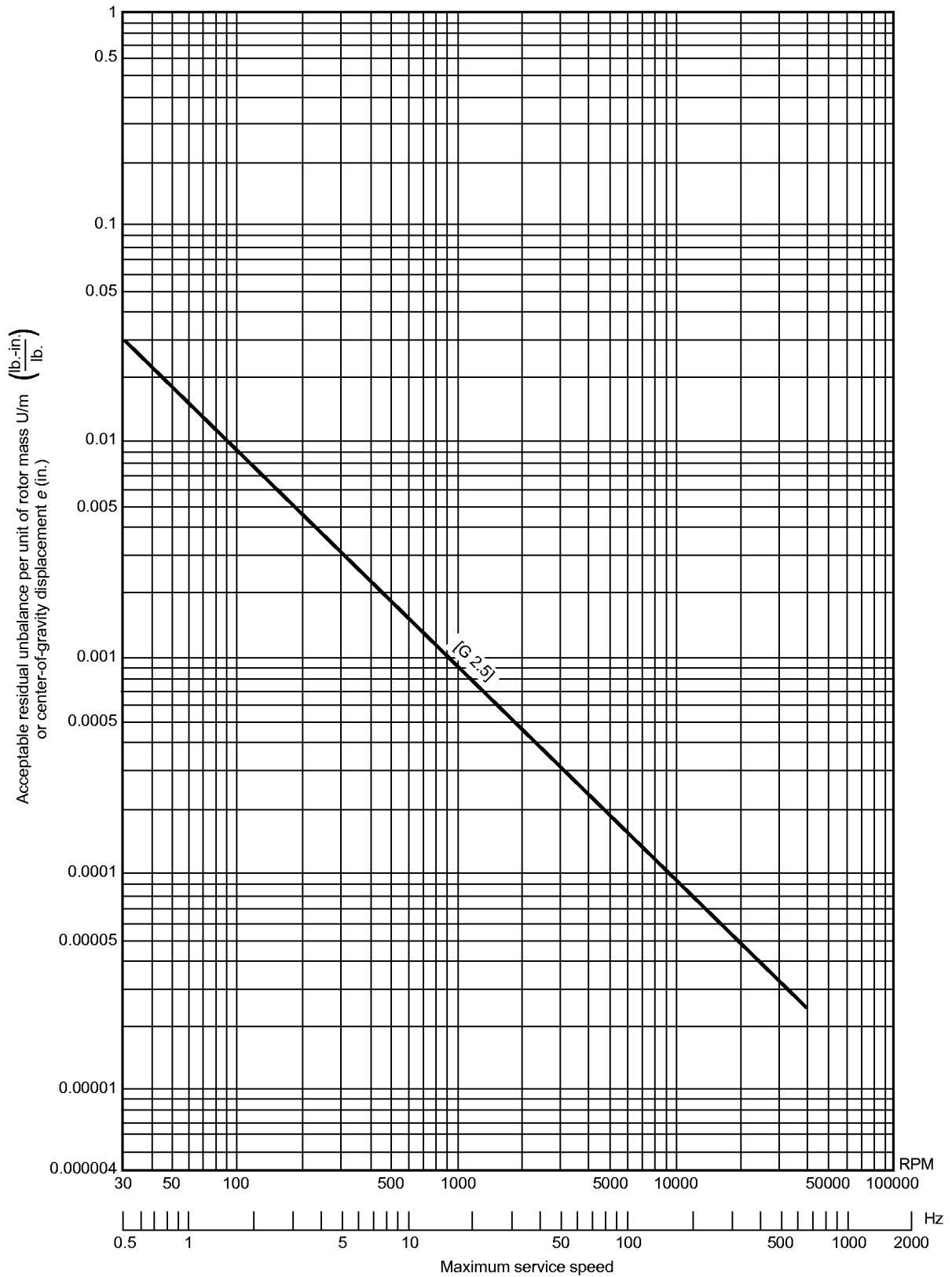


Figure D-1—Maximum Residual Specific Unbalance Corresponding to Balance Quality Grade G2.5 (ANSI S2.19) (Shown in Customary Units)

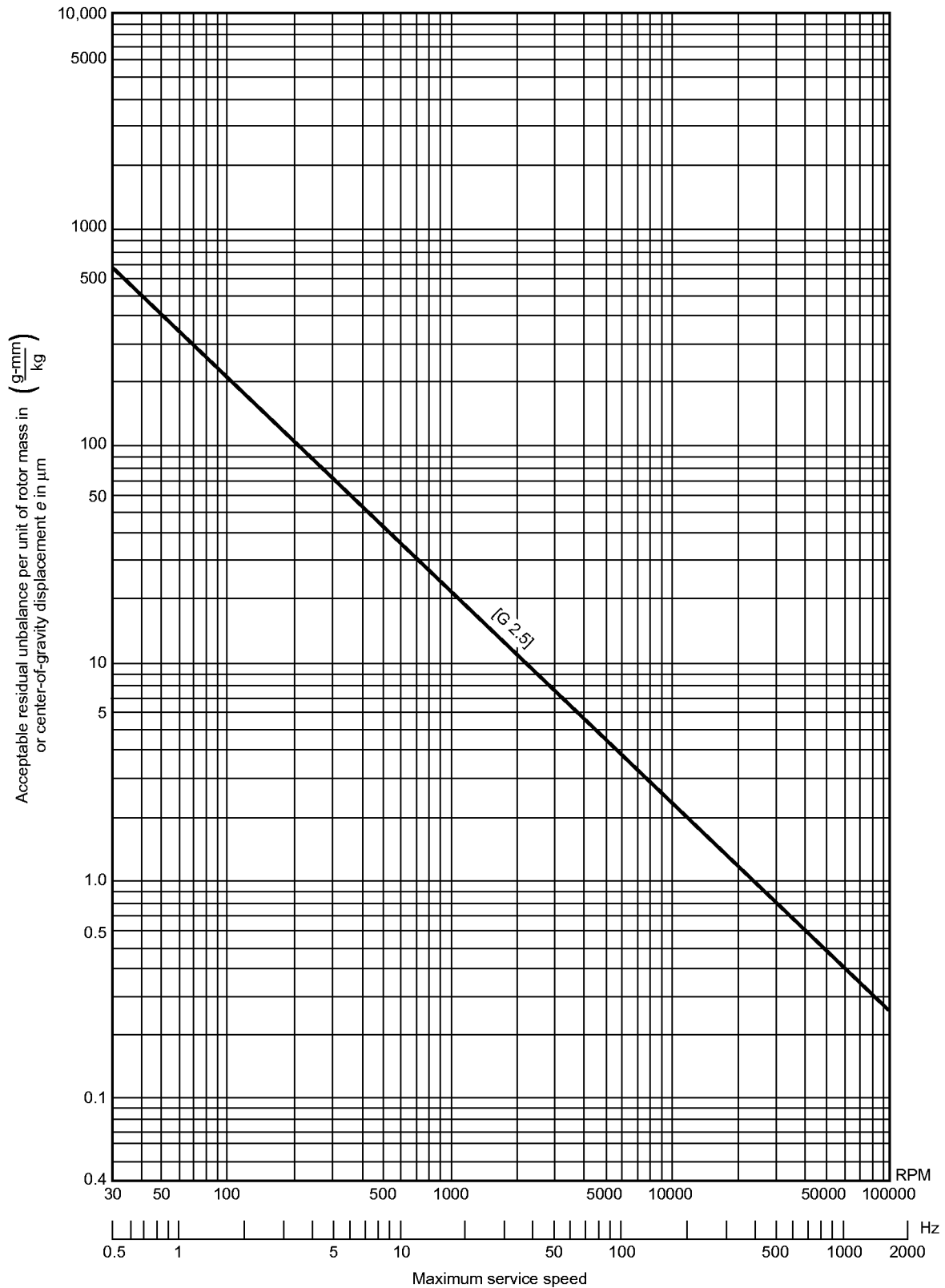


Figure D-2—Maximum Residual Specific Unbalance Corresponding to Balance Quality Grade G2.5 (ANSI S2.19)  
(Shown in SI Units)

## 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:  
 $U_{max} = \frac{(6350) \times (W)}{(N)} = \frac{(6350)}{\text{_____}} \times \text{_____} = \text{_____} \text{ (g-mm)}$

Customary Units:  
 $U_{max} = \frac{(113.4) \times (W)}{(N)} = \frac{(113.4)}{\text{_____}} \times \text{_____} = \text{_____} \text{ (g-in.)}$

Calculate the trial unbalance (TU):  
 Trial Unbalance (TU) is between  $(1 \times U_{max})$  and  $(2 \times U_{max})$   
 SI Units: \_\_\_\_\_ to \_\_\_\_\_ = \_\_\_\_\_ (g-mm)  
 Customary units: \_\_\_\_\_ to \_\_\_\_\_ = \_\_\_\_\_ (g-in.)  
 (1 x) to (2 x) (Selected Multiplier is) \_\_\_\_\_

Calculate the trial weight (TW):  
 $\text{Trial Weight (TW)} = \frac{U_{max}}{R} = \frac{\text{_____}}{\text{_____}} \text{ g-mm} \text{ or } \frac{\text{_____}}{\text{_____}} \text{ g-in.} = \text{_____} \text{ (g)}$

Conversion Information:  
 1 kg = 2.2046 lb.      1 oz. = 28.345 g

Obtain the test data and complete the table:

Sketch the rotor configuration:

Test Data		Balancing Mach Readout	
Position	Trial Weight Angular Location on Rotor (degrees)	Amplitude (grams)	Phase Angle (degrees)
1	0		
2	60		
3	120		
4	180		
5	240		
6	300		
Repeat 1	0		

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.

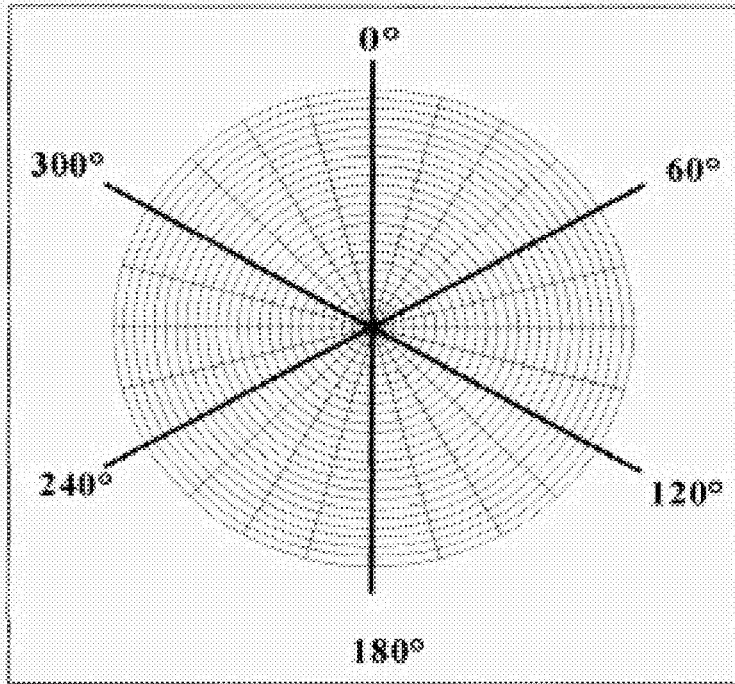
Balanced By: \_\_\_\_\_ Date: \_\_\_\_\_  
 Approved By: \_\_\_\_\_ Date: \_\_\_\_\_

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 Phase (Left or Right) - use sketch \_\_\_\_\_ (grams)

**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: \_\_\_\_\_  
 $Y = (\text{Maximum} - \text{Minimum}) / 2$  { \_\_\_\_\_ } / 2 = \_\_\_\_\_  
 $Z = (\text{Maximum} + \text{Minimum}) / 2$  { \_\_\_\_\_ } / 2 = \_\_\_\_\_

Residual Unbalance  
 Left in Rotor =  $(Y) \times (1) / (2)$  = \_\_\_\_\_  
 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:  
 $U_{max} = \frac{(6350) \times (W)}{(N)} = \frac{(6350) \times 530.7}{6900} = 488.4 \text{ (g-mm)}$

Customary Units:  
 $U_{max} = \frac{(113.4) \times (W)}{(N)} = \frac{(113.4) \times 1170}{6900} = 19.2 \text{ (g-in.)}$

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  
 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  $\frac{31 \text{ g-in.}}{15 \text{ in.}} = 2.1 \text{ (g)}$

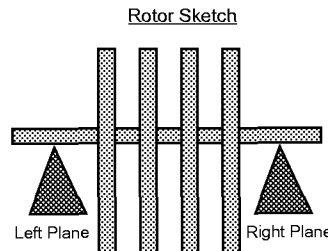
Conversion Information:

1 kg = 2.2046 lb. 1 oz. = 28.345 g

Obtain the test data and complete the table:

Sketch the rotor configuration:

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



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 ( $U_{max}$ ).

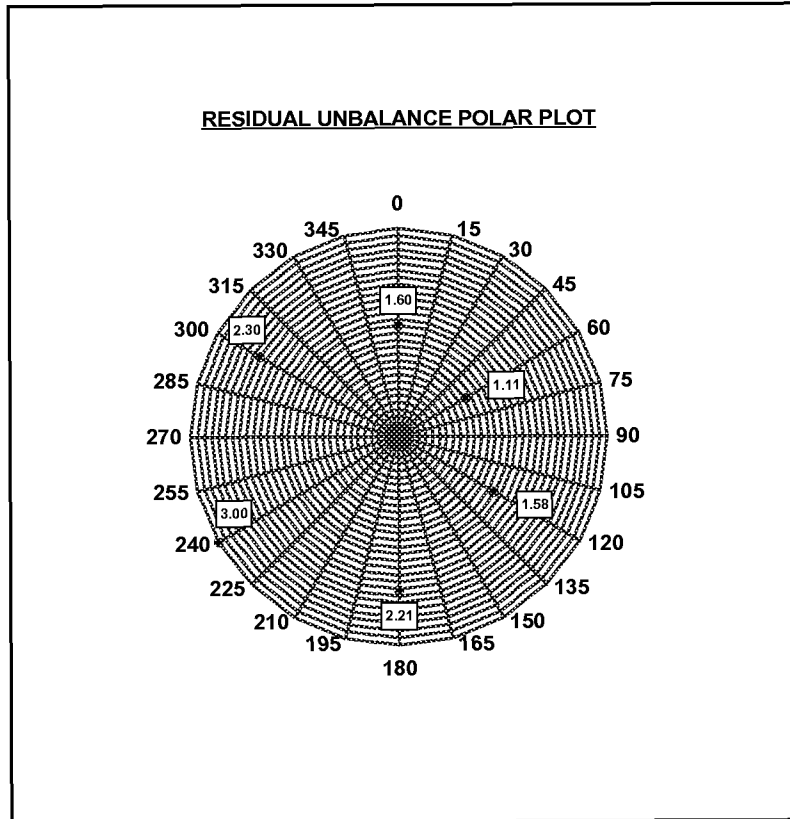
NOTES:

- 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)



Rotor Rotation:  CCW    Phase is layed out:  CCW  
 CW     CW

Calculate Y and Z values:

Maximum amplitude value is:	<input type="text" value="3.00"/> grams	Minimum amplitude value is:	<input type="text" value="1.11"/> grams
Y = (Maximum - Minimum) / 2 (	<input type="text" value="3.00"/> -	<input type="text" value="1.11"/> ) / 2 =	<input type="text" value="0.9"/> grams
Z = (Maximum + Minimum) / 2 (	<input type="text" value="3.00"/> +	<input type="text" value="1.11"/> ) / 2 =	<input type="text" value="2.1"/> grams

Residual Unbalance

Left in Rotor =	(TU)	×	(Y)	/	(Z)	=	<input type="text" value="359.3"/> g-mm
SI Units:	<input type="text" value="781"/>	×	<input type="text" value="0.95"/>	/	<input type="text" value="2.06"/>	=	<input type="text" value="14.1"/> g-in
Customary Units:	<input type="text" value="31"/>	×	<input type="text" value="0.95"/>	/	<input type="text" value="2.06"/>	=	<input type="text" value="14.1"/> g-in

Allowable Unbalance Tolerance =  $U_{max}$  =  g-mm     g-in.

RESULT: Residual unbalance left in the rotor is equal to or less than the allowable unbalance tolerance?

As Received     Final     Other: w/o trim hardware    PASS

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):

Trial Unbalance (TU) is between  $(1 \times U_{max})$  and  $(2 \times U_{max})$   
 SI Units:  $525.9$  to  $1051.9$  (Selected Multiplier is 1.6)  
 Customary units:  $20.7$  to  $41.4$  is 33.1 (g-in.)

Calculate the trial weight (TW):

Trial Weight (TW) =  $\frac{U_{max}}{R} = \frac{842}{203}$  g-mm or  $\frac{33}{8}$  g-in. = 4.1 (g)

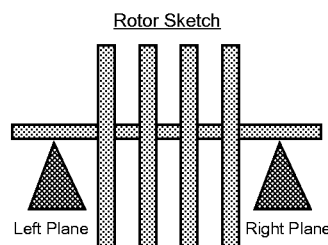
Conversion Information:

1 kg = 2.2046 lb. 1 oz. = 28.345 g

Obtain the test data and complete the table:

Position	Trial Weight Angular Location on Rotor (degrees)	Balancing Mach Readout	
		Amplitude (grams)	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:



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 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 ( $U_{max}$ ).

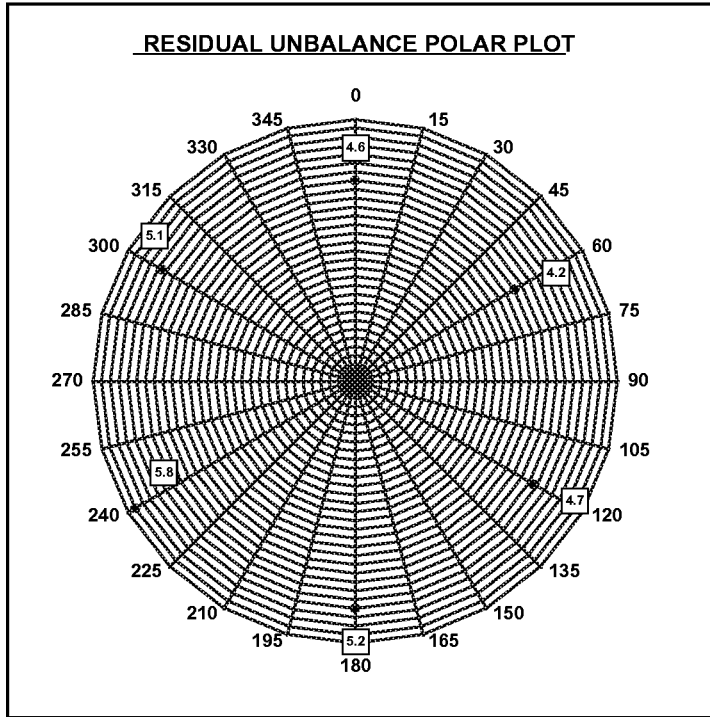
NOTES:

- 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 Phase is layed out:  CCW  
 CW  CW

Calculate Y and Z values:  
 Maximum amplitude value is: 5.80 grams Minimum amplitude value is: 4.20 grams  
 $Y = (\text{Maximum} - \text{Minimum}) / 2$  (5.80 - 4.20) / 2 = 0.8  
 $Z = (\text{Maximum} + \text{Minimum}) / 2$  (5.80 + 4.20) / 2 = 5.0

Residual Unbalance  
 Left in Rotor =  $\frac{(TU) \times (Y)}{SI \text{ Units}}$   $\times \frac{(Z)}{\text{Customary Units}}$  =  $\frac{842 \times 0.8}{33} \times \frac{5}{5}$  =  $\frac{134.6}{5}$  g-mm  
 SI Units: 842  $\times$  0.8 / 5 = 134.6 g-mm  
 Customary Units: 33  $\times$  0.8 / 5 = 5.3 g-in.

Allowable Unbalance Tolerance =  $U_{\text{max}}$  = 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<sup>a</sup> Bidder shall furnish \_\_\_\_\_ copies of data for all items indicated by an X.

Review<sup>b</sup> Vendor shall furnish \_\_\_\_\_ copies and \_\_\_\_\_ transparencies of drawings and data indicated.

Final<sup>b</sup> 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<sup>c</sup> \_\_\_\_\_  
Review—Returned to vendor \_\_\_\_\_  
Review—Received from vendor \_\_\_\_\_  
Review—Due from vendor<sup>c</sup> \_\_\_\_\_

**FAN**

			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						

<sup>a</sup>Proposal drawings and data do not have to be certified or "as-built."

<sup>b</sup>Purchaser will indicate in this column the time frame for submission of materials using the nomenclature given at the end of this form.

<sup>c</sup>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<sup>a</sup> Bidder shall furnish \_\_\_\_\_ copies of data for all items indicated by an X.

Review<sup>b</sup> Vendor shall furnish \_\_\_\_\_ copies and \_\_\_\_\_ transparencies of drawings and data indicated.

Final<sup>b</sup> 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<sup>c</sup> \_\_\_\_\_  
Review—Returned to vendor \_\_\_\_\_  
Review—Received from vendor \_\_\_\_\_  
Review—Due from vendor<sup>c</sup> \_\_\_\_\_

**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						

<sup>a</sup>Proposal drawings and data do not have to be certified or "as-built."

<sup>b</sup>Purchaser will indicate in this column the time frame for submission of materials using the nomenclature given at the end of this form.

<sup>c</sup>Bidder shall complete these two columns to reflect his actual distribution schedule and include this form with his proposal.

Notes:

- Vendor shall not proceed with manufacture without purchaser's review of drawings if required by 6.2.1.2.
- Send all drawings and data to \_\_\_\_\_
- 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.
- See expanded description below of specified items.
- 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.
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## 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 and 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 ( $C_v$ ).
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(s) 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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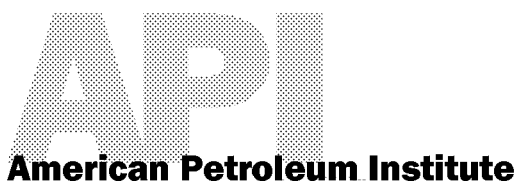
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