API 685 TUTORIAL

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ABSTRACT

For the first time, there is an API standard relating to the use of sealless pump technologies [canned motor pump (CMP) and magnetic drive pump (MDP)]. While sealless technology has been well accepted in chemical process applications, it has not been well adopted in the API market. The lack of an API specification certainly has been a contributing factor to this lack of acceptance. The API market tends to wait for a technology to be fully proven and commercialized prior to considering adoption of the product. However, the API industry is fully committed to utilizing the best technology available to protect plant personnel and the environment.

INTRODUCTION

API 685 (2000) covers sealless centrifugal pumps for petroleum, heavy-duty chemical, and gas industry services. API recommends the use of API 685 (2000) for sealless services with the following factors:

- Discharge pressures greater than 275 psig (1900 kPa)
- Suction pressures greater than 75 psig (500 kPa)
- Pumping temperatures greater than 300°F (150°C)
- Rotative speeds greater than 3600 rpm
- Rated total head greater than 400 ft (120 m)
- Maximum impeller diameter greater than 13 inches (300 mm)

Parameters that exceed the above stated ranges are solid criteria for determining when a heavy-duty pump is required. However, API does not give guidelines on when a sealless pump should be considered. Sealless technology is well suited for the following applications:

- Lethal
- Toxic
- Flammable fluids
- Expensive fluids
- Fluids with dissolved solids (i.e., caustic)
- Carcinogenic
- Heat transfer fluids (hot and cold)
- Emissions are regulated
- Fluids that are difficult to seal

Increasingly stringent environmental requirements surrounding volatile organic compounds (VOC) have lead to the increased use of sealless technology. A thorough, unbiased evaluation and application of the appropriate sealless technology results from carefully evaluating both technologies [canned motor pump (CMP) and magnetic drive pump (MDP)]. There are many refinery applications ideally suited to sealless technology. The following are a few examples of where sealless technology is being applied in refineries currently.

- Hydrofluoric acid (HF acid)
- Anhydrous hydrofluoric acid
- Naphtha
- Sulfuric acid
- Butane
- Isobutane
- Methanol
- Caustic
- Propylene
- Alkylate
- Methyl mercaptan
- Aromatics (benzene, xylene, toluene)

- Sour water (water containing H_2S)
- Olefins

Process units that would pump the above fluids (pure or as a mixture) are varied and could include:

- Alkylation (HF acid or sulfuric acid)
- Sulfur plant
- Aromatics recovery unit
- Hydrotreaters
- Boilerhouse
- Hydrocracker
- Fluidized catalytic cracker (FCC)
- Reformer
- Crude

KEY HIGHLIGHTS FROM API 685

- Stringent forces and moments
- Rotating assembly balancing to G1.0 ISO 1940
- Vibration (less than 0.12 in/sec rms/3.0 mm/sec rms)
- ASME, Section VIII, Division 1 or 2 (pressure containing components)
- Corrosion allowance
- Performance requirements
- Head (−2/+5 percent to −2/+2 percent, depending on overall head)
- Power (+4 percent)
- NPSHr (+0 percent)
- Pressure versus temperature profiles
- Centerline mounting required for all horizontal MDP
- Centerline mounting required for horizontal CMP above 350°F
- API baseplates required for horizontal mounted units

Key Application Data Required (By Customer)

- NPSHa
- Temperature versus vapor pressure curve
- Temperature versus viscosity curve
- Specific heat
- Specific gravity

In order to make a sound pump selection, it is important to make sure all process conditions are supplied to the pump vendor. API 685 refers to specific responsibilities of the pump user/contractor, and it is important that this information is shared with the pump vendor. A detailed vapor pressure margin analysis is critical to the success of many volatile fluid applications found in refinery applications. It is essential that the fluid remain a liquid throughout the full pump circuit. Hence, a full vapor pressure versus temperature curve is required to make an accurate comparison of the data. The vapor pressure and specific heat must be reflective of the pure fluid or mixture. A single point vapor pressure does not allow for the application to be evaluated at the elevated temperatures experienced in the motor or pump containment section of a sealless pump.

TECHNOLOGY COMPARISON (CMP VERSUS MDP)

Often times the decision to choose CMP or MDP technology is based upon customer preference. The biggest difference between the two technologies is absolute secondary containment (CMP) versus secondary control/containment (MDP). The application pyramid in Figure 1 also helps to explain where a CMP versus MDP is typically applied. Canned motor pumps are typically applied as an application moves up in toxicity. Magnetic drive pumps are applied in the center and lower section of the pyramid. However, the technology can certainly be applied lower down the pyramid if desired.

The decision tree on when to think sealless can be based upon the simplified flowchart shown in Figure 2. Additionally, this flowchart describes some key factors to consider when deciding between CMP and MDP technology.

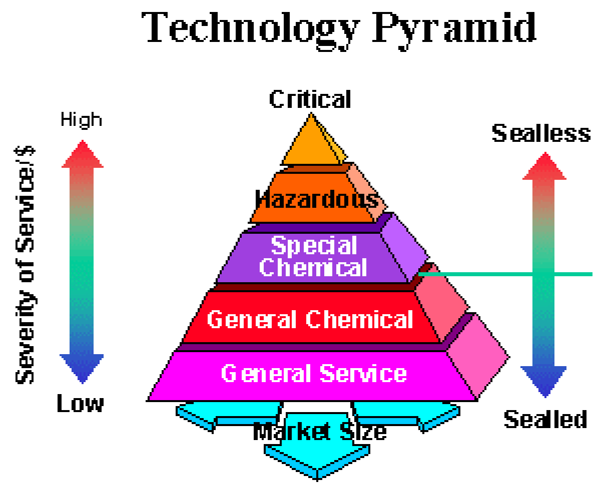

Figure 1. Sealed Versus Sealless.

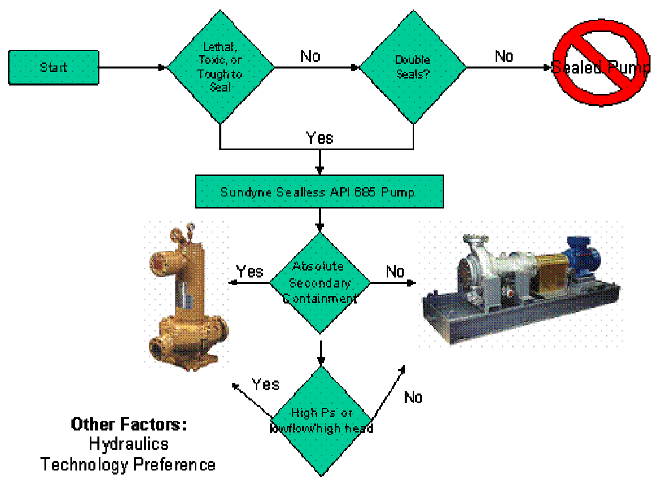

Figure 2. CMP Versus MD.

Canned Motor Pump Technology

The features of a canned motor pump are absolute secondary containment and an integral motor. Canned motor pumps are classified as totally enclosed liquid cooled (TELC). With canned motor pump technology, shaft alignment is inherently not required since there is only a single shaft. Canned motor pumps are inherently low noise and require nominal space requirements. CMP technology can be coupled with variable frequency drives (VFD) to run the pump above synchronous speed to achieve higher heads with smaller hydraulics. VFD technology also allows for tremendous operating flexibility, elimination of control valves, and energy savings.

Key Highlights of API 685 for Canned Motor Pump Technology

- Secondary containment
- ASME Section VIII design (motor housing) with 1/8 inch corrosion allowance
- Motor testing to include resistance measurement and dielectric
- Forces and moments to meet twice the requirements indicated in the specification
- Centerline mounting is required for horizontal units > 350°F (177°C)
- Stator housing to be designed to match pressure casing matching allowable working pressure (MAWP) at operating temperature (including the electrical feed through)
- Stator liner thickness to be a minimum of 0.46 mm/.018 inch with a corrosion allowance of 0.15 mm/0.005 inch

• Rotor liner corrosion allowance to be a minimum of 0.15 mm/0.005 inch

Sample Vapor Pressure Versus Temperature Profiles

From the pressure versus temperature profiles shown in Figures 3 and 4, it is clear the vapor pressure has a big affect. In Figure 4, the vapor pressure is greater than circuit pressure indicating that flashing is occurring (at points D, E, and F). It is essential that this pressure versus temperature evaluation be performed for all sealless applications.

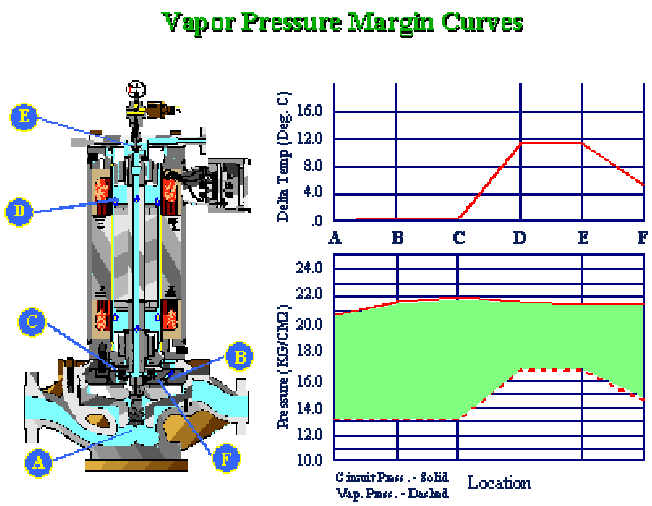

Figure 3. Adequate Vapor Pressure Margin.

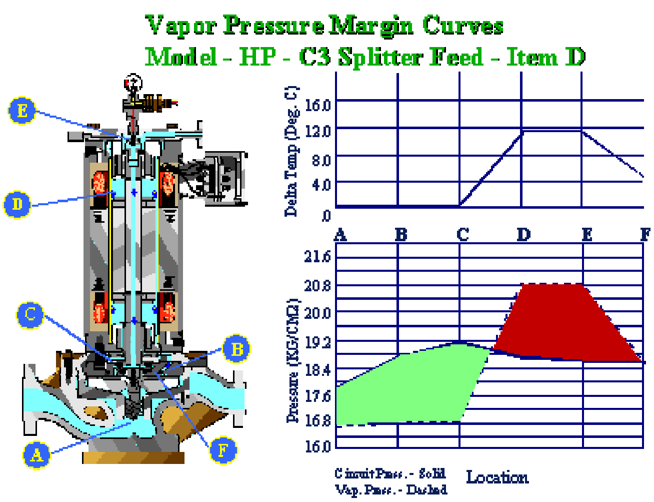

Figure 4. Vapor Pressure Greater than Circuit Pressure.

API 685 MAGNETIC DRIVE PUMPS

API 685 covers both magnetic drive pump configurations (synchronous and asynchronous). The synchronous style unit is available up to 500°F (205°C). The synchronous drive comprises an outer magnetic ring assembly (OMR) built to magnetically couple with an inner magnetic ring assembly (IMR). These two magnet rings are locked together by the flux of attracting magnet poles flowing through the containment shell. The magnet/magnet coupling is therefore a fixed speed drive and has a constant torque performance.

For higher temperature applications above 500°F (260°C), a torque ring configuration is utilized. The torque ring drive is similar in method to the synchronous drive except the inner magnet ring is replaced in this drive system with a special torque ring (series of copper bars). Magnetic eddy currents are created that rotate the torque ring. Since there are no magnets in the process liquid, torque ring pumps can operate up to 662°F (350°C) without cooling.

Key Highlights

- Centerline mount
- Synchronous or asynchronous configuration
- Rare earth or aluminum nickel cobalt magnets
- Outer and inner magnetic rings must be mechanically retained
- API baseplate
- Secondary control options
- Impeller and pump case wear rings
- Drive end and pump driver must be removable without disturbing the pressure casing
- Pump design to protect the outer magnetic ring (OMR) from contacting the containment shell if a shaft or bearing fails

The pressure versus temperature diagram (Figure 5) indicates the pump circuit pressure (head) is greater than the vapor pressure of the liquid. This indicates the fluid is remaining a liquid throughout the full flow path, which is the criterion for an acceptable sealless application.

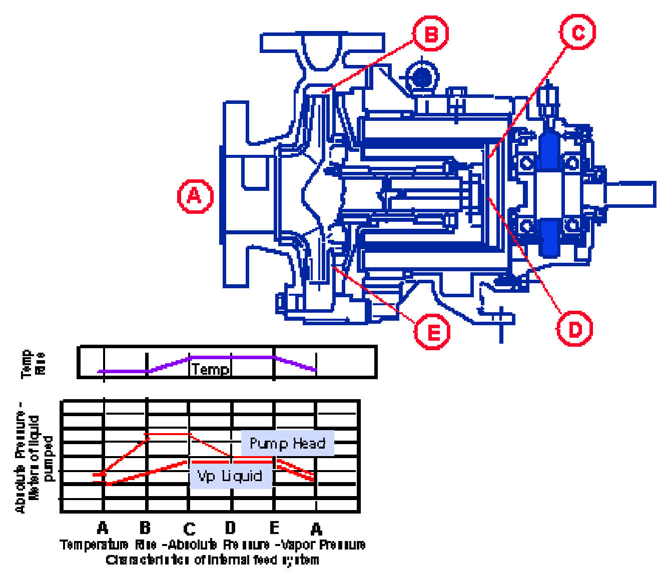

Figure 5. Magnetic Drive Pressure Versus Temperature Profile.

APPENDIX A— JUSTIFICATION FOR DEVELOPMENT OF API 685

Section 111 of the Clean Air Act (1990), as amended in 1977, directed the US Environmental Protection Agency (EPA) to set standards of performance for newly constructed, modified, or reconstructed sources of air pollution that may endanger public health or welfare. These New Source Performance Standards (NSPS) were to be issued to dozens of industries recognized to have significant emissions and public risk. The ranking of these industries was issued in 1979, and the Synthetic Organic Chemicals Manufacturing Industry (SOCMI) was first on the list. Parallel to this regulatory development, fugitive emissions of volatile organic compounds were being assessed from petroleum refineries. Fugitive emissions refer to leaks of VOC from equipment such as valves, pumps, compressors, pressure relief devices, and connectors. In 1981 the first NSPS for fugitive emissions was proposed and later finalized in October of 1983 (40 CFR 60.480, Subpart VV). These regulations for fugitive leak detection and repair (LDAR) raised environmental consciousness for the hydrocarbon processing industry, as did later LDAR regulations for petroleum refineries after their NSPS were finalized in May 1984 (40 CFR 60.590, Subpart GGG) and the onshore natural gas industry LDAR NSPS for fugitives in June 1985 (40

CFR 60.630, Subpart KKK). Additionally, there have been incidents that added to concerns such as: the 1984 accident in Bhopal that killed over 2000, the 1989 accident at Phillips Chemical, the accidents at both Arco and BASF in 1990.

Avoidance of regulatory applicability required installation of double and tandem sealed pumps, though some state agencies had even more restrictive requirements. California's 500 ppm limits for definition of a leaker were being followed by several states, and local bodies were historically more restrictive than federal standards. Terms like maximum achievable control technology (MACT, used after 1990 Clean Air Act Amendments) for hazardous air pollutants, and best available control technology (BACT, required under some new source permitting regulations) were being used and no one knew what constituted compliance. Sealless pump technology was also a viable alternative to regulatory applicability. It had been proven in the chemical industry and was being fairly widely used in Europe. There seemed to be ample justification for extending the technology to heavy-duty process pumps, and several manufacturers had initiatives to develop such products.

This is the primordial soup that gave rise to a project justification to develop a sealless pump standard for the API sector. 685 was the standard number assigned. Chevron's David Mooney "volunteered" to be the Task Force Chairman, and he solicited both participants and company specifications for sealless pumps.

TASK FORCE COMPOSITION

The Task Force was composed of (Figure A-1):

- Chemical companies:
  - Chevron Chemical
  - Exxon Chemical Company
  - Hoechst Celanese Company
  - Tennessee Eastman Company
- Oil companies
  - Amoco Oil
  - Arco
  - Mobil Oil
  - Shell Canada Limited
  - Ultramar
- Contractors
  - Bechtel
  - Fluor Daniel, Inc.
  - Foster Wheeler USA
  - M.W. Kellogg Company
- Manufacturers
  - (Synchronous) Magnetic drive
    - Dresser Pump
    - Goulds Pump
    - IMO Pump
    - Ingersoll Rand
    - Iwaki Walchem Company
    - Sulzer Bingham Pump
    - Union Pump
    - Wilson Snyder Pumps
  - Canned motor
    - ABS Pumps/Lawrence Pump & Engine
    - Crane Chempump
    - Sundyne
  - Synchronous and eddy current drive
    - HMD/Kontro Company

RESOURCES USED TO DEVELOP API 685

Starting documents from which API 685 was developed included (Figure A-2):

- API 610, Seventh Edition
- API Standard Paragraphs R20
- Company specifications from: Chevron, Dupont, Exxon, Mobil, Texaco

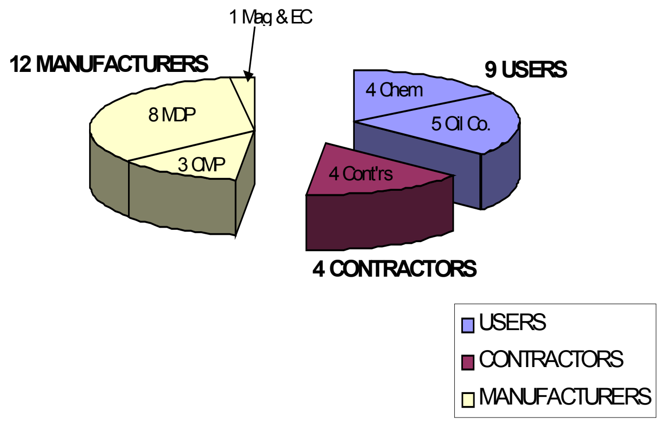

Figure A-1. Task Force Composition.

- Contractor specifications from: Bechtel, Brown & Root, M.W. Kellogg
- Hydraulic Institute Sealless Centrifugal Pump Standards
- ANSI B73.3 and 73.4
- EEMUA Pub 164 Class 1

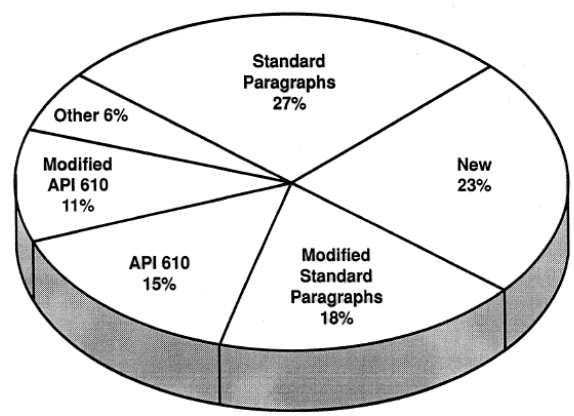

Figure A-2. Sources of Paragraphs in Draft 2 of API 685.

TIMELINE ON 685 DEVELOPMENT

The effort for development of API 685 occurred in three distinct spurts. The first was a "normal" development plan for a new standard.

Requested user and contractor specifications:	Jun 91
Initial organization meeting:	Aug 91
Prepare first draft:	Sep 92
Prepare second draft (to SP R20) for subcommittee review:	Feb 93
Formal subcommittee review:	May 93
(Publication deferred for API 610, Eighth Edition)	
Fourth draft incorporating all review comments:	Jul 93
API 610, Eighth Edition, presented to subcommittee:	Sep 93

Second Push

After the presentation of the draft to the Mechanical Equipment Subcommittee in Toronto, and handling of comments received during the presentation, the decision was made by the Mechanical Equipment Subcommittee to defer publication of API 685 until after publication of API 610, Eighth Edition (1995) (and API 682, First Edition). One reason was that Eighth Edition was a major stride forward to gain international acceptance of the API standards. This included dual units and reference to ISO standards. This was thought to be important to API 685 since sealless pumps had a more established market in Europe.

In addition to the delay, following the format of API 610 also required a significant effort in reformatting since API 685 had been developed to API Standard Paragraphs R20, whereas API 610 had been developed to R19. Having the two standards parallel each other to the extent possible would facilitate a possible future integration of API 685 into API 610. Even though the Eighth Edition was presented in September 1993, API 685 did not resume until API 610 had dealt with all the review comments received. API 685 resumed in the summer of 1994 under a new Task Force Chairman, Richard Beck with Chevron.

Publication of API 682: Oct 94
Fifth draft (reformatted to parallel API 610/SP R19 and incorporate references to International Standards): Dec 94
API 610, Eighth Edition published: Aug 95
Sixth draft incorporating Task Force comments submitted for subcommittee ballot: Oct 95
Ballot suspended before deadline, comments received processed: Aug 96
Seventh draft sent out for reballot: Nov 96

Third Push

Following reballot, the effort took another hiatus. This was due in part to Mr. Beck going on a foreign assignment, and partially to lost momentum from the success of API 682 to satisfy both the reliability issues with mechanical seals and the emission limitations by oversight authorities. However, in late 1998 Jim Bryant with M.W. Kellogg was tagged to complete the effort.

Because of the time lapse, there were several obstacles to the effort:

- The demand/market had not materialized for sealless pumps and development efforts had been halted by some manufacturers.
- Mergers had reduced the number of manufacturers involved.
- Many former Task Force members had changed jobs or responsibilities.
- Access to originals of many of the figures and appendices had been lost.
- Much of the R19 based text had been improved with issue of Standard Paragraphs R22.

Task Force reactivated: Feb 99
Received subcommittee agreement on comments to ballot (recreated figures and appendices): May 99
Final draft submitted to API Editors: Oct 99
Galley proofs received for review (formatted to R22): Feb 00
Second galley proofs received for review: Apr 00
Third galley proofs received for review: Jul 00
Published: Oct 00

OVERVIEW OF API 685 REQUIREMENTS

As most have a basic familiarity of API 610 requirements, this paper covers the major requirements and features that are different from those in API 610, Eighth Edition (1995).

Applicability

API 685 is applicable to sealless centrifugal pumps for the petroleum, heavy-duty chemical, and gas industry services. It specifically covers overhung, single-stage pumps (horizontal and vertical) of the canned motor, synchronous magnetic drive, and asynchronous (eddy current) magnetic drive types. It was intended to be the sealless equivalent of the API 610 single-stage overhung process pump (Figure A-3). It ignores other API 610 pump types, specifically between bearing horizontal pumps and vertically suspended pumps.

API 685 recognizes (as does API 610, Ninth Edition) that purchasers may wish to consider (sealless) pumps that do not comply with API 685 for process services with:

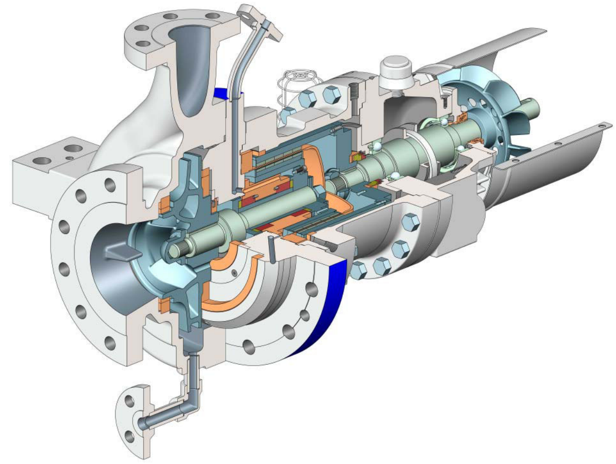

Figure A-3. Typical API 685 MDP.

Maximum discharge pressure:	275 psig
Maximum suction pressure:	75 psig
Maximum pumping temperature:	300°F
Maximum rotative speed:	3600 rpm
Maximum rated total head:	400 ft
Maximum impeller diameter:	13 inches

Definition of Terms

Requirements of API 685 required numerous definitions not found in API 610 (Table A-1, Figure A-4).

Table A-1. Definition of Terms.

Air gap (3.1)	Journal sleeve (3.21)	Rotor liner (3.61)
Axial thrust (3.2)	Liquid end (3.22)	Sealless pump (3.62)
Canned motor pump (3.5)	Liquid gap (3.23)	Secondary containment (3.63)
Containment shell (3.6)	Locked rotor torque (3.24)	Secondary containment system (3.64)
Coupling (magnetic) (3.7)	Magnetic drive pump (3.25)	Secondary control (3.65)
Decouple (3.10)	Outer magnet ring (3.47)	Secondary control system (3.66)
Demagnetization (3.11)	Pole (3.49)	Secondary pressure casing (3.67)
Eddy current losses (3.14)	Power end (3.50)	Sleeve bearing (3.68)
Electrical feed-through barrier (3.15)	Primary pressure casing (3.51)	Slip (3.69)
Hydraulic thrust bearing (3.16)	Product lubricated bearings (3.52)	Stator housing (3.73)
Hysteresis (3.18)	Radial loading (3.54)	Stator liner (3.74)
Inner magnet ring (3.19)	Rotor chamber (3.59)	Tolerance ring (3.79)
Inner magnet sheathing (3.20)	Rotor chamber temperature rise (3.60)	Torque ring drive (3.80)

Critical Design and Application Considerations (6.2)

Many early installations of sealless pumps were tarnished by unrealistic expectations and misapplication. API 685 has a section to emphasize the importance and responsibility of communicating information about the services—items that probably should have been aired for all pump services, but were not as critical for sealed pumps. These include:

- Properties of the pumped fluid
  - Temperature/vapor pressure curve
  - Temperature/viscosity curve
  - Specific heat
  - Specific gravity
  - Thermal conductivity
  - Thermal expansion characteristics
  - Polymerization characteristics
  - Solids present
    - Particle size
    - Percent solids
    - Particle distribution by size
- NPSHa
- System arrangement
  - Location of pump relative to suction vessel
  - Vessel arrangement
  - Piping arrangement

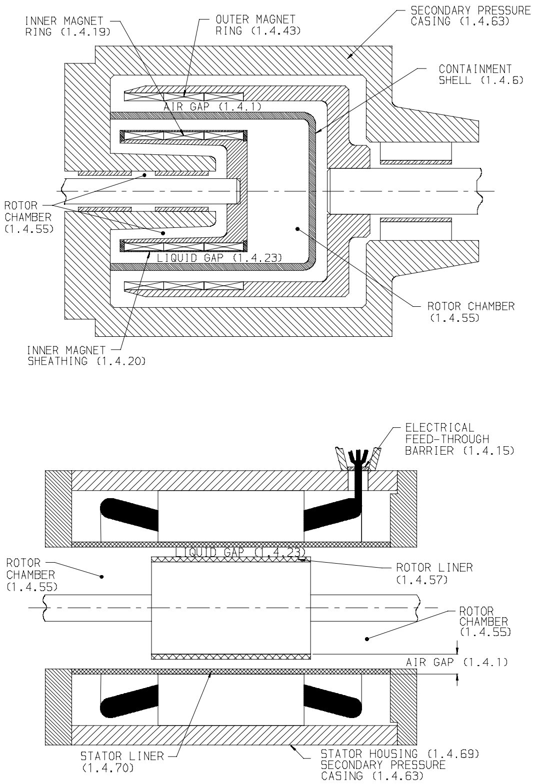

Figure A-4. Appendix C Illustrations of Terms Defined.

Information required of the vendor includes:

- NPSHr
- Temperature rise of the pumped fluid:
  - During operation
  - After shutdown
- Effect of wear on flow/temperature distribution
- Minimum continuous stable flow
- Minimum continuous thermal flow
- Temperature profile of the fluid recirculation flow path (Appendix K)
- Pressure profile of the fluid recirculation flow path (Appendix K)

Pressure Casings (6.3/9.1.2.1 and 9.2.3)

The pump volute requirements are the same as API 610, Eighth Edition (1995); the impact is on design of the pressure boundary between the primary and secondary casing. Because losses are related to the separation between magnets or rotor and stator, there is a need to avoid too much margin in thickness. More refined design techniques are used for the containment shell (MDP). In a CMP, the stator liner depends on backing supports in the stator for most of the pressure containment strength.

Nozzle and Pressure Casing Connections (6.4)

This section eliminates all mention of cast-iron connections since they are in conflict with most fluids handled in sealless pumps. Threaded connections are not allowed on the primary pressure casing.

Sections 6.5, 6.6, 6.7, and 6.9

Sections dealing with external nozzles force and moments, rotors, wear rings and running clearances, and rotordynamics have been pared down from API 610, Eighth Edition (1995), to apply to single-stage overhung pumps. Requirements for other pump types were removed.

Secondary Control/Containment (6.8)

The purchaser is to specify which option the pump shall have:

- *Secondary containment system*—is for the confinement (capture) of the pumped fluid within a secondary pressure casing in the event of a failure of the primary containment shell or stator liner. It includes provisions to indicate a failure of the containment shell or liner. Secondary containment is inherent with canned motor pumps so long as the electrical feed through barrier is properly designed. For magnetic drive pumps it requires either a double wall containment shell or a shaft seal in the secondary casing.
- *Secondary control system*—minimizes or safely directs release of pumped fluid in the event of failure of the primary containment shell or stator liner. It includes provisions to indicate a failure of the containment shell or liner. For a magnetic drive, it includes the further provision for a replaceable nonsparking restriction device (lip seal not acceptable) around the external shaft to minimize leakage. Secondary control is a nonissue for canned motor pump technology as it is expected the feed through barrier will be properly designed.

A further option for secondary containment or control is to include the leakage monitoring devices in the vendor's scope.

Secondary Containment Design with Monitoring

As an option, the pump end bearing isolator can be replaced with a maintenance-free, gas secondary seal. In this case a secondary containment chamber is formed together with the intermediate piece and the bearing bracket (Figure A-5). In normal operation the mechanical gas seal runs in standby as an unpressurized secondary seal. If the containment shell fails, the seal will be closed by the product pressure and the product will then be confined within this secondary pressure casing. The failure of the primary containment shell will be indicated by a liquid detector or a pressure switch.

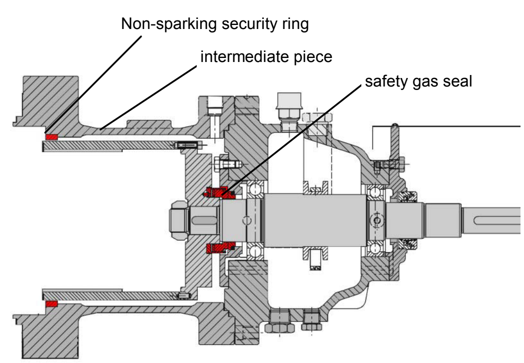

Figure A-5. Secondary Containment with Safety Mechanical Seal.

The secondary containment system is rated for the same pressure as the pressure casing. The secondary *control* system is required to have a standby life of at least 25,000 hours in a pump operating mode and has a functional design life of at least 24 hours in the event of containment shell failure. This should have applied to secondary containment as well (next issue?).

Special construction features of a typical gas seal are shown in Figure A-6.

A security ring is mounted in the intermediate piece (Figure A-5). In case of a failure of the outer rotor bearings the outer rotor will touch this ring (and not the shell). Temperature monitoring is optional (refer to later section, *"Magnetic Drive Specific"*).

Process Cooled/Lubricated Bearings (6.10)

Another distinguishing requirement of sealless design is the application of bearings operating in, and depending on, the process fluid for cooling and lubrication. A clean liquid from an external source can be used with purchaser's approval. These bearings are of the precision-bored sleeve type.

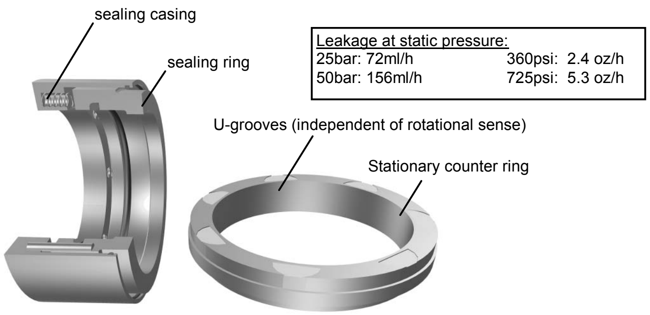

Figure A-6. Maintenance-Free Gas Seal.

Bearing materials are usually silicon carbide, tungsten carbide, or carbon. These materials often have much lower coefficients of thermal expansion than metal parts of the pump and require a radial clearance designed to accommodate relative thermal expansion. Tolerance rings are used to maintain position between dissimilar materials. Also, bearings normally have grooves for flushing of foreign particles and increased flow for heat removal. The following illustrates one design, but many variations exist.

The Product (Fluid) Lubricated Bearings (PLB)

The pump shaft (with impeller and inner rotor of the magnetic coupling) runs in product-lubricated, maintenance-free bearings (Figure A-7). Lubricating grooves are incorporated (Figure A-8). The self-adjusting bearings absorb axial thrusts and radial forces. The journal bearing is made of a highly wear-resistant, solid silicon carbide (SiC). Shrink-fitting them into the metal retainers ensures the SiC thrust plates' mechanical stability. The inner bore of the thrust plate centers the SiC shaft sleeve. That allows the SiC shaft sleeve to not have any contact with the shaft and therefore be independent of shaft growth due to temperature changes. Even if the radial bearing should fail, this design provides maximum reliability and serviceability during coastdown.

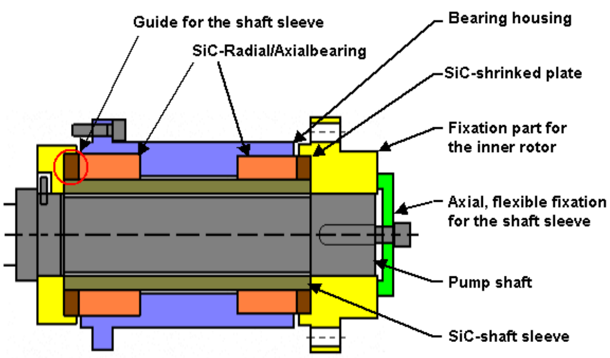

Figure A-7. Process Lubricated Bearings.

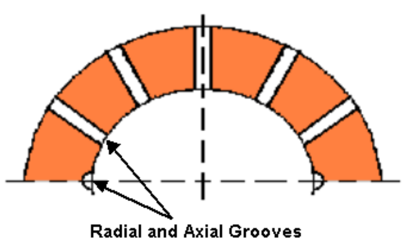

Figure A-8. View of Axial Thrust Bearing Plate. Circulation Through Groove Essential to Lubricate Bearing.

Circulation through the product lubricated bearing is essential to lubricate the bearing. A minimum viscosity of 0.2 mPas (cP) is required. Alternately, carbon graphite versus SiC sleeve may be used for lower viscosity with engineering approval.

Materials of Construction (6.11.1 and Appendix H)

The need for low hysteresis materials such as Hastalloy® and the reactivity of some fluids typically pumped in sealless pumps demanded an expanded (from API 610, Eighth Edition) materials table. Also, the need to assign minimum materials to previously undefined parts caused and expanded Appendix H. The minimum material for stator and rotor liners and for containment shell and inner magnet sheathing for all classes is 316L stainless steel. Cast-iron casings would not be used with the hazardous materials usually associated with sealless applications.

Protective Instrumentation (7.2.2.4)

It is the purchaser's option what instrumentation is supplied and whether it is supplied by the vendor or the purchaser, but the following instruments are recommended:

- Pump power monitoring to detect pump dry-run conditions (this is usually an amp monitor)
- Leakage monitoring in the secondary casing
  - Pressure measurement for flashing fluids
  - Optical moisture sensor for nonflashing liquids
- Temperature monitoring of the fluid circulating in the rotor chamber

Requirements from API 610
Applicable Only to Magnetic Drive Pumps

Several requirements of API 610 (1995) are applicable to magnetic drive pumps, but not canned motor pumps. These include:

- Antifriction bearings, bearing housings, and oil lubrication (9.1.4)
- Shaft couplings and guards (9.1.5.2)
- Separately coupled motor and turbine drivers (9.1.5.1)
- Heavy-duty baseplates (9.1.5.3)

Other Requirements Not Covered by API 610

Magnetic Drive Specific

- *Deflection criteria (6.3.7)*—Rather than concern for deflection at mechanical seal, mag-drive pumps are to have liquid and air gap clearances sufficient to avoid contact between the magnet assemblies and the containment shell even from pressure deformations, nozzle loading, and thermal expansion. A replaceable device of nonsparking material is required to prevent the outer drive magnet from contacting the containment shell in the event of a shaft or bearing failure.

- *Magnet materials (9.1.3.1)*—Developments of rare earth magnetic materials in the late 1980s improved the feasibility of synchronous magnetic drives (Figure A-9). API 685 specifies that synchronous magnetic couplings are to be supplied as rare earth magnets: neodymium-iron-boron (NdFeB) or samarium cobalt (SmCo). Asynchronous couplings are supplied as either rare earth or aluminum-nickel-cobalt (AlNiCo) magnets. AlNiCo is more temperature tolerant than rare earth magnets (Figure A-10). More information is given in Appendix I.

- *Sizing of magnets (9.1.3.7-8)*—In sizing the magnetic coupling, the manufacturer is to consider:
  - The torque required to accelerate the motor during starting.
  - The torque required for rated conditions plus allowance for future head or a speed increase for variable speed drives.
  - Torque for end of curve operation such as transfer pumps, loading pumps, and pumps operating in parallel (only when specified).

Speed-Torque Curve (9.1.3.10)

When specified, the vendor shall submit a speed torque curve defining capability of the synchronous magnetic coupling during startup and operation at the rated temperature. The torque requirements are to be shown as well as the coupling service factor. It is to be shown in the format presented in Figure A-11.

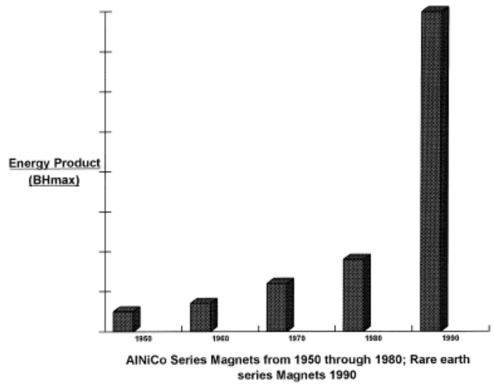

Figure A-9. Energy Product of Magnetic Materials.

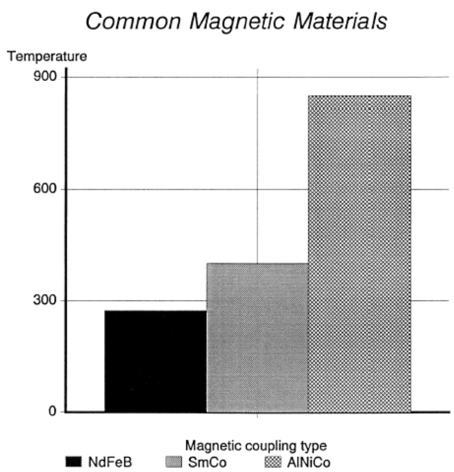

Figure A-10. Recommended Maximum Operating Temperatures (°F).

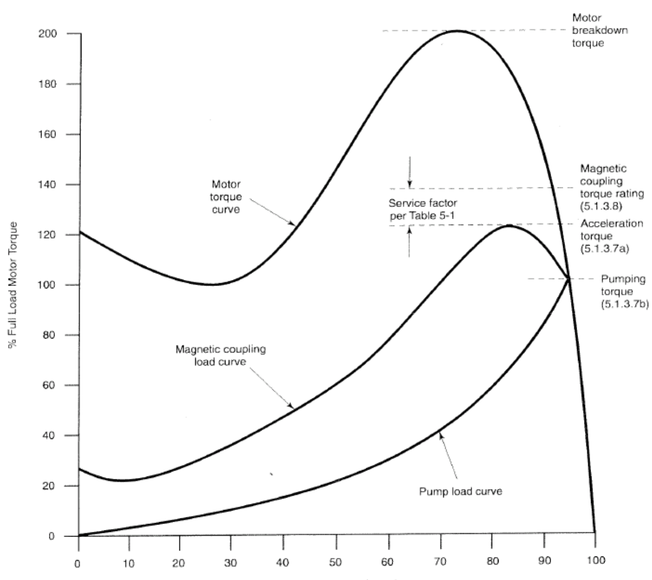

Figure A-11. Speed-Torque Curve.

Cautionary Note on Oversizing Magnetic Couplings

Hysteresis losses or "eddy currents" are generated in the metallic containment shell by the moving magnetic field of the inner and outer rotating magnets. The circulated fluid is required to remove the generated heat. An oversized coupling results in higher hysteresis losses and greater heat generation.

Eddy-current losses are very significant and are independent of the hydraulic power requirement. Hydraulic losses require correction for water tests. Therefore, it is important to understand the shop procedure for quantifying these losses prior to performance tests and for relating test conditions to guaranteed efficiencies in the specified service. The Task Force was not able to agree on an acceptable industry standard procedure (9.1.6.2).

Requirements Specifically for Canned Motor Pumps

Many of the concerns for coupled pumps can be ignored for canned motor pumps (refer to previous section, *"Requirements from API 610 Applicable Only to Magnetic Drive Pumps*).

Many of the requirements for motors seen in most user specs and standards such as IEEE 841 are included in 9.2.2.

- Connection box sized at least one size larger than IEC or NEMA size for the motor used (9.2.2.4)
- Motor designed for across-the-line starting (9.2.2.5)
- Motor capable of three starts per hour from ambient (9.2.2.6)
- Insulation good for 175,000 hours at maximum temperature (9.2.2.7)
- Class F insulation minimum (9.2.2.8—this paragraph needs updating)
- Supplemental nameplate requirements (9.2.5)
- Winding resistance tests and dielectric tests of winding insulation (9.2.7)

Some "when specified" options are included because some users would not always want to pay a premium for the feature. These include:

- Design to special operating conditions such as frequent starts or multispeed operation.
- UL, FM, or equivalent certifications provided.
- Decontamination flush or purge connection on the stator assembly.

Vendor's Data Specific to Sealless Pumps

When a coordination meeting is held, some of the topics for discussion that are unique to sealless pumps would include: (10.1.3)

- Magnetic coupling sizing (MDP only)
- Temperature-pressure profile

Also, the proposal is to include: (10.2.3)

- A description of special requirements specified in purchaser's inquiry and outlined in 6.1.8, 6.1.11, 6.1.12, 6.4.2.3, 6.9.3.1, 6.11.2, 7.2.4.1, 7.4.1, 9.1.3.8, 9.1.4.2.2.

Otherwise, the drawing and data requirements read essentially the same as for an API 610 pump.

APPENDICES

Appendix A lists referenced publications including many ISO references. Appendix A also contains two tables of corresponding international standards but cautions that "the requirements contained in those standards may be significantly different and determining the equivalence or acceptability is the responsibility of the parties involved."

Appendix B is the SI and US Customary data sheets created in Microsoft® Excel format. It follows closely the format of API 610 Data Sheets with the addition of sealless pump specifications and deletion of requirements for nonapplicable pump types.

Appendix C is the nomenclature for sealless pumps. It identifies the major parts typically used in MDP and CMP, and also shows some of the terms applicable only to the sealless designs.

Appendix D illustrates the typical auxiliary plans associated with sealless pumps. These are typically modifications of API 610, Eighth Edition, plans and use a similar numbering system. There are plans for clean pumpage, plans for dirty or special pumpage, and plans using cooling water.

Appendix E lists and illustrates many of the instrumentation and protective systems that may be applied to sealless pumps.

Appendix F is the criteria for piping design (allowable forces and moments transmitted to the pump casing). It is a simplified version of the API 610, Eighth Edition, criteria. Only the portion applicable to overhung pumps is included.

Appendix G is the material class selection guide. It shows the minimum suggested material class for some general services. It is basically the API 610 list and should be more tailored in the future for services that are more typically an application for sealless pumps.

Appendix H is the listing of materials for specific parts applicable to the material classes. It is expanded from API 610 to include material combinations often applied in sealless applications. Additions include:

- S-9: Carbon steel casing and Monel® internals
- H-1 and H-2: Hastalloy® B and C casings and internals
- T-1: Titanium casing and internals
- A-9: Alloy 20 casing and internals

Appendix I is information on materials for magnetic couplings. It includes information on the manufacturing processes and properties for the materials noted in the standard. It should probably be updated in the next issue to reflect present technology improvements.

Appendix J is the standard API procedure for determination of residual unbalance. It should be revised in the next issue to include current corrections.

Appendix K is a further explanation and examples of how to document the pressure-temperature profile in the circulation circuit.

Appendix L is the API 610 requirement for baseplate and soleplate grouting applicable to magnet drive sealless pumps.

Appendix M is the dimensional table and illustrations of standard baseplates applicable to magnetic drive sealless pumps.

Appendix N is the inspector's checklist. The checklist suggests things that would need to be covered relative to the applicable inspection level. It is to be used as a checkoff for these requirements.

Appendix O is the detailed requirement suggested for vendor drawings and data submittal.

Appendix P is a checklist of requirements that are to be specified by the purchaser. It is suggested that it be used in conjunction with the data sheets, but in that regard is somewhat redundant. There are places on the data sheet to address all these items. Appendix P is a good quality assurance tool to assure all items have been addressed.

Appendix Q is the supplement to the API 610, Eighth Edition, standard electronic data exchange file specification. It addresses all the data sheet fields that are different to API 610, Eighth Edition. It follows the same format but uses the next sequential segment (G).

Appendix R is the standard API table of factors to convert metric to US units.

Appendix S was the API 610, Eighth Edition, appendix for determination of true peak vibration measurements. It was withdrawn in final editing consistent to the suggestion of the API 610, Ninth Edition, Task Force.

Appendix T contains the API 610, Eighth Edition, forms for documentation of pump testing as modified for sealless specific requirements.

Appendix U is somewhat unique in that it contains application information for sealless pumps. This was offered because sealless technology was very new for much of the hydrocarbon industry and it was known that many users had been soured by early failures caused by misapplication of the technology.

FUTURE OF API 685

API reports that to date there have been roughly 125 copies sold plus another couple of dozen given to task force members, steering committee members, etc. While not insignificant, this is still far below the thousands sold for the more popular standards such as API 610 (1995) and API 611 (1997). There continues to be strong interest from European concerns while the US market has lagged behind. At present only a couple of US companies are heavily promoting API 685 designs. Most of the US installations for sealless pumps have involved chemical duty applications, but there are a few notable exceptions (Figure A-12).

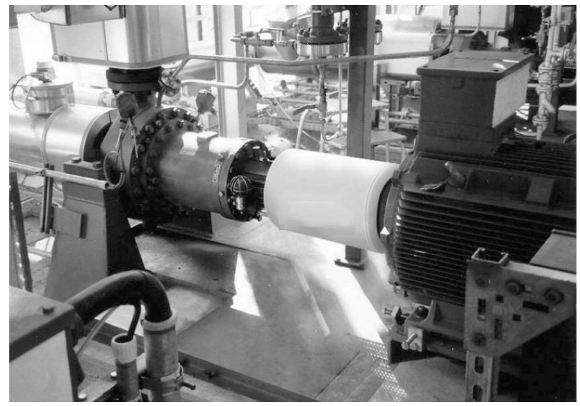

Figure A-12. API 685 MDP Installation.

And stories of successes involving long mean time between failures (MTBFs) and the ease of installation especially for canned motor pumps have some users thinking about API 685 sealless pumps from a life-cycle cost perspective. Now that the industry has a tool for specifying a reliable heavy-duty product for those difficult services, we expect to see the number of installations multiply.

While there are a few upgrades that we have pointed out that could be done, the basic document is ISO formatted and will probably just be reaffirmed by the API Subcommittee on Mechanical Equipment. The Task Force may issue an addendum with corrections. More application base is needed before there is justification for integration into API 610, Tenth Edition, but that always remains a possibility. What the Task Force really needs is more input from the user community.

APPENDIX B— DATA SHEETS

Copies of "API 685 Sealless Centrifugal Pump Data Sheet US Customary Units" follow.

API 685 SEALLESS CENTRIFUGAL PUMP DATA SHEET US CUSTOMARY UNITS

PAGE ____ OF ____
JOB NO. ____ ITEM NO. ____
REQ / SPEC NO. ____ / ____
PURCH ORDER NO. ____ DATE ____
INQUIRY NO ____ BY ____
REVISION ____ DATE ____

No.		
1	APPLICABLE TO: ○ PROPOSALS ○ PURCHASE ▢ AS BUILT	
2	FOR	UNIT
3	SITE	SERVICE
4	NO. REQ ____ PUMP SIZE	TYPE ____ NO. STAGES
5	MANUFACTURER	MODEL ____ SERIAL NO.
6	DIMENSIONS PER: ○ SI ○ US UNITS	EQUIPMENT TO COMPLY WITH APPLICABLE: ○ ISO ○ US STANDARDS
7	NOTES: INFORMATION BELOW TO BE COMPLETED: ○ BY PURCHASER	▢ BY MANUFACTURER ▢ BY MANUFACTURER OR PURCHASER
8	○ GENERAL (5.15.1.1)	
9	PUMPS TO OPERATE IN (PARALLEL) NO. MOTOR DRIVEN	NO. TURBINE DRIVEN
10	(SERIES) WITH ____ PUMP ITEM NO.	PUMP ITEM NO.
11	GEAR ITEM NO. ____ MOTOR ITEM NO.	TURBINE ITEM NO.
12	GEAR PROVIDED BY ____ MOTOR PROVIDED BY	TURBINE PROVIDED BY
13	GEAR MOUNTED BY ____ MOTOR MOUNTED BY	TURBINE MOUNTED BY
14	GEAR DATA SHT. NO. ____ MOTOR DATA SHT. NO.	TURBINE DATA SHT. NO.
15	○ OPERATING CONDITIONS (6.1.3)	○ LIQUID
16	CAPACITY, NORMAL ____ (gpm) RATED ____ (gpm)	TYPE OR NAME OF LIQUID
17	OTHER	PUMPING TEMP., (°F) NORMAL ____ MAX. ____ MIN.
18	SUCTION PRESSURE MAX./RATED ____ / ____ (psig)	VAPOR PRESSURE ____ (psia) @ ____ (°F)
19	DISCHARGE PRESSURE ____ (psig)	(TEMPERATURE VAPOR PRESSURE CURVE NO.)
20	DIFFERENTIAL PRESSURE ____ (psi)	RELATIVE DENSITY (SPECIFIC GRAVITY):
21	DIFF. HEAD ____ (ft) NPSHA ____ (ft)	NORMAL ____ MAX ____ MIN
22	PROCESS VARIATIONS (7.1.2)	SPECIFIC HEAT, Cp ____ (BTU/lb-°F)
23	STARTING CONDITIONS (7.1.3)	VISCOSITY ____ (Cp) @ ____ (°F)
24	SERVICE: ○ CONT. ○ INTERMITTENT (STARTS/DAY)	MAX. VISCOSITY ____ (Cp) @ ____ (°F)
25	○ PARALLEL OPERATION REQ'D (6.1.12)	(TEMPERATURE-VISCOSITY CURVE NO.)
26	○ SITE DATA	(THERMAL EXPANSION:) ____ (in/in/°F)
27	LOCATION: (6.1.29)	(THERMAL CONDUCTIVITY:) ____ (BTU/ft-°F)
28	○ INDOOR ○ HEATED ○ UNDER ROOF	CORROSIVE / EROSIVE AGENT ____ (6.11.7)
29	○ OUTDOOR ○ UNHEATED ○ PARTIAL SIDES	CORROSION ALLOWANCE (6.3.3) ____ min
30	○ GRADE ○ MEZZANINE ○	○ CHLORIDE PRESENT: CONCENTRATION (PPM) ____ (7.3.2.6)
31	○ ELECTRIC AREA CLASSIFICATION (6.1.24)	○ WET H_2S PRESENT: CONCENTRATION (PPM) ____ (6.11.11)
32	CL ____ GR ____ DIV	○ (SOLIDS PRESENT (6.2.1):) (CONCENTRATION (% by wt.))
33	○ WINTERIZATION ○ TROPICALIZATION REQ'D.(7.2.4.5)	(PARTICLE SIZE) ____ (HARDNESS)
34	SITE DATA (6.1.29)	(SIZE DISTRIBUTION)
35	○ ALTITUDE ____ (ft) BAROMETER ____ (psia)	LIQUID (6.1.3) ○ HAZARDOUS ○ FLAMMABLE
36	○ RANGE OF AMBIENT TEMPS: MIN/MAX ____ / ____ (°F)	(POLYMERIZATION CHARACTERISTICS (6.2.1))
37	○ RELATIVE HUMIDITY: MIN / MAX ____ / ____ (%)	○ OTHER
38	UNUSUAL CONDITIONS: (6.1.29) ○ DUST ○ FUMES	REMARKS:
39	○ OTHER	
40	○ UTILITY CONDITIONS:	○ (SYSTEM DESCRIPTION (6.2.2))
41	STEAM: DRIVERS HEATING	(SUCTION VESSEL:) ○ (VENTED TO ATMOS.) ○ (CLOSED)
42	MIN: ____ (psig) ____ (°F) ____ (psig) ____ (°F)	(PUMP LOCATION:) ○ (BELOW LIQUID LEVEL) ○ (ABOVE LIQ. LEVEL)
43	MAX.: ____ (psig) ____ (°F) ____ (psig) ____ (°F)	(SUCTION VESSEL ON LEVEL CONTROL?) ○ (YES) ○ (NO)
44	ELECTRICITY DRIVERS HEATING CONTROL SHUTDOWN	(PRESSURE SENSOR ON SUCTION VESSEL) ○ (YES) ○ (NO)
45	VOLTAGE ____ / ____	(SUCTION VESSEL PRESSURE MAINTAINED BY:)
46	HERTZ:	
47	PHASE:	(IF FLUID LEVEL OR TANK PRESSURE DROPS TOO LOW, WILL)
48	COOLING WATER: (6.1.22) SOURCE	(SYSTEM AUTOMATICALLY STOP THE PUMP?) ○ (YES) ○ (NO)
49	TEMP. INLET ____ (°F) MAX. RETURN ____ (°F)	(WILL THE PUMP RUN DRY IN NORMAL OPERATION?) ○ (YES) ○ (NO)
50	PRESS. NORM ____ (psig) DESIGN ____ (psig)	REMARKS:
51	MIN RETURN ____ (psig) MAX ALLOW DP ____ (psi)	
52	CHLORIDE CONCENTRATION (PPM) ____ (7.3.2.6)	
53	INSTRUMENT AIR: MAX/MIN PRESS ____ / ____ (psig)	

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API 685 SEALLESS CENTRIFUGAL PUMP DATA SHEET US CUSTOMARY UNITS

PAGE ____ OF ____
JOB NO. ____ ITEM NO. ____
REQ / SPEC NO. ____ / ____
PURCH ORDER NO. ____ DATE ____
INQUIRY NO ____ BY ____
REVISION ____ DATE ____

No.		
1	▢ PERFORMANCE	CONSTRUCTION - CONT'D
2	PROPOSAL CURVE NO. ____ ▢ RPM	▢ NOZZLE CONNECTIONS: (6.4.2)
3	▢ IMPELLER DIA.; RATED ____ MAX. ____ MIN. ____ (in)	SIZE (NPS) / FLANGE RATING (lb) / FAC'G / POSITION
4	▢ (HYD. EFFICIENCY AT RATED) ____ (%)	
5	▢ (HYSTERESIS & MECH. LOSSES) ____ (hp)	SUCTION
6	▢ OVERALL EFF (%) ____ RATED POWER ____ (hp)	DISCHARGE
7	▢ MAX POWER @ RATED IMPELLER ____ (hp)	▢
8	▢ MINIMUM CONTINUOUS FLOW:	PRESSURE CASING AUX. CONNECTIONS: (6.4.3) NO. / SIZE (NPS) / TYPE
9	THERMAL ____ (gpm) STABLE ____ (gpm)	
10	▢ (ROTOR CHAMBER TEMP. RISE OPERATING (6.2.1)) ____ (°F)	▢ DRAIN
11	▢ (ROTOR CHAMBER TEMP. RISE ON SHUTDOWN) ____ (°F)	▢ VENT
12	▢ PREFERRED OPER. REGION ____ TO ____ (gpm)	▢ PRESS. GAUGE
13	▢ ALLOWABLE OPER. REGION ____ TO ____ (gpm)	▢ TEMP GAUGE
14	LIMITED BY: ▢ VIBRATION ▢ OTHER	▢ WARM-UP
15	▢ MAX HEAD @ RATED IMPELLER ____ (ft)	▢ EXT. FLUSH / LEAK OFF
16	▢ PERCENT RISE TO SHUTOFF (6.1.12)	▢ PURGE/FLUSHOUT
17	○ ORIFICE USED TO STEEPEN CURVE OR GIVE CONT. RISE (6.1.12)	▢
18	▢ NPSHR AT RATED CAPACITY (6.1.19) ____ (ft)	VENDOR SUPPLY VALVES FOR: (7.3.2.6) ○ VENT(S) ○ DRAIN(S)
19	○ MAX. SUCTION SPECIFIC SPEED ALLOWED (6.1.10)	▢ (ROTOR CAVITY DRAINABLE THRU SECONDARY DRAIN (6.1.8))
20	▢ SUCTION SPECIFIC SPEED QUOTED	○ CYLINDRICAL THREADS REQ'D FOR AUX. CONN'S (6.4.3.3)
21	○ MAX. SOUND PRESS. LEVEL REQ'D (6.1.15) ____ (dBA)	○ FLANGE THICKNESS REQ'S NON-STD. BOLT LENGTH (6.4.2.3)
22	▢ EST MAX SOUND PRESS. LEVEL ____ (dBA)	○ THD. CONN. TO SECONDARY CASING IS NOT ACCEPT. (6.4.3.8)
23	REMARKS:	SECONDARY CASING HAS: (6.8.8)
24		▢ (DRAIN CONN.) ▢ (& FLUSH PROVISION)
25	CONSTRUCTION	AUXILIARY PIPING (7.3)
26	APPLICABLE STANDARD:	○ AUXILIARY PIPING PLAN
27	○ API 685 ○ OTHER ____ (SEE REMARKS)	CIRC. PIPING MATERIALS:
28	ROTATION: (VIEWED FROM COUPLING END) ▢ CW ▢ CCW	▢ TUBING ▢ CARBON STEEL
29	PUMP TYPE:	▢ PIPE ▢ STAINLESS STEEL
30	▢ OH1 ▢ OH2 ▢ OH3 ▢ OTHER	CIRC. PIPING ASSEMBLY: (7.3.2.10)
31	CASING MOUNTING:	▢ THREADED ▢ UNIONS ▢ SOCKET WELDED
32	▢ CENTERLINE ▢ NEAR CENTERLINE	▢ FLANGED ▢ TUBE FITTINGS
33	▢ FOOT ▢ IN-LINE ▢ OTHER	▢ COOLING WATER PIPING PLAN (7.3.4)
34	CASING TYPE:	C.W. PIPING ASSEMBLY:
35	▢ SINGLE VOLUTE ▢ MULTIPLE VOLUTE ▢ DIFFUSER	▢ PIPE ▢ TUBING; FITTINGS
36	CASE PRESSURE RATING:	C.W. PIPING MATERIALS:
37	▢ MAX ALLOWABLE WORKING PRESSURE ____ (psig)	▢ STAINLESS STEEL ▢ C. STEEL ▢ GALVANIZED
38	@ ____ (°F)	COOLING WATER REQUIREMENTS:
39	▢ HYDROTEST PRESSURE ____ (psig)	▢ JACKET ▢ BEARING HOUSING ____ (GPM)
40	DESIGN PUMP FOR: ○ FULL ○ ____ (psig VACUUM)	HEAT EXCHANGER ____ (GPM)
41	REMARKS:	TOTAL COOLING WATER ____ (GPM)
42		STEAM PIPING: ○ TUBING ○ PIPE ○ OTHER
43		REMARKS:
44	ROTOR:	MATERIALS
45	○ OPEN ○ SEMI-OPEN ○ FAB'D IMPELLERS ARE ACCEPT	○ APPENDIX H CLASS 6.11.1)
46	○ RENEWABLE CASE WEAR RINGS ARE NOT REQUIRED (6.7.1)	○ MIN DESIGN METAL TEMP (6.11.4.5) ____ (°F)
47	○ RENEWABLE IMP. WEAR RINGS ARE NOT REQUIRED (6.7.1)	▢ CASE ____ IMPELLER
48	○ (NON-GROOVED BEARINGS ARE ACCEPTABLE (6.10.5))	▢ CASE/IMPELLER WEAR RINGS
49	▢ SHAFT DIAMETER BETWEEN BEARINGS ____ (in)	▢ SHAFT
50	▢ SPAN BETWEEN BEARING CENTERS ____ (in)	▢ (CONTAINMENT SHELL / STATOR LINER)
51	▢ SPAN BETWEEN BEARING & IMPELLER ____ (in)	▢ (INNER MAG. SHEATHING / ROTOR LINER)
52	REMARKS:	▢ (BEARINGS)
53		○ OTHER

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API 685 SEALLESS CENTRIFUGAL PUMP DATA SHEET US CUSTOMARY UNITS

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JOB NO. ____ ITEM NO. ____
REQ / SPEC NO. ____ / ____
PURCH ORDER NO. ____ DATE ____
INQUIRY NO ____ BY ____
REVISION ____ DATE ____

No.		
1	SECONDARY CONTROL / CONTAINMENT	MAG-DRIVE SPECIFIC - CONT'D
2	○ (SECONDARY)(CONTROL)(6.8.1)	SHAFT COUPLINGS: (DRIVER-TO-PUMP)
3	○ (MAX LEAKAGE ON PRIMARY FAILURE) ____ (gpm)	○ MAKE ____ ▢ MODEL
4	○ (SECONDARY CONTAINMENT (6.8.1))	○ NON LUBE ○ LUBRICATED: (SEE REMARKS)
5	(AUX. SEAL DEVICE.) ○ (MECHANICAL SEAL) ○ (BUSHING)	▢ RATING (hp/100 RPM) ____ ▢ SERVICE FACTOR
6	○ OTHER:	▢ LIMITED END FLOAT REQUIRED
7	(DEVICE IS:) ○ (DRY RUNNING) ○ (WET RUNNING)	▢ SPACER, LENGTH ____ (IN) ○ NOT REQUIRED
8	○ (INSIDE) ○ (OUTSIDE) (OF BEARINGS (MAG-DRIVE))	▢ MATERIAL: HUBS ____ SPACER
9	○ OTHER:	ELEMENTS
10	MECHANICAL SEAL DATA:	▢ SHAFT DIAMETER AT COUPLING ____ (in)
11	○ APPENDIX H SEAL CODE	DRIVER HALF COUPLING MOUNTED BY:
12	▢ SEAL MANUFACTURER	○ PUMP MFR. ○ DRIVER MFR. ○ PURCHASER
13	▢ SIZE AND TYPE ____ / ____	REMARKS
14	▢ MANUFACTURER CODE	SEPARATE MOTOR DRIVE
15	○ REMARKS	APPLICABLE SPEC: ○ IEEE841 ○ API541 ○ OTHER:
16		▢ FRAME ____ ▢ ENCLOSURE
17		▢ LUBE
18		BEARINGS (TYPE / NUMBER):
19		▢ RADIAL ____ / ____
21	MAG-DRIVE SPECIFIC	▢ THRUST ____ / ____
22	○ DESIGN FOR REMOVAL OF DRIVE END WITHOUT DISTURBING	REMARKS
23	THE PRESSURE CASING OR DRIVER (9.1.1.4)	
24	(MAGNETIC COUPLING:) ○ (SYNCHRONOUS) ○ (TORQUE RING)	BASEPLATES (9.1.5.3):
25	(MAGNETS:) (OUTER) (INNER)	▢ API BASEPLATE NUMBER ____ (APPENDIX M)
26	▢ (MAG. MATERIAL)	○ NON-GROUT CONSTRUCTION: (9.1.5.3.13)
27	▢ (MOUNT. METHOD)	○ BASEPLATE MATERIAL
28	▢ (TEMP. LIMIT, (°F))	○ BOLT V-INLINE PUMP TO PAD / FOUNDATION (6.1.30.3)
29	▢ (HERMETIC. SEALED)	REMARKS
30	▢ (NO. OF MAGNETS)	
31	○ (SOFT START REQ'D) ▢ (HARD START CAPABILITY)	(CANNED MOTOR SPECIFIC)
32	▢ (TORQUE RATING (DECOUPLING), ft-lb)	○ (SOLID MEDIA POTTING ALLOWED IN STATOR (9.2.2.2))
33	▢ (MAX TORQUE REQ'D ON STARTING, ft-lb (9.1.3.7a))	○ (CERAMIC INSULATION ACCEPTABLE (9.2.2.8))
34	▢ (PUMP TORQUE AT RATED (+ 5%), ft-lb (9.1.3.7b))	○ DESIGN MOTOR FOR FREQUENT STARTS (9.2.2.9)
35	▢ (ACTUAL SERVICE FACTOR (9.1.3.8)) ____ (%)	▢ (STARTS PER) ▢ (IMPACT ON LIFE: (REMARKS))
36	▢ (TORQUE REQ'D FOR FULL CURVE, Nm (9.1.3.7c))	○ (DESIGN MOTOR FOR: (9.2.2.9)) ○ (TWO-SPEED)
37	○ (DESIGN FOR FULL CURVE TORQUE REQUIREMENTS (9.1.3.7c))	○ (VARIABLE SPEED)
38	○ (SUBMIT MAG COUPLING TORQUE - TEMP. CURVE (9.1.3.9))	○ (UL, FM OR EQUIVALENT REQ'D (9.2.2.10)) ▢ (UL) ▢ (FM) ▢ (OTHER)
39	○ (SUBMIT SPEED VS TORQUE CURVE(5.1.3.10))	○ (CERTIFICATION OF IEEE 252 TEST REQUIRED (9.2.7))
40	○	○ (DECONTAMINATION CONNECTION ON STATOR (9.2.2.11))
41	EXTERNAL BEARING (TYPE/NUMBER):	REMARKS
42	▢ RADIAL ____ / ____	
43	▢ THRUST ____ / ____	
44	LUBRICATION: (9.1.4.3)	
45	▢ RING OIL ▢ FLINGER ▢ FLOOD	
46	○ PURGE OIL MIST ○ PURE OIL MIST ▢ OTHER	
47	○ CONSTANT LEVEL OILER PREF. (SEE REMARKS) (9.1.4.2.1)	
48	▢ OIL VISC. ISO GRADE	
49	ADDITIONAL REMARKS:	
50		
51		
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API 685 SEALLESS CENTRIFUGAL PUMP DATA SHEET US CUSTOMARY UNITS

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PURCH ORDER NO. ____ DATE ____
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No.		
1	INSTRUMENTATION (7.2)	DRIVE MOTOR (7.1)
2	○ (INSTRUMENT PANEL REQ'D (7.2.1.4)) ○ (FREESTANDING)	▢ MANUFACTURER
3	○ (ON BASEPLATE) ○ (OTHER:)	▢ ____ (hp) ▢ ____ (RPM)
4	REMARKS:	▢ HORIZONTAL ▢ VERTICAL ▢ SERVICE FACTOR
5		▢ VOLTS/PHASE/HERTZ ____ / ____ / ____
6	○ (MONITOR LEAKAGE INTO SECONDARY CASING (7.2.2.5.3))	○ TYPE
7	○ (OPTICAL MOISTURE SENSOR) ○ (SIGHT GLASS)	○ MINIMUM STARTING VOLTAGE (7.1.8)
8	○ (PRESSURE SWITCH) ○ (CONDUCTIVITY PROBE)	▢ INSULATION ○ TEMPERATURE RISE °K
9	○ (LOCAL) ○ (ON PANEL) ○ (ALARM) ○ (SHUTDOWN)	▢ FULL LOAD AMPS
10	REMARKS:	▢ LOCKED ROTOR AMPS
11		▢ STARTING METHOD (7.1.3)
12	○ (PUMP POWER MONITORED (7.2.2.5.1/2)) ○ (WATTS) ○ (AMPS)	
13	○ (LOCAL) ○ (ON PANEL) ○ (IN PURCHASER MCC)	○ SIZE MOTOR FOR MAX POWER OF RATED IMPELLER (7.1.4.2)
14	○ (ALARM) ○ (SHUTDOWN)	○ MAXIMUM ACCELERATION TIME (SEC) ____ ▢ QUOTED
15	(SENSOR BY:) ○ (PURCHASER) ○ (VENDOR)	REMARKS:
16	REMARKS:	
17	○ (TEMPERATURE MONITOR OF:) ○ (ROTOR CAVITY FLUID)	SPARE PARTS (TABLE 11)
18	○ (CONTAINMENT SHELL/LINER) ○ (INTERNAL BEARING(S))	○ START-UP ○ NORMAL MAINTENANCE
19	(READOUT:) ○ (LOCAL) ○ (PANEL) ○ (ALARM) ○ (SHUTDOWN)	○ SPECIFY
20	○ (PROVISION FOR INSTRUMENTS ONLY)	
21	(SENSOR BY:) ○ (PURCHASER) ○ (VENDOR)	
22	▢ (TYPE:)	
23	○ (MONITOR AND CABLES BY:) ○ (PURCHASER) ○ (VENDOR)	SURFACE PREPARATION AND PAINT
24	○ (PRESSURE MONITOR OF:) ○ (ROTOR CAVITY)	○ MANUFACTURER'S STANDARD
25	○ (SECONDARY CASING) ○ (OTHER:)	○ OTHER (SEE BELOW)
26	(READOUT:) ○ (LOCAL) ○ (PANEL) ○ (ALARM) ○ (SHUTDOWN)	PUMP:
27	○ (PROVISION FOR INSTRUMENTS ONLY)	○ PUMP SURFACE PREPARATION
28	(SENSOR BY:) ○ (PURCHASER) ○ (VENDOR)	○ PRIMER
29	▢ (TYPE:)	○ FINISH COAT
30	REMARKS:	BASEPLATE: (9.1.5.3)
31		○ BASEPLATE SURFACE PREPARATION
32	○ VIBRATION (7.2.2.4.1-3) ○ READOUT ○ ALARM ○ S/DN	○ PRIMER
33	○ PROVISION FOR INSTRUMENTS ONLY	○ FINISH COAT
34	○ FLAT SURFACE REQ'D (6.9.3.11) ○ THREADED CONN. (2.9.3.10	SHIPMENT: (8.4.1)
35	SENSOR BY: ○ PURCHASER ○ VENDOR	○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQUIRED
36	○ TYPE:	○ OUTDOOR STORAGE MORE THAN 6 MONTHS
37	MONITORS AND CABLES BY: ○ PURCHASER ○ VENDOR	REMARKS
38	REMARKS:	
39	○ (BEARING WEAR DETECTOR (7.2.2.4.4)) ▢ (MECHANICAL)	OTHER PURCHASER REQUIREMENTS FOR VENDOR
40	▢ (ELECTRICAL) ▢ (HYDRAULIC) ▢ (OTHER (see remarks))	○ COORDINATION MEETING REQUIRED (10.1.3)
41	○ (ALARM) ○ (S/DN) ○ (READOUT) ○ (LOCAL) ○ (PANEL)	○ REVIEW & COMMENT ON PURCHASER'S PIPING DWGS (6.1.27a)
42	REMARKS:	○ OBSERVE PIPING CHECKS AFTER INSTALLATION (6.1.27b)
43		○ OBSERVE INITIAL ALIGNMENT CHECK (6.1.27c)
44	GENERAL	○ CHECK ALIGNMENT AT OPERATING TEMPERATURE (6.1.27d)
45	○ LIQUID FILLED GAUGES FOR VIB. SERVICES(7.2.2.3.2)	○ CONNECTION DESIGN APPROVAL (6.11.3.5.4)
46	○ REPLACE INSTRUMENT WHILE RUNNING NOT REQ'D (7.2.1.6)	○ INSTALLATION LIST IN PROPOSAL (10.2.3L)
47	○ PROVISION FOR TESTING OF SHUTDOWN SYSTEMS WHILE	○ PROGRESS REPORTS ARE NOT REQUIRED (10.3.4)
48	RUNNING IS NOT REQUIRED (7.2.3.4)	REMARKS:
49	SWITCHES (7.2.3.3)	
51	ALARM CONTACTS: ○ OPEN ○ CLOSE TO SOUND ALARM	
52	AND BE NORMALLY: ○ ENERGIZED ○ DE-ENERGIZED	
53	S/D CONTACTS SHALL: ○ OPEN ○ CLOSE TO SOUND ALARM	
54	AND BE NORMALLY: ○ ENERGIZED ○ DE ENERGIZED	

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#	QA INSPECTION AND TEST	NON-WIT	WIT	OBS
1	QA INSPECTION AND TEST			
2	○ REVIEW VENDORS QA PROGRAM (8.1.7)			
3	○ PERFORMANCE CURVE APPROVAL			
4	○ SHOP INSPECTION (8 1 4)			
5				
6	TEST	NON-WIT	WIT	OBS
7	HYDROSTATIC (8.3.2)	○	○	○
8	PERFORMANCE (8.3.3)	○	○	○
9	○ NPSH (8 3 4 1)	○	○	○
10	○ COMPLETE UNIT TEST (8.3.4.2)	○	○	○
11	○ SOUND LEVEL TEST (8.3.4.3)	○	○	○
12	○ SECONDARY CONTAINMENT	○	○	○
13	SYSTEM HYDROTEST (8.3.4.5)			
14	○ CLEANLINESS PRIOR TO	○	○	○
15	FINAL ASSEMBLY (8.2.3.1)			
16	○ NOZZLE LOAD TEST (7.3.6)	○	○	○
17	○ SECONDARY CONTAINMENT /	○	○	○
18	CONTROL SYSTEM INST. TEST (8.3.4.6)			
19	○ REMOVE/INSPECT INTERNAL	○	○	○
20	BEARINGS AFTER TEST (9.2.8.5)			
21	○ DISASSEMBLY / INSPECT	○	○	○
22	AFTER TEST (8.4.3.1)			
23	○ AUXILIARY EQUIPMENT	○	○	○
24	TEST (8.3.4.4)			
25	○ PRESS-TEMP PROFILE TEST(8 3 4 7)	○	○	○
26	○ ____	○	○	○
27	○ ____	○	○	○

29 ○ MATERIAL CERTIFICATION REQUIRED (6.11.6)
30 ○ CASING ○ IMPELLER ○ SHAFT
31 ○ OTHER ____
32 ○ CASTING REPAIR PROCEDURE APPROVAL REQ'D (6.11.2.5)
33 ○ INSPECTION REQUIRED FOR CONNECTION WELDS (6.11.3.5.6)
34 ○ MAG PARTICLE ○ LIQUID PENETRANT
35 ○ RADIOGRAPHIC ○ ULTRASONIC
36 ○ INSPECTION REQUIRED FOR CASTINGS (8.2.1.3)
37 ○ MAG PARTICLE ○ LIQUID PENETRANT
38 ○ RADIOGRAPHIC ○ ULTRASONIC
39 ○ ADDITIONAL INSPECTION REQUIRED FOR: (6.11.3.5.6) (8.2.1.3)
40 ____
41 ○ MAG PARTICLE ○ LIQUID PENETRANT
42 ○ RADIOGRAPHIC ○ ULTRASONIC
43 ○ ALTERNATE ACCEPTANCE CRITERIA (SEE REMARKS) (8.2.2.1)
44 ○ HARDNESS TEST REQUIRED FOR: (8.2.3.2)
45 ____
46 ○ WETTING AGENT HYDROTEST (8.3.2.5)
47 ○ VENDOR SUBMIT TEST PROCEDURES (8.3.1.2/10.2.5)
48 ○ RECORD FINAL ASSEMBLY RUNNING CLEARANCES
49 ○ INSPECTION CHECK-LIST (APPENDIX N) ____ (8.1.6)
50 ○ SUBMIT DATA FOR MODEL STATIC TORQUE TEST (9.1.6.1)
51 ○ JOB SPECIFIC STATIC TORQUE TEST REQUIRED (9.1.6.1)
52 REMARKS ____

☐ **WEIGHTS**

MOTOR DRIVEN:
WEIGHT OF PUMP (lb) ____
WEIGHT OF BASEPLATE (lb) ____
WEIGHT OF MOTOR (lb) ____
TOTAL WEIGHT (lb) ____
DIMENSIONS OF PLOT: (LxWxH) ____
TURBINE DRIVEN:
WEIGHT OF BASEPLATE (lb) ____
WEIGHT OF TURBINE (lb) ____
WEIGHT OF GEAR (lb) ____
TOTAL WEIGHT (lb) ____
DIMENSIONS OF PLOT: (LxWxH) ____

GENERAL REMARKS

REMARK 1: ____
REMARK 2: ____
REMARK 3: ____
REMARK 4: ____
REMARK 5: ____
REMARK 6: ____

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API Standards may be obtained by calling API Publications and Distribution (202-682-8375).