
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NASA-15445 (June 2004)
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DIVISION 15 - MECHANICAL

SECTION 15445

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06/04

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SECTION 15445

SUMP PUMPS
06/04

NOTE: Delete, revise, or add to the text in this section to cover project requirements. Notes are for designer information and will not appear in the final project specification.

This section covers automatic, electric-motor-driven, centrifugal, wet-pit and submersible sump pumps.

Motors are covered in Section 16225 MOTORS.

PART 1 GENERAL

1.1 REFERENCES

NOTE: The following references should not be manually edited except to add new references. References not used in the text will automatically be deleted from this section of the project specification.

The publications listed below form a part of this section to the extent referenced:

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11 (1990; R 2000) Load Ratings and Fatigue Life for Roller Bearings

ABMA 9 (1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings

ASTM INTERNATIONAL (ASTM)

ASTM A 53/A 53M (2002) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

HYDRAULIC INSTITUTE (HI)

HI SCRRP (1994) Standards for Centrifugal, Rotary and Reciprocating Pumps

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1	(2003) Mechanical Vibration - Balance Quality Requirements of Rigid Rotors - Part 1: Determination of Permissible Residual Unbalance
ISO 2858	(1975) End Suction Centrifugal Pump (Rating 16 Bar) Designation Nominal Duty Point and Dimensions
ISO 5199	(2002) Technical Specifications for Centrifugal Pumps, Class II

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2003) Enclosures for Electric Equipment (1000 Volts Maximum)
NEMA MG 1	(2002) Motors and Generators

1.2 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01330 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control. Include a columnar list of appropriate products and tests beneath each submittal description.

The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES in sufficient detail to show full compliance with the specification:

SD-02 Shop Drawings

The following shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

Connection Diagrams
Control Diagrams
Fabrication Drawings
Installation Drawings

SD-03 Product Data

Manufacturer's Catalog Data shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

SD-06 Test Reports

Test reports shall be submitted for the following tests in accordance with the paragraph entitled, "Tests," of this section.

Hydrostatic Leak
Static Heads
Pump Flow Capacity

SD-07 Certificates

Listing of product installations for the following items shall identify at least five installed units similar to those proposed for use, that have been in successful service for a minimum of five years. List shall include purchaser, address of installation, service organization, and date of installation.

Wet-Pit Sump Pumps
Submersible Pumps

Certificates shall be submitted for the following items showing conformance with the referenced standards contained in this section.

Wet-Pit Sump Pumps
Submersible Pumps
Accessories

SD-08 Manufacturer's Instructions

The following shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

Manufacturer's Installation Instructions
Vibration Specifications

1.3 GENERAL REQUIREMENTS

NOTE: If Section 15003 GENERAL MECHANICAL PROVISIONS is not included in the project specifications, applicable requirements therefrom should be inserted and the following paragraph deleted. If Section 15072 VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT is not included in the project specification, applicable requirements therefrom should be inserted and the second paragraph deleted. If Section 16225 MOTORS is not included in the project specification, applicable requirements therefrom should be inserted and the third paragraph deleted.

[Section 15003 GENERAL MECHANICAL PROVISIONS applies to work specified in this section.]

[Section 15072 VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT, applies to work specified in this section.]

[Section 16225 MOTORS applies to this section.]

Connection Diagrams for sump pumps shall show details of connection of cables and pump motors.

Control Diagrams shall be submitted for sump pumps showing motor starters, relays, or any other component necessary for safe operation.

Fabrication Drawings for sump pumps shall indicate size, type, and efficiency rating.

Installation Drawings for sump pumps shall be in accordance with the manufacturer's recommended instructions.

Manufacturer's Catalog Data shall be submitted for sump pumps showing equipment foundation data and equipment and performance data including performance curves and indicating brake horsepower, head (gpm) (liter per minute), and NPSH.

Manufacturer's Installation Instructions and Vibration Specifications shall be provided.

PART 2 PRODUCTS

Pump and Motor vibration levels shall conform to ISO 1940-1 unless otherwise noted. Motor vibration levels shall conform to NEMA MG 1, Motors and Generators, Part 7 unless otherwise noted.

2.1 WET-PIT SUMP PUMPS

NOTE: Select simplex or duplex pump units; delete the parts and the paragraphs not applicable to the project requirements.

Unit-capacity conditions should be specified herein or shown on the drawings.

Cast-iron, carbon-steel, or concrete cast-in-place sumps or basins should be dimensioned on the drawings or specified herein. Capacities for each pump of the simplex or duplex unit range from 40 to 1,000 gallons 150 to 3800 liter per minute; total dynamic heads range from 10 to 130 feet 3 to 40 meter.

The number of pump units required should be indicated on the drawings or specified herein.

This specification covers automatic, electric-motor-driven, centrifugal, wet-pit, suspended, sump pumps and Accessories.

Pumps shall be constructed and furnished in accordance with the applicable requirements of HI SCRRP ISO 2858 and ISO 5199 standards and those specified herein.

Simplex pump unit shall include a vertical, submerged, volute, centrifugal pump mounted below a coverplate; a vertical, flexible-connected, solid-shaft motor; a motor and bearing-support housing attached to the coverplate; pump-support and shaft-housing pipe; discharge pipe; and automatic controls.

Duplex pump unit shall include two individual, vertical, submerged, volute, centrifugal pumps mounted below a coverplate; vertical, flexible-connected, solid-shaft motors; motor and bearing-support housing attached to the coverplate; pump-support and shaft-housing pipes; discharge pipes; and automatic controls. Unit shall be designed to permit removal of one pump assembly without disturbing the operation of the other.

Requirements for each material designation shall be in accordance with the applicable definition listed in the centrifugal pump section of HI SCRRP ISO 2858 and ISO 5199 standards. Materials for components and accessories not covered by these definitions shall be as specified herein.

Contact between dissimilar metals shall be avoided. Where such contact cannot be avoided, joints between dissimilar metals shall be protected against galvanic corrosion by plating, organic-insulation coatings, gaskets, or other suitable means.

2.1.1 Pump Selection

Where parallel pump operation is indicated, pumps shall be selected with characteristics specifically suited for the service without unstable operation.

Pumps shall be selected for service within 4 percent of maximum efficiency for a given casing and impeller series.

Pumps having impeller diameter larger than 90 percent of the published maximum diameter of the casing or less than 15 percent larger than the published minimum diameter of the casing will be rejected.

**NOTE: Show duty conditions on drawings and select
the following paragraph or rewrite the paragraph to
include duty conditions.**

Pump duty conditions shall be as indicated.

A pump unit shall deliver, at rated speed, not less than the specified gallons liter per minute against the specified or indicated discharge head while the liquid level is not more than 1 foot 300 millimeter above the datum elevation of the pump. Datum elevation shall be taken as the level of the entrance eye of the impeller. Discharge head, specified or indicated, shall include the friction head of the system piping external to the pump unit and the static head measured from a point of reference on the sump to the highest point in the system. Ratings shall be based on pumping clear, fresh water at a temperature of 68 degrees F 20 degrees C.

2.1.2 Pump Casing

Pump casing shall be cast iron. Volute and discharge nozzle of the pump casing shall be cast in one piece. Casing shall be constructed with a bolted plate to permit inspection and removal of the impeller. Casing shall be designed to withstand a hydrostatic pressure of not less than 1-1/2 times the design shutoff head of the pump.

2.1.3 Impeller

Impeller shall be cast iron or bronze, enclosed or semi-open, with vanes on

back shroud. Refer to the part entitled, "Bearings and Lubrication," in this section for additional requirements. Impeller shall be dynamically balanced.

2.1.4 Strainer

Intake shall be protected with a large cast-iron, slotted intake strainer with an effective free area sufficient to prevent cavitation and degradation of efficiency. Strainer shall have a free area of at least four times the cross-sectional area of the suction casing.

2.1.5 Pump Shaft

Pump shaft shall be constructed of ground and polished AISI Type 304 or 316 corrosion-resistant steel with hardened wearing surfaces at intermediate shaft-bearing locations. Hardened surfaces may be overlays of 500 Brinell Stellite, Wall Colmonoy, or similar proprietary metals, or plasma-spray-applied ceramic materials of not less than 900 Brinell hardness.

Mechanical properties and diameter of the shaft shall ensure that whip, deflection, or vibration will not be of sufficient magnitude to impose greater than design loads on the specified shaft bearings under normal operating conditions. Means shall be provided for external adjustment of the clearance between the impeller and the inner surfaces of the volute section.

2.1.6 Bearings and Lubrication

One or more antifriction ball- or roller-bearings shall be furnished in the motor and bearing support housing above the cover-plate surface, with full provision for the mechanical and hydraulic radial and thrust loads imposed. Bearings shall be sealed and grease-lubricated and shall have an L-10 rating of not less than 80,000 hours in accordance with ABMA 9 or ABMA 11. Shop drawings shall bear the manufacturer's certification of bearing life. Bearings shall be manufactured from vacuum-processed or degassed-alloy steels. Bearings shall be furnished with grease and pressure-relief fittings at bottom or opposite side the bearing where discharge may be viewed.

Intermediate shaft bearings shall be of the sleeve type. Center distance between any two bearings on the shaft shall not exceed 4 feet 6 inches 1370 millimeter for pumps operating between 1,700 and 1,800 revolutions per minute (rpm) or 5 feet 1520 millimeter for pumps operating at 1,200 rpm or less. Sleeve-bearing length shall be not less than 2 times the shaft diameter. A sleeve bearing located near the lower extremity of the shaft shall be provided.

NOTE: Select the appropriate paragraphs for grease-or water-lubricated intermediate bearings.

Where water contains suspended matter such as sand, etc., Supply solenoid-operated flush water to bearings from protected potable or other clean source.

If heads are sufficiently high, a plastic centrifugal separator may be provided to cleanse

suspended matter from flushing water taken from pump discharge. Drain separator underflow back to sump.

Sleeve bearings shall be heavy-duty bronze or bronze-backed, babbitt-lined. Appropriate nonferrous piping and fittings shall be provided to permit individual lubrication of the intermediate and lower bearings from above the sump coverplate. Means shall be provided to prevent the pumped fluid from entering the lower bearing. Such means shall include a suitable seal or a system wherein a partial vacuum developed below the bearing by the impeller rotation induces a positive flow of lubricant into the bearing. Bearings shall be fitted with a centralized grease lubricator that is manually or electrically operated from a single point.

Sleeve bearings shall be heavy-duty bronze- or corrosion-resistant steel-backed cutless-rubber type.

NOTE: Where flushing water is used, delete the previous paragraph and select the following paragraph.

Sleeve bearings shall be heavy-duty bronze- or corrosion-resistant steel-backed cutless-rubber type with nonferrous piping and fittings provided for individual flushing of intermediate and lower bearings.

NOTE: Where potable water is used, include the following paragraph. If discharge water is centrifugally cleaned, delete the following paragraph and specify centrifugal separator and performance requirements.

Potable water shall be supplied through a piping system containing a pressure regulator, a solenoid, and a backflow preventer. All wetted components shall be plastic, nonmetallic composition, elastomer, or nonferrous metal.

2.1.7 Flexible Couplings

Pump shaft shall be connected to the motor shaft through a flexible coupling. Flexible member shall be a tire shape or a solid-mass serrated-edge disk shape made of chloroprene material and retained by fixed flanges. Flexible coupling shall act as a dielectric connector, shall not transmit vibration or end thrust, and shall permit up to 4-degree misalignment under normal duty.

2.1.8 Support Pipe

A wrought-iron or steel support pipe concentric with the pump shaft shall connect the pump to the sump coverplate. Support-pipe flanges shall be machined and doweled to ensure proper alignment of the pump and shaft whenever the pipe is disassembled and reassembled in the field.

2.1.9 Discharge Pipe

A discharge pipe running from the pump-discharge outlet to the sump

coverplate shall be furnished as an integral part of the pump unit. Discharge pipe shall be arranged to preclude discharge piping beyond the pump assembly from imposing loads which would tend to cause shaft misalignment. Pipe shall be black steel or wrought iron, with wall thickness not less than that specified in ASTM A 53/A 53M for Schedule 40 pipe. Discharge pipe shall be gastight through the sump coverplate. Discharge end of the pipe shall terminate in a screwed or flanged connection in accordance with the manufacturer's standard practice.

2.1.10 Liquid-Level Control

Simplex unit shall have a float mechanism to provide automatic operation of the pump unit when the liquid in the sump rises to a predetermined level. A means of adjustment, such as float-rod stops, shall be provided to allow for variation in the start and stop level-control points. Float and stem shall be AISI Type 304 or 316 corrosion-resistant steel, and all other parts of the fluid-level-sensing mechanism below the coverplate shall be bronze, brass, or material of equivalent resistance to the corrosive effects of sewage.

Duplex pump unit shall be furnished with the electrical and mechanical devices required to provide automatic operation of the pump unit when the liquid in the sump rises to a predetermined level. Controls shall automatically transfer the operating cycle from one pump to the other and shall operate both pumps simultaneously whenever the inflow to the sump exceeds the capacity of the operating pump. A means of adjustment such as float-rod stops shall be provided to allow for variations in the start and stop level-control points. Float and rod shall be AISI Type 304 or 316 corrosion-resistant steel, and all other parts of the fluid-level sensing mechanism below the cover shall be bronze, brass, or material of equivalent resistance to the corrosive effects of sewage.

NOTE: Select the following paragraph for deep settings and where a great deal of turbulence may be expected.

Stilling tubes shall be provided where indicated.

Floatless electrode level controls may be submitted for approval, provided the electrodes are isolated from the fluid being sensed.

2.1.11 High-Water Alarm

NOTE: Coordinate with electrical drawings.

[A high-water alarm switch, complete with actuating mechanism, shall be provided for operation on an electrical circuit other than the motor circuit. Switch shall be designed to operate indicated alarm device(s) whenever a predetermined high-water level is reached in the sump because of failure of either pump or a fluid inflow that exceeds the combined capacity of both pumps. Controls shall be mounted on the sump coverplate.]

2.1.12 Sump Tank and Coverplate

NOTE: Delete the following paragraph if a concrete sump is designed.

If size of tank is such that a fabricated steel tank is specified, provide coal-tar epoxy internal protection.

Drawings or specifications should show size of tank and influent line.

For deep settings, drawing should show antisway bracing of shaft column.

2.1.12.1 Tank

Sump tank shall be cast iron, sized to provide a clearance of 6 inches 150 millimeter or one discharge pipe iron pipe size (ips) diameter, whichever is larger, between the bottom of the pump and the bottom of the tank.

A standard opening for connection to the sewage inflow pipe shall be furnished in the indicated size and location with respect to the top of the tank.

NOTE: If concrete sump is provided, include the following paragraph if concrete requires protection from sewage components.

Concrete sump-tank interior surfaces shall be protected by not less than a two-coat, two-component system of amine-cured coal-tar epoxy totaling 15 mils 0.381 millimeter in thickness.

2.1.12.2 Coverplate

Sump tank coverplate shall be cast iron or steel, of adequate strength to support the pumps without distortion, and of adequate strength to safely support maintenance personnel. Openings through the sump tank coverplate shall be gasketed, unless otherwise specified. A 2-inch DN50 ips or larger threaded outlet shall be provided to permit installation of a vent pipe. Sump coverplate shall provide either manhole or handhole access to the tank.

2.1.13 Painting

Equipment shall be treated and painted in accordance with the manufacturer's standard practice for the specified duty.

2.2 SUBMERSIBLE PUMPS

NOTE: Select simplex or duplex; delete the parts and the paragraphs not applicable to the project.

Unit capacity conditions should be specified herein or shown on the drawings.

Cast-iron, carbon-steel, or concrete cast-in-place sumps or basins should be dimensioned on the

drawings or specified herein. Capacities for each pump of the simplex or duplex unit range from 40 to 85 gallons 150 to 320 liter per minute; total dynamic heads range from 10 to 105 feet at 29 gpm3 to 32 meter at 110 liter per minute.

Number of pump units required should be indicated on the drawings or specified herein.

Pumps and Accessories shall be constructed and furnished in accordance with the requirements of HI SCRRP ISO 2858 and ISO 5199 standards and those specified herein.

NOTE: Take precautions to properly identify pump.

Revise if other type controls are required.

[Simplex pump unit shall include a submersible pump with an automatic level-control mechanism mounted above water level.]

[Simplex pump unit shall include a submersible pump with an integral diaphragm or float-switch automatic level-control mechanism.]

Failure of operating switch shall not require breaking of pump-motor seals for repairs.

Duplex unit shall include two submersible pumps, each with float level controls.

Requirements for each material designation shall be in accordance with the applicable definition listed in the centrifugal pump section of HI SCRRP ISO 2858 and ISO 5199 standards. Materials for components and accessories not covered by these definitions shall be as specified herein.

Contact between dissimilar metals shall be avoided. Where such contact cannot be avoided, joints between dissimilar metals shall be protected against galvanic corrosion by plating, organic insulation coatings, gaskets, or other suitable means.

2.2.1 Pump Selection

Pumps shall be selected for the service within 4 percent of maximum efficiency for a given casing and impeller series.

NOTE: Modify to include project duty conditions.

Due to the nature of construction, submersible pump motors are not always nonoverloading for a given motor-volute-impeller series, and therefore possible operation at low heads must be avoided.

Pump duty conditions shall be as indicated.

Pump seals, lubricant, and electrical insulation shall be suitable for

service in liquids up to 140 degrees F 60 degrees C.

2.2.2 Pump Housing

Pump housing shall enclose the pump motor and volute with its integrally cast feet. Pump housing shall be cast iron, watertight under all heads normal to the service, and constructed to permit inspection and repair. Volute shall be designed to withstand a hydrostatic pressure of not less than 1-1/2 times the design shutoff head of the pump.

2.2.3 Impeller

Impeller material shall be bronze. Impeller shall be dynamically balanced and totally enclosed.

NOTE: Submersible pumps may be furnished for heavy debris or sewage service by specifying as follows and deleting the preceding paragraph.

Modify solid-sphere handling-capability dimension as required. Lower the capacity, the smaller the passable solid sphere.

Impeller shall be the cast-iron nonclogging type with design features to provide maximum freedom from clogging when liquid containing rags and stringy material is handled. Impeller shall be dynamically balanced and shall have a minimum size solid-sphere handling capability of 1-1/2 inches 40 millimeter.

2.2.4 Pump Shaft

Pump shaft shall be an extension of the motor shaft and shall be constructed of ground and polished AISI Type 300 or 400 series corrosion-resistant steel with hard wearing surfaces (over 300 Brinell).

2.2.5 Mechanical Seal

Pump shaft seal shall be manufacturer's standard mechanical type specifically constructed for the service duty temperature and resistance to pumped fluid.

2.2.6 Bearings and Lubrication

Antifriction ball or roller bearings shall be furnished with full provision for the mechanical and hydraulic, radial, and thrust loads imposed. Bearings shall be sealed and permanently grease- or oil-lubricated.

2.2.7 Motor and Power Cord

Motor shall be manufacturer's standard construction for the service and shall be permanently sealed, oil-filled, and watertight. Motor space shall be fitted with watertight expansion provisions to accommodate temperature normal to specified duty. Motor seals shall remain watertight under any pressure developed in the volute and under a sump-level static head of not less than 30 feet 9100 millimeter of water; shop drawings shall so certify. Motor control for three-phase motor shall provide overload protection.

NOTE: Some submersible pumps are available as three-phase type in 3/4 horsepower 560 watt and larger only.

Select the following paragraph for single-phase motors only.

Single-phase motors shall have automatic-reset thermal-overload protection.

Power cord shall be of indicated length, waterproof, internally grounded, oil-resistant, Type SO chloroprene, with three-prong plug.

2.2.8 Liquid-Level Control

NOTE: Simplex unit controls are specified to be integral with housing. Following remote controls may be specified upon revision of selected paragraph under general heading.

Simplex unit shall have a float-operated switch mechanism to provide automatic operation of the pump unit when the liquid in the sump rises to a predetermined level. Switch shall be cover-mounted, and enclosure shall be NEMA 250, Type 1, general purpose. Means of adjustment such as float-rod stops shall be provided to allow for variation in the start and stop level-control points. Float and stem shall be AISI Type 304 or 316 corrosion-resistant steel; all other wetted parts of the fluid-level sensing mechanism shall be bronze, brass, or material of equivalent resistance to the corrosive effects of pumped fluid.

NOTE: Select two of the following three paragraphs if duplex units are used.

Duplex pump unit shall be furnished with the electrical and mechanical devices required to provide automatic operation of the pump unit when the liquid in the sump rises to predetermined level. Controls shall automatically transfer the operating cycle from one pump to the other, and shall operate both pumps simultaneously whenever the inflow to the sump exceeds the capacity of the operating pump. Means of adjustment such as float-rod stops shall be provided to allow for variations in the start and stop level-control points. Float and rod shall be AISI Type 304 or 316 corrosion-resistant steel; all other wetted parts of the fluid-level sensing mechanism shall be bronze, brass, or material of equivalent resistance to the corrosive effects of the pumped fluid.

Controls shall be mounted on the discharge pipe below the basin cover. Enclosures shall be NEMA 250, Type 6, submersible, watertight, dusttight, and sleet (ice) resistant.

Control shall be pedestal mounted above the coverplate, and the enclosures shall be NEMA 250, Type 1, general purpose.

NOTE: Select the following paragraph for deep

settings and where a great deal of turbulence may be expected.

Stilling tubes shall be provided where indicated.

Floatless electrode level controls may be submitted for approval provided the electrodes are isolated from the fluid being sensed.

2.2.9 High-Water Alarm

NOTE: Coordinate with project requirements and electrical drawings.

A high-water alarm switch complete with actuating mechanism shall be provided for operation on an electrical circuit other than the motor circuit. Switch shall be designed to operate indicated alarm device(s) whenever a predetermined high-water level is reached in the sump because of failure of either pump or a fluid inflow that exceeds the capacity of both pumps. Switch enclosure shall be the same as that for the level-control switch.

2.2.10 Sump Tank and Coverplate

NOTE: Delete the following paragraph if a concrete sump is designed.

If size of tank is such that a fabricated steel tank is specified, provide coal-tar epoxy internal protection.

Drawings or specifications should show size of tank and influent line.

For deep settings, drawings should show antisway bracing and support of power cord and discharge pipe.

2.2.10.1 Tank

Sump tank shall be [cast iron], [high-density linear polyethylene], sized as indicated.

A standard opening for connection to the drainage inflow pipe shall be furnished in the indicated size and location with respect to the top of the tank.

NOTE: If concrete sump is provided, include the following paragraph if concrete requires protection from sewage components.

Concrete-sump interior surfaces shall be protected by not less than a two-coat, two-component system of amine-cured coal-tar epoxy totaling 15 mils 0.381 millimeter in thickness.

2.2.10.2 Coverplate

Sump coverplate shall be cast iron or steel, of adequate strength to support not less than 200 pounds per square foot 9500 pascal without distortion. All openings through the sump cover shall be sealed to be gastight and watertight. A standard outlet shall be provided for a vent pipe. Sump cover shall provide either manhole or handhole access to the interior.

2.2.11 Painting

Equipment shall be treated and painted in accordance with the manufacturer's standard practice for specified duty.

PART 3 EXECUTION

3.1 INSTALLATION

Equipment shall be installed in accordance with manufacturer's recommendations.

3.1.1 ALIGNMENT

Before attempting alignment, the contractor will demonstrate that the pump does not have any load/force imposed by the piping system. Minimum alignment values (below) are for pump and driver at normal running temperatures. Values must be compensated for thermal growth. Limited movement of the pump or driver (commonly known as bolt-bound) must be corrected to ensure alignment capability. Hold down bolts shall not be undercut in order to perform adjustment.

Shims shall be commercially die-cut, without seams or folds, and be made of corrosion resistant stainless steel. No more than four shims shall be used at any single point.

Units with drive motor over [7.5] [10] [15] [20] [25] hp shall have alignment jack bolts installed.

Pump and driver may have an intermediate shaft, spacer, or spool piece (sometimes called a jackshaft) Based on the motor nominal operating speed, the Pump and driver shall be aligned to the following minimum specifications:

Speed(RPM)	close-coupled offset (mils)	close-coupled angle(mils/in.)	spool piece angle (mils/in. @ coupling pt.)
600	6.0	2.0	3.0
900	5.0	1.5	2.0
1200	4.0	1.0	1.5
1800	3.0	0.5	1.0
3600	1.5	0.4	0.5
7200	1.0	0.3	0.4

Final alignment settings shall be provided as part of the final test data.

3.2 TESTS

3.2.1 Vibration Analyzer

Contractor shall use an FFT analyzer to measure vibration levels. It shall have the following characteristics: A dynamic range greater than 70 dB; a minimum of 400 line resolution; a frequency response range of 5 Hz-10 KHz(300-600000 cpm); the capacity to perform ensemble averaging, the capability to use a Hanning window; auto-ranging frequency amplitude; a minimum amplitude accuracy over the selected frequency range of + or - 20% or+ or - 1.5 dB.

An accelerometer, either stud-mounted or mounted using a rare earth, low mass magnet and sound disk(or finished surface) shall be used with the FFT analyzer to collect data. The mass of the accelerometer and its mounting shall have minimal influence on the frequency response of the system over the selected measurement range.

3.2.2 Pump Acceptance

Vibration analysis shall verify pump conformance to specifications. Vibration levels shall not be more than .075 in/sec at 1 times run speed and at pump frequency, and .04 in/sec at other multiples of run speed.

Tests, including Hydrostatic Leak checking of piping and operation of equipment, shall be performed in accordance with manufacturer's instructions.

Pumps shall be operated against Static Heads indicated, and Pump-Flow Capacity shall be verified.

Final test reports shall be provided to the Contracting Officer. Reports shall have a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

-- End of Section --