PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

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PIP RESP004
Liquid Ring Vacuum Pumps and Compressors Specification

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Data Forms

  PIP RESP004-DM Liquid Ring Vacuum Pumps
  Data Sheet (SI Units)

  PIP RESP004-D Liquid Ring Vacuum Pumps
  Data Sheet (US Customary Units)
1. Introduction

1.1 Purpose
This Practice provides the requirements for liquid ring vacuum pumps and compressors, drivers, and associated equipment.

1.2 Scope
This Practice describes the standard arrangement for liquid ring vacuum pumps and compressors and systems employing liquid ring machines. This Practice provides a framework for specifying a skid mounted liquid ring machines system “package,” for systems with drivers less than or equal to 150 kW (200 hp). This Practice can be applied to simple once-through arrangements, partial recirculation, and total recirculation systems.

Comment: This Practice can be used in conjunction with API 681.

A liquid ring machine data sheet, RESP004-DM/D, is included with this Practice. This data sheet may be used to communicate purchaser requirements; however, supplemental information may be necessary to fully define process requirements.

Vendor websites provide excellent visualizations of how LRV machines operate.

2. References
Applicable parts of the following Practices and industry codes and standards shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles will be used herein where appropriate.

2.1 Process Industry Practices (PIP)
- PIP CTCE1000 - External Coating System Selection Criteria
- PIP ELSMT01 - AC Squirrel Cage Induction Motors (600 Volts and Below) Specification
- PIP RECE002 - The Design of Piping Loads on Rotating Machinery Nozzles
- PIP REIE686/API RP686 - Recommended Practices for Machinery Installation and Installation Design
- PIP REIE686A - Recommended Practice for Machinery Installation and Installation Design (Supplement to PIP REIE686/API RP686)
- PIP RESE001 - Specification for General Purpose Skid-Mounted Packaged Equipment
- PIP REEE003 - Guidelines for General Purpose Nonlubricated Flexible Couplings
- PIP RESP002 - Design of ASME B-73.1 and General Purpose Pump Baseplates
- PIP VECV1001 - Vessel / S&T Heat Exchanger Design Criteria, ASME Code Section VIII, Divisions 1 and 2
- PIP VEDST003 - Shell and Tube Heat Exchanger Specification Sheet
- PIP VESSM001 - Specification for Small Pressure Vessels and Heat Exchangers with Limited Design Conditions
- PIP VESPMI01 - Positive Material Identification Specifications
2.2 **Industry Codes and Standards**

- American National Standards Institute (ANSI)
  - ASME/ANSI B16.21 - *Non-Metallic Flat Gaskets for Pipe Flanges*
  - ASME/ANSI B16.5 - *Pipe Flanges and Flanged Fittings*
- American Petroleum Institute (API)
  - API 681 - *Liquid Ring Vacuum Pumps and Compressors for Petroleum, Chemical, and Gas Industry Services*
  - API 682 - *Pumps Shaft Sealing Systems for Centrifugal and Rotary Pumps*
- American Society for Testing and Materials (ASTM)
  - A-193 - *Steel Bolting*
  - A-194 - *Steel Nuts*
- American Society of Mechanical Engineers (ASME)
  - ASME B16.20 (API 601) - *Metal Gaskets for Pipe Flanges*
  - ASME B46.1 - *Surface Texture*
  - *ASME Boiler and Pressure Vessel Code Section VIII*
- Heat Exchanger Institute
  - *Performance Standard for Liquid Ring Vacuum Pumps*
- International Organization for Standardization (ISO)
  - 1940 - *Mechanical Vibration–Balance Quality Requirements of Rigid Rotors*
- Rubber Manufacturers Association (RMA)
  - RMA IP-24 - *Drives Using Synchronous Belts*
- Tubular Exchanger Manufacturers Association (TEMA)
  - Type C or R

3. **Definitions**

*liquid ring vacuum pumps*: machines that use liquid as the working fluid and sealant, and have a rotor in an eccentric casing to reduce suction pressure below atmospheric.

*liquid ring compressors*: machines that use liquid as the working fluid and sealant, and have a rotor in an eccentric casing to increase gas pressure.

*liquid ring machines (LRM)*: either liquid ring vacuum pump or liquid ring compressor.

*maximum allowable working pressure (MAWP)*: defined in accordance with *ASME Code Section VIII*

*once-through system*: a vacuum system that uses a sealant that is pumped into the machine, exits with the gas discharge, and is not recovered for reuse.

*owner*: the party who owns the facility wherein the LRM system will be used.

*packaged liquid ring machine systems*: Complete systems that are assembled into purchaser-specified or manufacturer-designed “packages,” and are transportable, easy to install, and economical.
partial recirculation liquid ring machine system: a system that recovers and reuses only a part of the sealant and requires that a substantial portion of the sealant flow consist of fresh make-up fluid

purchaser: the party who awards the contract to the supplier. The purchaser may be the owner or the owner’s authorized agent.

purchaser’s inspector: the purchaser’s authorized representative with authority to act in the interest of, and on behalf of, the purchaser in all quality assurance matters

sealant: the liquid forming the liquid ring in the liquid ring machine. Also the same liquid as the working fluid.

supplier: the party responsible for providing the liquid ring machine system

total recirculation liquid ring machine system: a system that recovers and reuses substantially all the sealant and requires little make-up fluid for system losses. These systems are common in the chemical industry and when there are environmental concerns about contaminated sealant.

liquid ring systems: systems that employ liquid ring machine and include the necessary drivers and support equipment for a flange-to-flange system. These typically include the liquid ring machine and its driver; a discharge knock-out vessel; a sealant heat exchanger; a sealant circulation system (e.g., pump, etc.); and appropriate piping, instrumentation, and controls. See Figure 1 for schematics of systems with liquid ring machines.

Figure 1. Typical Systems
4. Requirements

4.1 General

4.1.1 Liquid ring system shall be in accordance with this Practice; local laws, rules, and regulations; and purchaser’s PIP RESP004-DM/D Data Sheets.

4.1.2 Quotation shall be accompanied by a completed PIP RESP004-DM/D Data Sheet and the necessary drawings to determine configuration and component details and control requirements.

4.1.3 Exceptions taken to this Practice shall be clearly shown in the quotation. Each exception shall be priced as an option with delivery effects noted.

4.1.4 A coordination meeting shall be conducted with the purchaser if specified on the PIP RESP004-D/M Data Sheet.

4.2 Vacuum System Design

4.2.1 The following properties of the sealant intended for use in the liquid ring machine system shall be in accordance with the purchaser’s PIP RESP004-DM/D Data Sheet:
   a. Chemical properties including reactivity and corrosivity
   b. Physical properties including temperature, vapor pressure, and particulate loading

4.2.2 The following properties of the gas being pumped shall be in accordance with the purchaser’s PIP RESP004-DM/D Data Sheet:
   a. Chemical properties and the allowable degree of saturation of the sealant
      
      Comment: Saturation of the seal liquid is a serious concern for equipment in a recirculation system.
   b. Physical properties including temperature and particulate loading

4.2.3 Unless otherwise specified, the nominal corrosion allowance for all components shall be as follows:
   a. For stainless steels and all nonferrous alloys, 0.0 mm (0.0 inch)
   b. For carbon and low-alloy steels, 1.3 mm (1/16 inch)

4.2.4 Except for the deletion of the heat exchanger and modification/replacement of any flow orifices, requirements for partial recirculation systems shall be the same as for total recirculation systems.

4.2.5 Unless otherwise specified, bolting shall be A-193, Grade B7, with SA-194, Grade 2H heavy hex nuts.

4.2.6 Total sealant flow required and cooler heat transfer requirements (if applicable) shall be provided in the quotation.

4.2.7 If required, a heat exchanger shall be provided. The tube length, diameter, exchanger construction, and exchanger tube excess surface area shall also be provided with the quotation. The temperature rise and minimum flow velocity through the cooler shall be provided with the quotation.

4.2.8 If a recirculation pump is required, a centrifugal circulation pump of appropriate construction shall be provided and shall include a mechanical seal.
4.2.9 If the purchaser furnishes for review the control philosophy and the intended application of alarms and protective shutdowns for the liquid ring machine system, supplier shall furnish comments, including any cautionary/corrective comments or recommendations with the quotation. Additionally, equipment required for compliance with the purchaser’s control philosophy shall be provided.

4.3 Liquid Ring Machine

4.3.1 If approved by the purchaser, tie rod casing construction shall be permitted.

4.3.2 Single-stage liquid ring machines designed for operation at less than 75 mm Hg (3 inch Hg) shall have cavitation protection.

4.3.3 The extent of using sleeves to protect sections of the rotor from corrosion and the method(s) of sealing the sleeves shall be clearly described in the quotation.

4.3.4 Unless otherwise specified, cartridge-type mechanical seal installations shall be provided. Seals shall be removable without removing the liquid ring machine end, housing, inlet or discharge piping or disturbing the drive.

4.3.5 Unless otherwise specified, a cartridge seal installation shall have the following characteristics:

a. Materials of construction shall be compatible with the process, reference API 682.

b. A method of detecting a seal leak shall be provided.

Comment: A seal leak is generally inward on vacuum systems and can be a concern and often a reason to use a multiple seal arrangement for leak sensitive applications.

c. A method for keeping sealing fluid on the seal faces shall be provided.

4.3.6 Rotor balance quality shall be ISO-1940, grade 2.5 or lower, and all balance weights shall be attached by welding or by locked stainless steel attachment hardware.

4.3.7 Rotor tip speed shall be 38 m/sec (80 ft/sec) maximum.

4.3.8 Constructions that do not require removal of the casing supports for seal replacement are preferred. If this construction is not provided, the alternate construction shall be described in the quotation.

4.3.9 The maintenance procedures for seal replacement shall be provided in the quotation.

4.3.10 Bearings shall be rolling element with L-10 life of 40,000 hours minimum based on maximum anticipated belt loading and lubrication.

4.3.11 Oil lubrication of bearings is preferred. If specified by the purchaser, provisions for oil mist lubrication shall be provided. Purchaser approval is required for grease lubricated bearings.

4.3.12 Bearing housing vibration shall comply with API 681.

4.3.13 The Supplier shall assure that the liquid ring machine and driver are free of harmful lateral or torsional critical speeds. Refer to API 681 for requirements of torsional and lateral critical speeds.

4.3.14 The limits on the allowable nozzle loads shall comply with PIP RECE002.
4.3.15 The critical clearance shall be stated, and performance degradation data shall be provided to correlate with incremental increases in the critical clearance. The data information shall include the following:

   a. A description of the specific critical clearance arrangement (i.e., whether the clearance is rotor-to-end-plate, rotor-to-cone, or some other arrangement)
   b. The minimum/nominal values and the acceptable ranges for the critical clearance
   c. The procedure for resetting the clearances and restoring operational efficiency
   d. Limitations with operational temperatures
   e. Limitation of rate of temperature change for the liquid ring machine or its seal fluid
   f. Material loss limitations (i.e., how much material on the critical clearance setting surfaces can be lost to corrosion, etc.) and the effects of non-uniform loss on performance. The threshold of performance loss perception shall be 5%. This percentage shall include the limitations on component re-machining (i.e., corrections to surfaces forming the critical clearances and the effects of the corrections on liquid ring machine performance).

4.3.16 Unless otherwise specified, the baseplate for a stand-alone liquid ring machine shall be in accordance with PIP RESP002.

4.3.17 Uniform equipment foot support shall be provided and verified with the “soft foot” checks in accordance with PIP REIE686/AI RP686.

4.3.18 For a package skid, a liquid ring machine may be mounted either as an individual piece of equipment on the skid or mated to a machined base that is either welded or bolted to the skid.

4.4 **Driver Design**

4.4.1 Unless otherwise specified, motors shall be in accordance with PIP ELSMT01.

4.4.2 All special motor requirements shall be shown on the purchaser’s PIP RESPP004-DM/D Data Sheet.

4.4.3 Direct drive arrangements are preferred.

4.4.4 The following motor data shall be included as a minimum in the quotation:

   a. Motor power nameplate rating
   b. Motor type (e.g., TEFC, explosion proof, etc.)
   c. Motor service factor
   d. Motor-operating speed in revolutions per minute (RPM)
   e. Motor power required for continuous operation at the design point
   f. Maximum power required for vacuum pump operation
   g. Motor frame identification numbers
   h. Motor bearing identification (i.e., the bearing manufacturer’s identification) and the part designation from the liquid ring machine manufacturer
4.4.5 The driver's starting-torque capabilities shall exceed the speed-torque requirements of the driven equipment. Particular attention shall be given to starting conditions when the liquid ring machine may be required to start with the suction at atmospheric pressure.

4.4.6 Unless otherwise specified, for direct drive arrangements, a spacer type, flexible element, non-lubricated coupling shall be provided and mounted in accordance with PIP REEE003.

4.4.7 Unless otherwise specified, belt drive arrangements shall be in accordance with RMA IP-24. Calculations for belt drives shall be included in the quotation and purchase order documentation.

Comment: V-Belts, per RMA IP-20, are not recommended above 50 horsepower.

4.4.8 A removable coupling/belt guard shall be provided that is in accordance with the following requirements:

   a. Site specific laws, rules, or regulations specified on the purchaser’s PIP RESP004-DM/D Data Sheet
   b. Preferably of a one-piece, ventilated baseplate-mounted design. Alternate designs shall be clearly described in the quotation.
   c. Permit access to the bearing housings with a vibration probe of 13-mm (1/2-inch) maximum diameter in both vertical and horizontal positions
   d. Permit visual inspection of the coupling or belt during operation.

4.4.9 Jack screws shall be provided for axial and lateral horizontal positioning of the motor. Full width stainless steel shims under the driver feet, shim pack shall consist of a maximum of 5 shims, none with a thickness greater than 3 mm (1/8 in).

4.5 System Components

4.5.1 Vessels

   4.5.1.1 Unless otherwise specified, vessels shall be in accordance with PIP VECV1001, PIP VESV1002 and VESSM001.

   4.5.1.2 If the vessels are not within the scope of PIP VECV1001, VESSM001, and ASME Pressure Vessel Code, the vessels shall be designed, fabricated, and inspected to meet the ASME Pressure Vessel Code.

   4.5.1.3 The Supplier shall state the quantity of the ring liquid that will remain entrained in the gas delivered from the separator at each specified operating condition. The Purchaser will specify any limitations on liquid carryover from the system.

Comment: Transient conditions such as start-up and shutdown may cause unusual carryover conditions.

4.5.2 Heat Exchangers

   4.5.2.1 Unless otherwise specified, heat exchangers shall be in accordance with PIP VESSM001.
4.5.2.2 Unless otherwise specified, minimum heat exchanger requirements shall be TEMA type C and ASME Boiler and Pressure Vessel Code Section VIII, Div 1.

4.5.2.3 The sealant for the liquid ring machine shall be on the shell side of the exchanger.

4.5.2.4 Exchangers shall be hydrostatically tested, and the hydrostatic test documentation shall be provided to the purchaser.

4.5.2.5 A nameplate shall be provided stating as a minimum the exchanger manufacturer’s identification, materials of construction, and test pressure.

4.5.2.6 Unless otherwise specified, heat exchangers in high-fouling services shall be TEMA C design and ASME Pressure Vessel Code stamped.

4.5.2.7 Heat exchangers shall be constructed and arranged to allow removal of tube bundles without dismantling piping or machine components.

4.5.3 Gaskets

4.5.3.1 Gasket-type(s) and materials shall be provided in accordance with the purchaser’s PIP RESP004-DM/D Data Sheet.

4.5.3.2 Unless otherwise specified, gaskets shall be in accordance with the dimensional requirements of the following industry standards:

   a. For non-metallic flat gaskets: Self-centering, PN 20 (ASME/ANSI B16.21, Class 150) minimum for ASME/ANSI B16.5 raised-face dimensions

   b. For spiral-wound gaskets: PN 20 (ASME B16.20 (API 601), (Class 150)) minimum with inner and outer gauge rings for ASME/ANSI B16.5 raised-face dimensions

   c. Gasket bearing surface finished shall be in accordance with purchaser’s PIP RESP004-DM/D Data Sheet.

4.5.3.3 Any deviation from the gaskets specified in Section 4.5.3.2 shall be submitted for purchaser’s approval. If alternate gaskets are approved, two spare gaskets shall be provided for each alternative gasket application.

4.5.3.4 Unless otherwise specified, gaskets used in factory tests shall be production gaskets and shipped in the assembled system.

4.5.4 Instrumentation/Controls/Electrical

4.5.4.1 Instrumentation, controls, and electrical requirements shall be agreed with purchaser.

4.5.4.2 Instrumentation and control drawings and logic diagrams shall be provided.

4.5.4.3 Pressure/vacuum relief protection for the equipment shall be provided and shall include applicable pressure/vacuum relief devices calculations.

4.5.5 Supports, Skid, and System Assembly

4.5.5.1 Unless otherwise specified, packaged equipment shall be in accordance with PIP RESE001.
4.5.5.2 The total assembled skid weight (i.e., both empty and filled with water) shall be shown on the assembly drawing.

4.5.5.3 Volumes (in liters or gallons) of each vessel shall be shown on each vessel assembly drawing.

4.5.5.4 The lifting weight of each vessel (i.e., both empty and liquid-filled) shall be shown on each vessel assembly drawing.

4.5.5.5 For system components weighing greater than 25 kilograms (50 lbs), the center of gravity of each component shall be shown on its drawing or specifically identified in the purchase order documentation.

4.5.5.6 The tabulated component weights, individual component center of gravity locations (i.e., empty and liquid-filled), and the skid center of gravity (i.e., both empty and liquid-filled) shall be clearly shown on the outline drawing for the skid.

4.5.5.7 If specified, datum line dimensional information shall be shown on the review/fabrication prints. The datum line used shall be clearly identified on review prints.

4.5.5.8 If needed for clarity or the datum line cannot be easily accessed after skid assembly and shipment, approximate reference transfer dimensions shall be provided in addition to datum line dimensions.

4.5.6 Pumps, Valves/Controls, and Miscellaneous Components

Miscellaneous components specified on purchaser’s PIP RESP004-DM/D Data Sheet shall be provided.

4.5.7 Materials to be Provided

Unless otherwise specified on the purchaser’s PIP RESP004-DM/D Data Sheet, all materials necessary for a complete system shall be provided.

4.5.8 Prohibited Materials

Unless otherwise specified, the following materials shall not be permitted in or on the vacuum pump, the skid, or any part of the system:

a. Asbestos
b. Mercury-containing products
c. Cadmium-plated products
d. SA-515 and SA-414 (B-G) carbon steels unless in accordance with toughness requirements of a recognized industry standard
e. Nuclear devices
f. Materials containing greater than 200 ppm of lead or chlorine

4.5.9 Coatings

Unless otherwise specified, coatings shall be in accordance with PIP CTCE1000.
4.5.10 Piping

4.5.10.1 Unless otherwise specified, piping shall be provided and inspected in accordance with ASME B31.3.

Comment: Socket weld or flanged piping should be provided to minimize leakage.

4.5.10.2 Piping flange alignment to equipment nozzles shall be in accordance with PIP REIE686/API RP686.

4.6 Inspection

4.6.1 Inspections shall be conducted in accordance with this Practice, the referenced standards, and additional specific inspection requirements, if any, shown on purchaser’s PIP RESP004-DM/D Data Sheet.

4.6.2 All alloy components in contact with the process to be subject to Positive Material Identification (PMI) in accordance with PIP VESPMI01.

4.6.3 The Liquid Ring Machine and skid shall be available to the purchaser or the purchaser’s inspector for inspection of workmanship and functionality.

4.6.4 Any problems shall be corrected before shipment.

4.7 Testing

4.7.1 Unless otherwise specified, a factory mechanical and water performance test on air shall be performed to verify compliance with the stated or guaranteed performance. Full documentation of this testing shall be provided to the purchaser.

4.7.2 If specified, a vacuum pump performance test shall be performed in accordance with Heat Exchanger Institute Performance Standard for Liquid Ring Vacuum Pumps. This test may be performed at the factory or at the installation site; however, the test shall be performed at the installation site if the fluids and gas performance cannot be reasonably predicted with a water test. Full documentation of this testing shall be provided to the purchaser at time of system delivery.

4.7.3 Unless otherwise specified, for pressure-testing stainless steel system components, including piping and vessels, only potable water with a chlorine ion concentration less than or equal to 50 ppm shall be used, or specific cleaning and drying procedures approved by the purchaser shall be used.

4.7.4 For variable speed machines, a test agreed between the Purchaser and the supplier shall be conducted to establish the operating limits of liquid ring stability.

4.8 Documentation

Unless otherwise specified, the following documentation shall be provided to the purchaser:

a. Assembly/arrangement drawings
b. P&ID drawings
c. Maintenance/operations instructions
d. Spare parts information and recommendations
e. Positive material identification certification
f. Certified performance curves
g. Completed data sheets for all provided equipment

4.9 Shipping and Receiving

4.9.1 Shipping requirements shall be agreed with purchaser before shipment of any system components.

4.9.2 Equipment openings shall be suitably blanked or sealed to prevent contamination.

4.9.3 Any components subject to damage from shifting or movement during shipment shall be blocked in position for shipping.

4.9.4 The equipment shipped shall be prepared for 6 months minimum of outdoor storage.

4.9.5 Components that are not shipped assembled into the system or installed on the skid shall be identified with 75 mm by 75 mm (3-inch by 3-inch) stainless steel tags that are securely attached with stainless steel wire. A tag shall show the following information about the component being shipped separately:

   a. Component name and identification
   b. The component(s) to which the separately shipped component mates
   c. The system of which the component is a part
   d. The drawing(s) that show the component’s location and installation

4.9.6 Details of shipping arrangements and identification conventions shall be provided and agreed with purchaser for systems that are not shipped fully assembled or that require special installation and/or handling considerations.

4.9.7 The guidelines for equipment receipt and installation included in PIP REIE686/API RP686, Chapter 3, shall be consulted.
A. LIQUID RING VACUUM PUMP:

MODEL: ___________________________  NOTE: PURCHASER MAY FILL OUT SECTION C OF THIS DATA SHEET FOR MODEL SELECTION BY SUPPLIER.

INLET CAPACITY: ___________ M³  SUCTION PRESS.: _________ TORR  DISCHARGE PRESS.: _________ kPa

SEAL LIQUID TEMP.: ___________ °C

MATERIAL OF CONSTRUCTION: □ MANUF. STD.  □ NODULAR IRON  □ OTHER: ___________

B. PUMP PACKAGE SPECIFICATIONS:

☐ STANDARD SKID UNIT WITH COOLER (TOTAL RECIRC.)  ☐ MACHINE, MOTOR, AND BASE-PLATE ONLY

☐ STANDARD SKID UNIT WITHOUT COOLER  ☐ SUPPLY BAREMACHINE ONLY, OMIT PACKAGE

PIPING MOC: ☐ CARBON STEEL  ☐ OTHER  ☐ SEPARATOR POT MOC: ☐ CARBON STEEL

MIN DESIGN METAL TEMP.: ___________

ITEM/EQUIP. NOS.: MACHINE: ___________  SEPARATOR POT: ___________  COOLER: ___________  MOTOR: ___________

ELEC. AREA CLASSIFICATION: CLASS: ___________  GROUP: ___________  DIVISION: ___________

C. PUMP LOAD (OPTIONAL) LRVP:

NONCONDENSABLES:

MOLECULAR WEIGHT  LOAD (KG/HR)  SOLUBILITY IN SEALANT WT % AT 1 ATM  K (CP/CV)

CONDENSABLES:

MOLECULAR WEIGHT  LOAD (KG/HR)  MISCIBLE WITH SEALANT?  K (CP/CV)  LATENT HEAT (W/kg)  VAPOR PRESSURE (TORR)

T1: ___________ °C  T2: ___________ °C

NO. DATE REVISION DESCRIPTION BY APVD.
4.1 GENERAL:
4.1.1 LOCAL REGULATIONS:

4.2 VACUUM SYSTEM DESIGN:
4.2.1 PROPERTIES OF SEALANT:
CHEMICAL COMPOSITION (INCLUDING REACTIVITY AND CORROSIVITY):

PHYSICAL PROPERTIES:
TEMPERATURE: °C
VAPOR PRESSURE: kPa @ °C
S. G.:
VISCOSITY: cP
LATENT HEAT: W/kg
THERMAL CONDUCTIVITY: W/kg/HR·m-°X
HEAT CAPACITY: W/kg-°C
HEAT CAPACITY:
SOLIDS/PARTICULATE CONTAMINATION:
PARTICULATE LOADING: PPM (WT)
SIZE:
PROPERTIES:
OTHER:

4.2.2 PROPERTIES OF GAS BEING PUMPED:
CHEMICAL PROPERTIES AND THE ALLOWABLE DEGREE OF SATURATION:

COMPOSITION: WT OR MOL %

PHYSICAL PROPERTIES:
TEMPERATURE: °C
PARTICULATE LOADING: PPM (WT)
MOLE WEIGHT:
SPECIFIC HEAT:
OTHER:

4.2.3 NOMINAL CORROSION ALLOWANCE:
☐ 0.00 MM STAINLESS STEEL AND ALL NONFERROUS ALLOYS
☐ 1.30 MM CARBON AND LOW-ALLOY STEELS
☐ OTHER:

4.5.3.2c ☐ 3.2-6.3 µm RA WITH SPIRAL OR CONCENTRIC MARKINGS (ONLY)
☐ OTHER:
4.2.5 BOLTING:
- SA-193, GRADE B7, WITH SA-194, GRADE 2H HEAVY HEX NUTS
- OTHER:

4.2.7 HEAT EXCHANGER REQUIRED:
- TUBE LENGTH: ________ M
- DIAMETER: ________ mm
- EXCHANGER CONSTRUCTION:
- EXCHANGER TUBE EXCESS SURFACE AREA (DESIGN):

4.2.8 RECIRCULATION PUMP REQUIRED

4.2.9 PROCESS CONTROL DOCUMENTATION REVIEW REQUIRED

ADDITIONAL EQUIPMENT:

4.3 LIQUID RING VACUUM PUMP

4.3.4 SEAL INSTALLATIONS:
- CARTRIDGE TYPE MECHANICAL SEAL:
- MODEL:
- OTHER:

4.3.5 CARTRIDGE TYPE SEALS:
- METHOD FOR DETECTING SEAL LEAK:
- METHOD FOR KEEPING LIQUID ON SEAL:

4.3.6 O-RING MATERIALS:
- VITON
- EPR
- KALREZ
- OTHER:

4.3.8 CASING SUPPORTS:
- MAINTENANCE PROCEDURES FOR SEAL REPLACEMENT IF CASING SUPPORTS REQUIRE REMOVAL:

4.4 DRIVER DESIGN:

4.4.1 ELECTRIC MOTOR:
- PIP ELMT01 - 200 HP AND BELOW
- IEEE-841 - UP TO 500 HP
- OTHER:

4.4.6 DIRECT DRIVE COUPLINGS:
- COUPLINGS PER PIP REEEE003
- OTHER:

4.4.7 BELT DRIVE:
- PER RMA IP-24
- OTHER:
4.5 SYSTEM COMPONENTS:

4.5.1 VESSELS:
- Designed in accordance with PIP VECV1001
- Other:

4.5.2 HEAT EXCHANGERS:
HEAT EXCHANGER CONSTRUCTION:
- Per PIP VESST001
- Other:

INSIDE DIAMETER LESS THAN 15 CM (6 INCHES):
- Not ASME code stamped or TEMA design
- Other:

INSIDE DIAMETER GREATER THAN OR EQUAL TO 15 CM (6 INCHES):
- ASME code stamped
- TEMA design
- Other:

4.5.2.6 HEAT EXCHANGERS, HIGH-FOULING SERVICES:
- TEMA design and ASME code stamped
- Removable bundle
- Other:

FOULING FACTOR TO BE USED FOR DESIGN:

4.5.3 GASKETS:
- Non-metallic flat gaskets
- Spiral-wound gaskets
- Other:

MATERIALS:
- Teflon
- Gylon 3510
- Paper
- Other:

4.5.4 INSTRUMENTATION/CONTROL/ELECTRICAL:
SEPARATOR POT LEVEL INDICATION:
- Provision for transmitter only
- Include sight glass
- Include transmitter
- Other:

4.5.4.3 PROVIDERS FOR INSTALLATION OF PRESSURE/VACUUM RELIEF DEVICES ONLY
PRESSURE SAFETY VALVES SHALL BE PER PIP PCPS001 AND PCPS010
- Other:

4.5.5 SUPPORTS, SKID, AND SYSTEM ASSEMBLY:
- Per PIP RESE001
- Manufacturer's standard
- Datum line dimensional information required on the review/fabrication prints
- Connect and run completion

4.5.6 MISCELLANEOUS COMPONENTS:

4.5.7 MATERIALS TO BE PROVIDED:
- Supplier shall furnish all materials necessary to provide a complete system
- Materials supplied by purchaser:
4.5.8 PROHIBITED MATERIALS:
THE FOLLOWING MATERIALS ARE NOT PERMITTED IN OR ON THE VACUUM PUMP, THE SKID, OR ANY PART OF THE SYSTEM PROVIDED BY THE SUPPLIER:

- ASBESTOS
- MERCURY-CONTAINING PRODUCTS
- CADMIUM-PLATED PRODUCTS
- SA-515 AND SA 414 (B-G) CARBON STEELS UNLESS TOUGHNESS REQUIREMENTS OF A RECOGNIZED INDUSTRY STANDARD ARE MET
- NUCLEAR DEVICES
- MATERIALS CONTAINING GREATER THAN 200 PPM OF LEAD OR CHLORINE

☐ OTHER: ____________________________

☐ MATERIALS LISTED ABOVE THAT ARE ACCEPTABLE FOR THIS PROJECT: ____________________________

4.5.9 COATINGS:
☐ PER PIP CTCE1000
☐ MANUFACTURER'S STANDARD COATING

☐ OTHER: ____________________________

4.5.10 PIPING:
☐ SUPPLIED AND INSPECTED IN ACCORDANCE WITH ASME B 31.3

☐ OTHER: ____________________________

4.6 INSPECTION:
ADDITIONAL INSPECTION REQUIREMENTS:

☐ MAINTAIN QUALITY ASSURANCE AND COMPLIANCE INSPECTION DOCUMENTATION FOR 3 YEAR PERIOD

☐ OTHER: ____________________________

4.7 TESTING:
☐ FACTORY MECHANICAL AND WATER PERFORMANCE TEST
☐ HEAT EXCHANGER INSTITUTE STANDARD PERFORMANCE TEST
☐ WITNESSED
☐ NO LIMIT ON CHLORIDE ION CONCENTRATION FOR WATER USED IN PRESSURE TESTING

☐ OTHER: ____________________________

4.8 DOCUMENTATION:
EXCEPTIONS:

4.9 SHIPPING AND RECEIVING:
☐ SUPPLIER'S STANDARD PROCEDURES

☐ OTHER: ____________________________

4. D. ADDITIONAL NOTES: ____________________________

____________________________________
____________________________________
____________________________________
____________________________________
____________________________________
____________________________________

LIQUID RING VACUUM PUMPS AND COMPRESSORS
(SI UNITS)

ASSOC. PIP
RESP004

DATA SHEET

RESP004-DM

PAGE 5 OF 5
JANUARY 2014
A. LIQUID RING VACUUM PUMP:

PUMP MODEL: ___________________________  NOTE: PURCHASER MAY FILL OUT SECTION C OF THIS DATA SHEET FOR MODEL SELECTION BY SUPPLIER.

INLET CAPACITY: ___________ ACFM  SUCTION PRESS.: ___________ TORR  DISCHARGE PRESS.: ___________ PSIG

SEAL LIQUID TEMP.: ___________ °F  PUMP MATERIAL OF CONSTRUCTION:  □ APPEN G&H  □ NODULAR IRON  □ 316 STAINLESS STEEL  □ OTHER: ___________

B. PUMP PACKAGE SPECIFICATIONS:

□ STANDARD SKID UNIT WITH COOLER (TOTAL RECIRC.)  □ PUMP, MOTOR, AND BASE-PLATE ONLY

□ STANDARD SKID UNIT WITHOUT COOLER  □ SUPPLY BARE PUMP ONLY, OMIT PACKAGE

PIPING MOC:  □ CARBON STEEL  □ 316L SST  SEPARATOR POT MOC:  □ CARBON STEEL  □ 316L SST

MIN DESIGN METAL TEMP.: ___________

ITEM/EQUIP. NOS.:  PUMP: ___________  SEPARATOR POT: ___________  COOLER: ___________  MOTOR: ___________

ELEC. AREA CLASSIFICATION:  CLASS: ___________  GROUP: ___________  DIVISION: ___________

C. PUMP LOAD (OPTIONAL) LRVP:

NONCONDENSABLES:

<table>
<thead>
<tr>
<th>MOLECULAR WEIGHT</th>
<th>LOAD (LB/HR)</th>
<th>SOLUBILITY IN SEALANT WT % AT 1 ATM</th>
<th>K (CP/°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

CONDENSABLES:

<table>
<thead>
<tr>
<th>MOLECULAR WEIGHT</th>
<th>LOAD (LB/HR)</th>
<th>MISCIBLE WITH SEALANT?</th>
<th>K (CP/°C)</th>
<th>LATENT HEAT (BTU/LB)</th>
<th>VAPOR PRESSURE (TORR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T1: °F  T2: °F</td>
</tr>
</tbody>
</table>

NO.  DATE  REVISION DESCRIPTION  BY  APVD.
## 4.1 GENERAL:

### 4.1.1 LOCAL REGULATIONS:

- [ ] Coordination meeting required

## 4.2 VACUUM SYSTEM DESIGN:

### 4.2.1 PROPERTIES OF SEALANT:

**CHEMICAL COMPOSITION (INCLUDING REACTIVITY AND CORROSIVITY):**

**PHYSICAL PROPERTIES:**

- Temperature: °F
- Vapor pressure: PSIA @ °F
- S. G.:
- Viscosity: cP
- Latent heat: BTU/LB
- Thermal conductivity: BTU/HR-FT-°F
- Heat capacity: BTU/LB-°F
- Heat capacity:
- Solids/particulate contamination:
  - Particulate loading: PPM (WT)
  - Size:
  - Properties:
  - Other:

### 4.2.2 PROPERTIES OF GAS BEING PUMPED:

**CHEMICAL PROPERTIES AND THE ALLOWABLE DEGREE OF SATURATION:**

**PHYSICAL PROPERTIES:**

- Temperature: °F
- Particulate loading: PPM (WT)
- Mole weight:
- Specific heat:
- Other:

### 4.2.3 NOMINAL CORROSION ALLOWANCE:

- 0.00 MM (0.0 INCH) STAINLESS STEEL AND ALL NONFERROUS ALLOYS
- 1.30 MM (1/16 INCH) CARBON AND LOW-ALLOY STEELS
- Other:

### 4.5.3c GASKET-BEARING SURFACE FINISH:

- 125-250 RA WITH SPIRAL OR CONCENTRIC MARKINGS (ONLY)
- Other:
4.2.5 BOLTING:
- SA-193, GRADE B7, WITH SA-194, GRADE 2H HEAVY HEX NUTS
- OTHER:

4.2.7 HEAT EXCHANGER REQUIRED:
- TUBE LENGTH: _______ FT
- DIAMETER: _______ INCH
- EXCHANGER CONSTRUCTION:
- EXCHANGER TUBE
- EXCESS SURFACE AREA (DESIGN):

4.2.8 RECIRCULATION PUMP REQUIRED

4.2.9 PROCESS CONTROL DOCUMENTATION REVIEW REQUIRED

4.3 LIQUID RING VACUUM PUMP

4.3.4 SEAL INSTALLATIONS:
- CARTRIDGE TYPE MECHANICAL SEAL:
  - MODEL:
  - OTHER:

4.3.5 CARTRIDGE TYPE SEALS:
- METHOD FOR DETECTING SEAL LEAK:
- METHOD FOR KEEPING LIQUID ON SEAL:

4.3.8 CASING SUPPORTS:
- LUBRICATION OF BEARINGS:
- SPECIAL PURCHASER MOTOR REQUIREMENTS:
- ELECTRICAL:
  - 460 VOLTS, 3 PHASE, 60 HZ
  - OTHER: _______ VOLTS _______ HZ
- MOTOR TYPE:
  - TEFC
  - EXPLOSION PROOF
  - OTHER:

4.4 DRIVER DESIGN:

4.4.1 ELECTRIC MOTOR:
- PIP ELSMT01 - 200 HP AND BELOW
- IEEE-841 - UP TO 500 HP
- OTHER:
- SPECIAL PURCHASER MOTOR REQUIREMENTS:

4.4.6 DIRECT DRIVE COUPLINGS:
- COUPLINGS PER PIP REEE003
- OTHER:

4.4.7 BELT DRIVE:
- PER RMA IP-24
- OTHER:
4.5 SYSTEM COMPONENTS:

4.5.1 VESSELS:
- Designed in accordance with PIP VECV1001
- Other:

4.5.2 HEAT EXCHANGERS:
- Heat exchanger construction:
  - Per PIP VESST01
  - Other:

Inside diameter less than 15 cm (6 inches):
- Not ASME code stamped or TEMA design
- Other:

Inside diameter greater than or equal to 15 cm (6 inches):
- ASME code stamped
- TEMA design
- Other:

4.5.2.6 HEAT EXCHANGERS, HIGH-FOULING SERVICES:
- TEMA design and ASME code stamped
- Removable bundle
- Other:

Fouling factor to be used for design:

4.5.3 GASKETS:
- Non-metallic flat gaskets
- Spiral-wound gaskets
- Other:

Materials:
- Teflon
- Gylon 3510
- Paper
- Other:

4.5.4 INSTRUMENTATION/CONTROL/ELECTRICAL:
- Separator pot level indication:
  - Provision for transmitter only
  - Include transmitter
  - Include sight glass
  - Other:

4.5.4.3 Provisions for installation of pressure/vacuum relief devices only:
- Pressure safety valves shall be per PIP PCPS001 and PCPS010
- Other:

4.5.5 SUPPORTS, SKID, AND SYSTEM ASSEMBLY:
- Per PIP RESE001
- Datum line dimensional information required on the review/fabrication prints
- Manufacturer's standard
- "Connect and Run" completion

4.5.6 MISCELLANEOUS COMPONENTS:

4.5.7 MATERIALS TO BE PROVIDED:
- Supplier shall furnish all materials necessary to provide a complete system
- Materials supplied by purchaser:
4.5.8 PROHIBITED MATERIALS:

The following materials are not permitted in or on the vacuum pump, the skid, or any part of the system provided by the supplier:

- Asbestos
- Mercury-containing products
- Cadmium-plated products
- SA-515 and SA 414 (B-G) carbon steels unless toughness requirements of a recognized industry standard are met
- Nuclear devices
- Materials containing greater than 200 ppm of lead or chlorine

☐ Other:
☐ Materials listed above that are acceptable for this project:

4.5.9 COATINGS:

☐ Per PIP CTCE1000
☐ Manufacturer’s standard coating
☐ Other:

4.5.10 PIPING:

☐ Supplied and inspected in accordance with ASME B 31.3
☐ Other:

4.6 INSPECTION:

Additional inspection requirements:

☐ Maintain quality assurance and compliance inspection documentation for 3 year period
☐ Other:

4.7 TESTING:

☐ Factory mechanical and water performance test
☐ Heat exchanger institute standard performance test
☐ Witnessed
☐ No limit on chloride ion concentration for water used in pressure testing
☐ Other:

4.8 DOCUMENTATION:

☐ Exceptions:

☐ Other:

4.9 SHIPPING AND RECEIVING:

☐ Supplier’s standard procedures
☐ Other:

4.9.10 ADDITIONAL NOTES: