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The RheoVac Probe

AIR-IN-LEAK MONITOR



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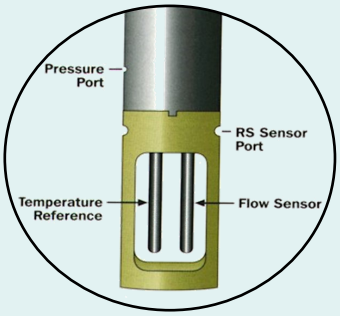
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Overview

The RheoVac is a multi-sensor probe installed in the vent line of a steam condenser. A one-of-a-kind monitoring system, it is capable of measuring several key parameters through one line penetration:

- **Temperature**
- **Mass Flow Rate**
- **Relative Saturation**
- **Pressure**



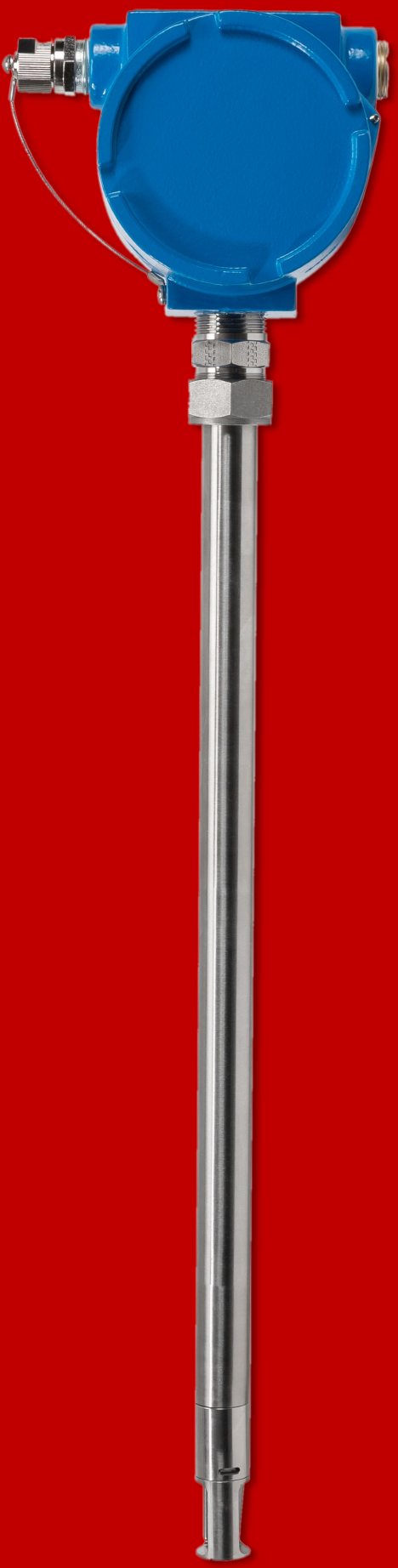
Through these measurements, the RheoVac directly calculates essential parameters for monitoring plant performance:

- **Air-In-Leakage:** An absolute reading of all non-condensable gases traveling from the condenser to the exhauster.
- **Water-to-Air Mass Ratio:** This value is a measure of vacuum quality, a value above ~3 indicates no excess back pressure is present due to air-in-leakage or stagnant zones.
- **Volumetric Flow Rate:** A measurement of the total flow of condensable and non-condensable gases used to measure pump capacity.
- **Mass Flow Rate:** A measurement of the total flow of condensable and non-condensable gases used to measure ejector capacity.

The RheoVac monitor is the only instrument capable of analyzing the complex and dynamic nature of the mixture of non-condensable gases and water vapor in the condenser vent line. This allows plant operators to immediately differentiate between backpressure increases due to increased condenser air in-leak vs reduced exhauster capacity. Analysis of the RheoVac data also permits identification of some condenser configuration design deficiencies.

By measuring air-in-leakage flow between the condenser and the exhauster(s), a true reading of condenser air in-leakage is made. A measurement made at the exhauster discharge is often inaccurate as it includes air in-leakage from exhauster seals and vent line valves. Exhauster outlet measurements generally require proper seating of a manually operated diverter valve, which can affect the reading.

The RheoVac Monitor is a valuable tool for decision makers, providing accurate, real time data for more precise identification of air removal related causes of condenser problems. It reduces the man-hours spent in physical inspections and diagnostic analysis, permits more orderly maintenance scheduling, assists operations regarding venting equipment, and lowers the risk of untimely outages.



FEATURES

- Provides direct reading of condenser air in-leak
- Measures actual exhauster capacity
- Quantifies excess back pressure
- On-line insertion through leak-tight ball valve assembly
- On-board sensor diagnostics
- Real time data is stored locally and can be routed to DCS

BENEFITS

Supports efforts to:

- Locate air in-leak
- Detect tube fouling
- Reduce heat rate
- Lower fuel costs
- Recapture lost load
- Minimize chemical costs
- Increase availability
- Decrease Corrosion
- Detect Air Storage & Air Bound Zones

And More!

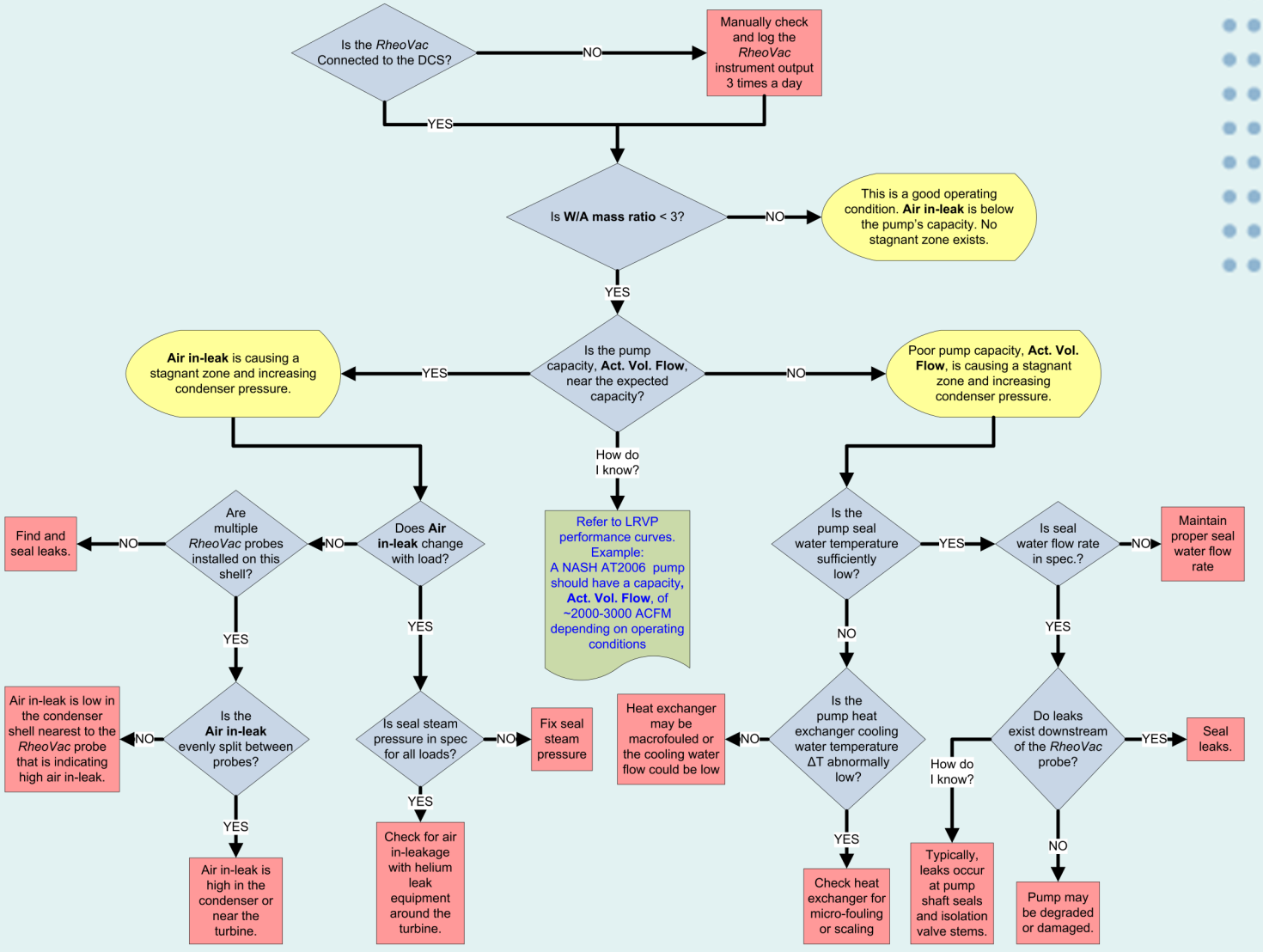
SPECIFICATIONS

Accuracy:	±5% of total mass flow
Repeatability:	±1.5% of reading
Line Size:	3” through 18”
Probe Connection:	1 1/2” Ball Valve Assembly
Wetted Surface	316 SS, Engineered Plastic
Temperature:	Operating — 40°-250°F Environment — 0 °F-120 °F
Pressure:	Operating — 0.5”-10” HgA
Mass Ratio:	Operating — 0.0001 - 20
Input Power:	100-250 VAC, 50-60 Hz
Signal Outputs:	Ethernet or Serial Modbus; Optional — 4-20 mA signal per data output or HART
Display:	Backlit two-line LCD; Optional touchscreen display

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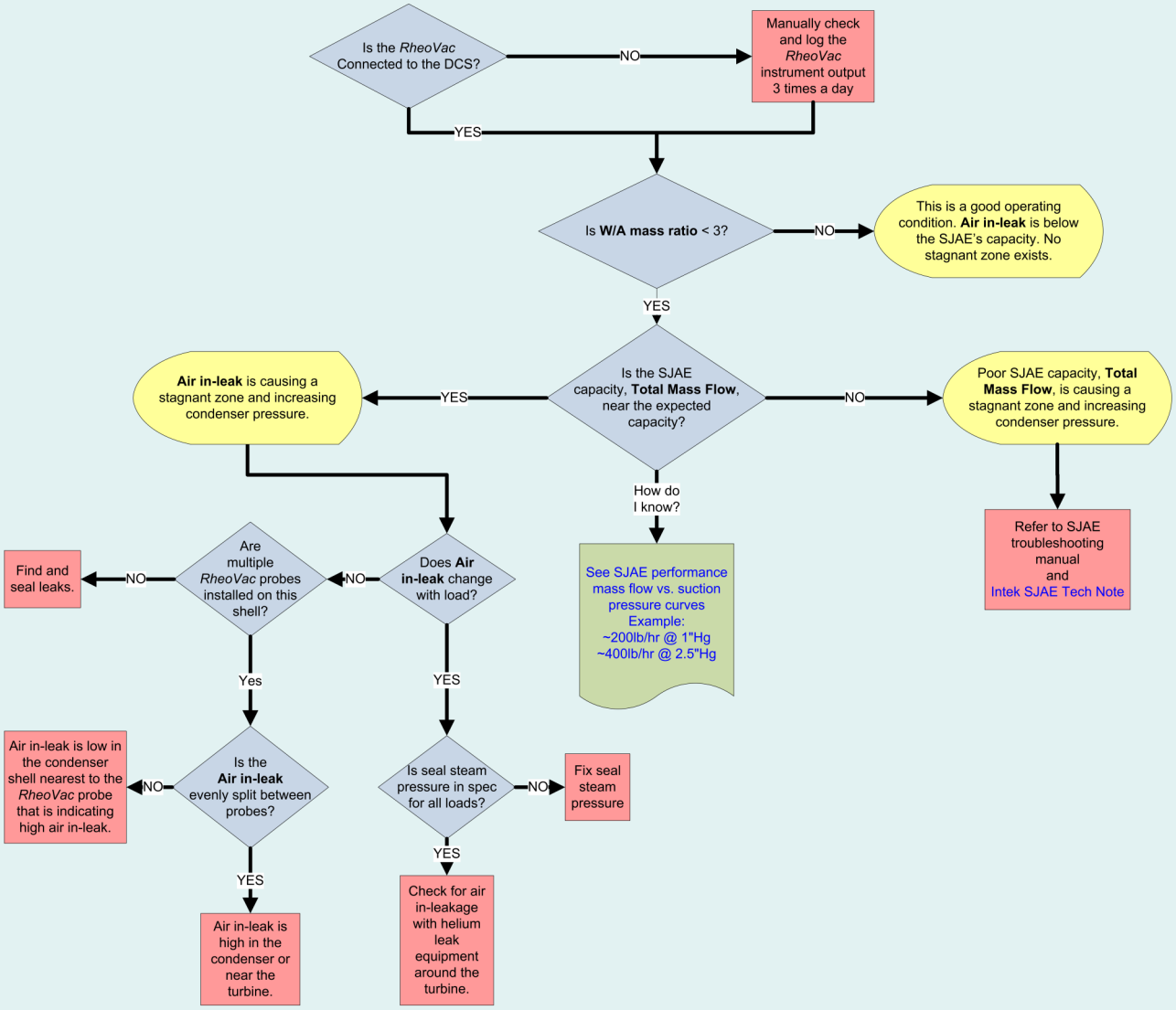
Diagnostic Flow Chart - LRVP

The Rheovac probe is able to help identify the root cause of underperforming condensers, and quickly troubleshoot performance issues as they arise. Two diagnostic flow charts were developed to assist RheoVac users in isolating the root cause of performance degradation, and provide recommendations on how to address the problems. The performance issues differ slightly depending on if the exhausters used are Liquid Ring Vacuum Pumps (LRVPs) or Steam-Jet Air Ejectors (SJAEs).



RheoVac Diagnostic Flow Chart for units with Liquid Ring Vacuum Pumps

Diagnostic Flow Chart - SJAE

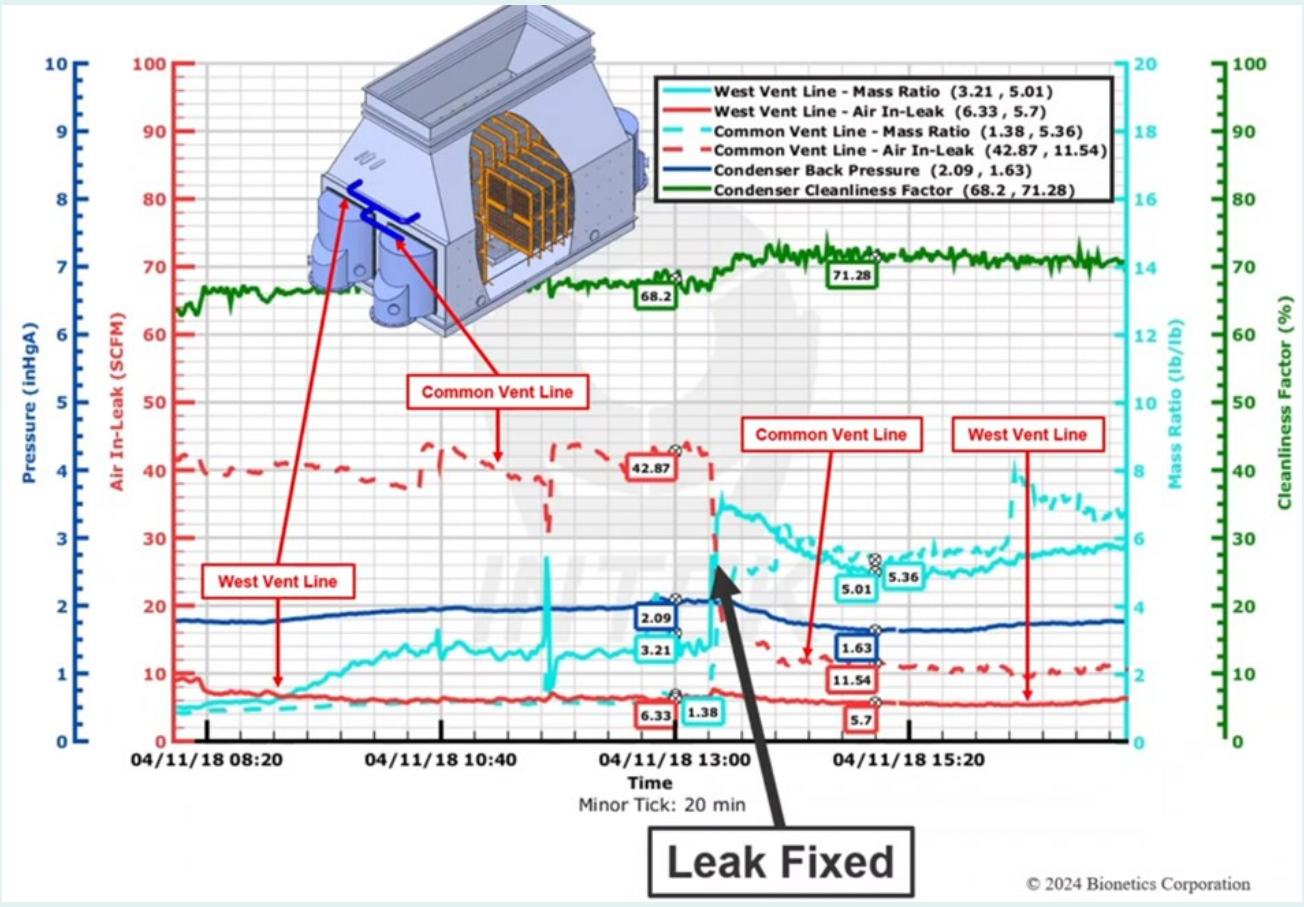


RheoVac Diagnostic Flow Chart for units with Steam Jet Air Ejectors



Air-in-Leakage Case Study

A power plant contacted Bionetics after they began experiencing high air-in-leakage. This plant had two Rheovac probes installed, one in the west vent line, and one in the common vent line. The east vent line was unable to be accessed, but could still be measured by subtracting the west vent line air-in-leak measurement from the common line measurement. Bionetics analyzed the data from the sensors and was able to determine that there was a large leak in the east side of the condenser. The data is shown in the multi-axis plot below.

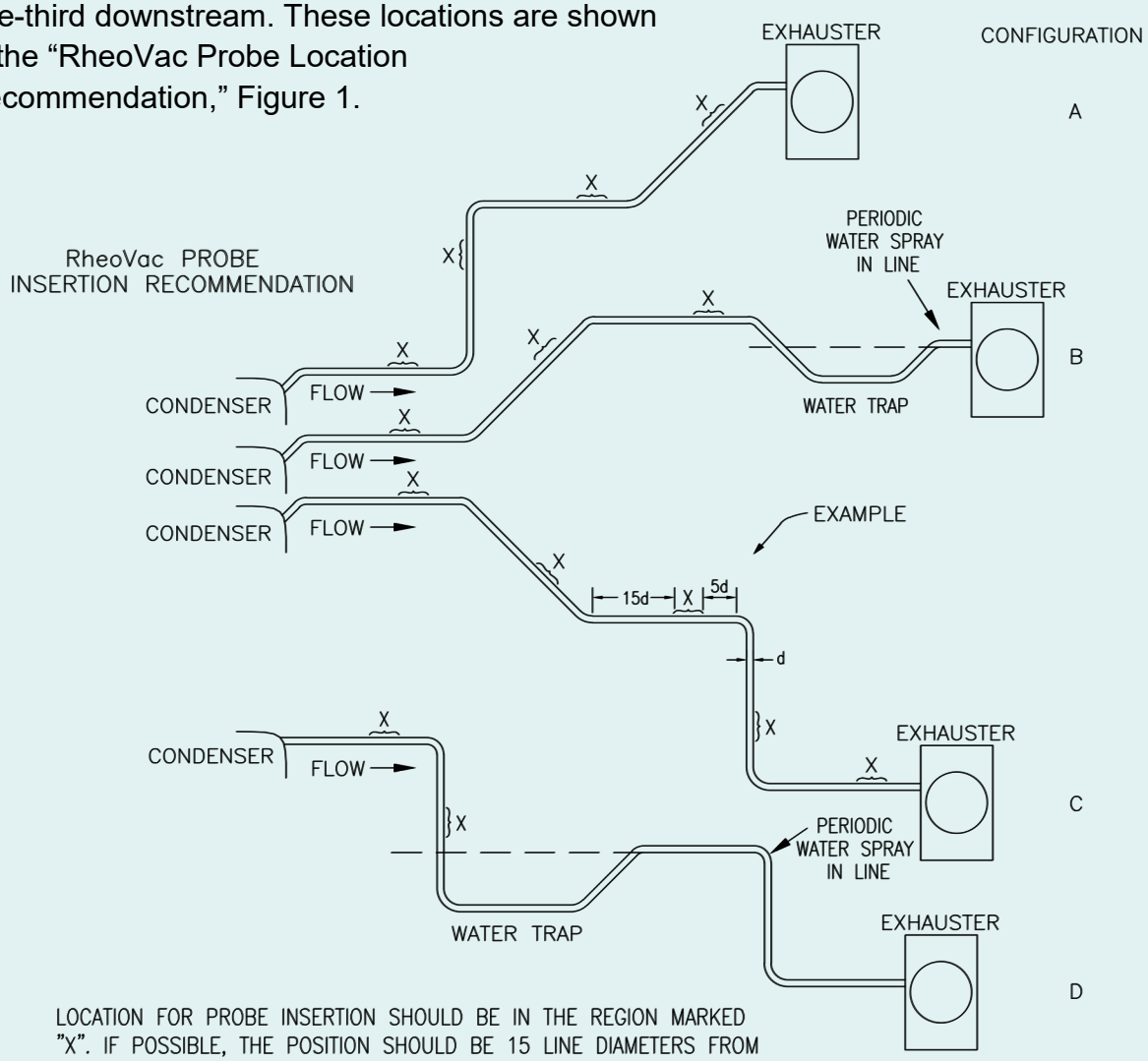


A helium leak survey was scheduled and technicians arrived at the plant, focusing the survey on components under vacuum on the east side of the condenser. Several uncapped pipes were located during the audit. It was discovered that during a recent outage, extraction steam check valves had been replaced with a different type that did not require drain lines and the old drain lines had been left in place without being plugged. Sealing the drain lines immediately reduced the air-in-leakage by 30 SCFM, increased the cleanliness factor by 4.08, and reduced the condenser backpressure by 0.46 inHgA. This resulted in significant performance improvements for the plant.

Probe Installation

The RheoVac probe can be installed only in the condenser-to-exhauster vacuum line where a conditioned gas/water vapor stream exists and where it will not be exposed to temperatures above 210 F (99 C). (or 250°F for options with Stainless Steel Shrouds) For best noise-free flow rate measurements, a location at least 15 diameters downstream of a line turn or valve and 5 diameters upstream of the next perturbation is recommended. If these distances are not available, install the probe with two-thirds of the available straight-run upstream of the probe and one-third downstream. These locations are shown in the “RheoVac Probe Location Recommendation,” Figure 1.





LOCATION FOR PROBE INSERTION SHOULD BE IN THE REGION MARKED "X". IF POSSIBLE, THE POSITION SHOULD BE 15 LINE DIAMETERS FROM AN UPSTREAM LINE TURN AND 5 DIAMETERS FROM A DOWNSTREAM TURN. IF NOT, HAVE TWO–THIRDS OF THE AVAILABLE STRAIGHT–RUN UPSTREAM OF THE PROBE.

Figure 1.

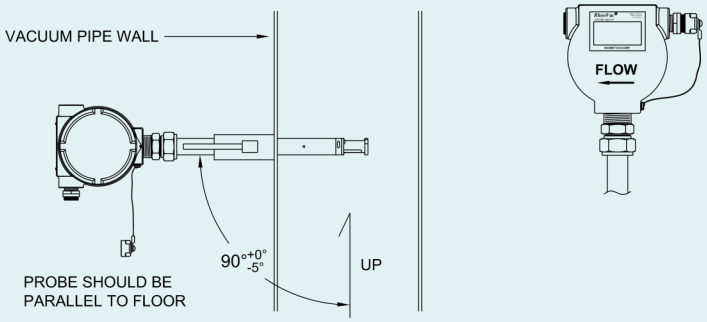
Probe Installation

Figure 1 shows four plane line configurations found in operating power plants. Configurations A and B feature line layouts that generally place the exhauster inlet above the condenser outlet. In Configurations C and D, the exhauster inlet can be found below the condenser outlet. When considering probe placement in Configurations A and C, select a location with acceptable straight-run and accessibility to aid in probe insertion and removal.

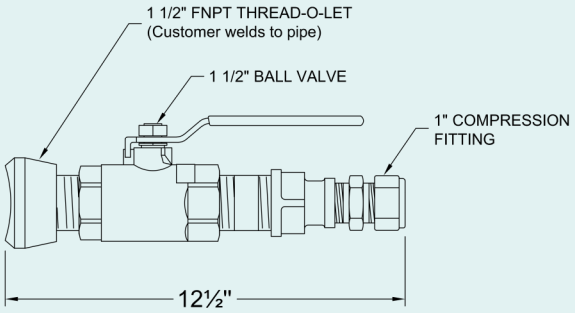
Configurations B and D show exhauster lines which have been installed in a manner that creates a water trap. Under conditions where ambient temperature outside the line is lower than the stream temperature, condensation of water vapor can occur and accumulate in the trap, restricting or completely shutting off the vapor/gas flow stream to the exhauster. This condition eventually leads to water spray or water surging in the line beyond the trap. For this reason, probe installation in the trap or between the trap and the exhauster is not recommended.

Probes in horizontal, vertical (flow up or down), or angled runs should be installed at a 90 angle to the pipe in a position where the probe is parallel to the ground (see Figure 2). This prevents water droplets from clinging to the probe tips, which can occur if the probe axis is angled with the tips downward. There are no other critical orientation requirements except the probe must be rotated such that the flow vector passes between the probe tips. The junction box on the probe will have a directional arrow which should be properly aligned with flow in the pipe.

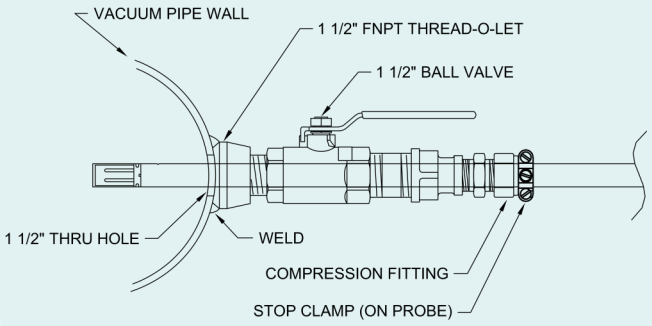
REQUIRED INSTALLATION ANGLE
FOR VERTICAL PIPE RUN



BALL VALVE ASSEMBLY



BALL VALVE ASSEMBLY INSTALLATION



REQUIRED INSTALLATION ANGLE
FOR HORIZONTAL PIPE RUN

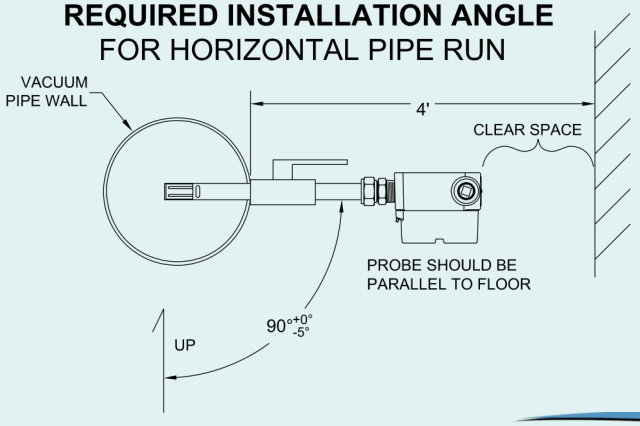


Figure 2.

Probe Installation

POWER and PREPARE
1. Connect Cable to warm up for ~ 30 minutes
2. Align Probe with Compression fitting to prevent tip damage

INSERTION
1. Insert to Extraction Line
2. Snug Compression fitting by hand to control against vacuum
3. Open Valve

INSTALLATION
1. Insert to stop clamp
2. Ensure "FLOW" arrow is parallel to the pipe centerline within ±5°
3. Snug Compression Fitting to finger tight plus ~ 1/2 turn to secure. Do not crimp ferrule to the probe shaft

EXTRACTION
1. Loosen Compression fitting.
2. Hold securely, extract to extraction line
3. Close Valve
4. Extract fully, maintain alignment to prevent tip damage

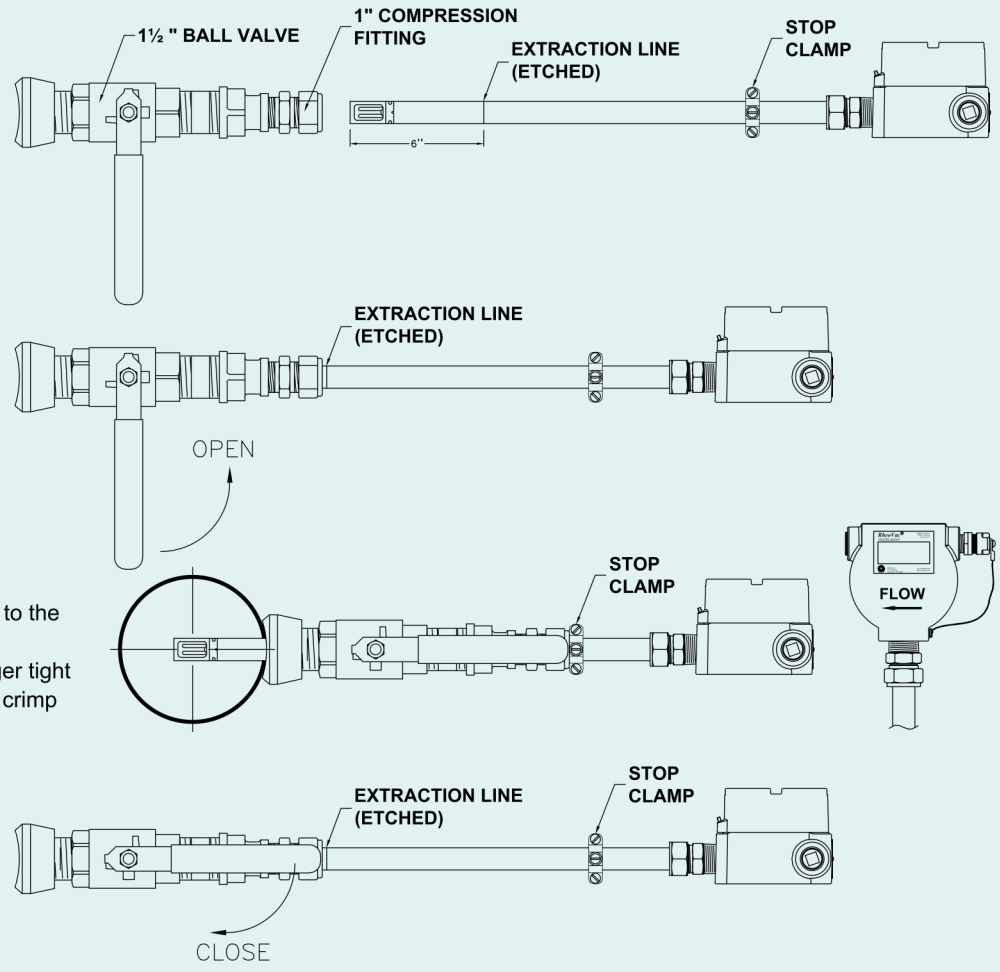


Figure 3.

The RheoVac probe installs through an Bionetics-supplied ball valve assembly. A 1½" female NPT coupling (supplied) must be welded on the pipe as shown in Figure 2, and the pipe must have a 1½" hole drilled through it. Allow 4 feet of clearance out from the coupling to accommodate probe installation through the hot tap assembly.

Prior to inserting probe, loosen the compression nut on the thermocouple connector of the assembly and clean the inner surface of the thermocouple connector to ensure it is free of particles that may cause probe damage.

*Straight-run is limited in many plants. Lack of straight-run does not prevent use of the unit. This suggestion comes from good practices for high accuracy flow measurement, but several of the primary RheoVac measurements are not affected by straight-run and a mass flow measurement error only affects the air in-leakage reading by a small percentage. There is much value in trending data over time and observing changes in RheoVac readings in relation to plant events.

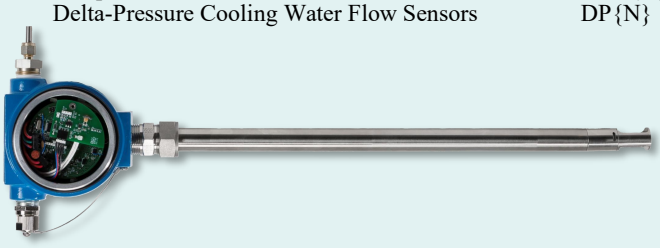
Model Selection Guide

The RheoVac monitoring system includes a Main Electronics box that connects with up to 3 RheoVac probes. Several options are available for different installations based on temperature, output type, distance from the control center, and number of probes. For multi-unit condensers, additional systems may be needed or the (CMS) Condenser Monitoring System electronics upgrade can be selected that supports up to 14 probes. The RheoVac system is very versatile, and probes can be swapped into different locations as needed for diagnostics, and even rented on a short-term basis as problems arise. However, the main indication of developing problems is the ability to trend performance changes and air-in-leakage rates over time, therefore continuous on-line monitoring is recommended.

EXAMPLE: 960(SS) - 3P - 2U - 4/20
(1) (2) (3) (4)

1. Basic model
2. Number of Probes
3. Number of Condenser Units
4. Output
5. Additional Options

1. BASIC MODEL	
RheoVac System, NEMA 4 Enclosure and Keypad	960
Upgrade to NEMA 4X (SS) Enclosure	960(SS)
Upgrade to Touchscreen Display	960D
Lightweight Portable Main Electronics Enclosure	960P
Standalone RheoVac probe without Main Electronics 24V DC input and Digital Output Only	960CM
Condenser Monitoring System	CMS
2. NUMBER OF PROBES	
RheoVac Probe with plastic sensor head for LRVPs N can be 1-3 for 960 Systems and 1-14 for CMS	{N}P
RheoVac Probe with SS sensor head for SJAEs	{N}P(SS)
RheoVac Probe with heated electronics for outdoor Installations in cold climates	{N}P(HTR)
OPTIONS FOR CMS / CUSTOM APPLICATIONS	
Flow Temperature and Pressure Probe	{N}FTP
Pressure Temperature Probe	{N}PT
Relative Saturation Probe	{N}RS
Low Relative Saturation Probe	{N}LRS
3. NUMBER OF UNITS	
N is # of condensers probes will be installed on	{N}U
4. OUTPUT OPTION	
Modbus Output Supports RS 232/422, Modbus RTU RS-485, and Ethernet	blank
HART Output: Air in-Leak over 4-20mA plus 4 digital process variables	HART
4-20mA, one output per variable Additional 4-20mA distribution box required Not available with 960CM	4/20
5. ADDITIONAL OPTIONS — CMS SYSTEM ONLY	
Temperature Sensor Probes where N # of Probes	RTD{N}P
Delta-Pressure Cooling Water Flow Sensors	DP{N}





960CM — Standalone Probe

The 960CM is an option without Main Electronics. The RheoVac probe is sold as a unit with 24 V DC input power and digital outputs only. Because there is no Main Electronics, there is no datalogging capability and the plant will have to handle communication with each probe

CMS System

The CMS system is Bionetics' Condenser Monitoring System. It can support up to 14 RheoVac probes and supports additional sensors such as RTDs, Pressure Sensors, and DP flowmeters for cooling water flow rate. If all these sensors are installed, the CMS system can output a real-time calculation of condenser cleanliness factor and assist in troubleshooting lost load due to fouling, cooling water flow rate, air-bound zones, air-in-leakage, and poor exhauster capacity.