resource systems, inc.

INSTRUCTION MANUAL
HYDROGEN PURIFIER
MODEL RSD-50-VCR
(ABRIDGED)

Except, possibly, for cabinet size and pure outlet termination, this manual is correct for all single chamber RSD-Series Purifiers of current manufacture from 5 to 100 SCFH capacity.

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PRINCIPLE OF OPERATION

Resource Systems' line of integrated packaged purifiers takes advantage of the fact that hydrogen, and only hydrogen, can be made to pass through a palladium barrier. RSI uses palladium-silver alloy tubing which has been optimized for this use.

The rate of hydrogen diffusion through palladium alloy tubing:

1. Varies exponentially with temperature, increasing at a decreasing rate as the temperature increases, and

2. Varies directly with the difference between the square roots of the pressures of hydrogen on both sides of the palladium-silver alloy tubing.

The purifier operates at a constant temperature so that, in service, the pure hydrogen flow rate is controlled by varying the feed gas inlet pressure. The feed gas inlet pressure must not exceed 250 PSIG (18 atm).

RSI purifiers operate with the high feed pressure on the inside of the palladium-alloy tubing. This keeps the normal operating pressure from collapsing the tubing and causes intimate contact between the feed gas and the tubing along its entire length. This prevents stagnant areas where impurities can accumulate and allows high efficiency recovery of hydrogen from the feed gas.

The temperature of the purifier is held at 800˚F (425˚C) by an indicating temperature controller. The chamber is provided a with back-up limit controller[1] set at 850˚F (450˚C), which is still in a safe operating region. The unit, however, should not be operated for long periods with a malfunctioning primary temperature controller.

In order to prevent impurities from building up inside the palladium alloy tubing, where they would decrease and eventually stop the flow of pure hydrogen, the impurities are bled out of the purifier with a small amount of undiffused hydrogen. This flow is controlled by a front panel bleed flow controller and must be safely vented. (The bleed flow controller assures bleed rates for hydrogen and nitrogen that are essentially independent of feed pressures from 45 to 250 PSIG [4 to 18 atm]. The presence of a check valve in the bleed line allows optional evacuation of the feed gas volume when desired.)

1..and audible alarm.

OPERATING INSTRUCTIONS

CAUTION: Be sure the installation instructions on the preceding pages have been followed in detail.

START UP

1. Open the bleed control valve on the purifier and purge all feed lines and bleed gas lines with nitrogen to be certain that all air has been removed.

CAUTION: Be certain that no air pockets have been left in the feed gas and bleed gas lines. Hydrogen and air can form explosive mixtures. In addition, hydrogen and air or oxygen can burn catalytically on the palladium alloy tubes and cause destructively high temperatures on the surface of the tubing. If the feed gas will continuously contain small amounts of oxygen, contact Resource Systems, Inc., Six Merry Lane, East Hanover, NJ 07936 for special instructions.

2. Evacuate the pure gas lines in the purifier and downstream of the purifier to remove all air.

3. Move the electrical power switch to the "On" position. The purifier will heat to 800˚F (425˚C) in approximately 30 minutes.[2]

CAUTION: If the temperature controller does not operate properly, do not operate the purifier. Follow the "Long Term Shut-Down Procedure" immediately and have the defective temperature controller and/or thermocouple repaired or replaced.

4. When the temperature indicator shows that the chamber has reached 800˚F[3] (425˚C), close the vacuum connection to the pure hydrogen lines and close the nitrogen purge valves on the feed line.

Slowly open the feed hydrogen supply valve and be sure that the pressure regulator is set to keep the feed hydrogen pressure at or below 250 PSIG (18 atm). Note that the pure hydrogen flow rate is controlled by adjusting the feed gas pressure.

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[2]The right hand lamp in the power switch cycles on and off with the furnace.

[3]Hydrogen may be introduced at 700˚F (370˚C) if a faster startup is desired.

CAUTION: The pure hydrogen flow rate depends on the pressure difference between the feed hydrogen and pure hydrogen. The pure hydrogen flow rate should be controlled by adjusting the feed gas pressure and can also be controlled by adjusting the pure hydrogen pressure. A dangerous situation can occur if the pure gas flow is stopped because the pure gas pressure will then build up to the feed gas pressure. An analogous increase in the pure hydrogen line pressure can occur if the palladium alloy tubing perforates. For this reason, the users pure gas system must be constructed to withstand full line pressure or be protected with appropriately sized properly vented relief valves.

5. Adjust valve on the Bleed Rotameter to a ball height of approximately 10.

6. Before using the pure hydrogen, be certain that it has been flowing to a safe vent for a long enough time to be sure that all impurities have been purged from the lines.

SHORT-TERM SHUT-DOWN.

If the purifier is to be shut down for short periods of time or overnight, the heater is allowed to remain on. Short-term shut-down consists of closing off the flow of feed hydrogen and closing the external pure hydrogen valve. (The Bleed Control setting does not have to be touched.)

NOTE: The short term shut-down procedure creates the possibility of cooling the purifier in hydrogen in the case of a power failure. This risk may not be acceptable in areas where power failures are frequent or of long duration.

LONG-TERM SHUT-DOWN

1. Shut off the feed gas supply.

2. Remove all hydrogen from the purifier and from the pure hydrogen lines by purging and / or evacuating. Be sure evacuated hydrogen is safely vented.

3. Purge the feed gas lines with nitrogen allowing the nitrogen to flow through the purifier and bleed gas lines. It must be realized that purging the impure hydrogen lines with nitrogen can create a vacuum in the pure hydrogen lines since hydrogen can diffuse from the pure side into the nitrogen stream in the impure gas lines.

CAUTION: Since the nitrogen purge can cause a vacuum in the pure gas lines, care must be taken to keep from pulling unwanted impurities, such as doping agents, into the pure gas side of the hydrogen purifier.

4. After purging is complete, close the nitrogen purge valves.

5. Move the electrical power switch to the "Off" position. Pull out the electric plug.

CAUTION: The above startup and shutdown procedures prevent heating or cooling the palladium-silver alloy tubing in the presence of hydrogen. This is extremely important. Heating or cooling the unit in hydrogen can cause premature failure of the palladium alloy tubing. In the event of a power failure or any other reason for loss of temperature, the long-term shut-down procedure must be executed immediately.

CAUTION: After a long-term shut-down procedure has been completed and the purifier is below 300˚F (150˚C), it is necessary to relieve the vacuum in the pure hydrogen lines by admitting clean air into these lines. This prevents contamination, which may be present in the vacuum pump and vacuum lines, from being drawn into the purifier at the next startup.

MAINTENENCE

Periodic checks of the system integrity are recommended. The preferred method is by helium mass spectrometer leak checker. The system is checked at operating temperature with the helium mass spectrometer pumping directly on the pure gas outlet of the purifier and helium at moderate pressure, e.g., 5 PSIG (1.3 atm), filling the impure side of the system.

Any sign of a leak from crude to pure indicates a loss of integrity. The permeation cell must be replaced (or repaired at the factory.)

DERATING

The pure gas flow rate from an RSD purifier is proportional to the square root pressure difference between the feed and product hydrogen. The unit is rated at 250 PSIG (264.7 PSIA, 18.0 atm) feed pressure and one atmosphere (14.7 PSIA) product hydrogen pressure. The flow rating is included in the Model Number, e.g., an RSD-100 will deliver 100 SCFH (47.2 SLPM) at 1 atm from a 250 PSIG (18 atm) feed.

The derated flow at pressures other than 250 PSIG and 1 atm. can be calculated from the following equations:

$$F_{SCFH} = K(PSIA_{feed}^{1/2} - PSIA_{pure}^{1/2}) / 12.44$$

$$F_{SLPM} = K(atm_{feed}^{1/2} - atm_{pure}^{1/2}) / 6.872$$

where F_{SCFH} = calculated flow rate, SCFH.
F_{SLPM} = calculated flow rate, SLPM.
K = rated flow, e.g., 100 SCFH for an RSD-100

$PSIA_{feed}$ = absolute hydrogen feed pressure, e.g., 150 PSIG is 164.7 PSIA

atm_{feed} = absolute hydrogen feed pressure, e.g., 164.7 PSIA is 11.2 atm.

$PSIA_{pure}$ = absolute product hydrogen pressure, e.g., 5 PSIG is 19.7 PSIA.

atm_{pure} = absolute product hydrogen pressure, e.g., 19.7 PSIA is 1.34 atm.

Example: An RSD-100 is to operate from a 150 PSIG (164.7 PSIA, 11.2 atm) feed and deliver product at 5 PSIG (19.7 PSIA, 1.34 atm). Calculate throughput.

$$\mathbf{F_{SCFH}} = 100(164.7^{1/2} - 19.7^{1/2}) / 12.44$$
$$= 100(12.834 - 4.438) / 12.44$$
$$= 100(8.395) / 12.44 = \mathbf{67.5\ SCFH}$$

$$\mathbf{F_{SLPM}} = 100(11.2^{1/2} - 1.34^{1/2}) / 6.872$$
$$= 100(3.347 - 1.158) / 6.872$$
$$= 100(2.189) / 6.872 = \mathbf{31.9\ SLPM}$$

REGENERATION

CAUTION: The regeneration process involves the oxidation and subsequent reduction of the surfaces of the permeation barrier. Because the material oxidized no longer contributes to the strength of the barrier when reduced, regeneration can not be done very often without seriously weakening or perforating the barrier. Regeneration should only be attempted when absolutely necessary.

The RSD purifier may lose throughput because of poisons in the feed gas or because of backflow of contaminants from the user's process to the pure side of the barrier. If the throughput declines gradually, losses are generally due to carbonaceous (organic) materials and the regeneration process is effective. If the throughput drops sharply, the poisons may be inorganic (e.g., As, Hg, P, S, Zn) and regeneration may be ineffective or partially effective.

Remove Hydrogen

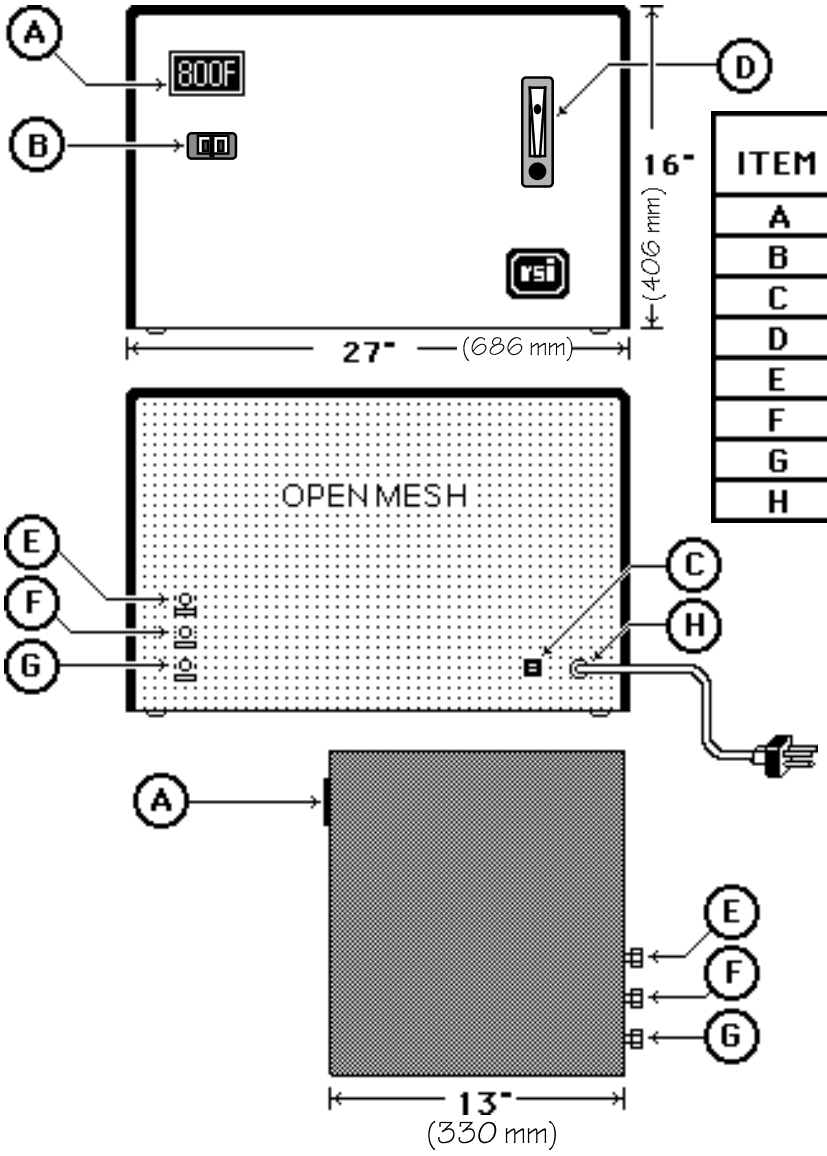
It is assumed that the purifier is at normal operating temperature. Any hydrogen present must be removed prior to the oxidation process. Follow the Long-Term Shut Down procedure up to but not including cooling the unit.

Admit Air

Once the hydrogen partial pressure has been reduced to 1 torr or less, admit clean air to both sides of the system. This can be done by breaking the vacuum, by cyclic pressurization and depressurization to replace the nitrogen cover gas or the like. Allow the unit to stand for 1 hour at normal operating temperature with air at 1 atm. on both sides of the diffusion barrier.

Remove Air and Admit Hydrogen

Follow the Start-Up instructions in this manual. Discard several cubic feet (ca. 100 liters) of product hydrogen (which may contain combustion products) before admitting the output of the unit to your process.



ITEM	DESCRIPTION
A	Temperature Indicator
B	Power Switch
C	Circuit Breaker
D	Bleed Flowmeter
E	Pure Outlet, 1/4"
F	Crude Inlet, 1/4"
G	Bleed Outlet, 1/4"
H	Power Cord

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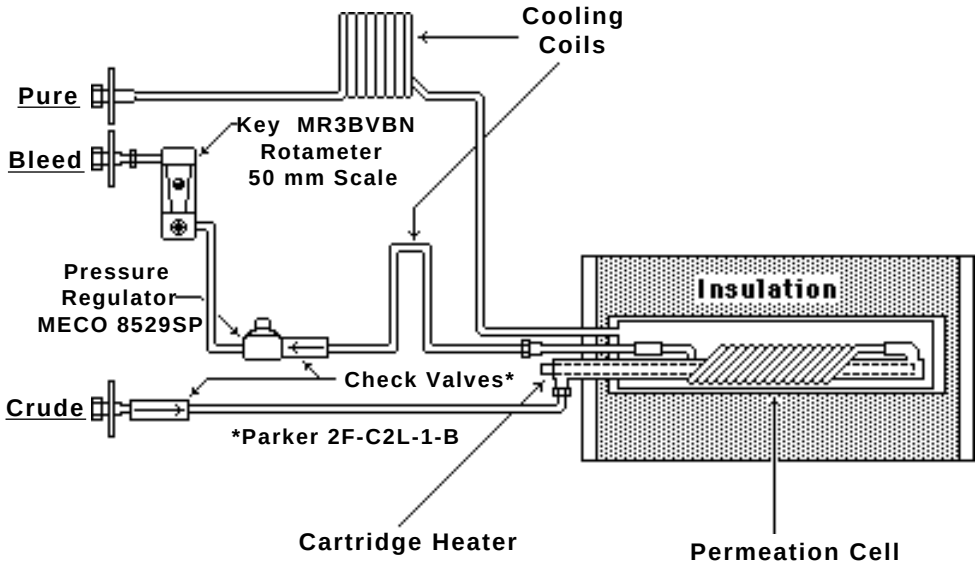
USED ON:
RSD-50, -75, -100

TITLE:
OUTLINE DRAWING

DRAWN BY

APPROVED BY
L.R.R. 12/20/93

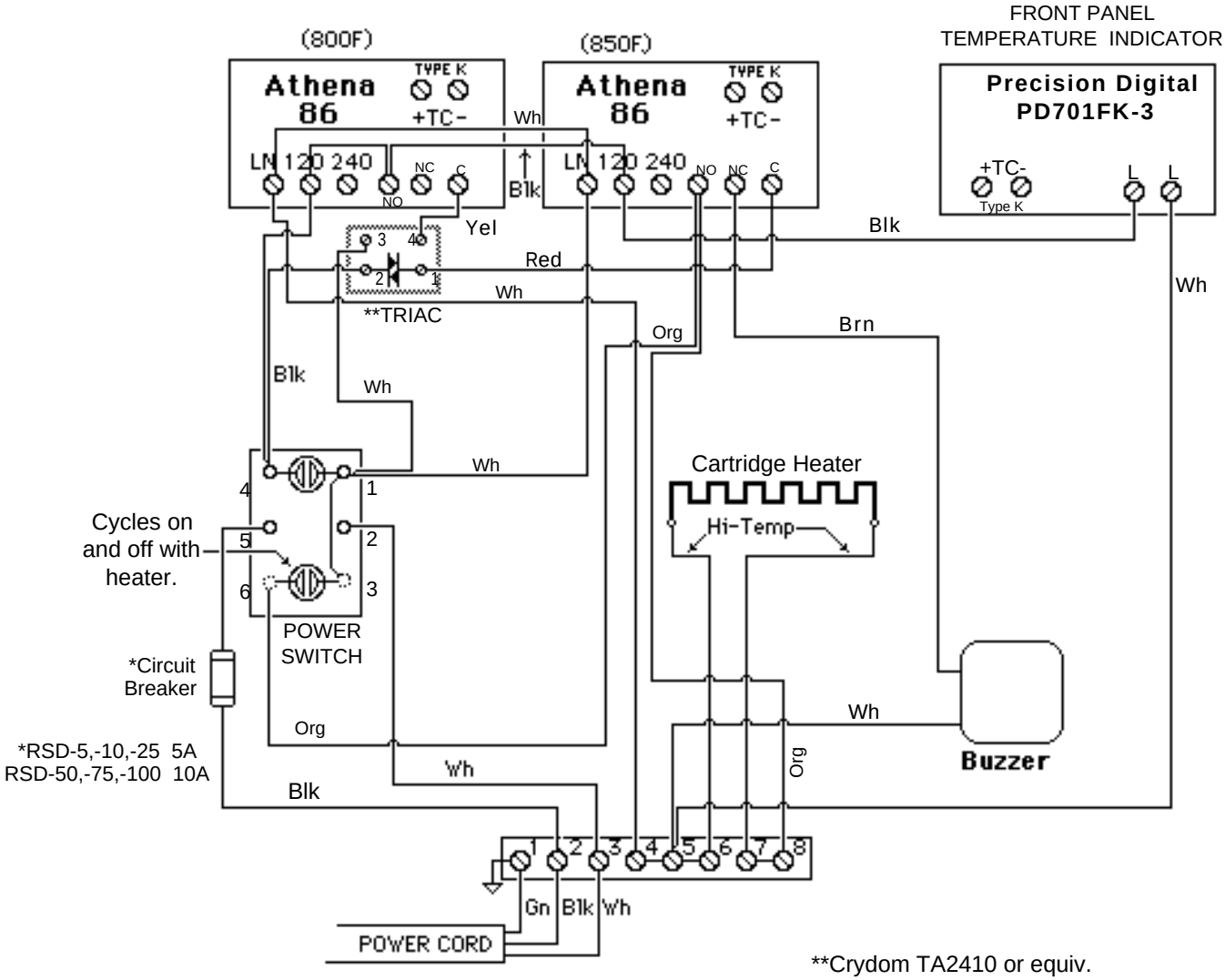
DWG. NO.
A-3688C



NOTE:

It is important that the bleed gas be vented into a system that is unlikely to develop back pressure. Bleed gas pressure is reduced to 15 PSIG by the line pressure regulator before it enters the front panel rotameter. Constant flow to vent requires the pressure in the rotameter to be constant. If the rotameter receives back pressure from the bleed line, flow will slow and, in the limit, if the back pressure reaches 15 PSIG, the bleed flow will stop!

resource systems, inc. SEVEN MERRY LANE • EAST HANOVER, NJ 07936	**USED ON:** RSD-5 THROUGH -100	**DRAWN BY**
	TITLE: FLOW SCHEMATIC	**APPROVED BY** L.k.k. 5/17/98 **DWG. NO.** A-3698H



resource systems, inc. SIX MERRY LANE • EAST HANOVER, NJ 07936	**USED ON:** RSD-5 THROUGH RSD-100 (120 VAC)	**DRAWN BY**
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