Vacuum Furnace Pumping Systems

Failures and Solutions

December 4, 2014

Presented By: William R Jones, CEO

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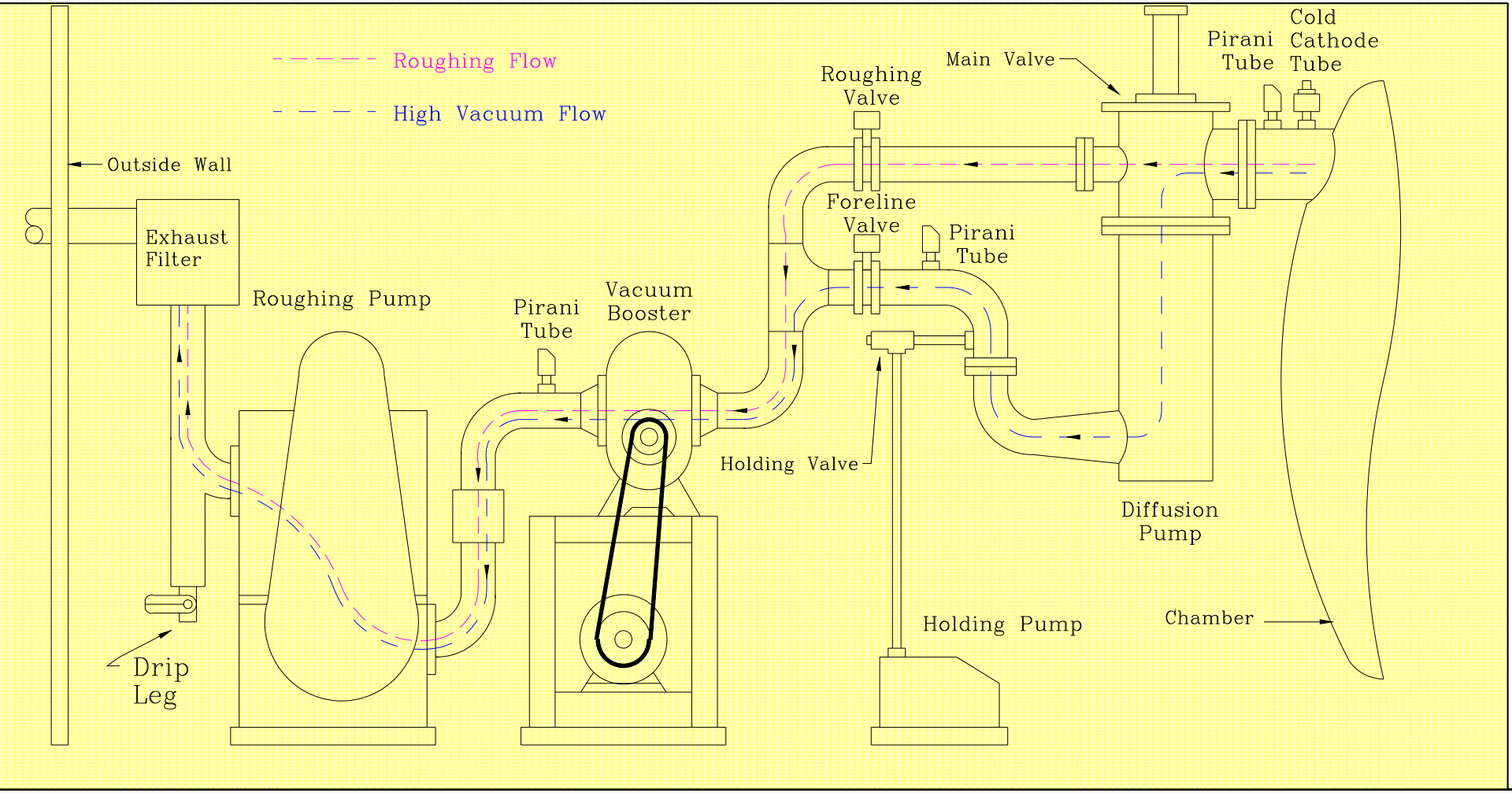
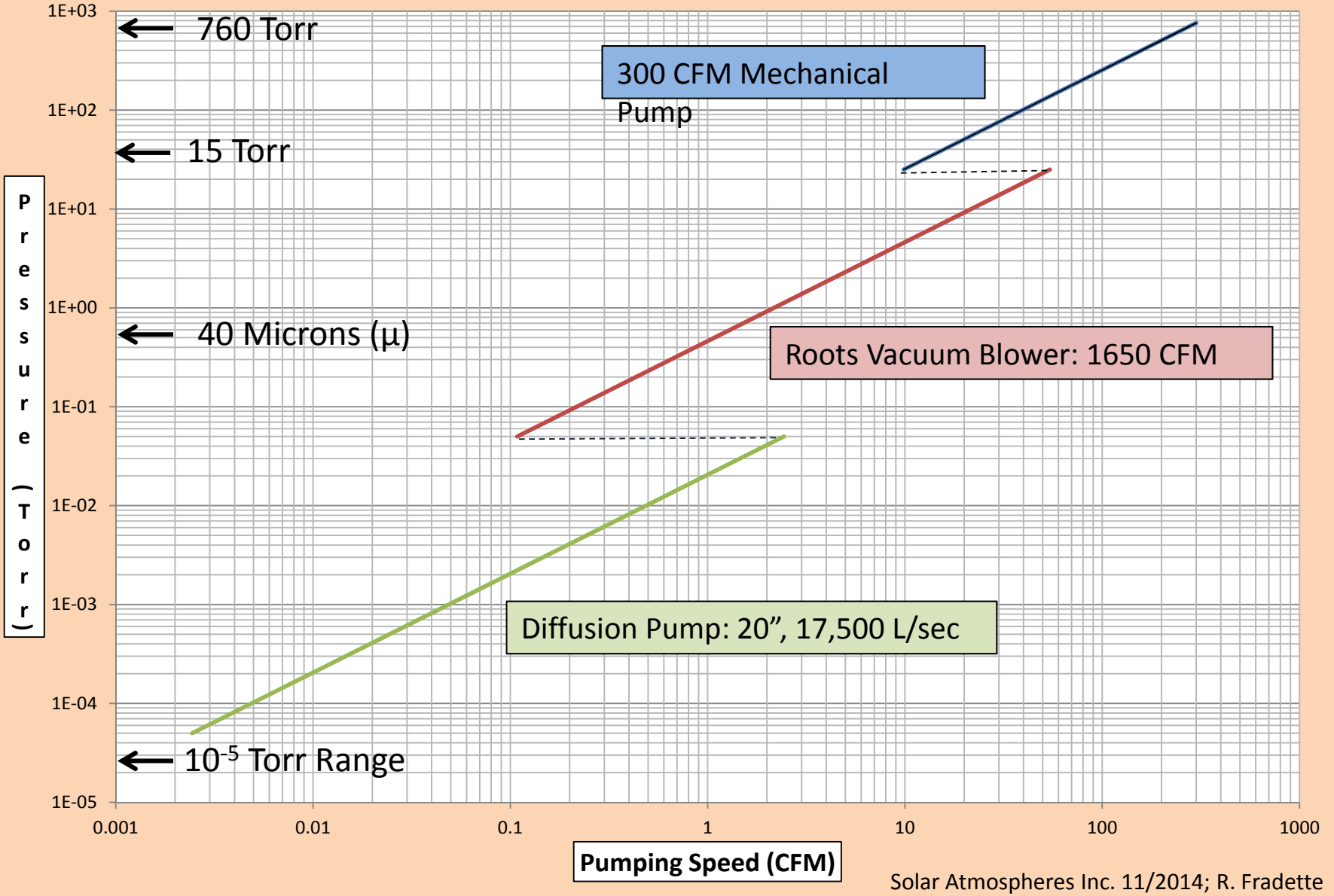
Typical Vacuum Pumping System



Actual Vacuum Pumping Speed Vs. Pressure



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Actual Vacuum Pumping Speed Vs. Pressure

Mechanical Pump (300 CFM)		*Roots Blower (1650 CFM)*		*Diffusion Pump (17,500 L/S or 37,080 CFM)*	
Pressure (Torr)	*Actual CFM*	*Pressure (Torr)*	*Actual CFM*	*Pressure (Torr)*	*Actual CFM*
760	300	25	54.27	0.05	2.43
700	276.31	20	43.42	0.01	0.48
600	236.84	15	32.56	0.005	0.24
500	197.36	10	21.71	0.001	0.048
400	157.89	5	10.85	0.0005	0.024
300	118.42	1	2.17	0.0001	0.0048
200	78.94	0.5	1.08	0.00005	0.0024
100	39.47	0.1	.21		
50	19.73	0.05	0.10		
25	9.86				

$$Q = SP$$

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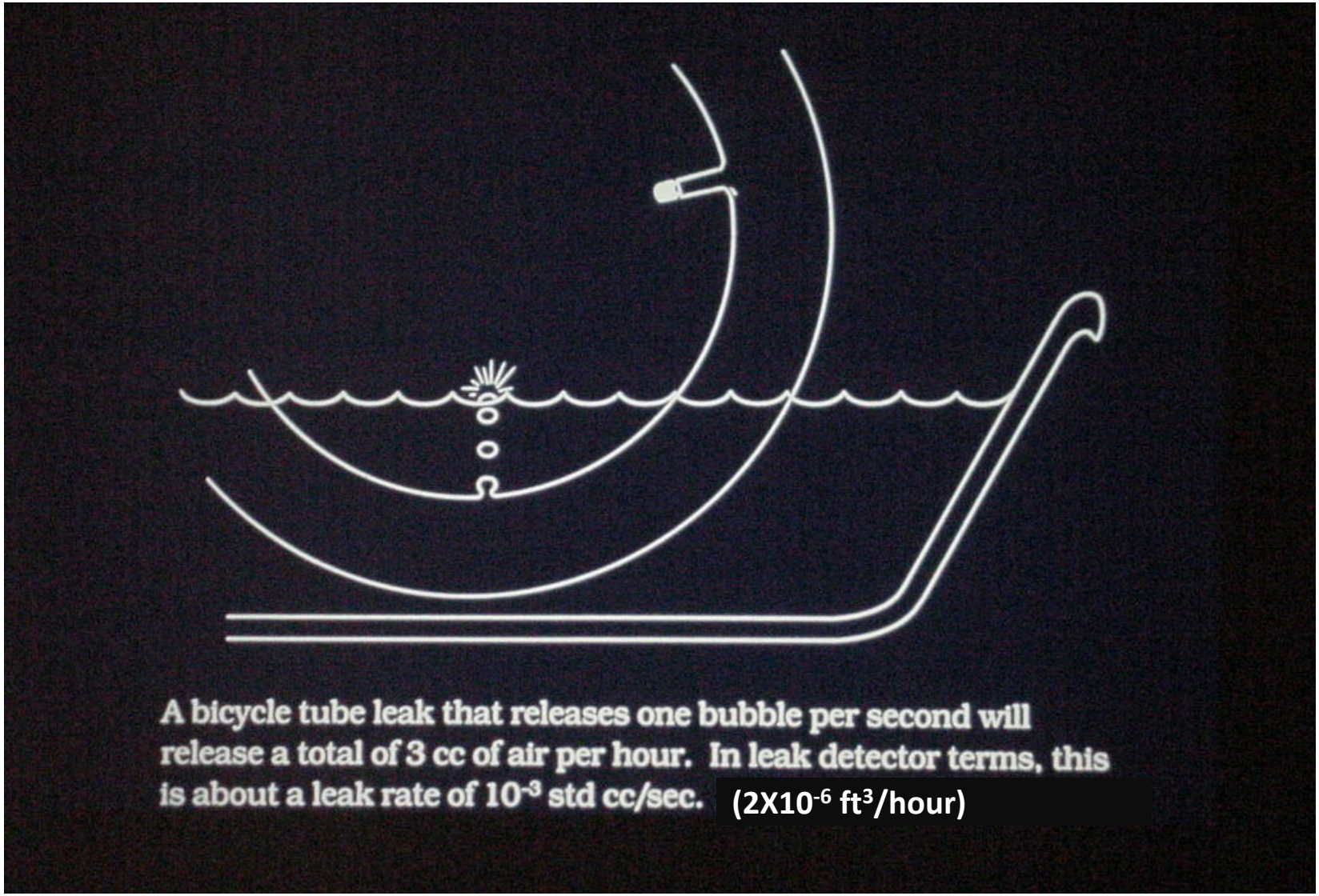
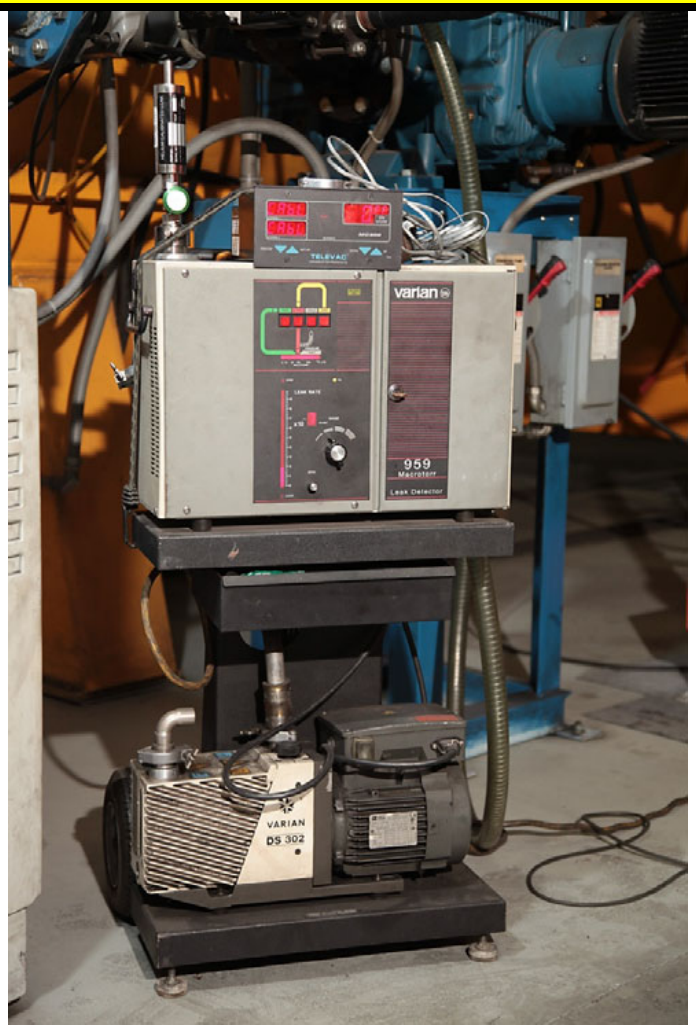
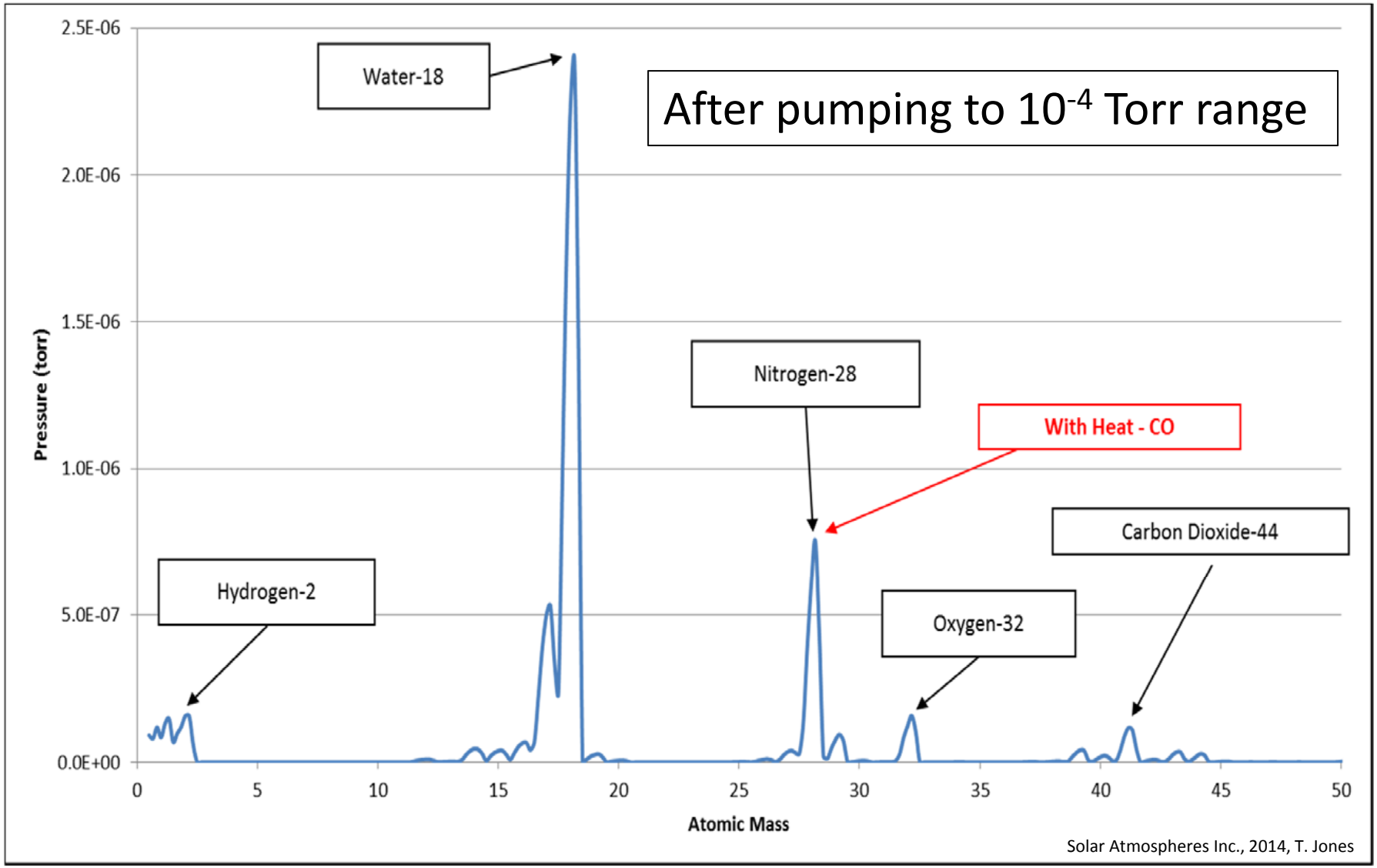
Air Leaks



Helium Mass Spectrometer

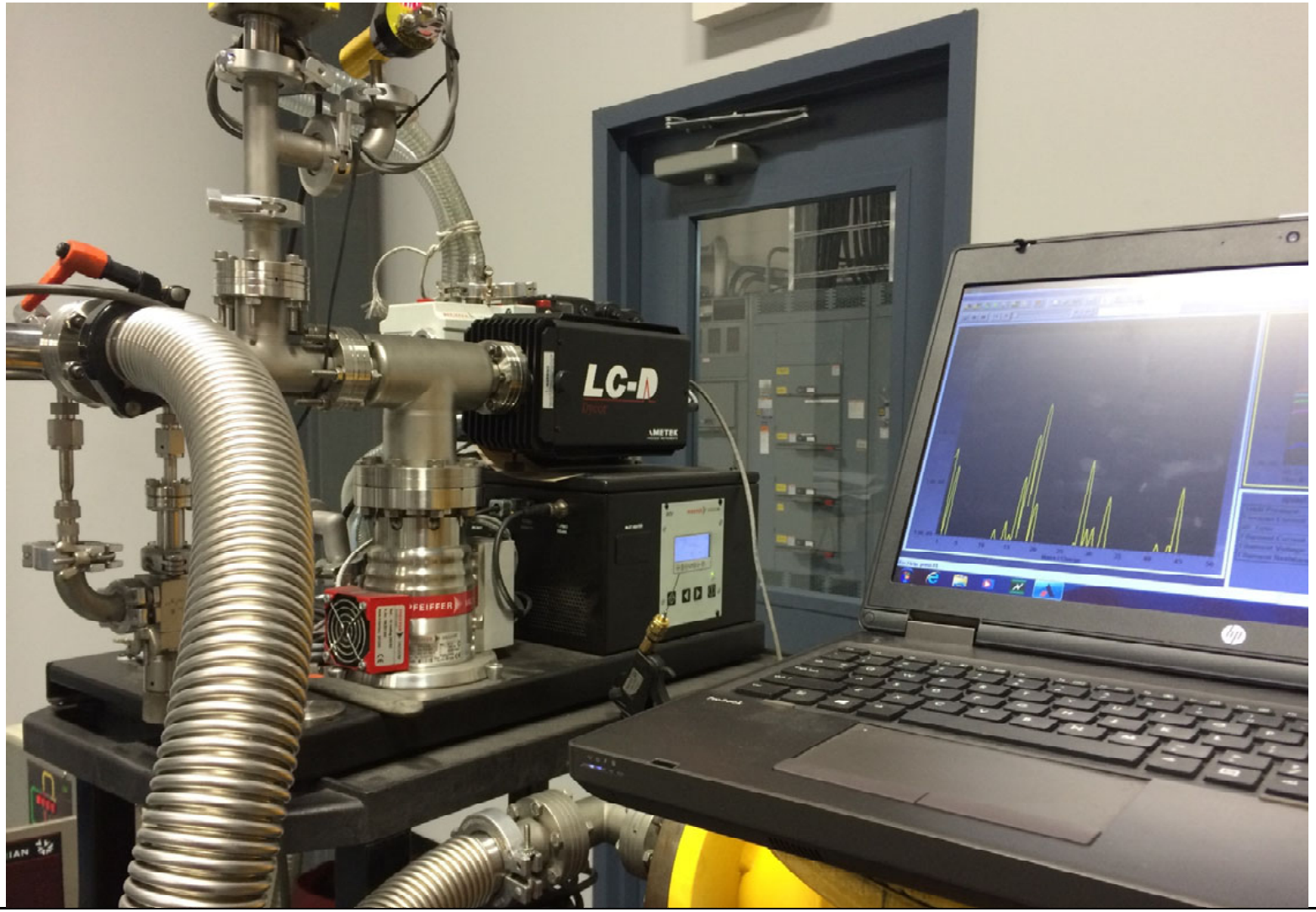


RGA Linear Scale Chart of Residual Gases

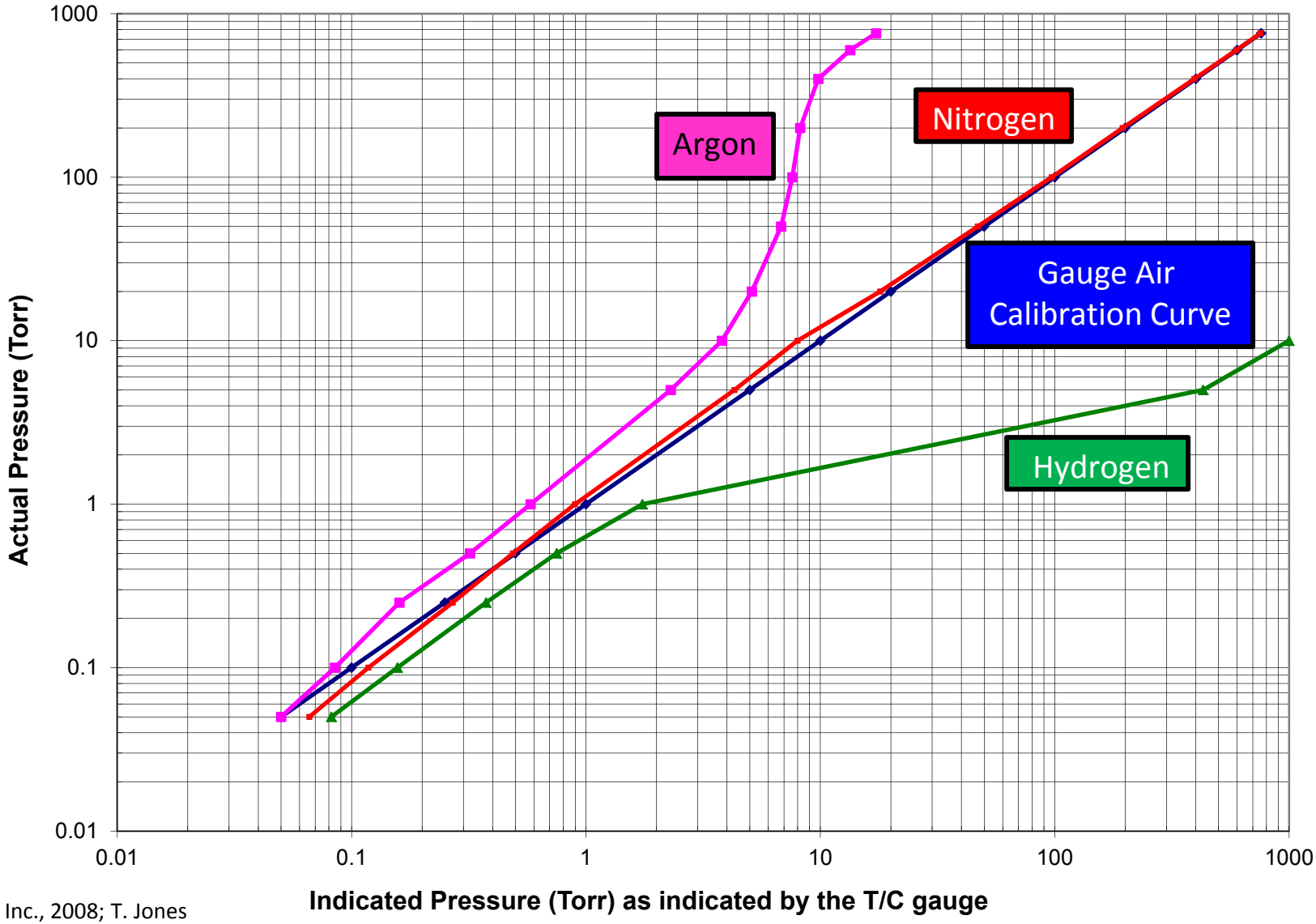


Solar Atmospheres Inc., 2014, T. Jones

RGA – Residual Gas Analyzer

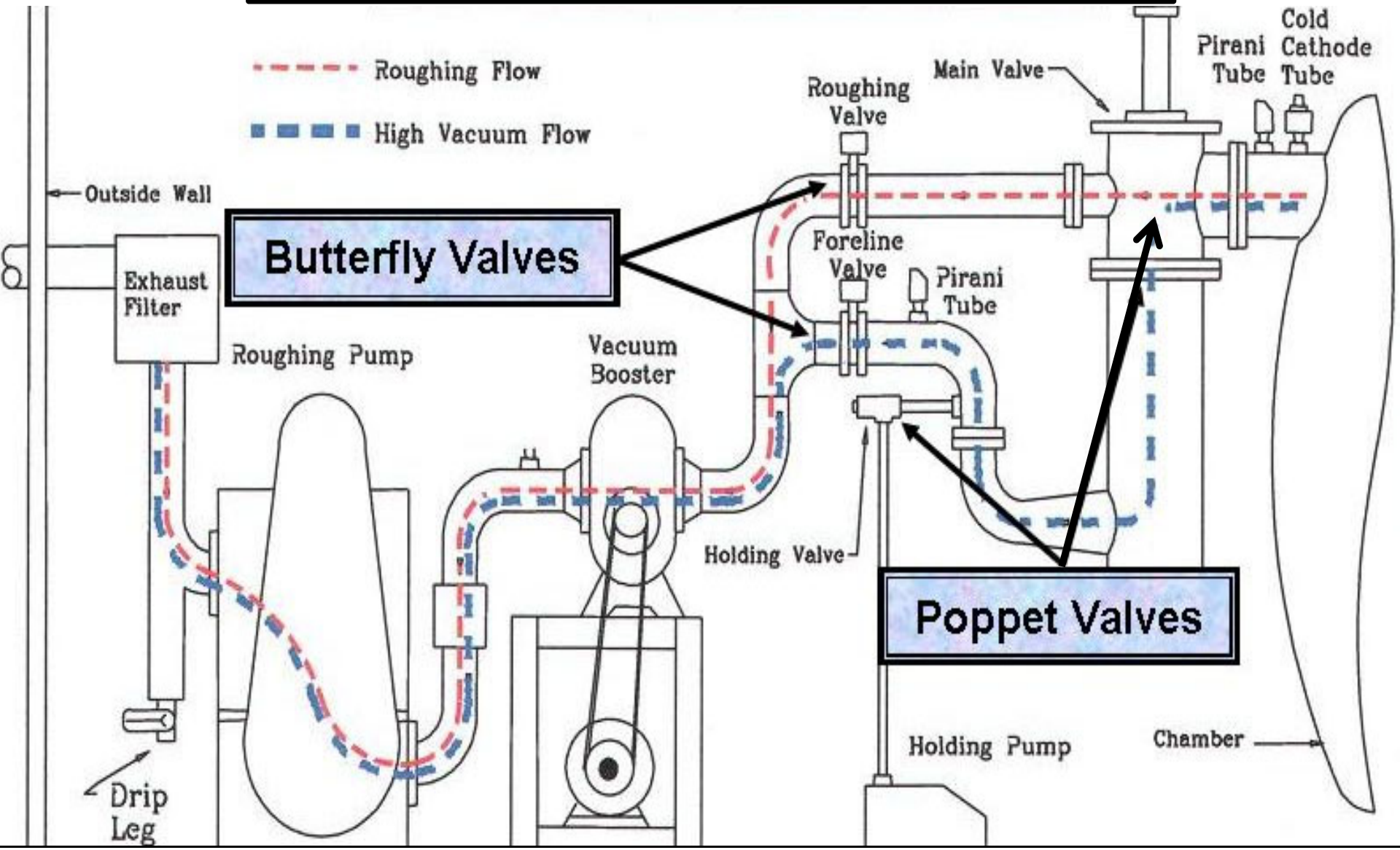


Gas Species Effect On Thermocouple Vacuum Gauges

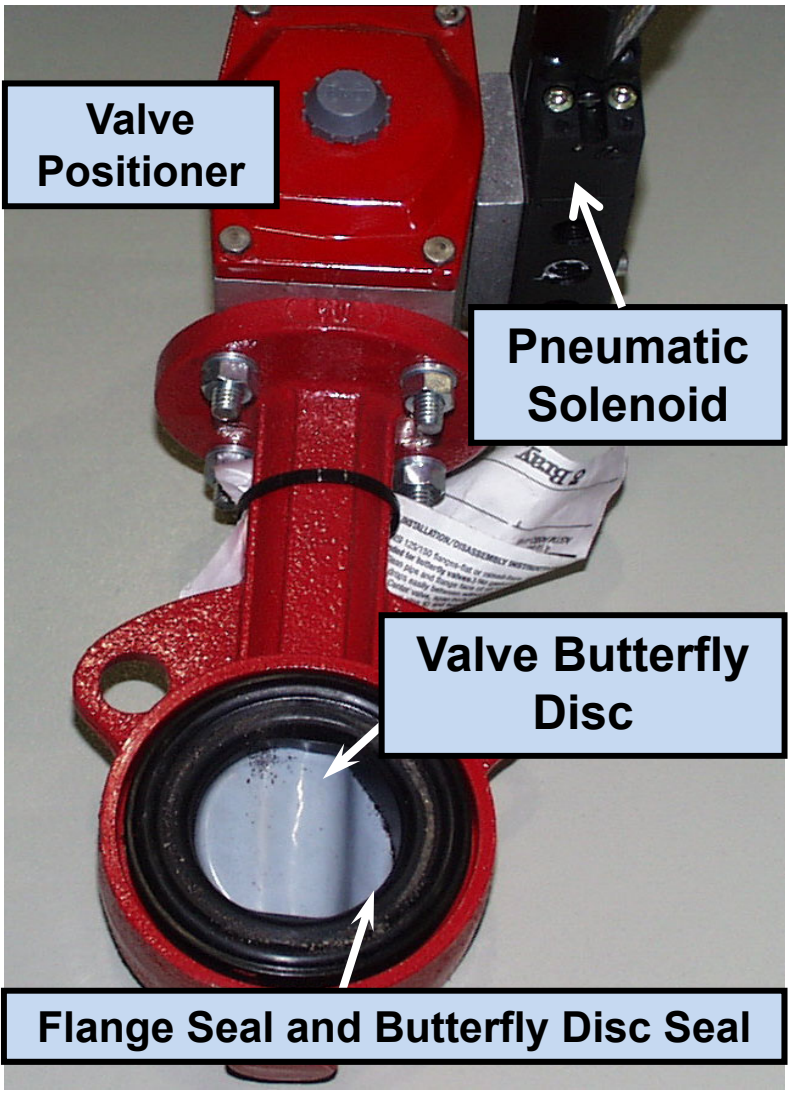


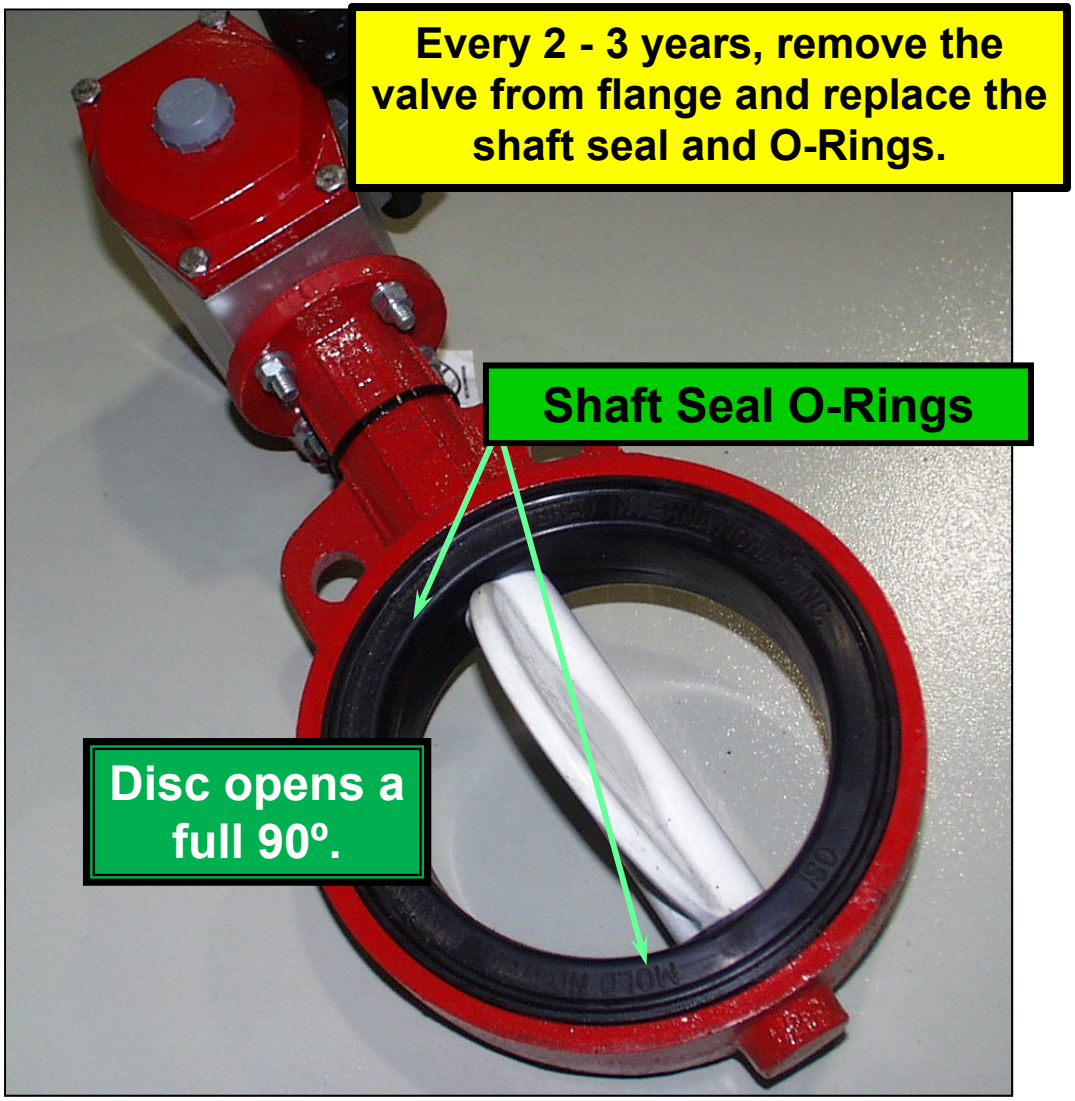
Solar Atmospheres Inc., 2008; T. Jones

Potential Sources for Leaks: Valves



Butterfly Vacuum Valves





Foreline and Roughing Valve – Care and Maintenance

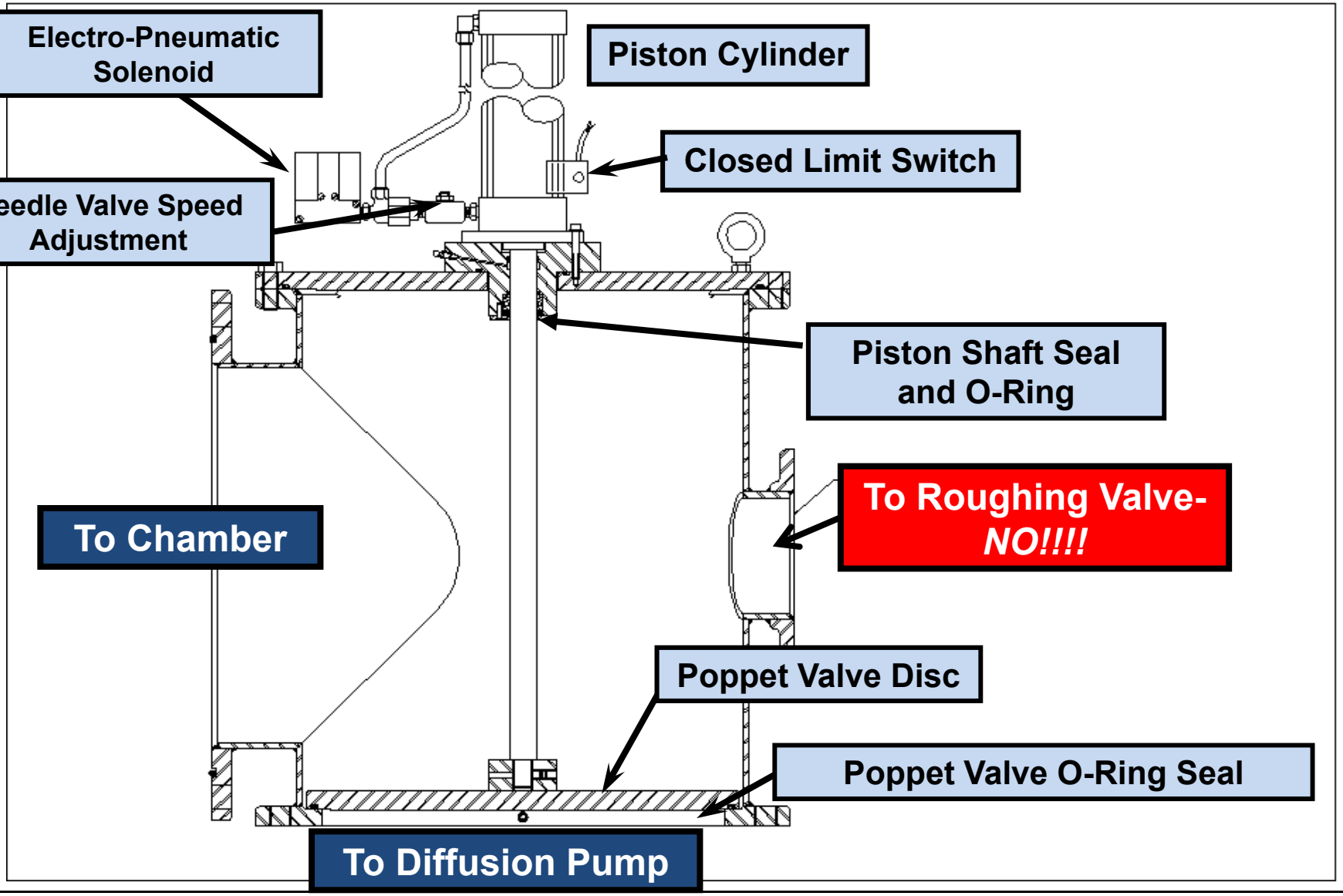
Butterfly type valves

- Require the least maintenance
- Designed for minimum wear and maintenance
- Replace valve seat every 2 years
- The valve disc should be rotated to the open position before the flange bolts are tightened*

- *In order to prevent valve from sticking

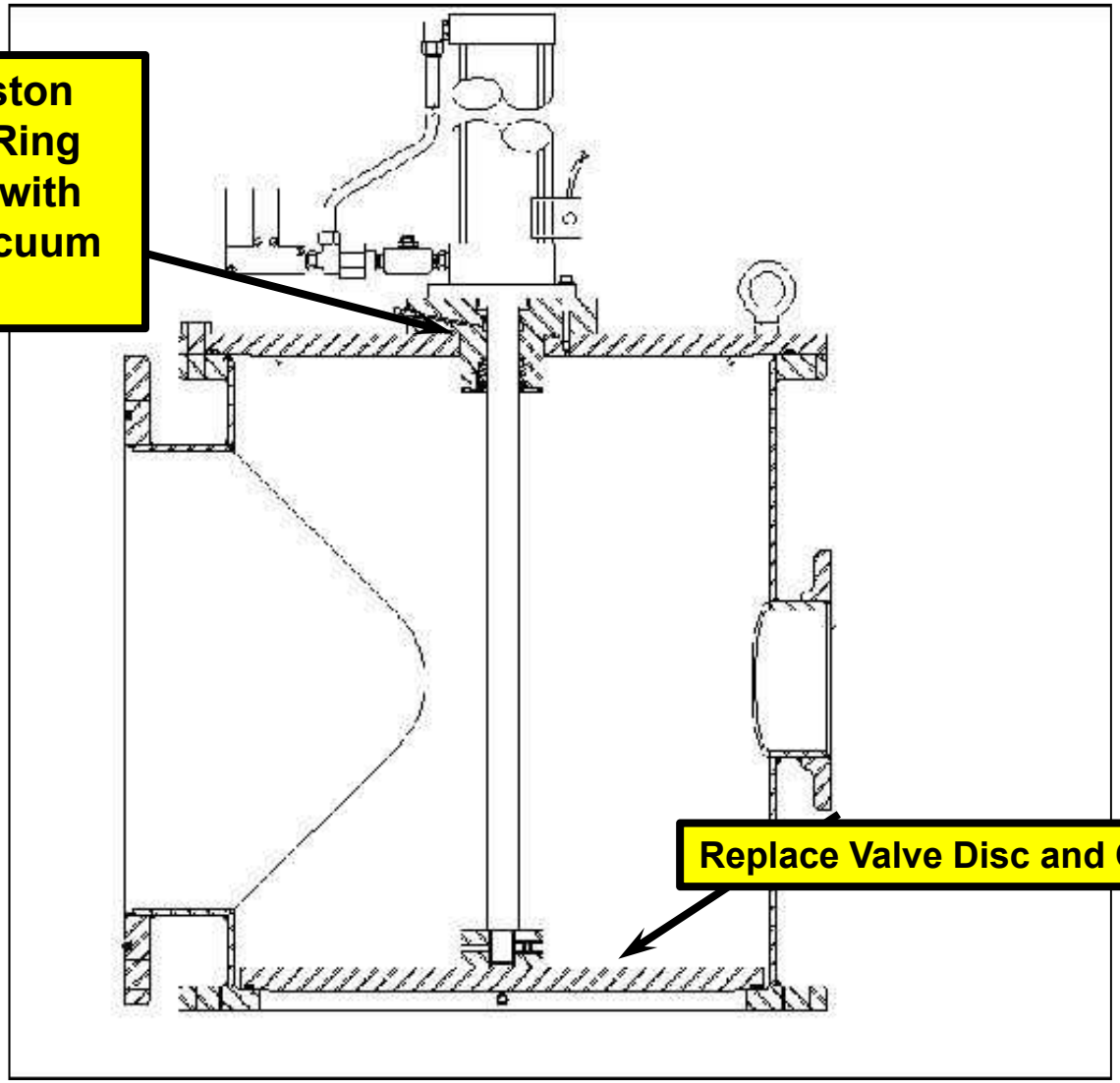
Typical Main Valve

Main Valve - Poppet Type



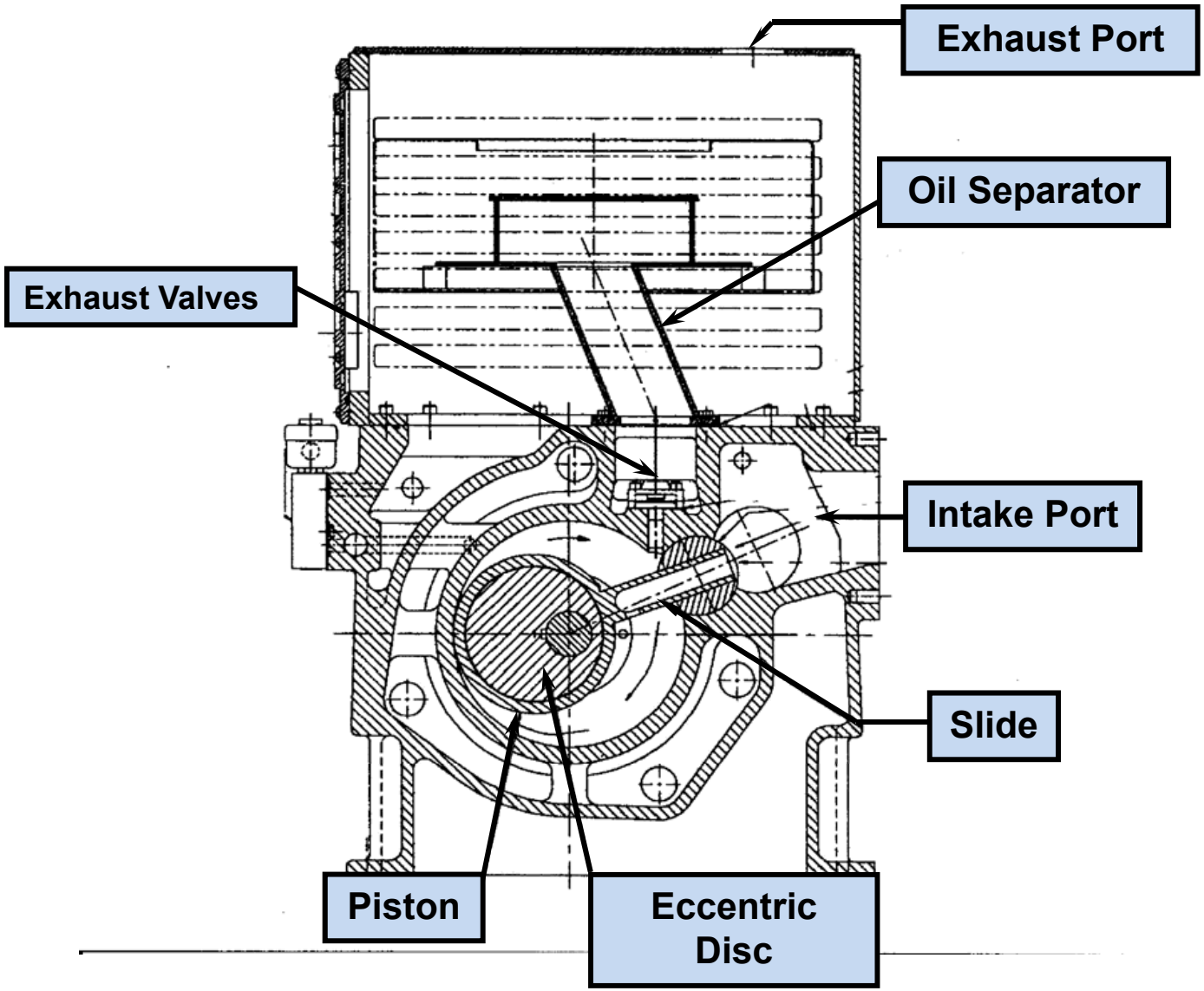
Main Valve Care and Maintenance

Lubricate Piston Shaft and O-Ring every month with high grade vacuum grease.



Replace Valve Disc and O-Ring annually.

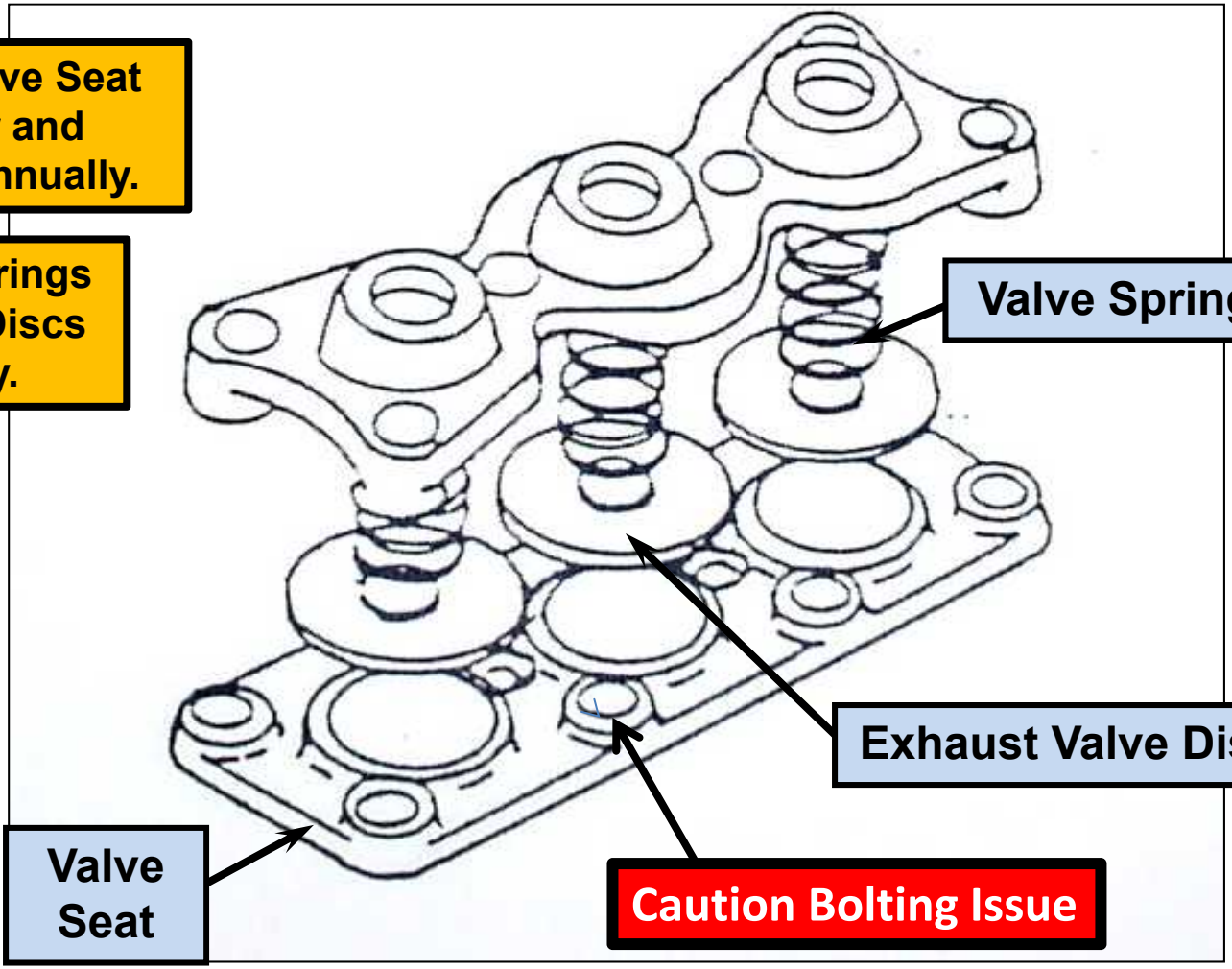
Typical Stokes Mechanical Pump



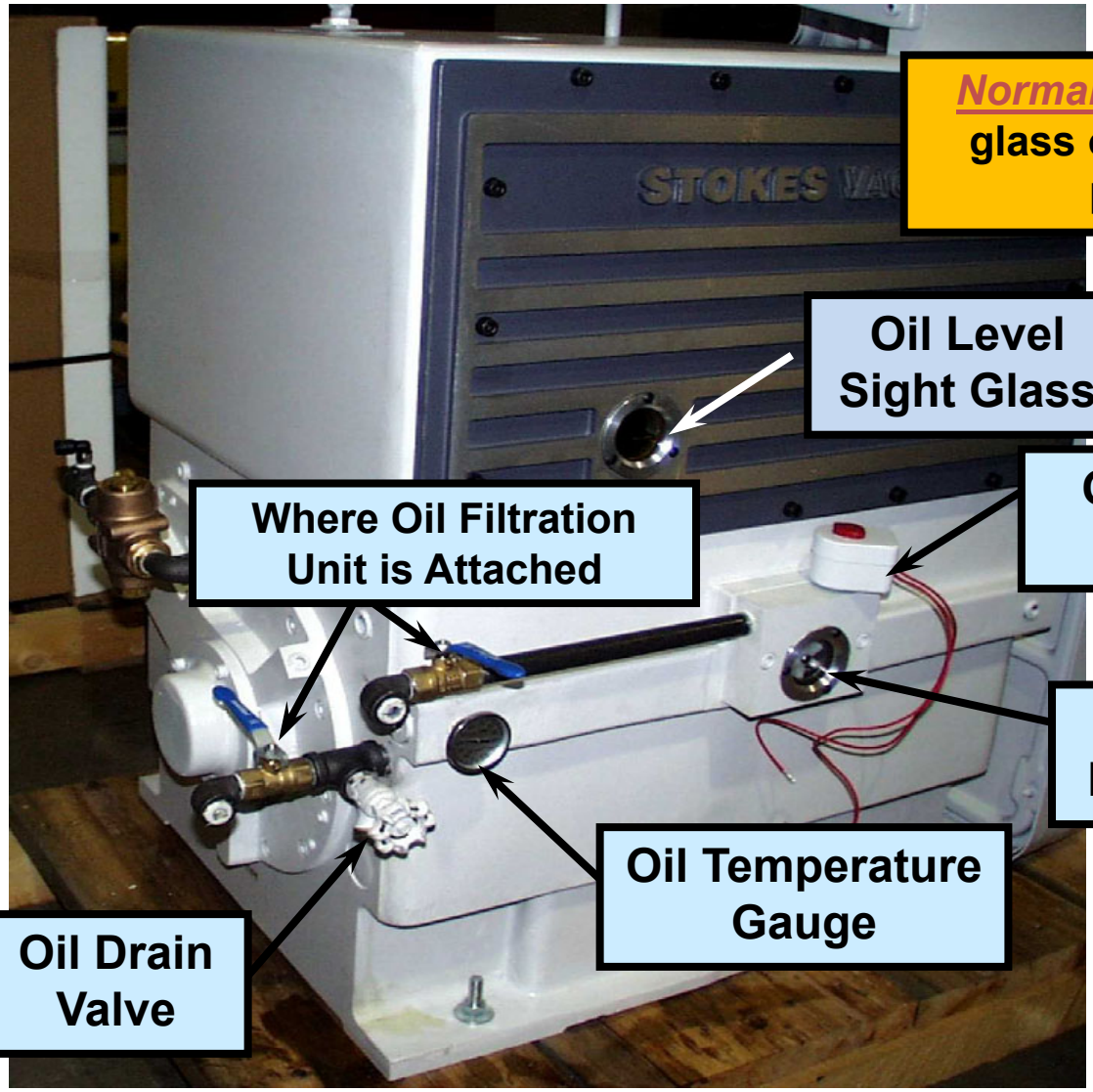
Stokes Mechanical Pump Exhaust Valve Assembly

Inspect Valve Seat for wear and cracking annually.

Replace Springs and Valve Discs annually.



Stokes Mechanical Pump (Roughing)

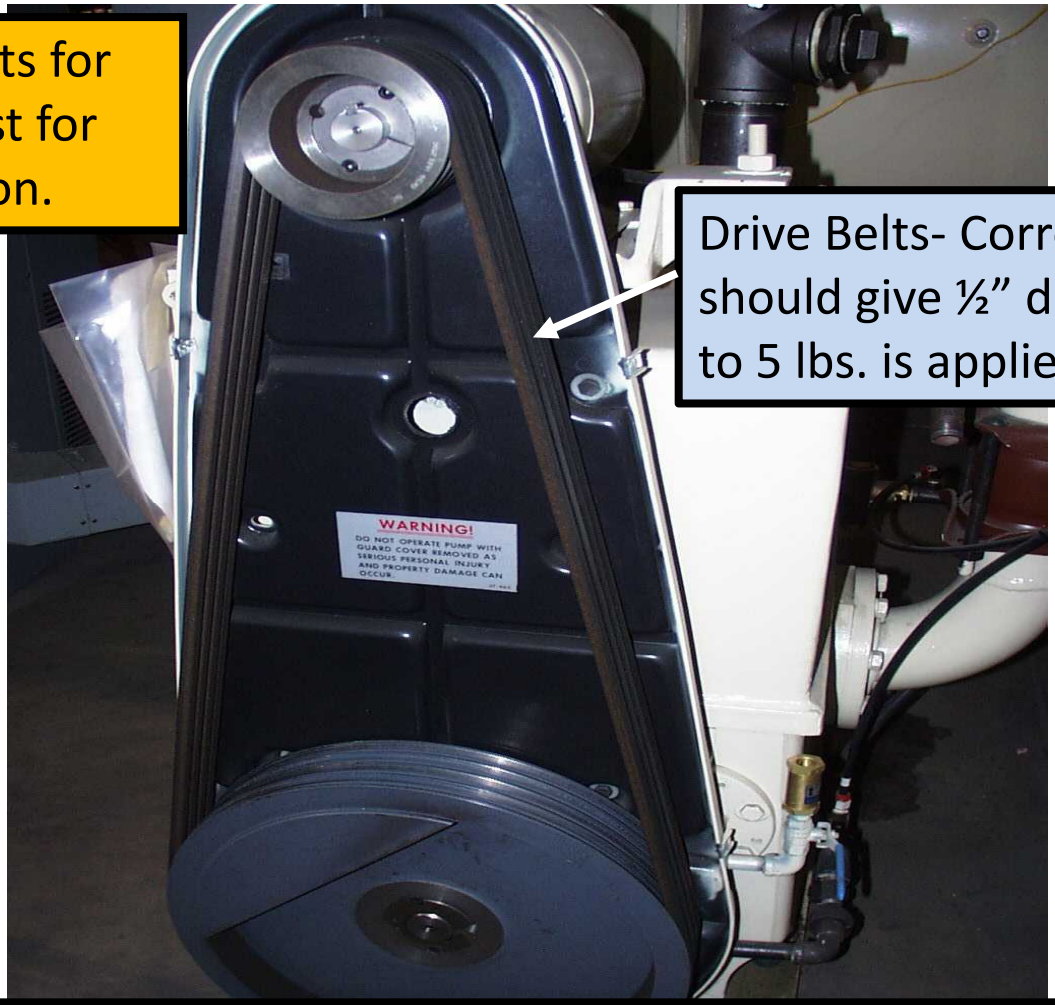


Normal Level - Center of sight glass or slightly below when pump is running

Normal Operating Temp. 140 ºF - 160 ºF

Mechanical (Roughing) Pump - Drive Belts

Check Drive Belts for wear and adjust for proper tension.



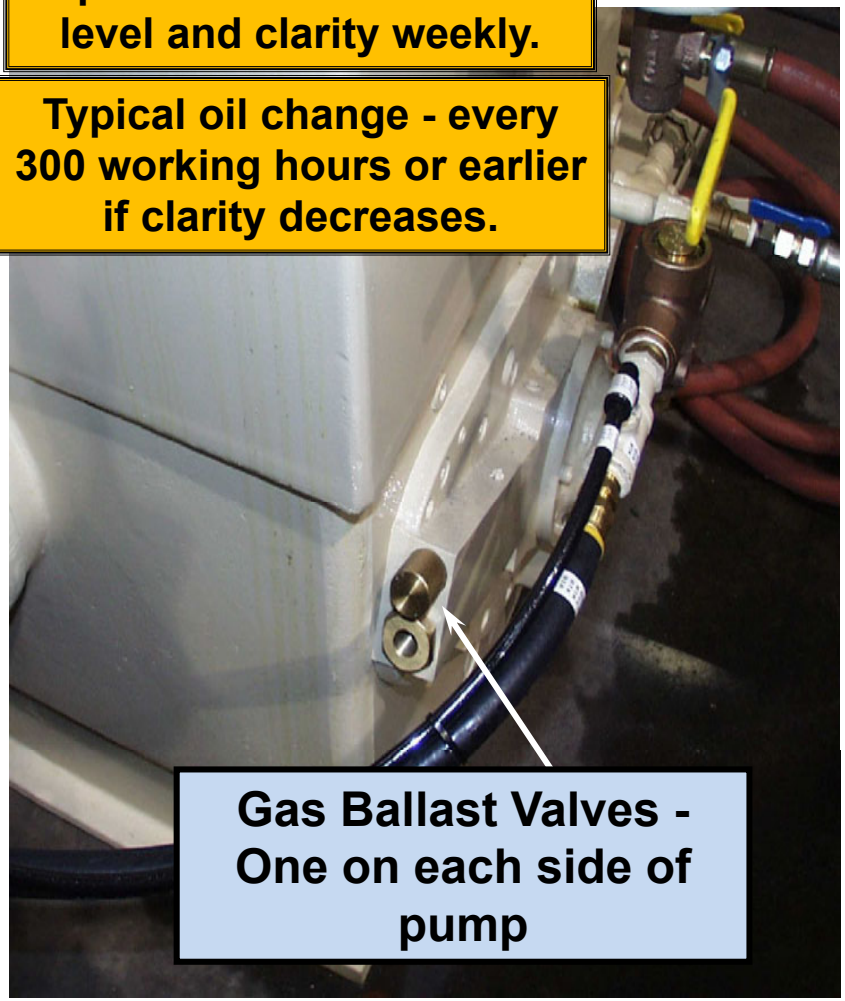
Drive Belts- Correct tension should give ½" deflection when 3 to 5 lbs. is applied to midpoint.

Too Tight – Results in damage to the drive shaft bearings.
Too Loose - Belts will slip and cause excessive wear.

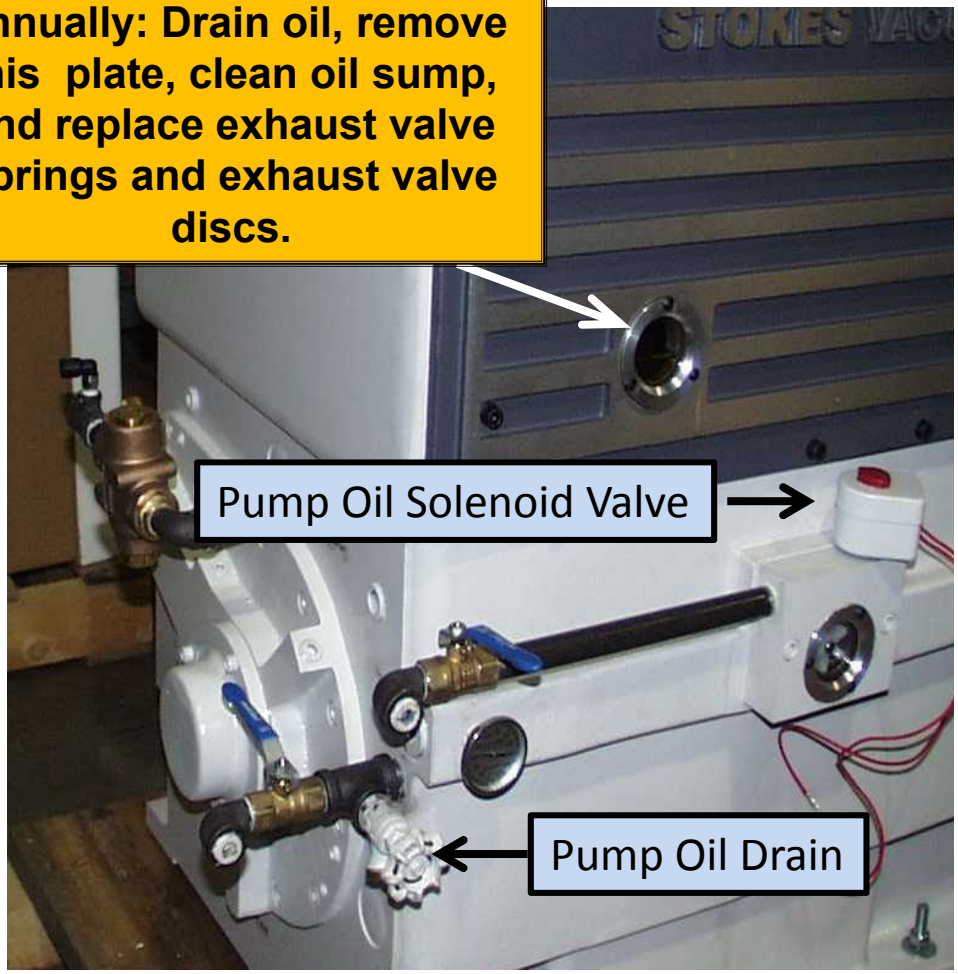
Roughing Pump Care

Operators must check oil level and clarity weekly.

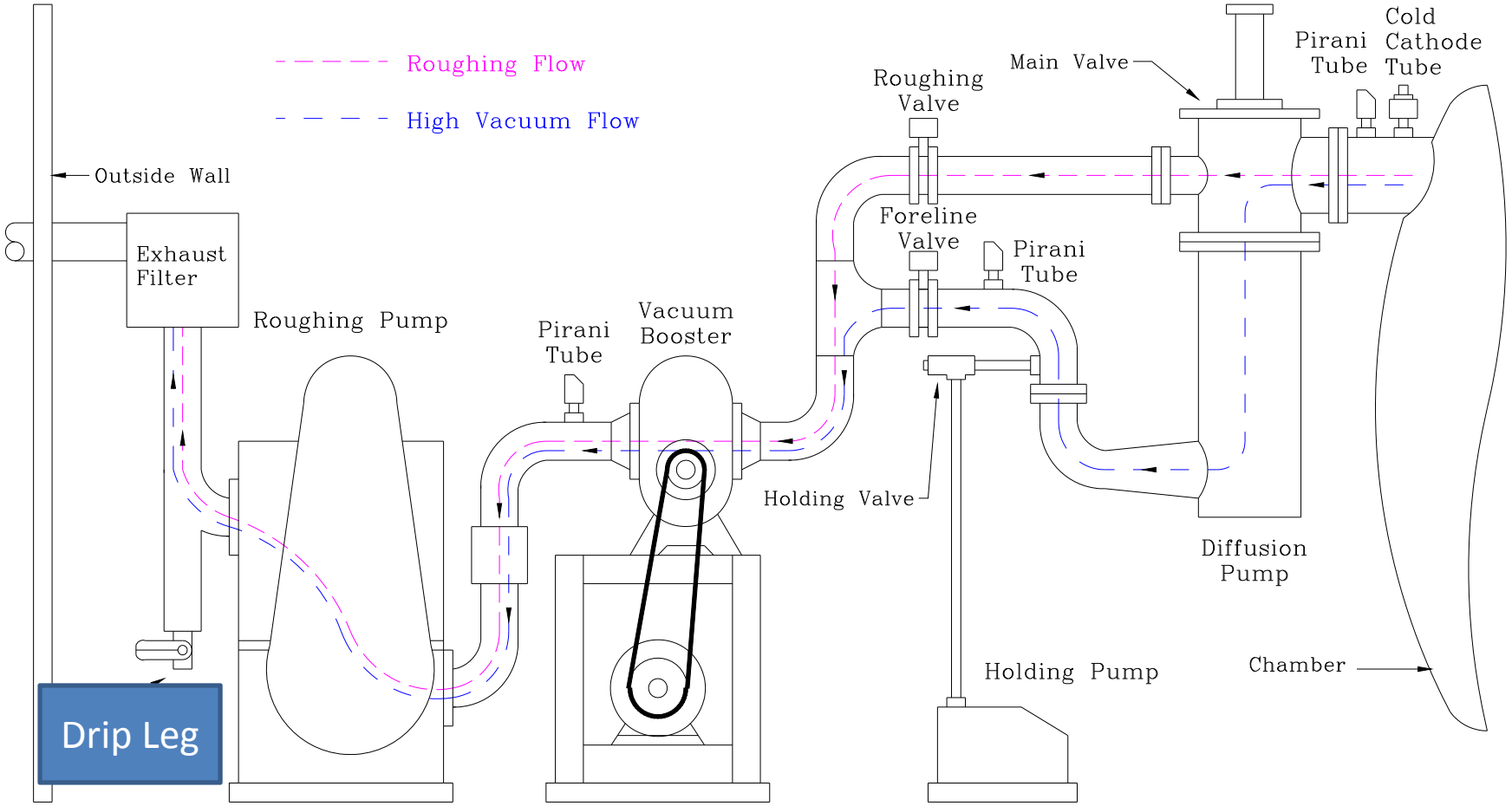
Typical oil change - every 300 working hours or earlier if clarity decreases.



Annually: Drain oil, remove this plate, clean oil sump, and replace exhaust valve springs and exhaust valve discs.



Vacuum Pumping System – Exhaust Line-Drip Leg



Drip leg collects dirty oil and moisture from roughing pump exhaust line. Check daily and drain as needed.

Roughing Pump – Daily Maintenance

- Oil level:
  Pump “running” - Correct oil level is center of sight glass
- Add oil if required - Pump should not run with low oil level
- Check and drain drip leg

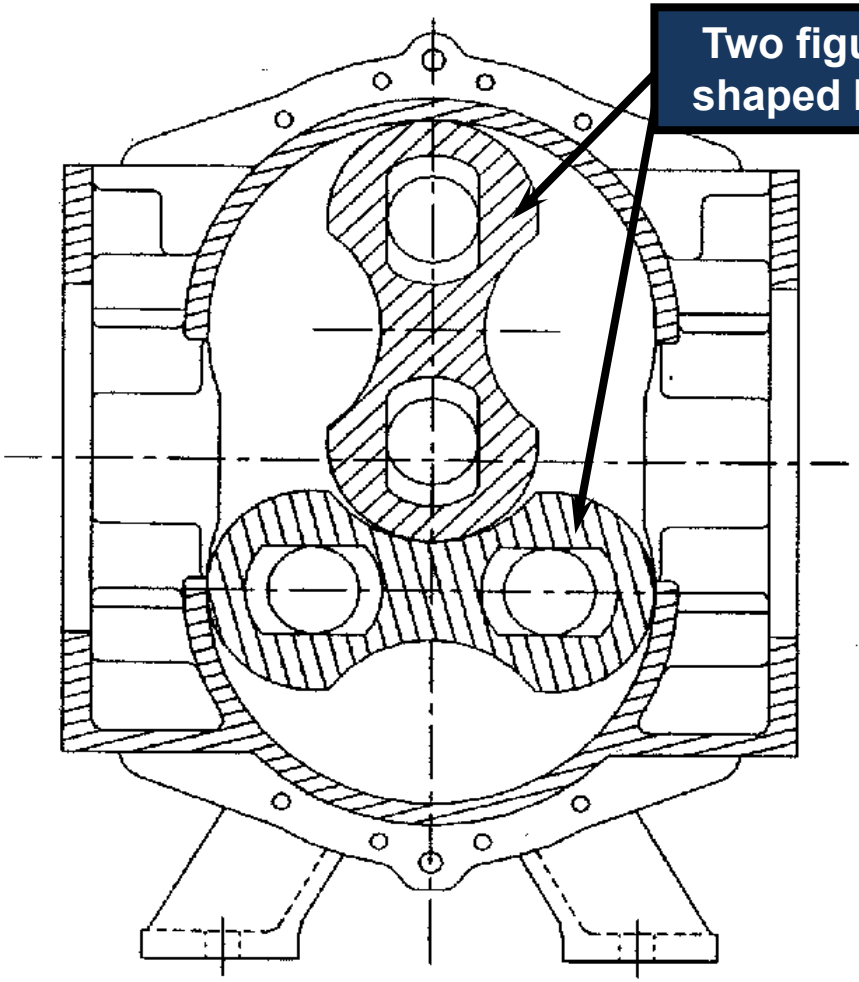
Oil condition:

- Good oil is clean and has good clarity.

- Cloudy or milky oil shows presence of moisture

- Open gas ballast valves to eliminate moisture from oil; approx. 30 minutes
- Change pump oil if dirty or extremely milky

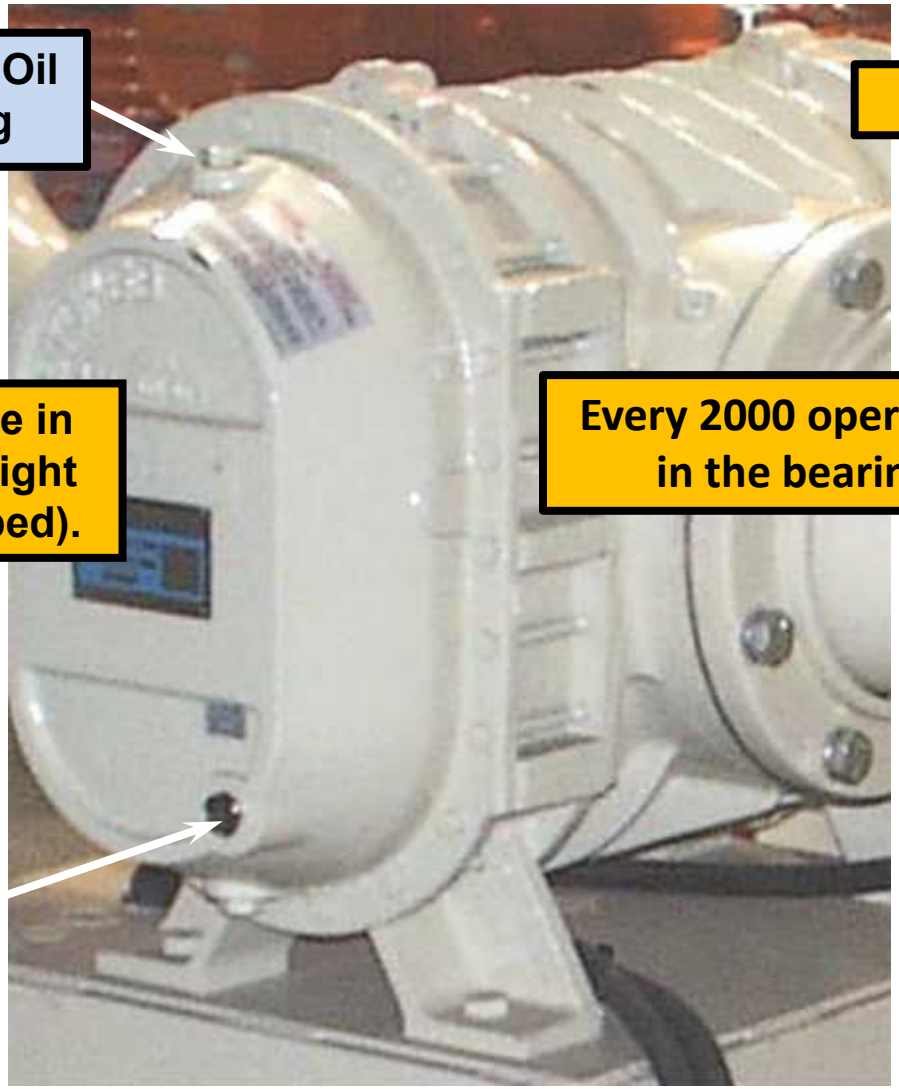
Roots 615 Vacuum Booster



Two figure-eight shaped Impellers

Impellers rotate in the opposite direction at 3000 RPM.

Vacuum Booster Gear End



Gear End Oil Fill Plug

Check oil levels weekly.

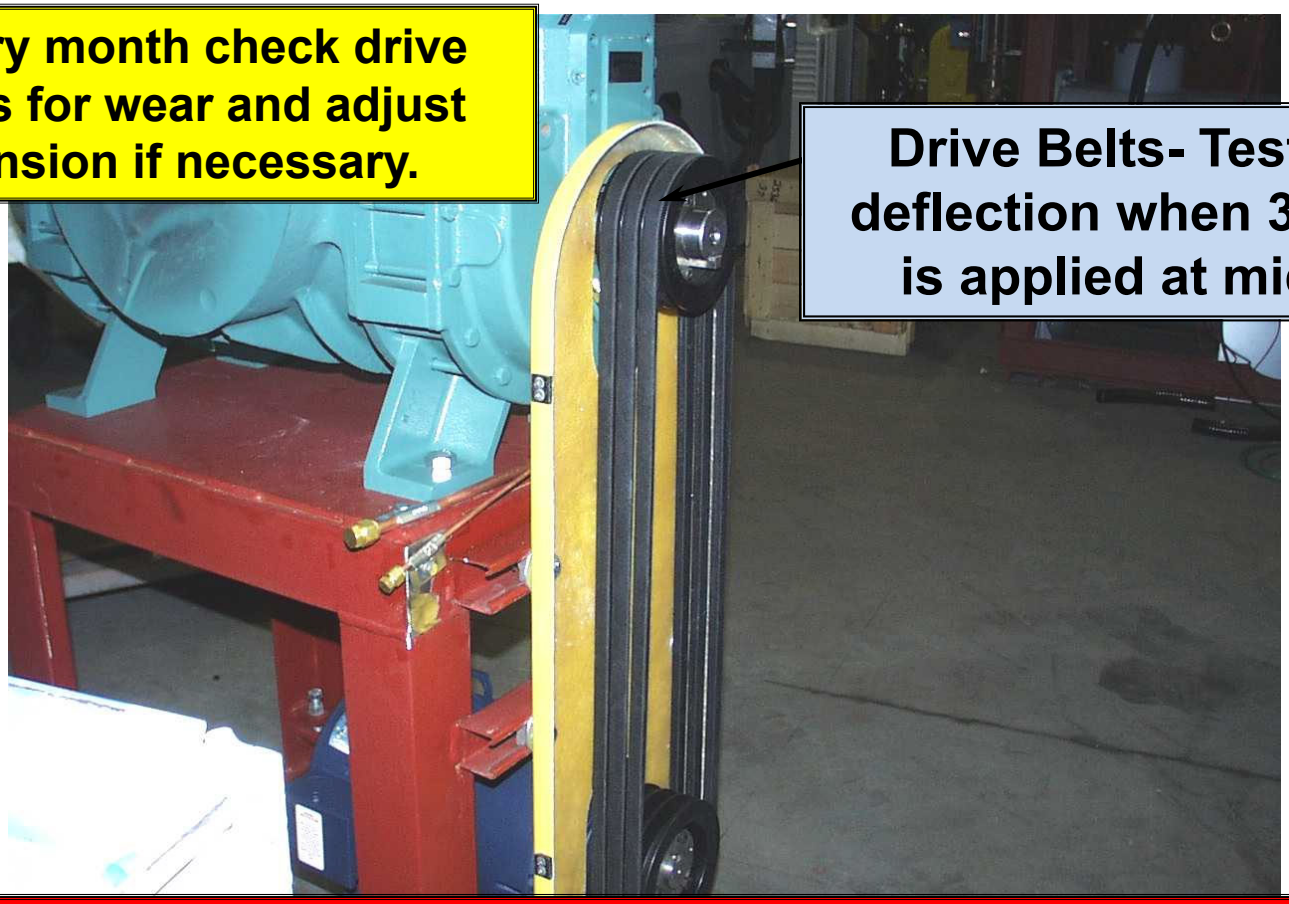
Oil level should be in the center of the sight glass (pump stopped).

Every 2000 operating hours, change the oil in the bearing and gear reservoirs.

Gear End Oil Drain Plug

Vacuum Booster Critical Care

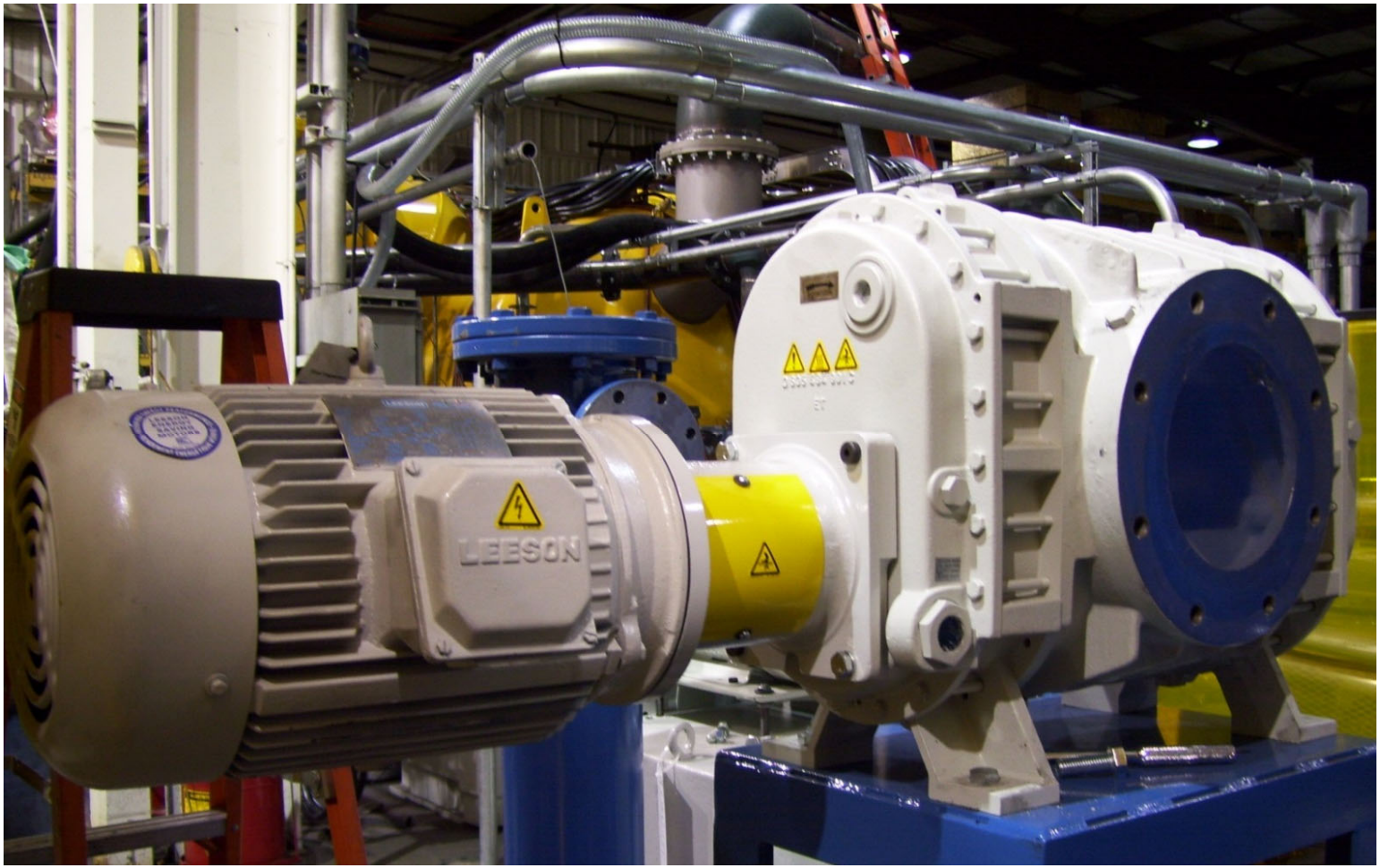
Every month check drive belts for wear and adjust tension if necessary.



Drive Belts- Test for ½" deflection when 3 to 5 lbs. is applied at midpoint.

Too tight – Results in damage to shaft bearings.
Too loose - Belts will slip and cause excessive wear.

Direct Drive Vacuum Booster Design

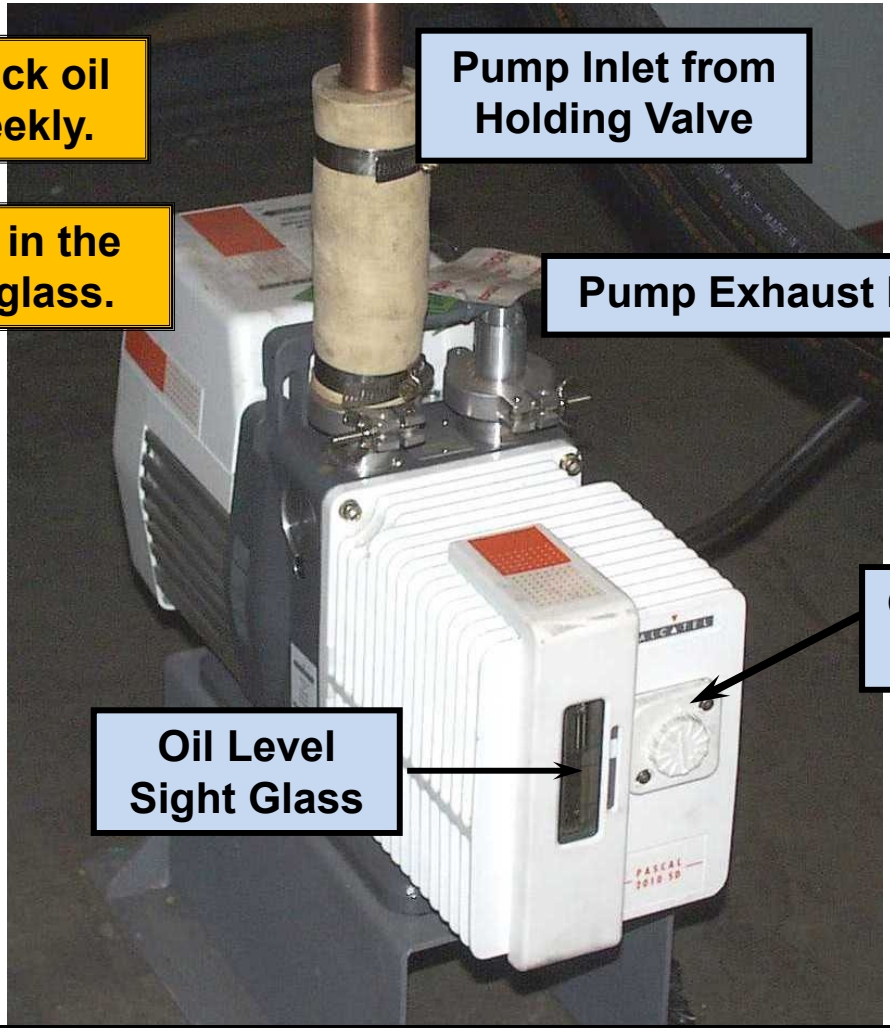


Alcatel Holding Pump

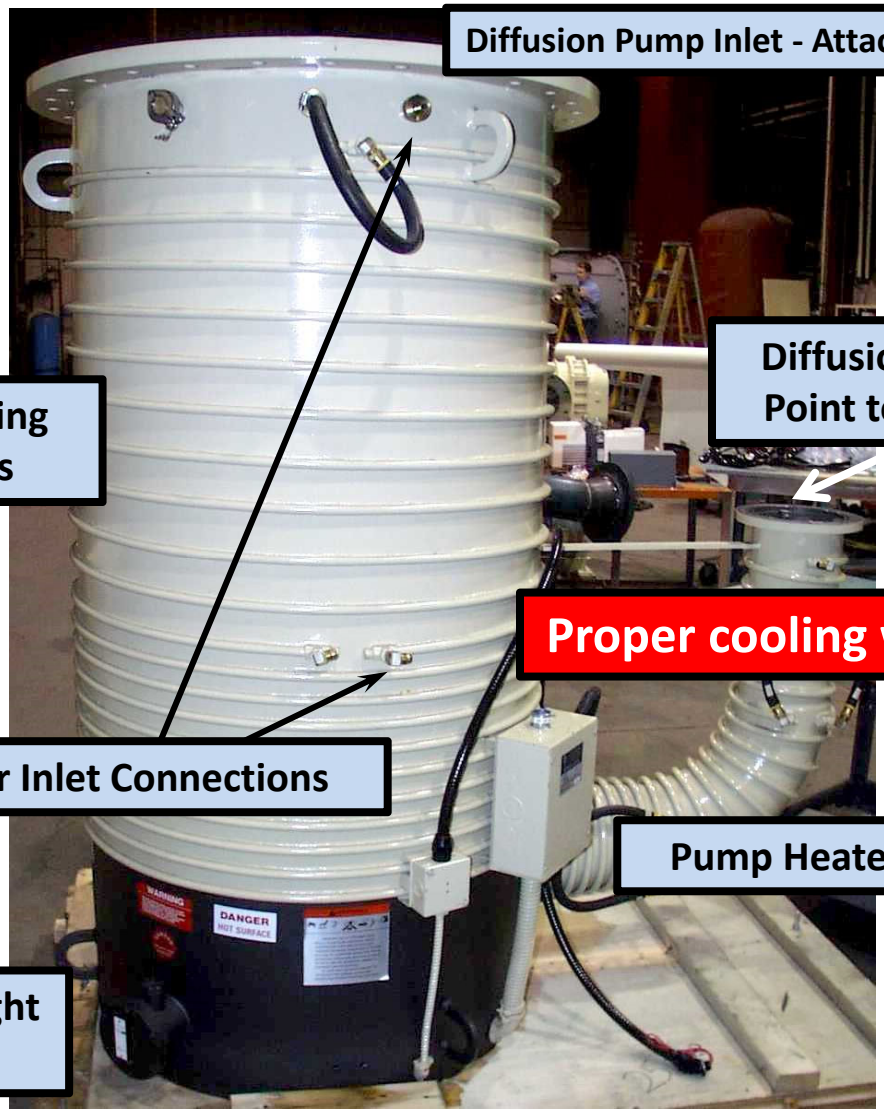
Operate Continuously

Operators must check oil level and clarity weekly.

Oil level should be in the center of the sight glass.



35” Varian Vacuum Diffusion Pump



Diffusion Pump Inlet - Attaches to and under the Main Valve.

Copper Cooling Water Coils

Diffusion Pump Foreline Connection Point to the Roughing Pump System

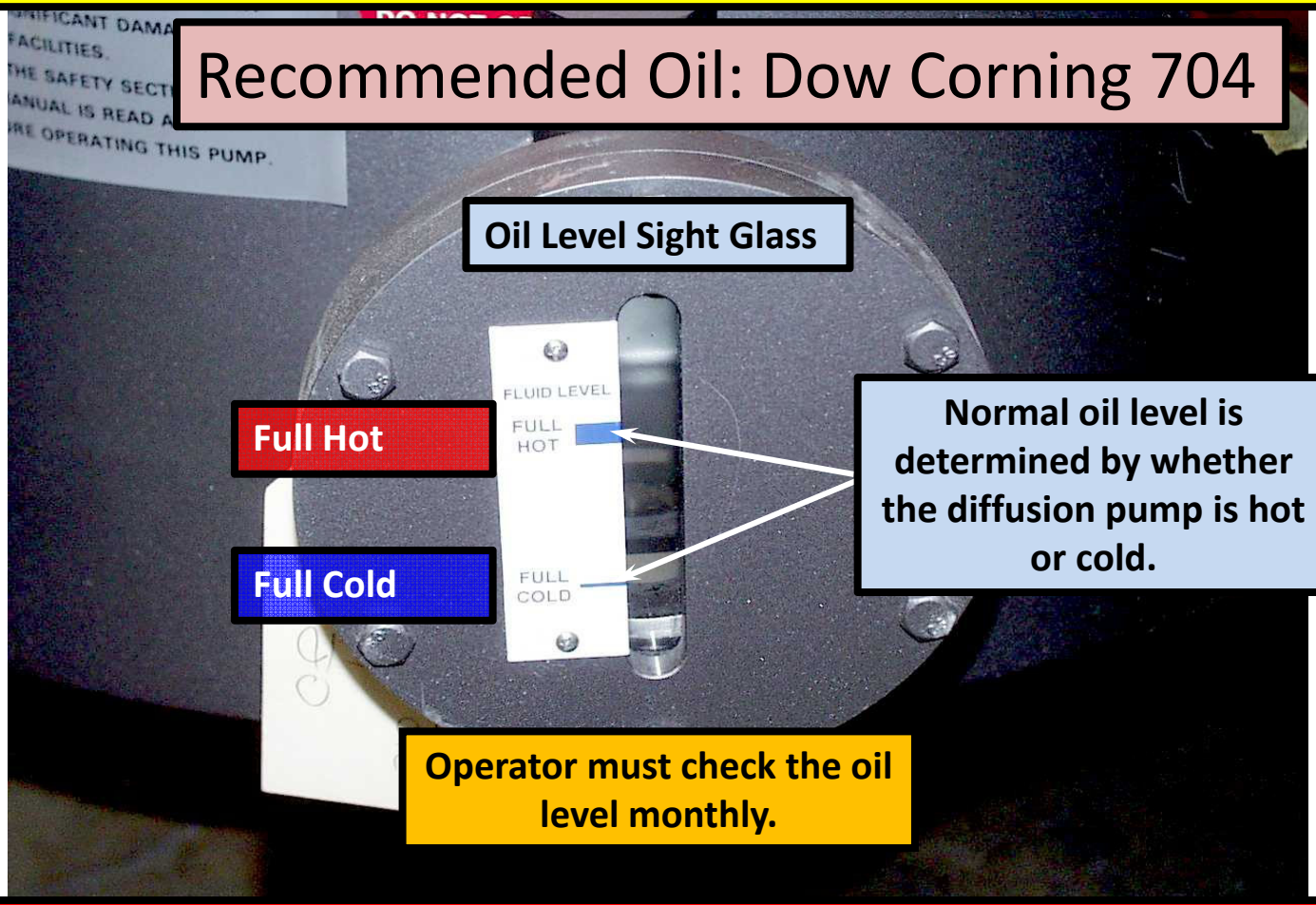
Proper cooling water flow is essential.

Cooling Water Inlet Connections

Pump Heater Electrical Connection Box

Oil Level Sight Glass

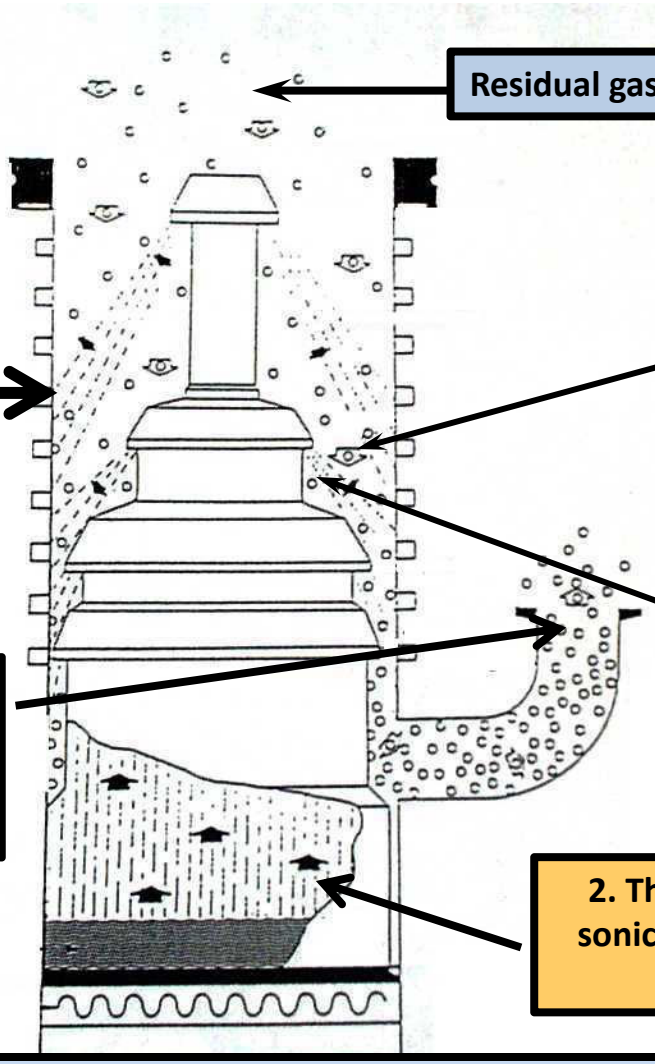
Diffusion Pump Maintenance



Never open the oil drain or fill plug when the pump is HOT! - *Risk of Explosion!!*

How A Diffusion Pump Operates

The Main and Foreline Valves must be open.



Residual gas molecules from furnace

4. As diffusion oil molecules return in a downward direction, the lighter gas molecules from the furnace are captured and forced down to the bottom of the pump.

5. When contacting the cold side walls, the oil returns to liquid form and returns to the bottom of the pump to be reheated.

3. Oil mist particles are deflected from Jet Nozzles.

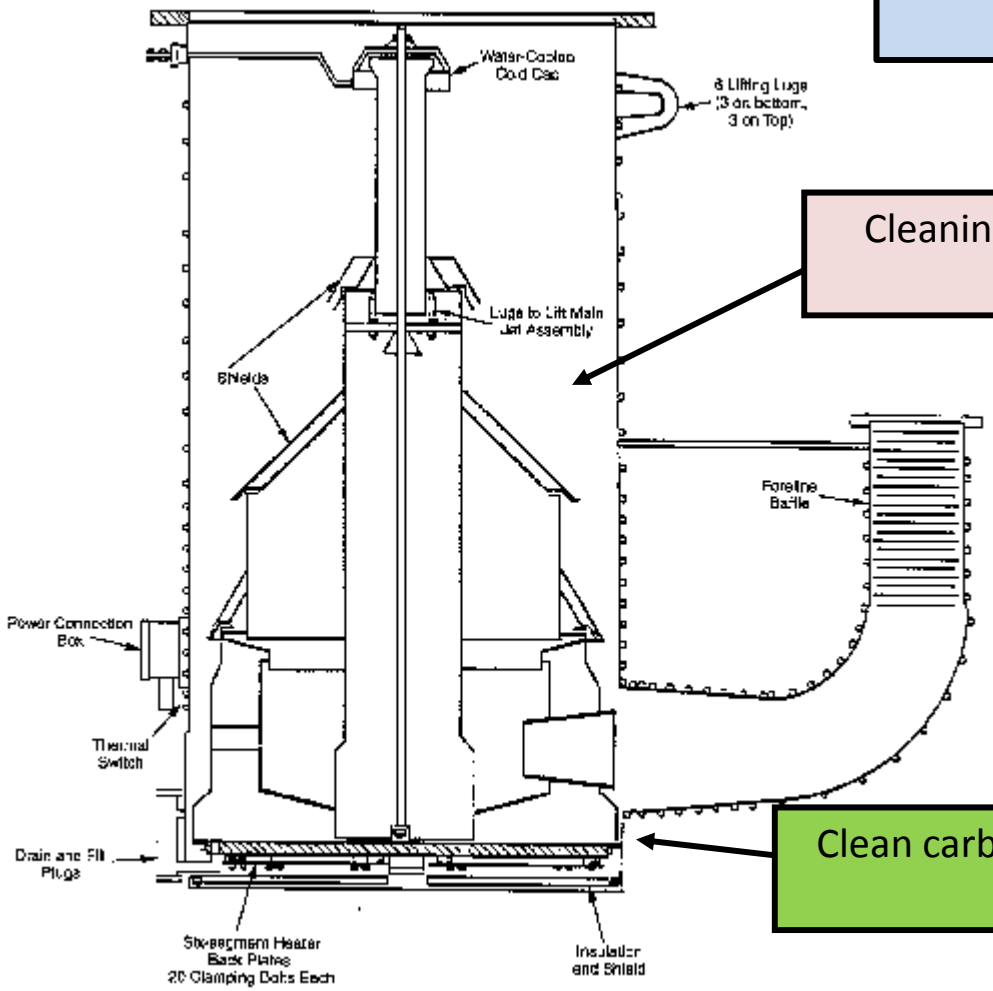
6. The gas molecules are collected at the Ejector Nozzle and pulled out of the pump by the roughing system.

2. The molecules in the oil mist reach sonic speeds as they travel through the Jet Assembly.

1. Oil is heated to boiling and forced up through the center of the Jet Assembly as a mist.

Diffusion Pump Maintenance

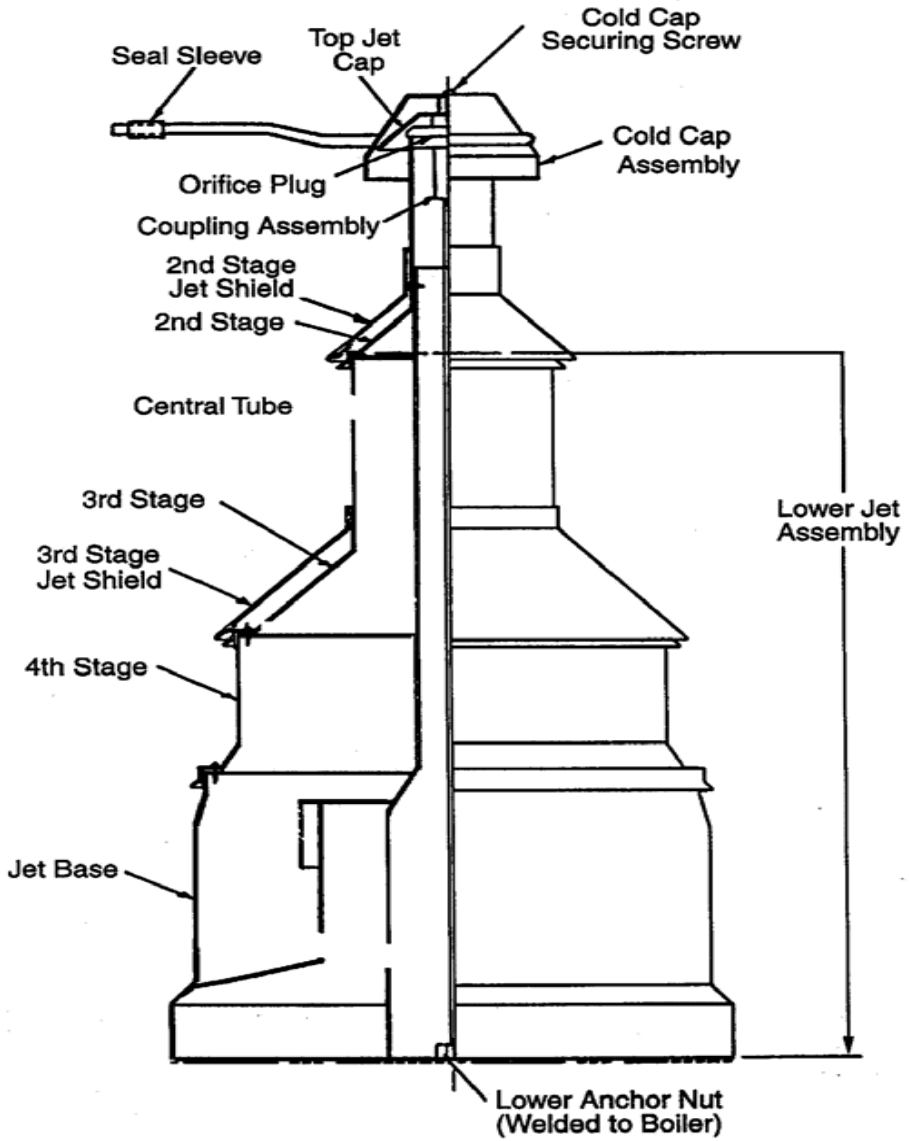
Every twelve (12) months, clean the inside of the pump and change oil.



Cleaning requires removing the pump from the Main Valve and removing Jet Assembly.

Clean carbon buildup on boiler plate at bottom of the pump.

Diffusion Pump Jet Assembly



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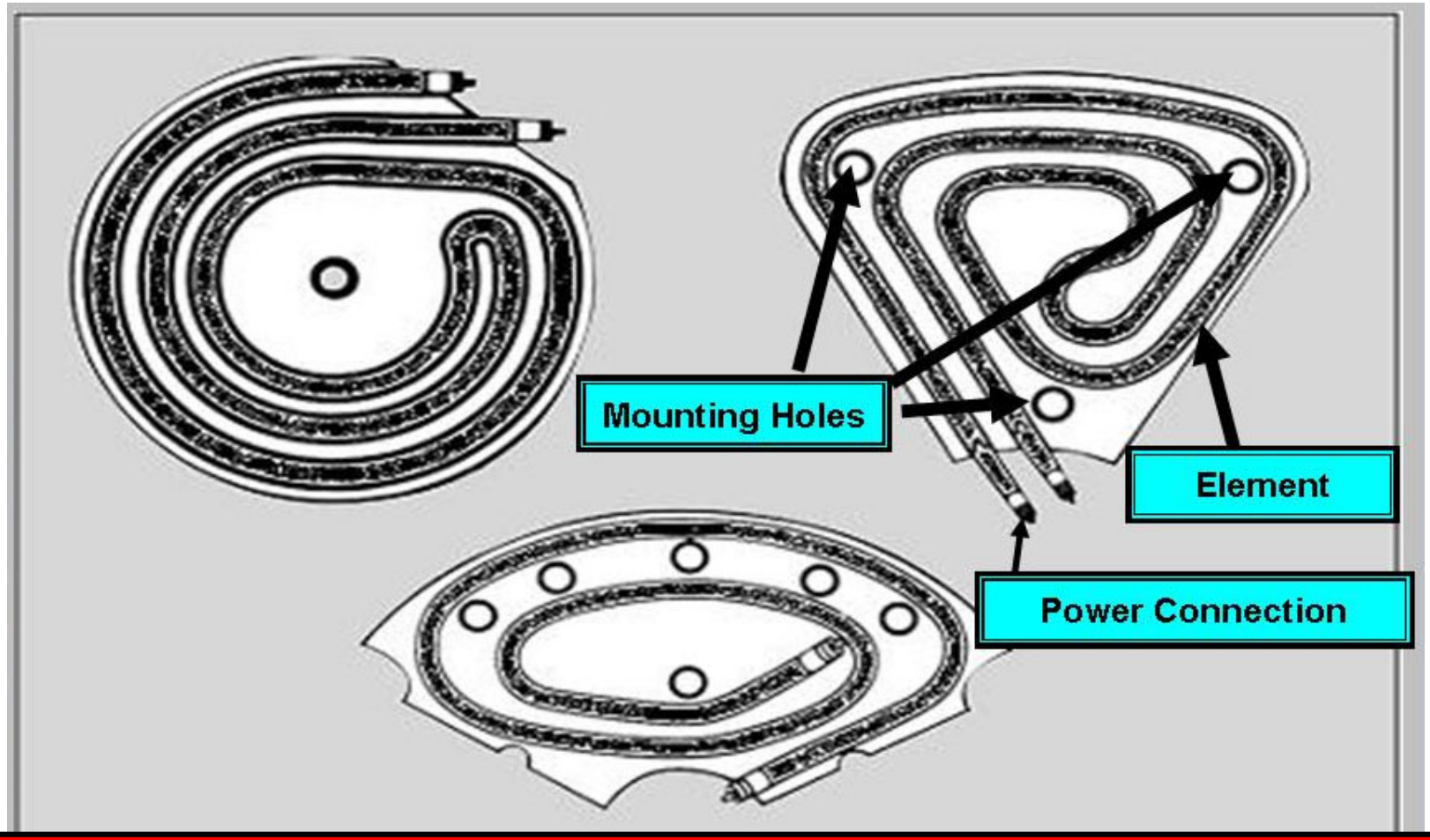
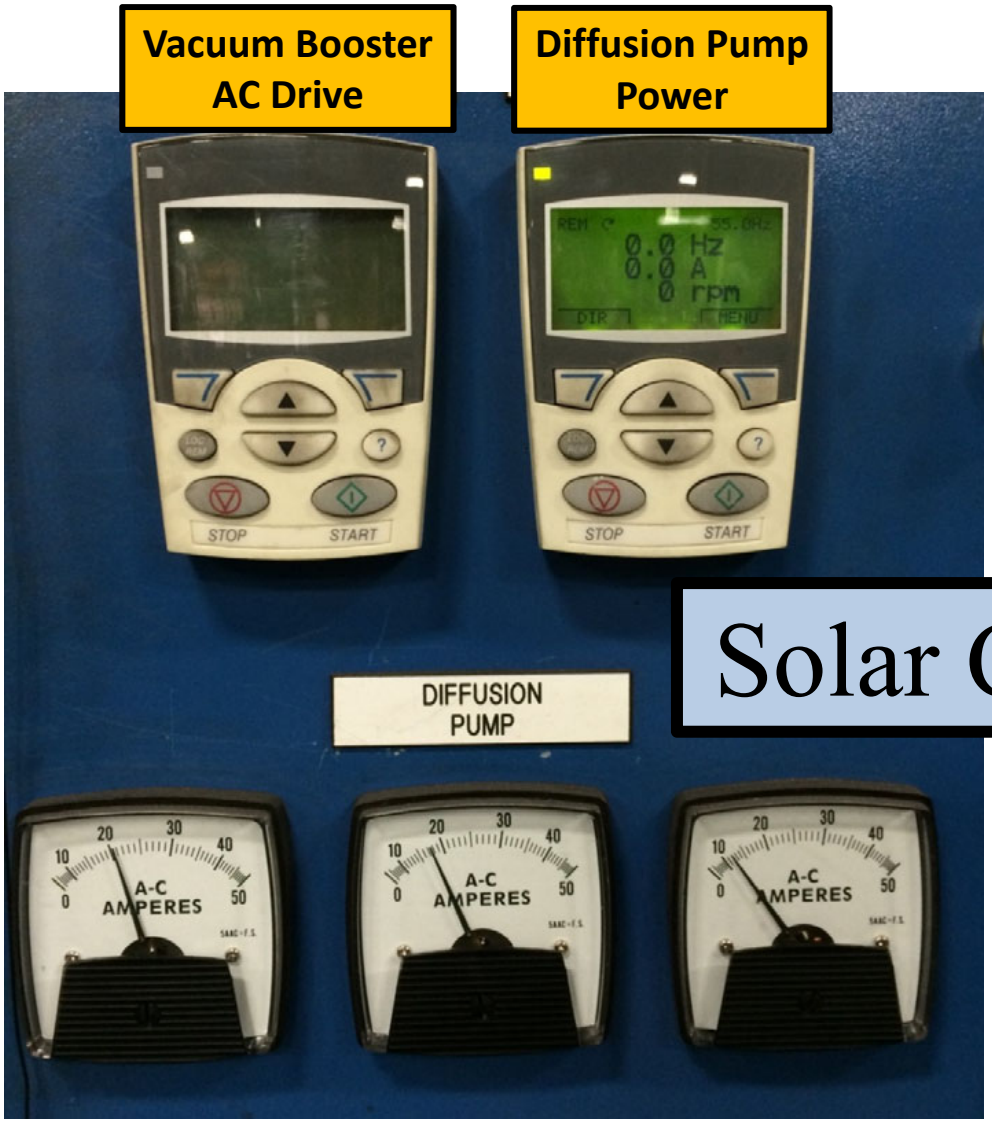
Foreline Mechanical Baffle

Diffusion Pump Heater Assemblies



It is very important that the heaters be firmly bolted to the base.

Diffusion Pump Ammeters



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Maintenance Records

Monthly Function	Furnace One	Furnace Two	Furnace Three
Change Roughing Pump Oil			
Change Holding Pump Oil			
Check Vacuum Booster Oil			
Check Holding Pump Oil			
Drain Exhaust Line Filter			
Grease Main Valve			
Clean Air Filters			
Check Belts			
Check Water Flow Ball Indicators			
Check Integrity of Door O-ring Seal			
Check Air Line Oilers			
Inspect Entire Hot Zone			

Maintenance Records (Cont'd.)

Six month/Yearly function	Furnace One	Furnace Two	Furnace Three
Change Diffusion Pump Oil (Annually)			
Change Vacuum Booster Oil (Every six Months)			
Replace Door O-ring seal (Every Three Months)			
Roughing Pump belt replacement (Annually)			
Clean Roughing Pump Reservoir (Annually)			
Check all Flowmeters (Annually)			
Do Electrical Cleaning			

Solar Atmospheres Technical Booklets and Articles

- *Critical Melting Points and Reference Data for Vacuum Heat Treating*
- *Temperature Uniformity Surveying of Vacuum Furnaces*
- *Operating a Vacuum Furnace Under Humid Conditions*
- *Understanding PID Temperature Control in Operating a Vacuum Furnace*
- *Understanding Power Losses in a Vacuum Furnace*
- *Important Considerations When Purchasing a Vacuum Furnace*
- *Considerations When Selecting a Vacuum Furnace Water Cooling System*
- *Reducing Energy Consumption When Operating a Vacuum Furnace*
- *Explaining Vacuum and Vacuum Instrumentation*
- *Understanding Emissivity and the Use of Thermocouple Test Blocks in a Vacuum Furnace*
- *Vacuum Gauge Correction Factors*
- *Leak Detection and Checking of Vacuum furnaces*
- *Critical Areas of Preventive Maintenance*
- *Evaluating Pan versus Rayon Graphite Felt Insulation for Vacuum Furnaces*
- *The Use of a Residual Gas Analyzer (RGA) to Determine Differences in Graphite and All-metal Hot Zone Vacuum Operation (To be published)*