VARIAN

# BASICS of MAINTENANCE and TROUBLESHOOTING of VACUUM DIFFUSION PUMPS

Inspiring Excellence

# Topics for Discussion

- Diffusion Pump Basics
- Maintenance
- Troubleshooting

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- Diffusion Pump Fundamentals
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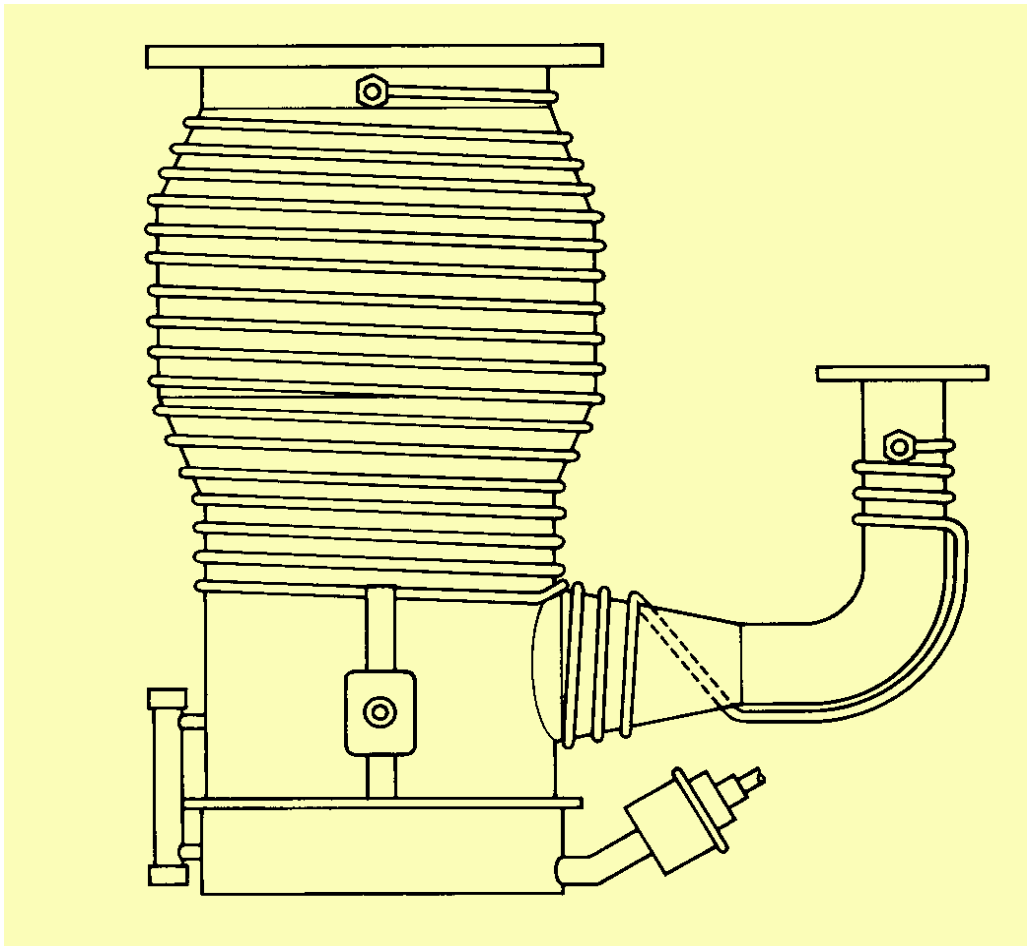
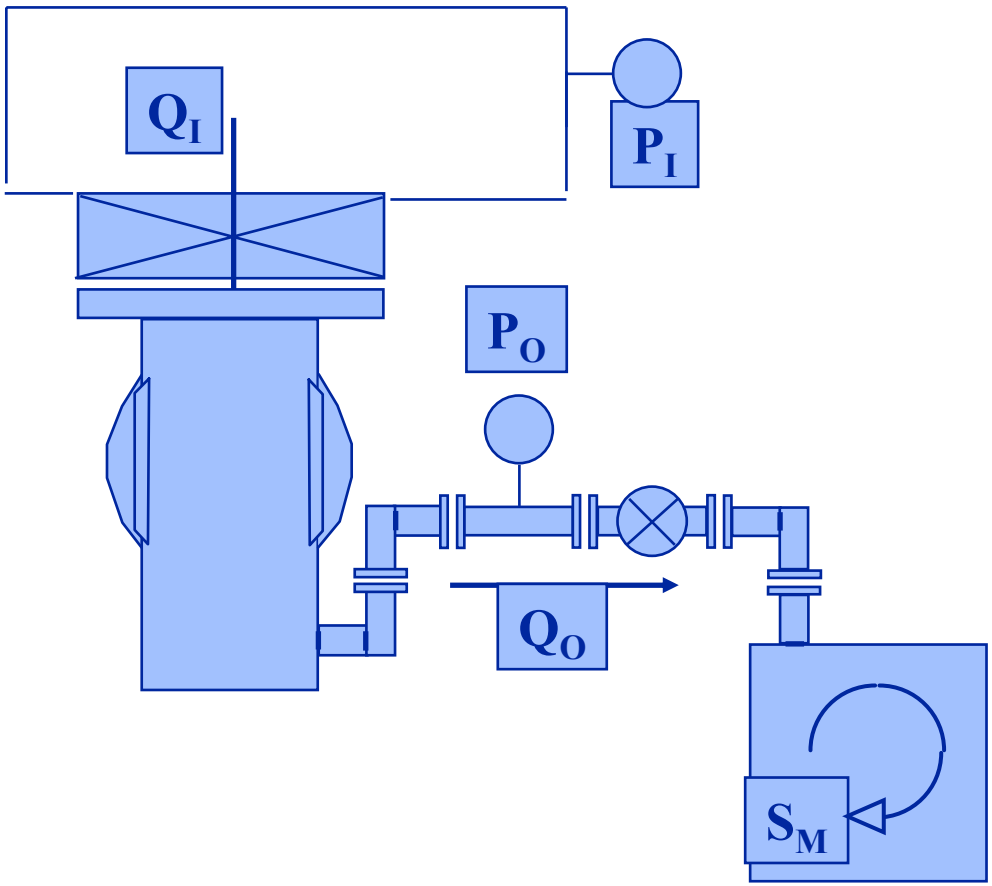
- Troubleshooting

# Diffusion Pump



# Diffusion Pump Fundamentals

## Typical pumping "system"

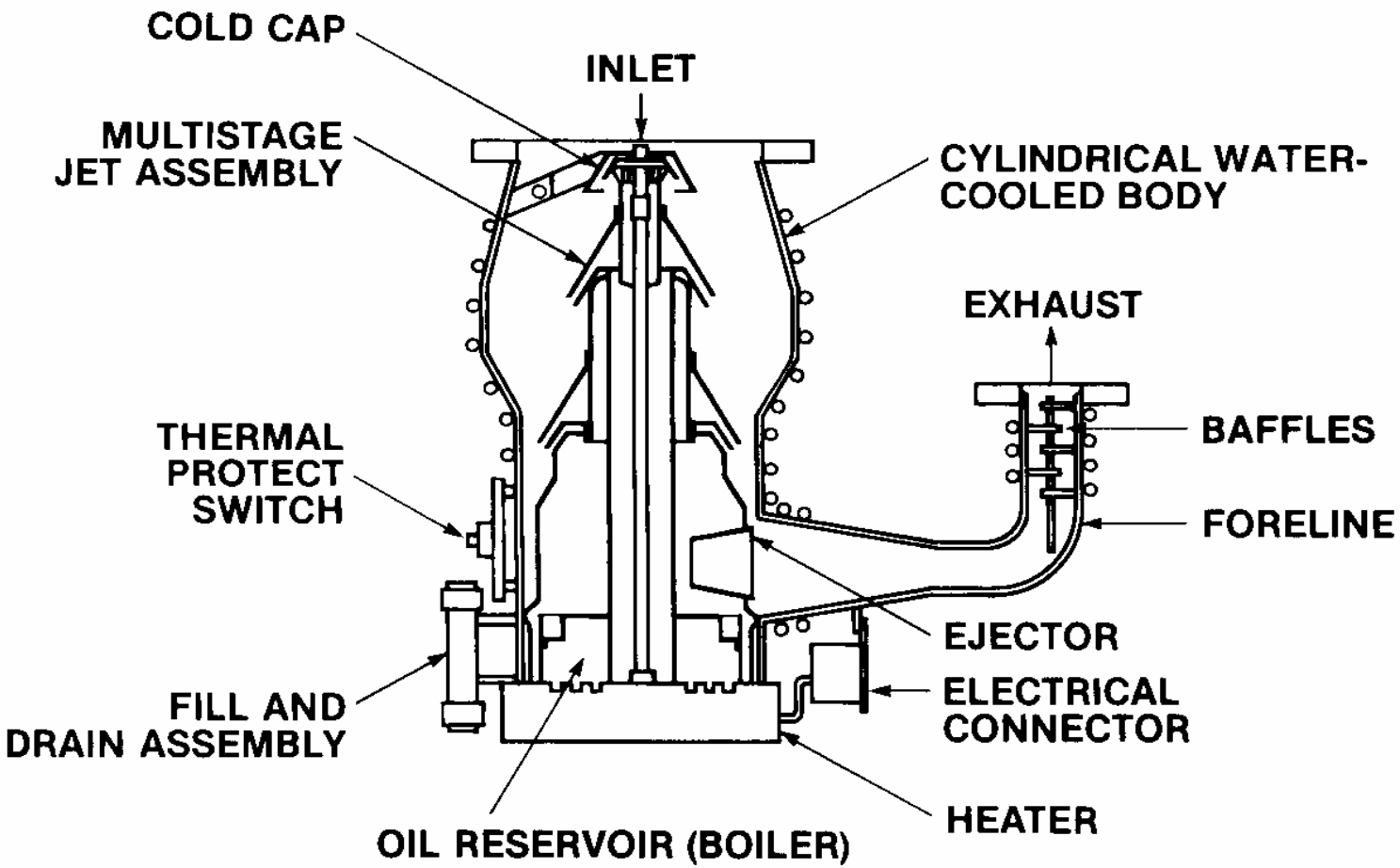



**Typical pumping system includes rough pumps, valves, gauging and vacuum hardware.**

**In this discussion we focus on the Diffusion Pump.**

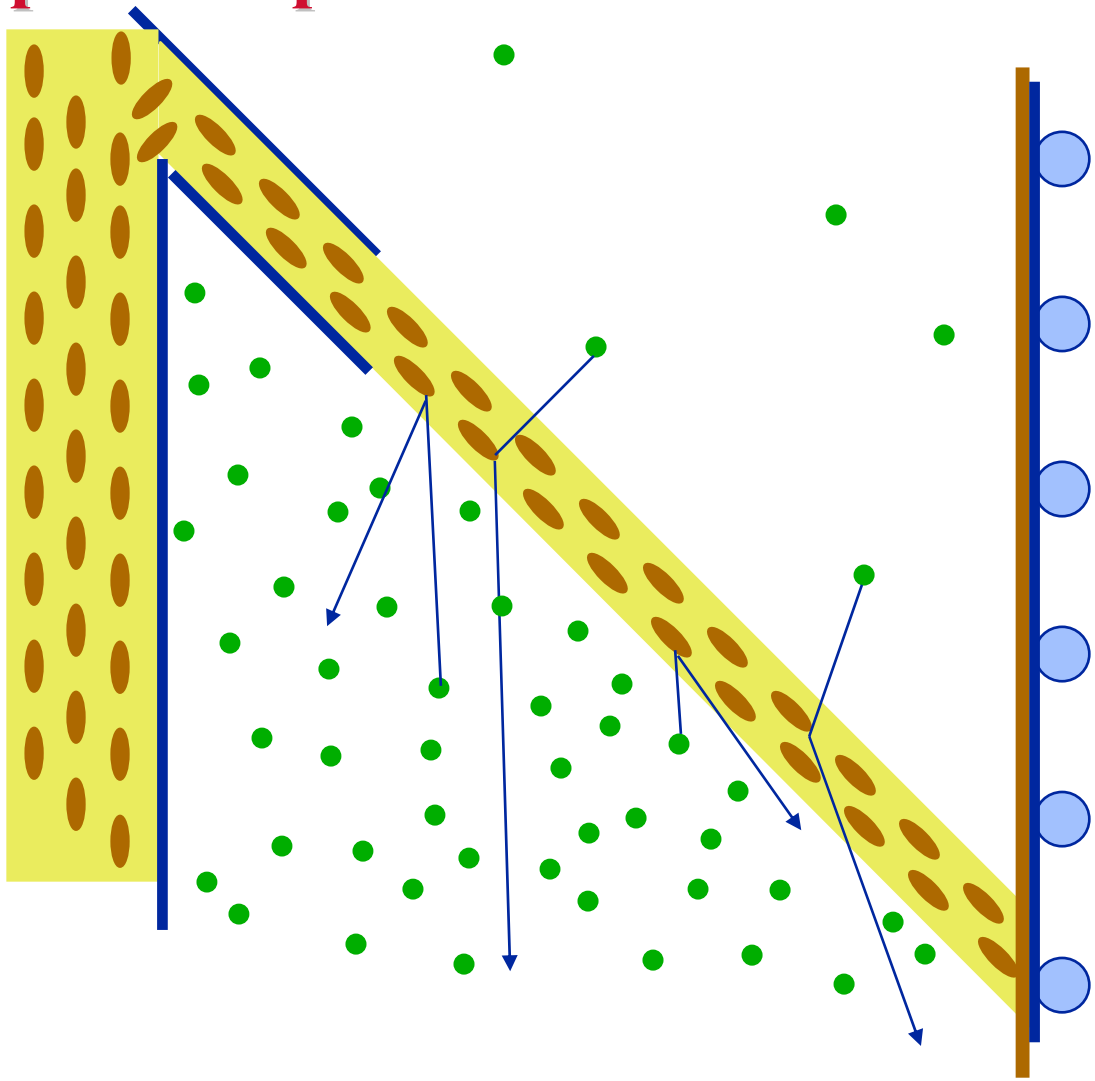
# Diffusion Pump Fundamentals

## Principles of Operation - Basic Pump Design



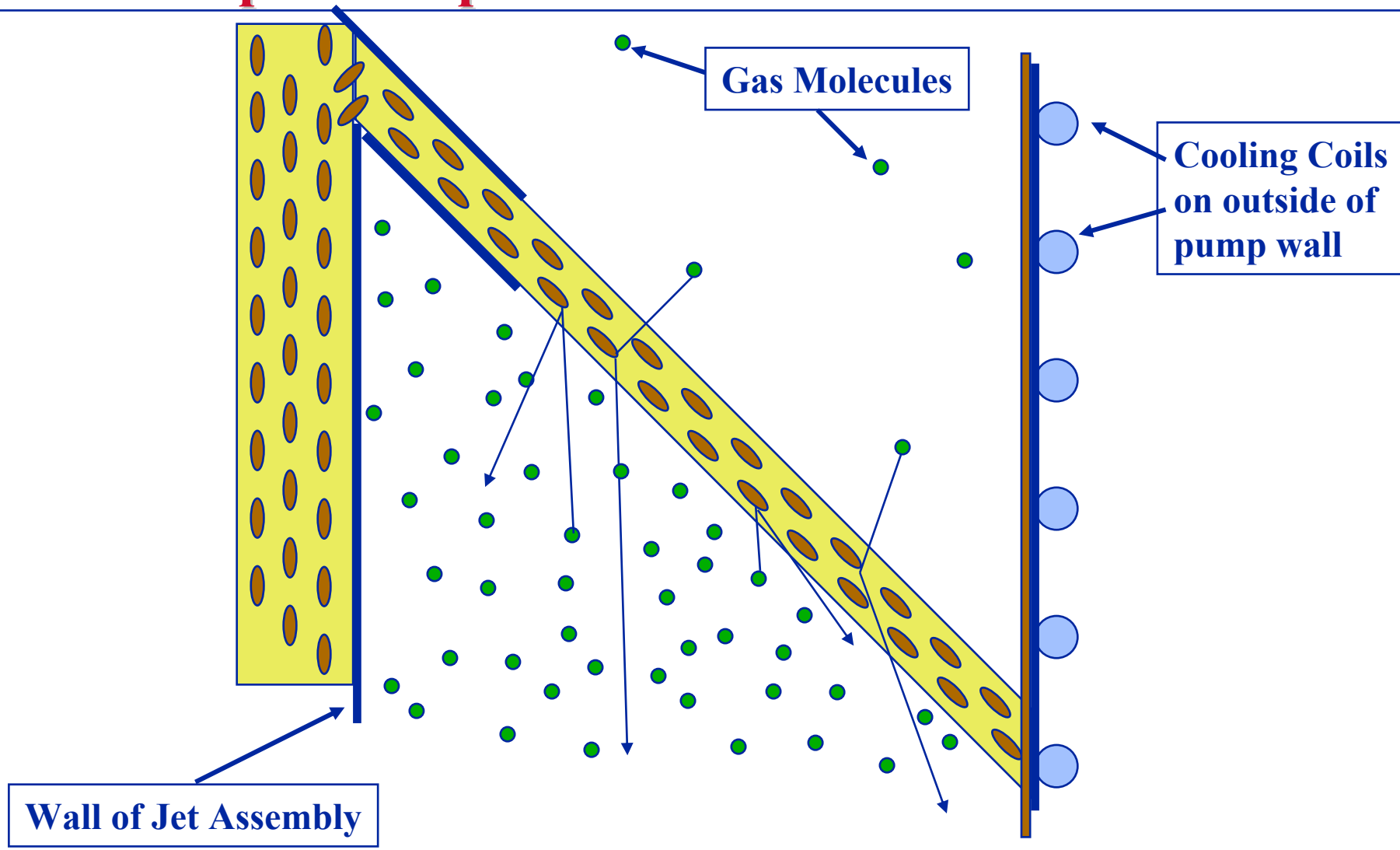
# Diffusion Pump Fundamentals

## Principles of Operation - Momentum Transfer



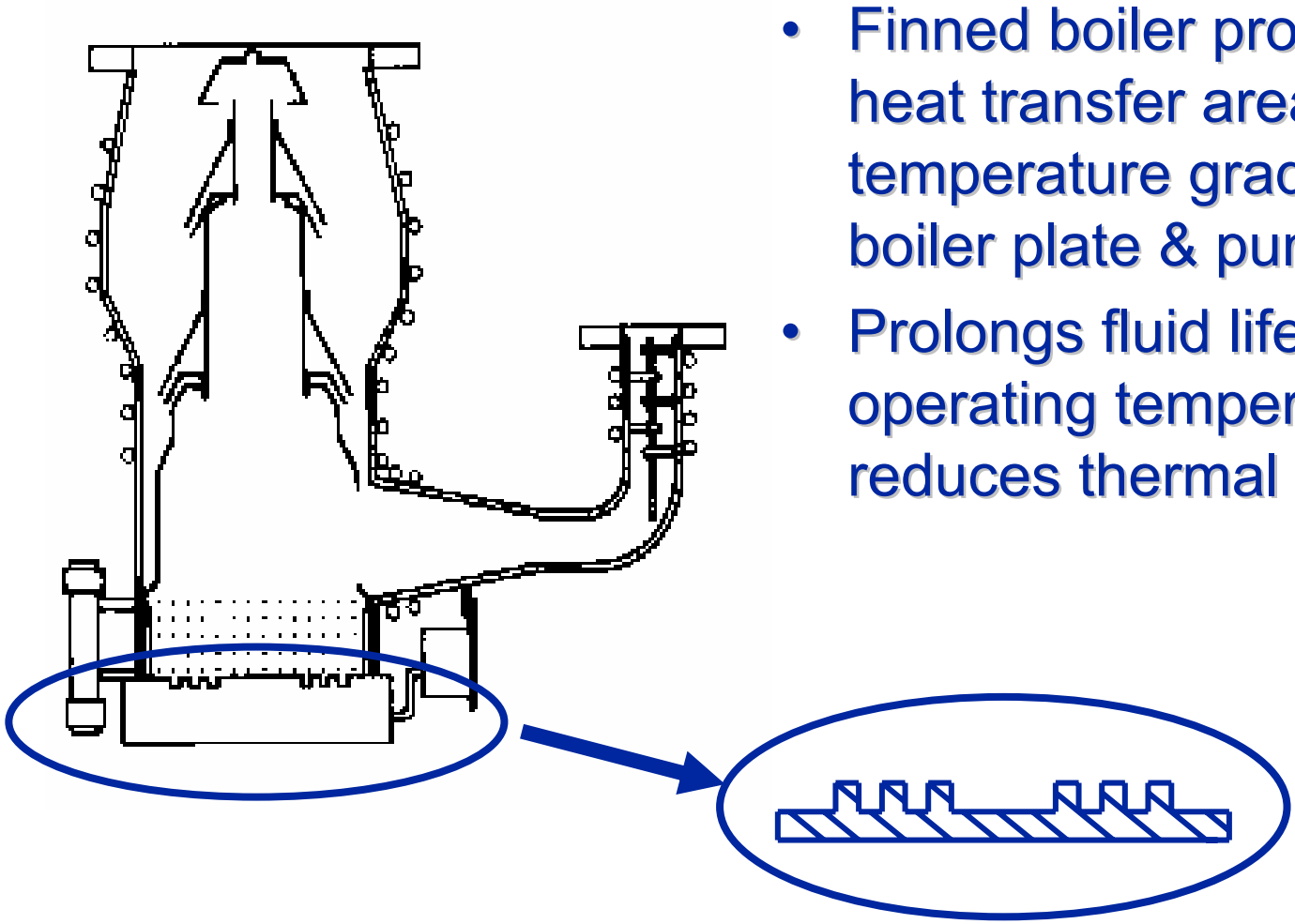
# Diffusion Pump Fundamentals

## Principles of Operation - Momentum Transfer



# Diffusion Pump Fundamentals

## Boiler Design



- Finned boiler provides larger heat transfer area & reduces temperature gradient between boiler plate & pump fluid
- Prolongs fluid life due to lower operating temperature, reduces thermal breakdown

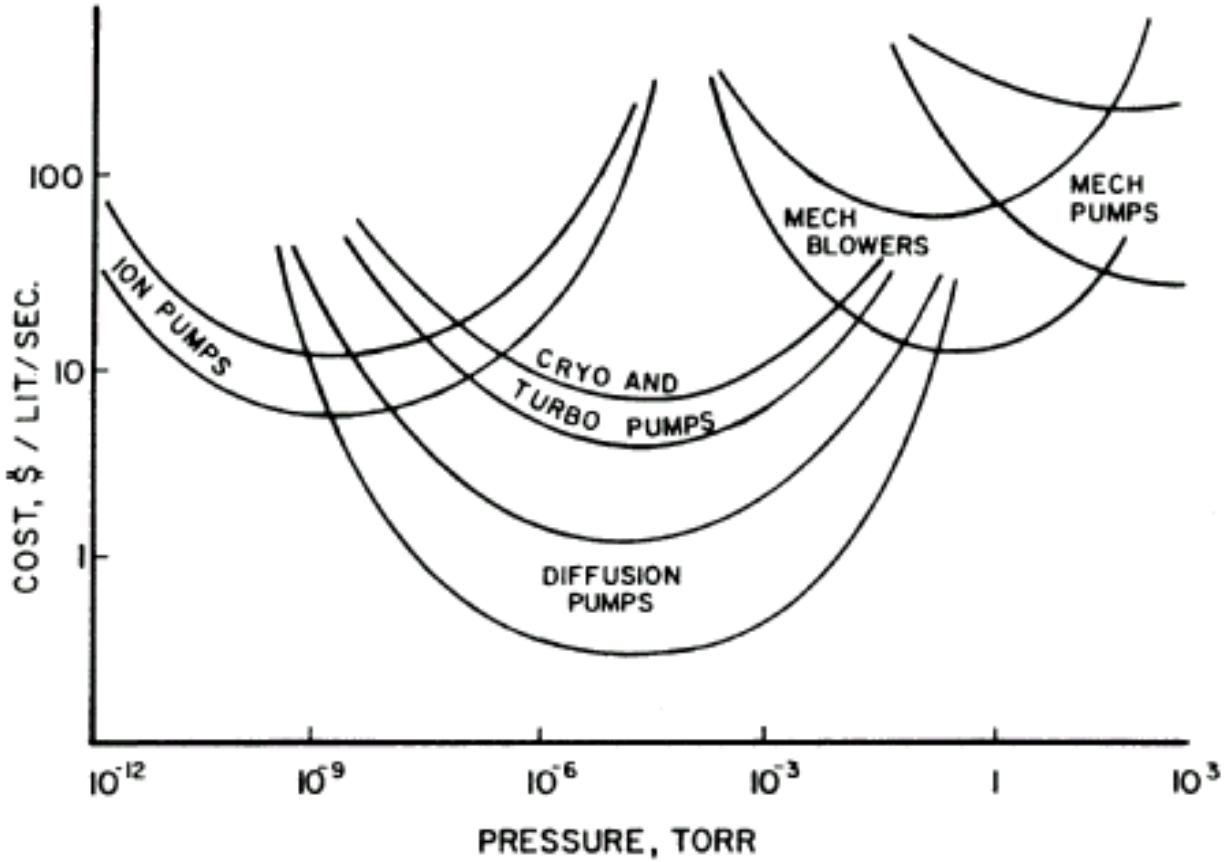
# Diffusion Pump Fundamentals

## Advantages of DP

- Provides high throughput for handling large gas loads
- Produces high pumping speed for long periods with little attention & minimal maintenance
- Extremely dependable, reliable, & durable
- Withstands improper operation w/o damage
- Pumps all gases efficiently
- Very economical per unit of pumping speed

# Diffusion Pump Fundamentals

## Diffusion Pumps are Economical



# Diffusion Pump Fundamentals

## Disadvantages of DP's

- Requires water (or air) cooling
- Must be installed vertically
- Diffusion pump fluid disposal
- Pump will operate outside intended range without signaling operator
- Backstreaming is always possible

# Topics for Discussion

- Diffusion Pump Basics
- Maintenance
- Troubleshooting

# Diffusion Pump Maintenance

- Diffusion Pumps require little maintenance.
  - only proper air/water cooling
  - electrical power
  - charge of fluid

- In event of problem, should confirm electrical power output, cooling water temperatures (in/out), and fluid level & quality

# Diffusion Pump Maintenance

- Day-to-day log of pump & system performance can be invaluable.
  - Indicates condition of pump.
  - Record of variations that require corrective action.
  - A simple log would include:
    - Cooling water
      - $T_{in}$ and $T_{out}$
    - Electrical
      - Voltage
      - Current
    - Fluid: level and visual (color)

# Diffusion Pump Maintenance

- Replace fluid periodically
- Clean internal components
- Remove oxidized fluid deposits
- Re-assemble with new o-rings
- Fill with new, clean fluid

# Operational Issues
## Diffusion Pump Maintenance

- Diffusion Pump Fluid
  - –Remove oxidized deposits
  - –Check fluid level and color regularly
  - –Replace fluid periodically

# Operational Issues
## Diffusion Pump Maintenance

- Clean internal pump components with appropriate solvents for the diffusion pump fluid being used
  - –Pump body
  - –Jet assembly

# Operational Issues
## Diffusion Pump Maintenance

- Keep boiler plate clean:

  a)Poor pumping performance

  b)Fluid life can be shortened

Keeping boiler plate clean prevents cold spots and allows for a uniform heating of the fluid

# Operational Issues
## Diffusion Pump Maintenance

- When reassembling pump:
  - Install new o-rings
  - Check for proper jet alignment
  - Add new diffusion pump fluid
  - Inspect & verify heater wiring

# Operational Issues

## Water-cooled Baffles

- Provides optically dense barrier
- Ideally provides high conductance & low height
- Suppresses rate of re-evaporation of condensed or intercepted fluid
- Reduces density of vapor in space
- Retains 50% of pumping speed

# Topics for Discussion

- Diffusion Pump Basics
- Maintenance
- Troubleshooting

# Troubleshooting
## Foreline Pressure

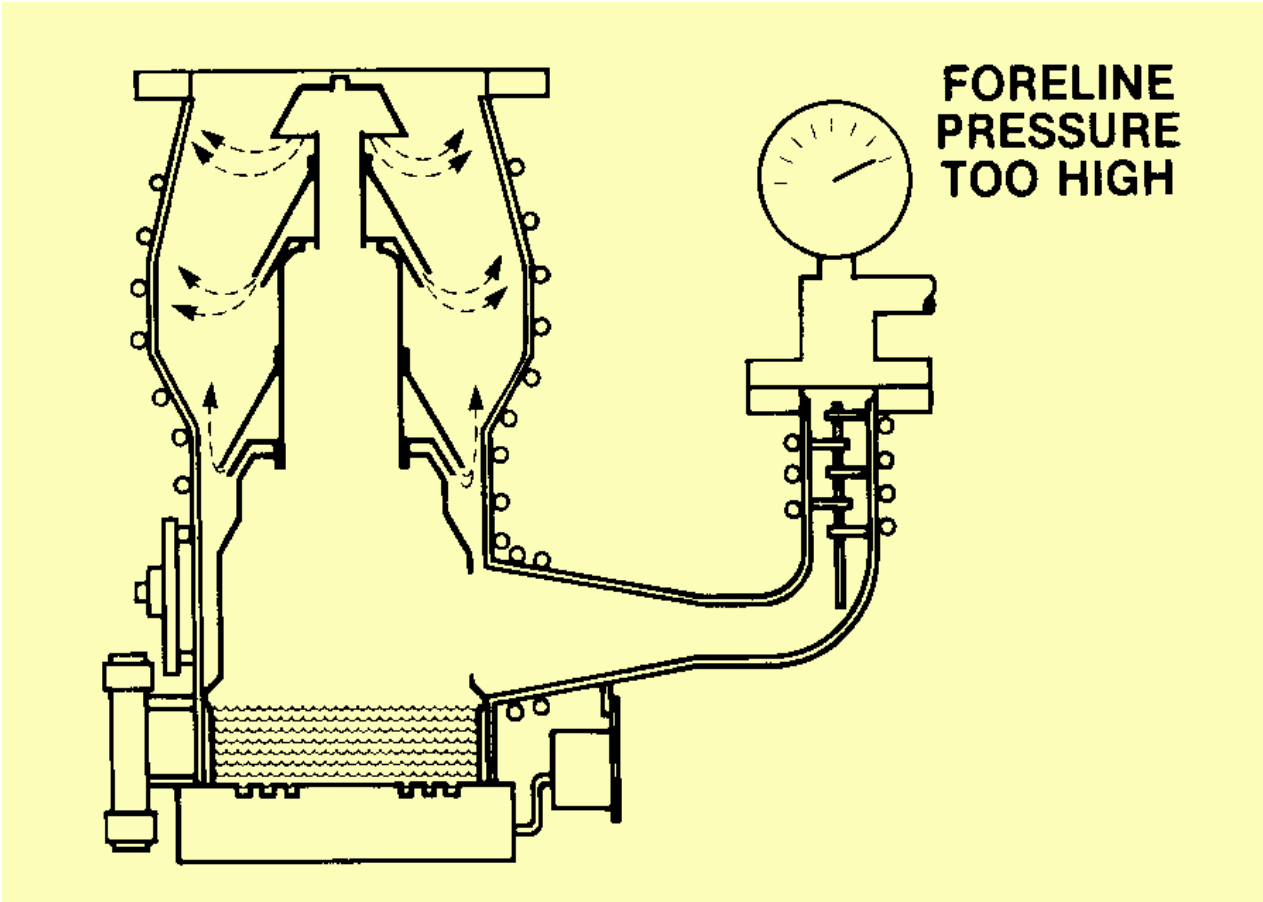
If foreline pressure is to high:

a) Will contaminate customer system.
b) Will cause poor pumping performance.
c) In extreme cases can cause explosion.

This is most likely caused by a lack of understanding of what an acceptable MTFP is or operator error.

# Troubleshooting

## Maximum Tolerable Foreline Pressure



# Troubleshooting
## Definition of Backstreaming

- Backstreaming: "migration of fluid beyond pump inlet plane"
- Leads to contamination of system & loss of fluid from pump
- Backstreaming Rate: Pump manufacturers report backstreaming rate at inlet of pump without inlet baffle
    - Steady state collection rate at inlet plane ($mg/cm^2/min$)
- System designers typically concerned with backstreaming rate above pump baffles (not the same)

# Troubleshooting

## Most common causes of Backstreaming

- Incorrect Start-up/Shut-down procedures
- Improper jet assembly alignment
- Extended transition pumping (crossover)
- Exceeding maximum throughput (Q)
- Exceeding Maximum Tolerable Forepressure
- High inlet pressures exceeding maximum Q capacity for long periods of time

# Troubleshooting
## Minimizing Backstreaming

- Primary backstreaming can be prevented via good pump design, use of cold caps & baffles at room temperature
- Cooled traps control backstreaming to such low level that contaminants from sources other than pump will predominate
- Properly operated & protected systems can be considered free of contamination from pumping fluid for most applications

# Troubleshooting
## Minimizing Backstreaming

- Use Good Vacuum Practices
- Proper interlocks & protection
- Sufficient training to operating personnel
- Use High Vacuum Valves & minimize diffusion pump operation at high pressures
- Cold Caps & Halo Baffles
- Liquid Nitrogen Cooled Traps

# Troubleshooting
## Common Problems – Heater Air Gap

- Between heating element and boiler plate:

a) Non-uniform heating of boiler plate

b) Shortened life of heater element because of over heating

Can be caused by the deformation of the boiler plate due to low fluid level

# Troubleshooting
## Water Leaks in System

a) Will destroy fluid
b) Could cause explosion from rapidly expanding gas
c) Will cause poor pumping performance

Most likely caused by a leak in the cooling system of chamber or cooling required for application (i.e. Cooling of target material)

# Troubleshooting

## Common Problems – Cooling water Flow

Low cooling water flow:

A)over heating the DP / explosion.

B)poor pumping performance.

C)shortened fluid life.

Max. T of cooling water in:  80 deg. F.

Max. T of cooling water out: 130 deg. F.

Thermal cut off switch to heater element will open to protect DP.

# Troubleshooting
## Common Problems – Low DP Fluid Level

a) Overheating of heater element
b) Overheating of fluid / can ruin DP
c) Can melt aluminum  DP stack
d) Poor pumping performance

Note:  Sight glass may be wrong as fluid volume at DP may be consumed with sludge or process material

Thermal cut off switch to heater element will open to protect DP

# Troubleshooting
## System Open to Atmosphere

- Opening chamber under vacuum.
- Not so common a problem.

The resulting in-rush of gas to the chamber attempts to lift the DP stack into the vacuum chamber and damages the DP stack as well as deforms heater plate.

Be sure the chamber is at atmosphere if valve is open.

# Troubleshooting
## Common Problems – Crossover Pressure

- If cross-over pressure is too high:

a) Will contaminate customer system.
b) In extreme cases can degrade DP fluid.
c) In extreme cases can cause explosion.

This is most likely caused by a lack of acceptable cross-over pressure or operator error.

# Troubleshooting
## Common Problems – Quick Cool Lines

- Water in quick cool lines during operation.

Quick cool (option) intended to be an open circuit.

All water MUST be out of DP quick cool lines before back into operation.

Note: quick cool lines should be shut off when DP is not in use to prevent condensation build up.

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# Thank You

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