High Pressure H_2 Recycle Compressor Dry Gas Seals Retrofit

Fernando Nirchi, Petro-Canada

John Sears, Flowserve

Abstract

Dry gas seal conversions over the last 20 years have progressively become a standard upgrade solution to improving reliability, efficiency, safety and environmental issues related to oil seal technology. The application window of the dry seal technology capabilities continues to expand and over the last 5 years has moved into the high pressure hydrogen recycle machine where new challenges have been experienced beyond the high pressure ranges.

Abstract – cont'd

This case study describes a dry seal conversion into a barrel-type recycle gas compressor operating at 2900 psig discharge pressure. This HYDROCRACKER process gas has a high dew point temperature and presents additional challenges that must be addressed in order to qualify this retrofit as a success story. The economic justification, technical approach, selection of systems, seals and integration of the seals into the compressor are provided. Knowledge gained through consultations with other users operating similar systems, and the learning's and experiences gained during this retrofit are also presented.

Abstract – cont'd

Many of the previous known causes of dry seal failures were addressed in the original design of this retrofit. Operation of the unit since the commissioning has been very positive. However, the retrofit did not come off without challenges, and further learning's from this application will help those currently using or considering dry gas seal technology for similar machines and applications.

Oil Seal System

- Poor Reliability → justification for retrofit
  - Oil Seal MTBF → 14 Months
  - Two or more stoppages recorded every year due to oil seal replacement or problems related to seal oil system
  - Operators reluctant to transfer from main to auxiliary seal oil pump

Advantages: Dry Seal vs. Oil Seal

- Reduced operating costs
- Increased reliability
- Increased efficiency
- Maintenance advantage
- Improved security
- Environmental impact

Reduction in Operating $$$

- Steam consumption main seal oil pump
- Seal oil consumption
- Maintenance costs
- Production costs related to seal oil system

Reduction in Operating $ – cont'd

- **Efficiency increase due to reduced mechanical losses**
- **Reduced H_2 emission**
- **Total Savings: $500k US/yr (approx.)**

Conversion Cost

- Main components
  - Engineering & tooling
  - Dry gas seals c/w carbon ring barrier set
  - Inner labyrinth seals
  - Conditioning and control system
  - Radial and thrust bearings
  - Spare parts

Conversion Cost – cont'd

- Mechanical rework
- DCS integration
- Installation (piping, instrumentation & electrical)
- Training
- Total Cost: $700k US (approx.)

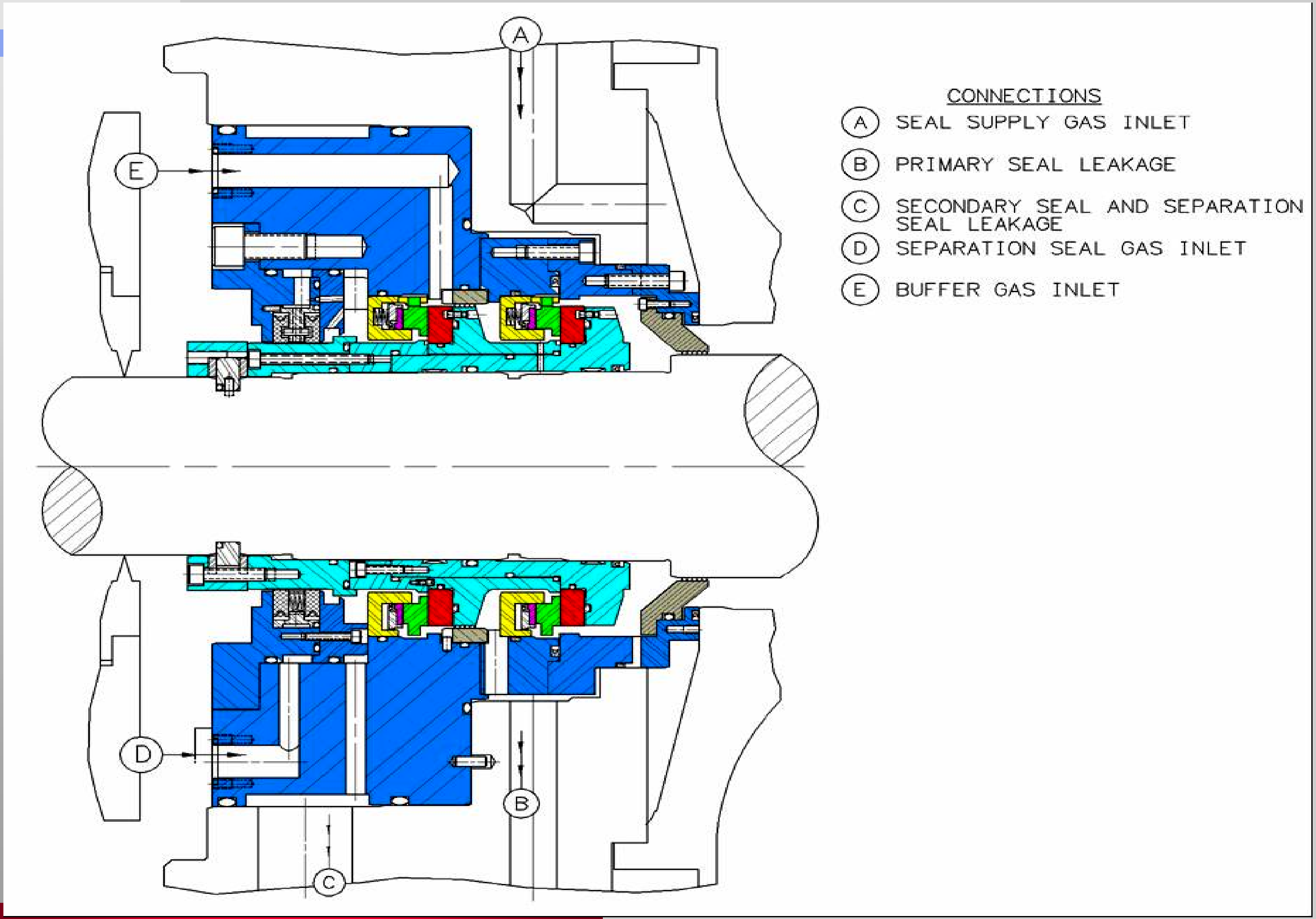
Key Issues to Consider

- Seal selection for high pressure H_2 applications
- Mechanical fits
- Gas supply management
- Control system
- PHD integration for monitoring and trending

Seal Selection

- Seal type options for high pressure H_2 applications
  - Tandem
  - Tandem-L with inter-stage labyrinth

Gaspac Seal:
Tandem-L with Circpac



Supply Gas Quality Requirements

- ***Dry, clean*** **, supply gas**
  - **1 to 3 Micron liquid and particles**
  - **Achieve 15 ft/s velocity past process seal**
  - **Adequate flow during all modes of operation**
  - **Minimum of 36 °F above dew point**

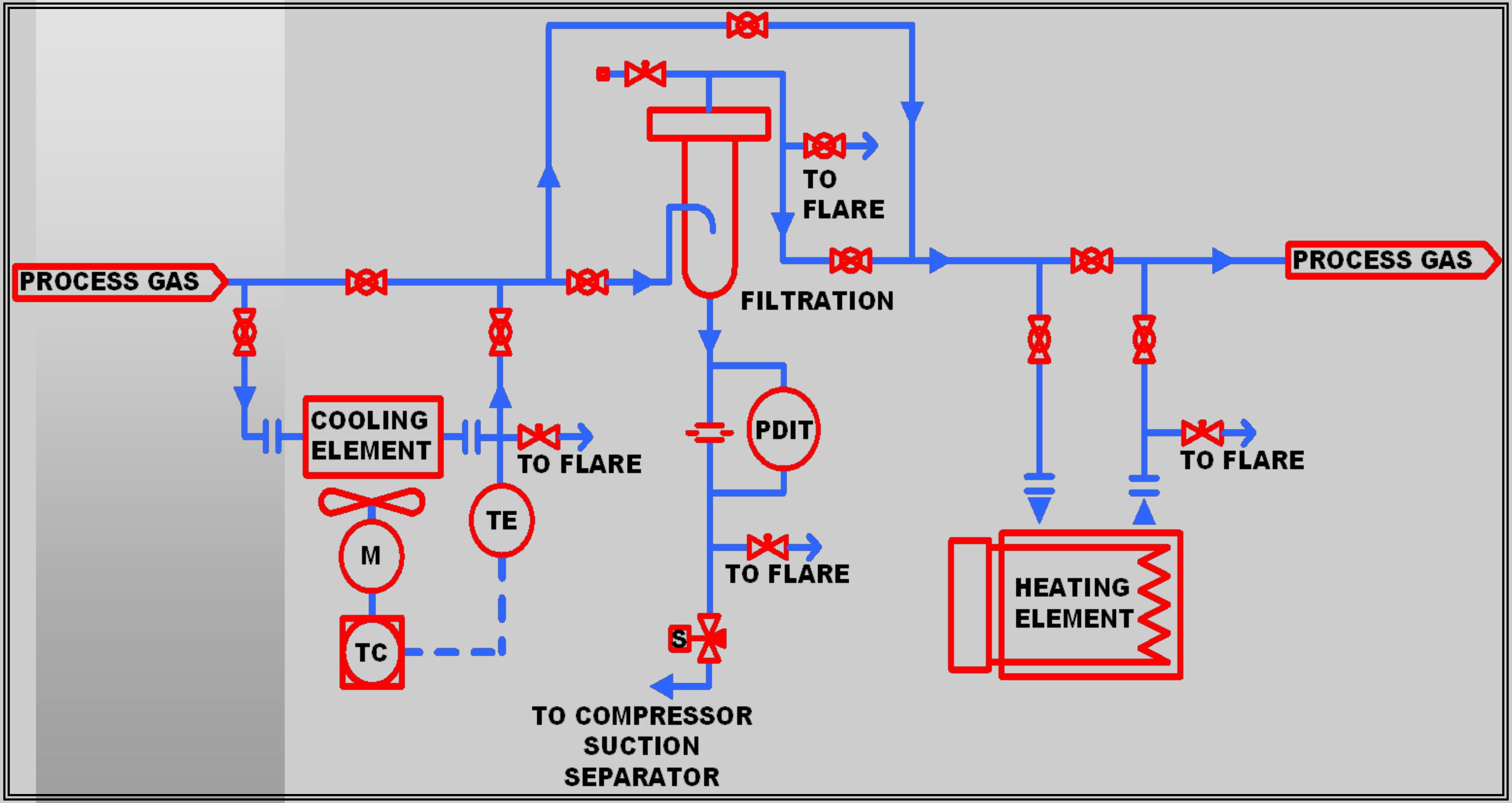
Seal Gas Control System

- Control system package
  - Pre-filter / continuous supply system required
  - Cooler and heater to manage dew point
  - Heat tracing to maintain temperature
  - Monitor both first and second stage leakages
  - Monitor all supply flows to seal individually

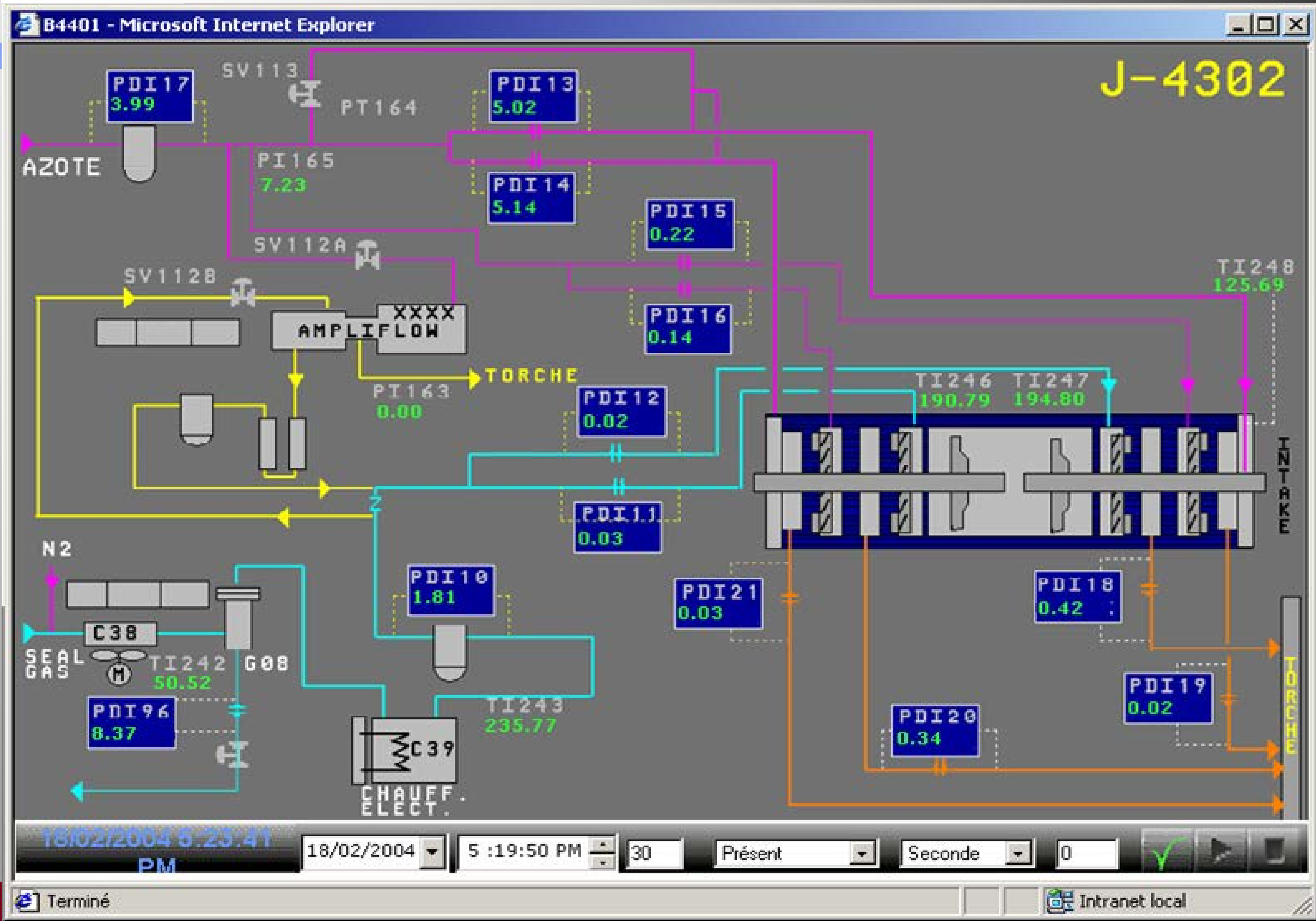
Dew Point Calculation – cont'd

- **Worst summer condition → 190°F @ suction drum**
  - **cool gas by 2°F below suction temperature to get liquid phase**
- **Winter conditions → 120°F @ suction drum**
  - **cool gas by 12°F below suction temperature to get liquid phase**
- **Conclusion → *Dew Point* is at suction drum (i.e. high pressure separator) exit temperature**

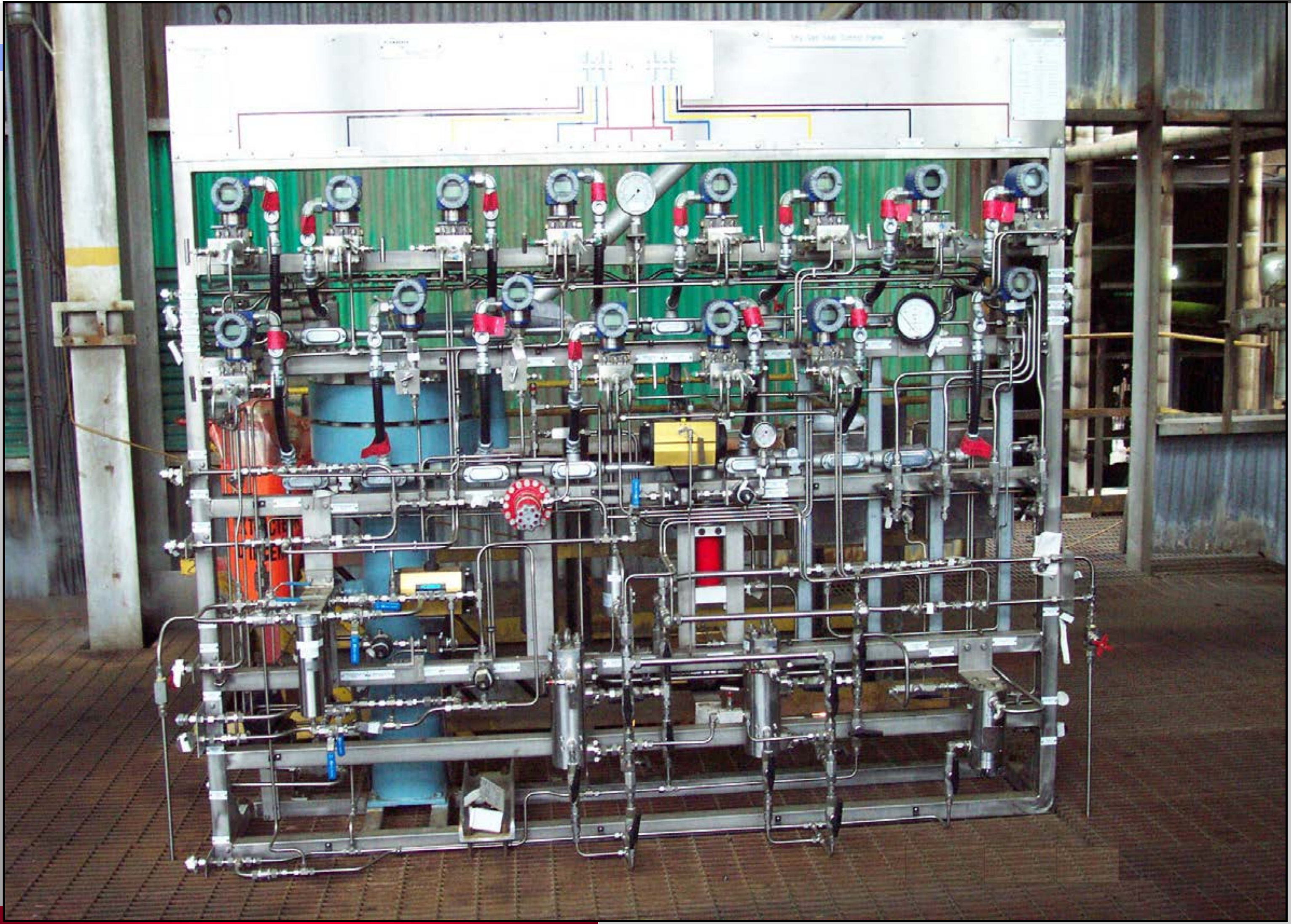
Managing Dew Point



Total Control System



Dry Seal Control Panel



Challenges

- Rotordynamic analysis → loss of stiffness and damping properties
- Surge protection
- Vibration protection
- Winterization
- AMPLIFLOW (i.e. emergency seal gas supply compressor)

Future Considerations

- Tubing vs. rigid piping for high pressure seal gas lines
- Managing seal gas demister (i.e. K-O) liquid dump to address liquid spill-back when unit trips occur
  - return liquid to compressor suction during operation
  - return liquid to low pressure drum during start-up and shutdown conditions

Future Considerations – cont'd

- 2/3 voting on transmitters with ESD signals
- Improve surge protection
- Minimize liquid spill-back to prevent flooding of dry seals & control system

Current Status

- 15 months operation without dry seal system induced shutdowns
- Managed over 20 compressor starts over 15 month period operation without damaging dry seals