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SAVANNAH RIVER NATIONAL LABORATORY
Operated by Savannah River Nuclear Solutions, LLC

We Put Science To Work

LET'S COMPARE TRITIUM DESIGN PRACTICES ACROSS THE DOE COMPLEX

X Steve Xiao

GENERAL REFERENCES

- **DOE-HDBK-1129-2008, “DOE Handbook Tritium Handling and Safe Storage”, 2008**
- **William W Weaver et al, DOE/EH-0417, Technical Notice Issue No 94-01, “Guidelines for Valves in Tritium Service”, 1994**
- **F Mannone, Springer, Editor, "Safety in Tritium Handling Technology", Kluwer Academic Publishers, 1993**
- **International Atomic Energy Agency, "Safe Handling of Tritium: Review of Data and Experience", Vienna, 1991**
- **ASME B31.3 process piping code, ASME Boiler and Pressure Vessel Code Section VIII and Section II**

SRS INTERNAL REFERENCES

- **PB Moore, WSRC-RP-98-00009, “Tritium Facilities Design Requirements Document”, Savannah River Site, 2012**
- **Blake Moore, U-TRT-H-00004, Rev 0, “Tritium Facilities Standardization of Swagelok Valves”, 2007**
- **WSRC-RP-92-431, "Tritium Materials Data Base (U)", Nov 20, 1992**
- **DP-MS-84-103, DuPont-WSRC, "Degradation of Elastomers by Tritium Beta Radiation," 1983**
- **Elliot A Clark and Kirk L Shanahan, WSRC-STI-2006-00049, “Effects of Tritium Exposure on UHMWPE, PTFE and Vespel”, 2006**

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SRS TRITIUM PROGRAMMATIC

- Design Authority (DA)
- Technical/Design Agency
- Drawings
- Instrument on Vendor's Skid-Mounted Equipment
- Instrument Spec Sheets
- Master Equipment List (MEL) and Smart Plant Foundation (SPF)
- Set point / Loop Tolerance Database
- Procurement and Procurement Support Services
- Construction and Startup Support
- Configuration Management (CM)
- Commercial Practices
- General Design
- Change and/or Deviations

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SRS SYSTEM / PROCESS DESIGN REQUIREMENTS

- Electrical
- Radiological
- Breathing Air
- Fire protection
- Instrumentation
- Industrial safety
- Material Selection
- Industrial hygiene
- Pressure Protection
- Process Information
- Helium leak detectors
- Environmental- waste
- Air Monitoring System
- Vessels / Piping / Valves
- Process control systems
- System Design Methodology
- Civil- structural- architectural
- Heating and ventilation (HVAC)
- Material control & accountability
- Cables installed inside of gloveboxes
- Chilled water / cooling water systems
- Cable installed outside of gloveboxes
- Pumps and Compressors-Design Requirements
- Room Oxygen Monitors And Glovebox Oxygen/Activity Monitors

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SRS FABRICATION, CLEANING & TESTING

- General
- Welding
- Test records
- Pressure testing
- Rate of rise testing
- Acceptance criteria
- Helium hood leak testing
- Cleanliness requirements
- Helium bell-jar leak testing
- Pressure decay / loss testing
- Helium leak testing- general
- Testing general requirements
- Helium semi-hood leak testing
- Fabrication, assembly, and erection
- Repairs, Replacements, Modif1cations
- Pneumatic pressure testing w/helium detector probe leak testing

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SRNL SUBJECT MATTER EXPERTS (PARTIAL LIST)

- Safety
- Conduct of R&D
- Fire Protection
- Electrical Safety
- Industrial Hygiene
- Radiological Safety
- Glovebox Programs
- ❖Pressure Protection
- Nuclear & Criticality Safety
- R&D Work Planning & Control
- Material Control & Accountability
- Safety Basis Regulatory Authority
- Chemical Safety (including nanomaterials)
- Management of Safety Basis (MSB)
- Unreviewed Safety Questions (USQ)
- Environmental Protection & Waste Management

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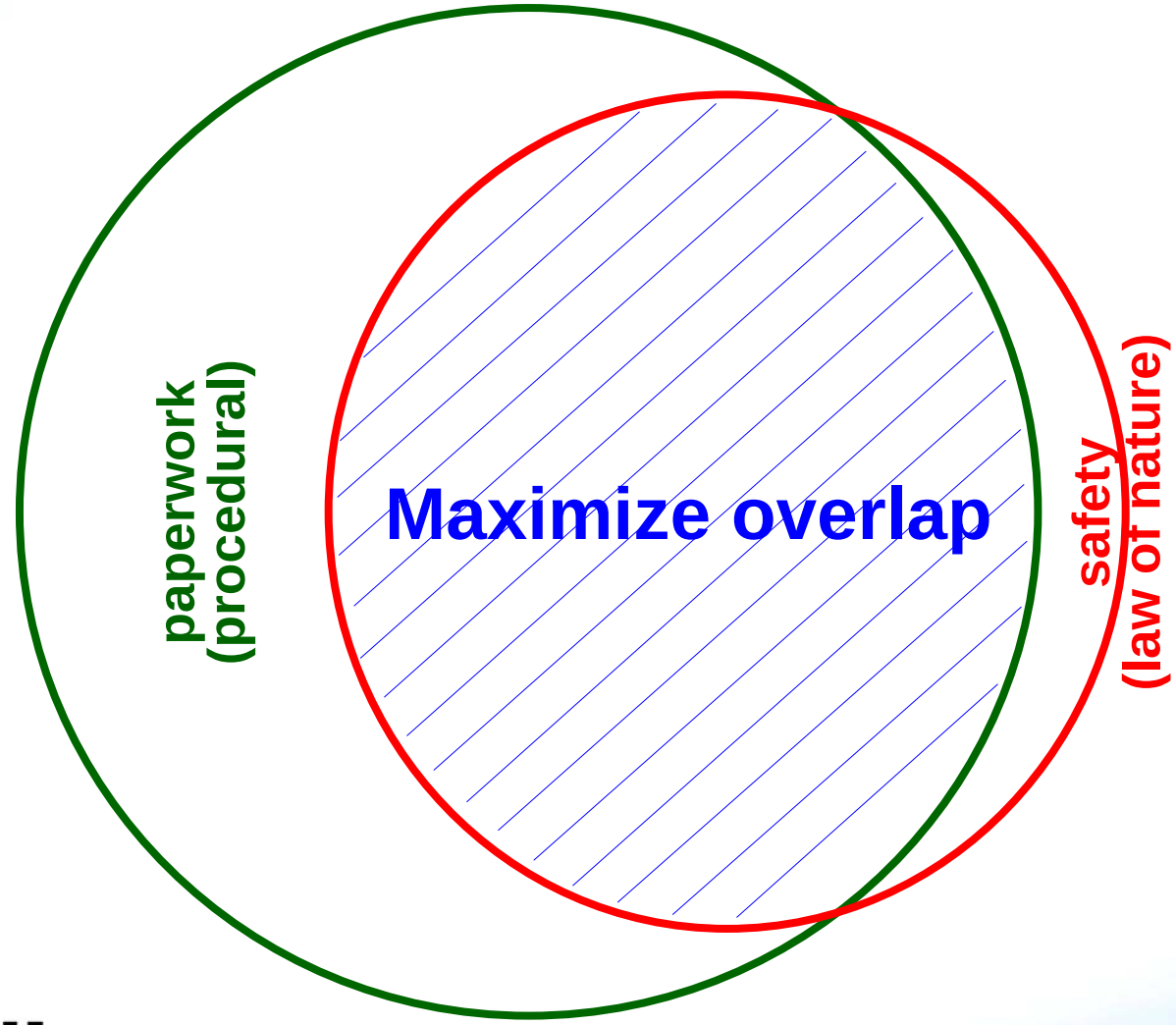
HAVE TO SATISFY BOTH…



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CONSIDERATIONS START WITH …

- **System concept / specifications / objective**
- **P&ID / description / engineering drawings / 3D model**
- **Conditions (T, P, V)**
- **Expected species/concentration/quantity/flow rates**
- **Calculations**
- **Specific location of components, sampling points …**
- **Confinement – primary / secondary / ventilation**
- **Floor plan / available space**
- **Experiences / lessens learnt**

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COMPONENT SELECTION / SPECIFICATION

- **Material compatibility**
- **Pressure / temperature rating**
- **Performance**
- **Service life**
- **Safety margin**
- **Testing**
- **Inspection**
- **Cleaning**

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TYPES OF COMPONENTS

- **Valves / actuators**
- **Pressure transducers / gauges / controls**
- **Temperature sensors / controls**
- **Vessels / Filters**
- **Tubings / Fittings (welds, VCR, compressed, NPT)**
- **Pumps (vacuum / compressor)**
- **Automation / interlock**
- **Analytical instruments**

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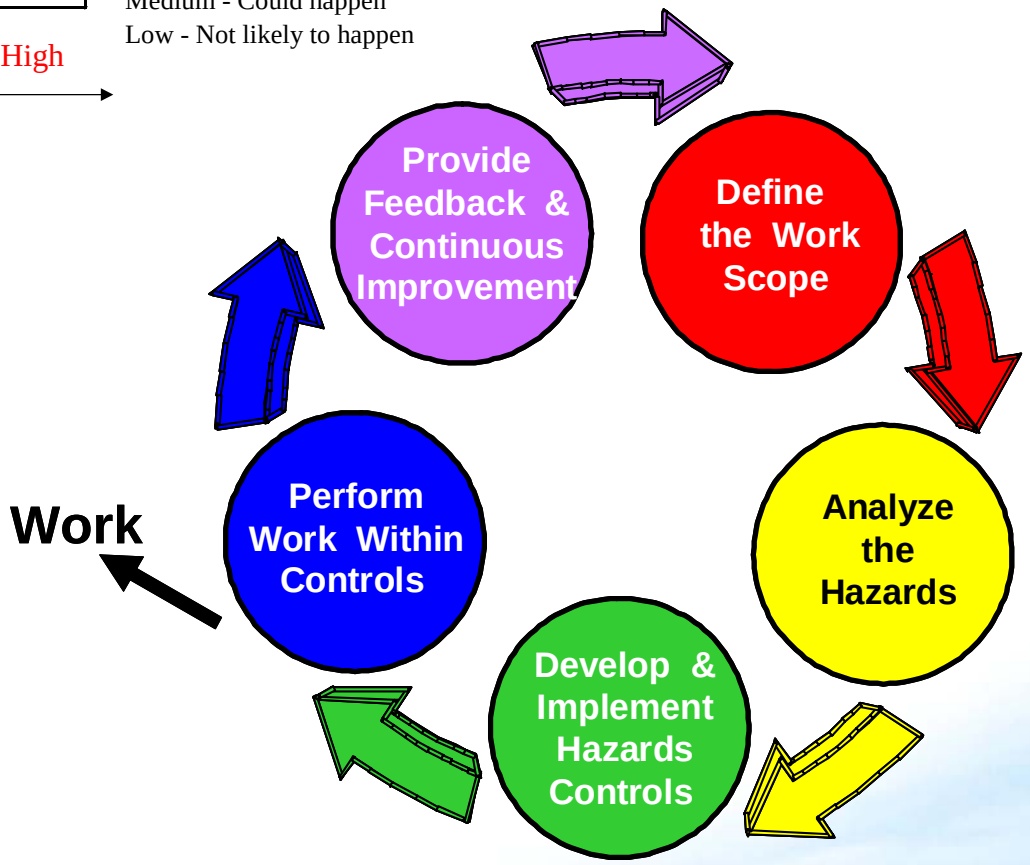
HAZARD REVIEW AND RISK MITIGATION

Severity \ Probability	Low	Medium	High
High	M	H	H
Medium	M	M	H
Low	L	L	M

Severity
High- Devastating
Medium - Some impact
Low - Little if any impact

Probability
High- Very likely to happen
Medium - Could happen
Low - Not likely to happen



HAZARD CONTROL HIERARCHY

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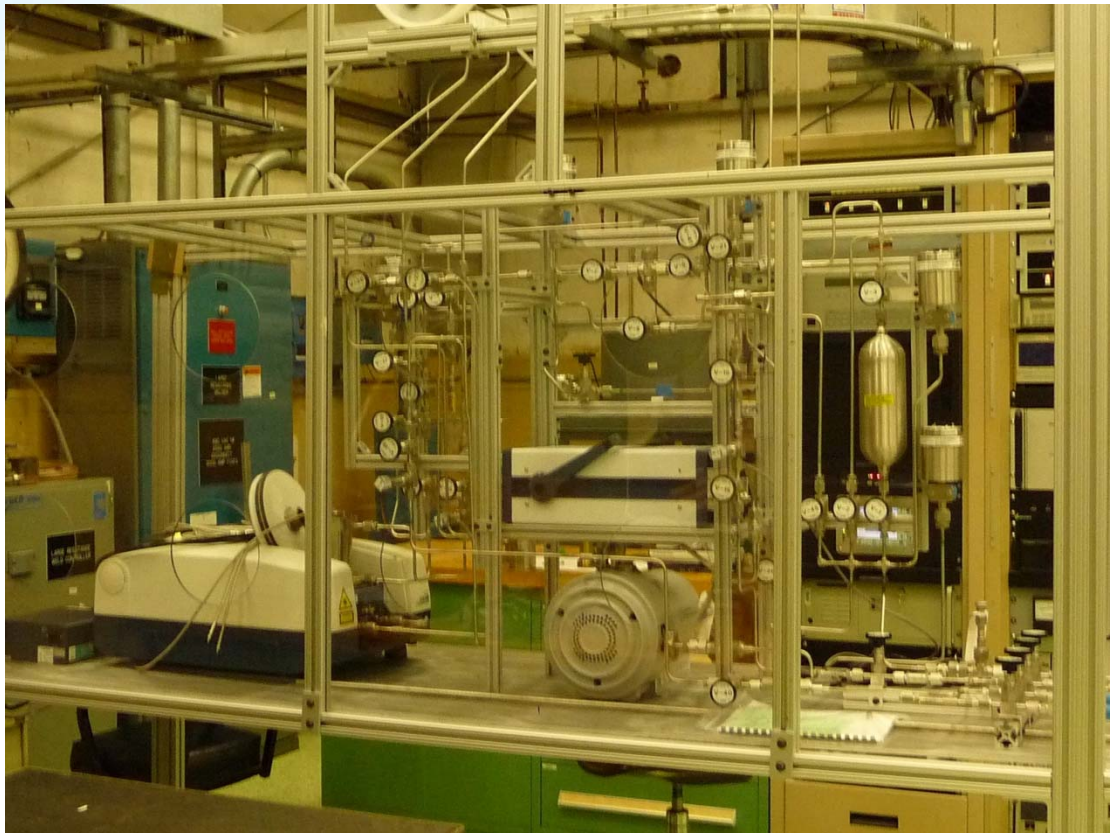
EXAMPLE 1 - TRITIUM INSTRUMENT TEST STATION



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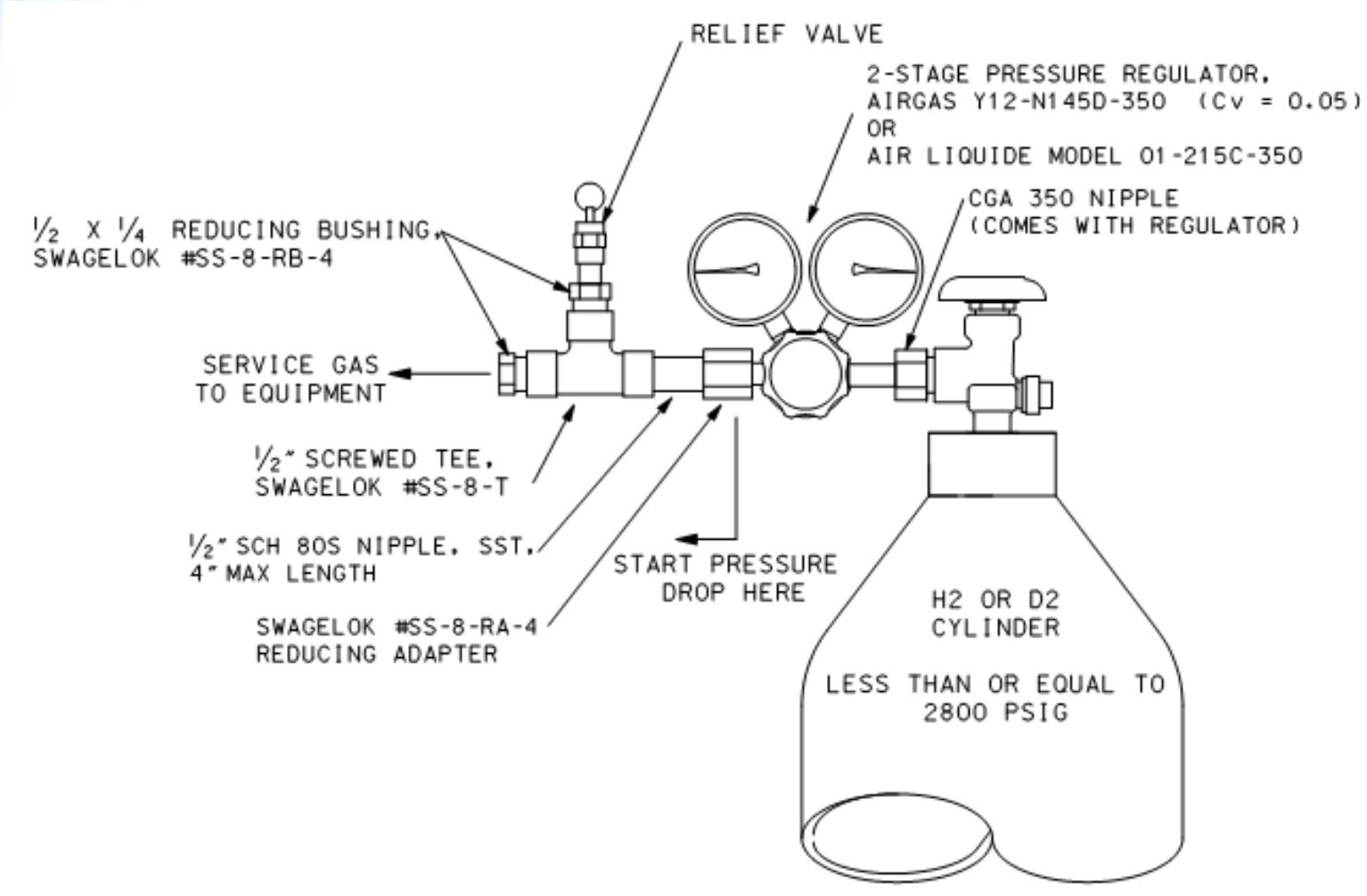
USE OF GAS CYLINDERS



PRESSURE RELIEF VALVE VERIFICATION RECORD

- **Calculations require several weeks to perform, generate 30+ pages documentation**
  - Determination of the required relieving flow
  - Design pressure and temperature
  - Find the failure flow of regulator
  - Calculate the orifice/regulator flow for a failed regulator scenario
  - Relief valve flow rate
  - Determination of pressure relief valve sizing
  - Determination of inlet/outlet pressure drop at relieving conditions

PRESSURE RATING OF A VACUUM PUMP

- **Varian Spec:**
  - Maximum inlet pressure 1.0 atmosphere (0 psig)
  - Maximum outlet pressure 1.5 atmosphere (7.5 psig)
- **ADIXEN Drytel Spec:**
  - Maximum inlet pressure: 5 mbar
  - Exhaust pressure: atmosphere

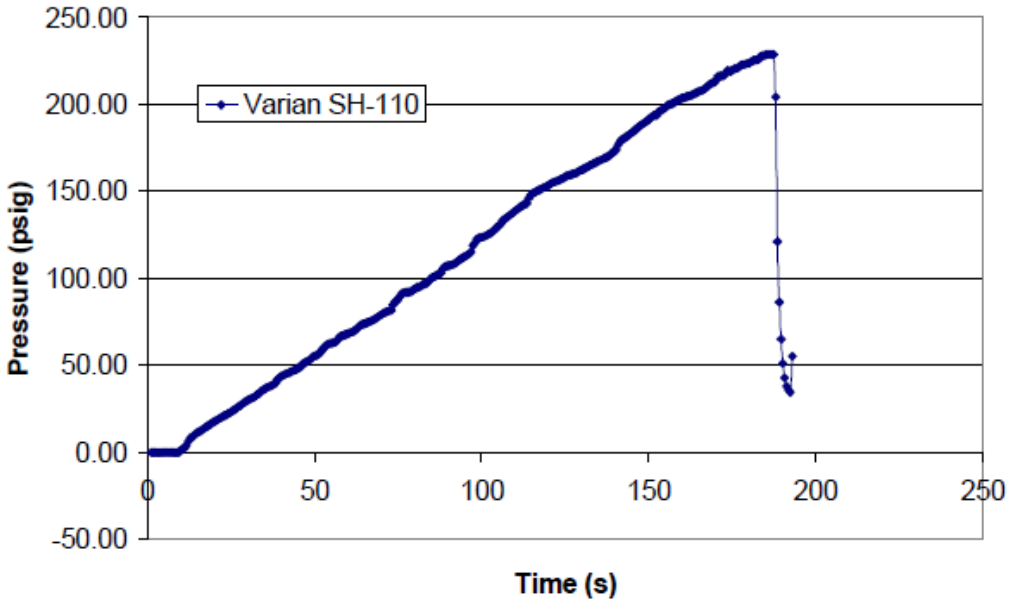


Figure 6: Pressure profile over time for the burst test

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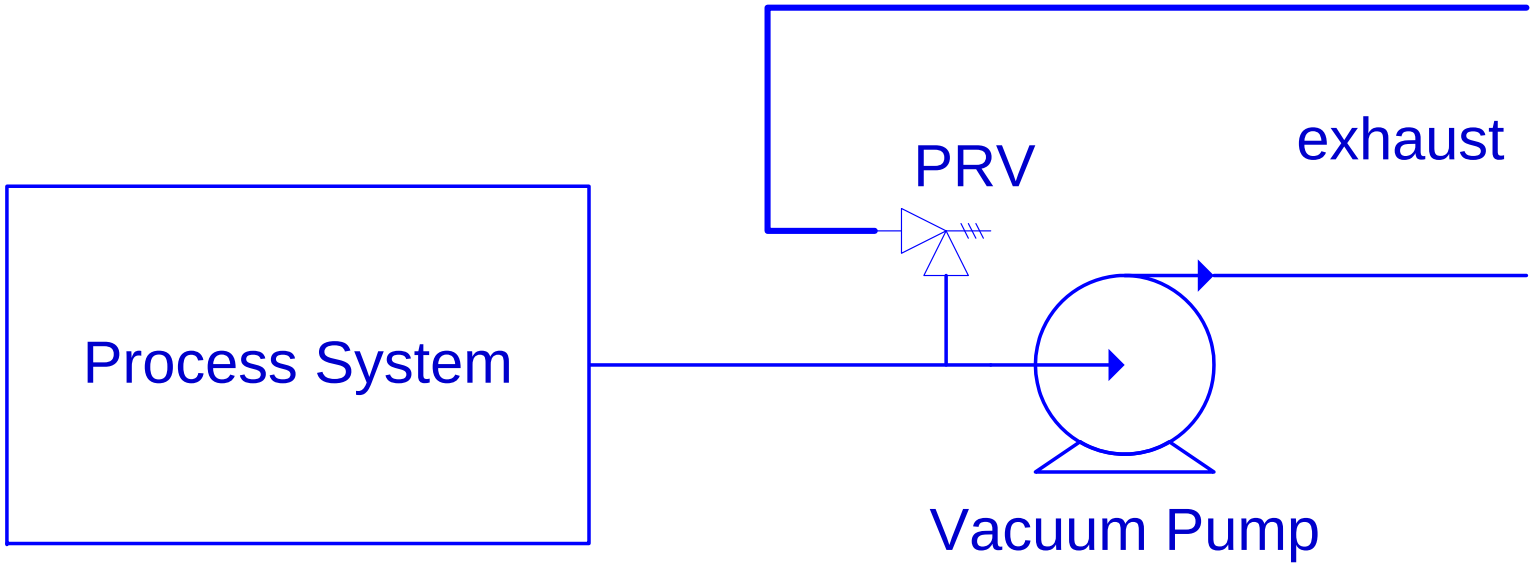
VACUUM PUMP PROTECTED BY PRV

Line size, number of elbows, etc.
carefully defined for pressure drop



PRV = 1/3 burst pressure

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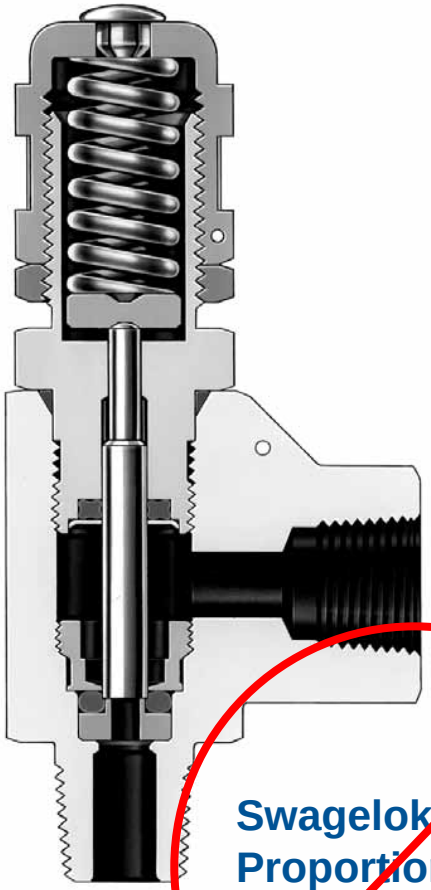
PRESSURE RELIEF VALVES & “CLI” SYSTEM



Swagelok R Series
Proportional Relief Valves

non-coded

ASME Section VIII Air/Gas,
'UV', National Board Certified
Safety valves

with CLI – Component
Location Identifier

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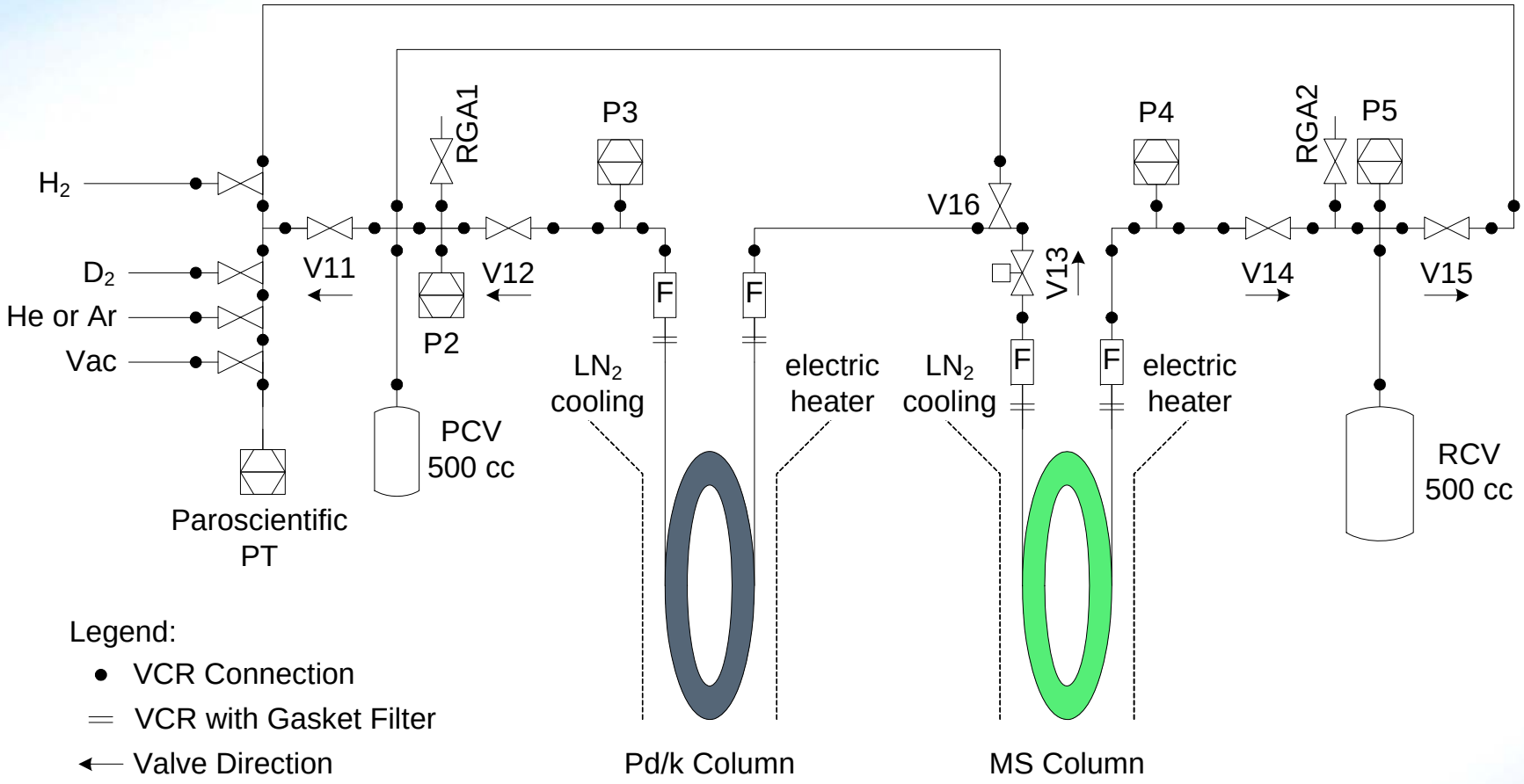
EXAMPLE 2 - MICRO-TCAP SYSTEM



MICRO-TCAP PRESSURE PROTECTION

- **Need 20+ years service life**
- **Rupture disk subjects to fatigue with pressure cycles**
- **Pressure relief valve not preferred for its leak rate**
- **Pressure Switches need scheduled calibrations**

MICRO-TCAP SAFETY APPROACH

- **Temperature range:**
  - -196 to -10 °C for MS column (control points), 40°C limit
  - -50 to 180°C for Pd/k column (control points), 200°C limit
  - ~10 min heating / cooling
- **Pressure boundary:**
  - 0-200 psi operation
  - 250 psi instrumentation (PT)
  - 2,000 psig safety (runaway scenario)
  - 5,100 psig column pressure rating
  - 22,940 psig actual burst

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- ***Dr. Jonathan Wright – SRNL, for information on Tritium Instrument Test Station***
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