LET’S COMPARE TRITIUM DESIGN PRACTICES ACROSS THE DOE COMPLEX

X Steve Xiao
GENERAL REFERENCES

- ASME B31.3 process piping code, ASME Boiler and Pressure Vessel Code Section VIII and Section II
SRS INTERNAL REFERENCES

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
<table>
<thead>
<tr>
<th>SRS SYSTEM / PROCESS DESIGN REQUIREMENTS</th>
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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, Modifications
- Pneumatic pressure testing w/helium detector probe leak testing
<table>
<thead>
<tr>
<th>Safety</th>
<th>Nuclear &amp; Criticality Safety</th>
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<td>Conduct of R&amp;D</td>
<td>R&amp;D Work Planning &amp; Control</td>
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<td>Fire Protection</td>
<td>Material Control &amp; Accountability</td>
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<td>Electrical Safety</td>
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<td>Management of Safety Basis (MSB)</td>
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<td>Glovebox Programs</td>
<td>Unreviewed Safety Questions (USQ)</td>
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<td>Pressure Protection</td>
<td>Environmental Protection &amp; Waste Management</td>
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HAVE TO SATISFY BOTH…

Maximize overlap

- paperwork (procedural)
- safety (law of nature)
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
COMPONENT SELECTION / SPECIFICATION

- Material compatibility
- Pressure / temperature rating
- Performance
- Service life
- Safety margin
- Testing
- Inspection
- Cleaning
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
<table>
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<th>Severity</th>
<th>Probability</th>
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<tr>
<td>High</td>
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<td>M M H</td>
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<td>Low</td>
<td>L L M</td>
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**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

**Cycle Diagram:**
- **Define the Work Scope**
- **Analyze the Hazards**
- **Develop & Implement Hazards Controls**
- **Perform Work Within Controls**
- **Provide Feedback & Continuous Improvement**
- **Work**
EXAMPLE 1 - TRITIUM INSTRUMENT TEST STATION
USE OF GAS CYLINDERS

RELIEF VALVE

2-STAGE PRESSURE REGULATOR,
AIRGAS Y12-N145D-350 (CV = 0.05)
OR
AIR LIQUIDE MODEL 01-215C-350

CGA 350 NIPPLE
(COMES WITH REGULATOR)

½ x ¼ REDUCING BUSHING
SWAGELOG #SS-8-RB-4

SERVICE GAS
TO EQUIPMENT

½" SCREWED TEE,
SWAGELOG #SS-8-T

½" SCH 80S NIPPLE, SST,
4" MAX LENGTH
SWAGELOG #SS-8-RA-4
REDUCING ADAPTER

START PRESSURE
DROP HERE

H2 OR D2
CYLINDER

LESS THAN OR EQUAL TO
2800 PSIG
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*
VACUUM PUMP PROTECTED BY PRV

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

Process System

Vacuum Pump

PRV = 1/3 burst pressure
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
EXAMPLE 2 - MICRO-TCAP SYSTEM

Legend:
- VCR Connection
- VCR with Gasket Filter
- Valve Direction
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
ACKNOWLEDGEMENTS

- Dr. Jonathan Wright – SRNL, for information on Tritium Instrument Test Station
- Dr. Walter T. Shmayda – Laboratory for Laser Energetics, University of Rochester, for collaboration on Micro-TCAP development