Current State of PSM

- Hydrocarbon Process Industry has exacting PSM audit requirements
- Current state of art tends more to manual or antiquated data processing systems
- Issues of data migration, operations and maintenance integration and handoff continue to vex the most forward thinking corporations
- This combination makes end-users compliance activities very inefficient
- The Internet and Intranet have already revolutionized the way data is accessed.
- Tremendous need for revolutionary “web-enabled” software* for intelligent Pressure Relief Safety Management

*Must satisfy both CSChE “PSM guidelines” and end-user requirements
A Chemical Plant is Born

- Owner defines the project
  - What needs to be produced, how much etc.
- Project schematic and very rough financials
- Process Design Basis and budget estimate +/- 20% (Schedule A)
  - Complete Piping and Instrument Diagrams (P&ID) / Process Flow Diagrams (PFD)
  - Equipment list
  - Specifications
  - Instrumentation
  - ** List of Pressure Relief Devices **
- Owner approval to proceed
- Front End Engineering Design (FEED)
- Complete the specifications for equipment, instrumentation and PRD’s
• Final design conducted by Engineering Procurement and Construction (EPC) company
  – Detailed engineering
  – Equipment list
  – Specifications
  – Instrumentation
  – Relief system design
  – Procurement
  – Project PHA
A Chemical Plant is Born

- Pressure relief system design
  - Conduct contingency analysis
    - Identify pressure-producing emergency events
    - Determine the worst credible case event (event requiring largest relief area)
  - Determine worst conditions for effluent handling, design flare header
  - Analyze reactivity conditions during relief or those causing relief
    - Use acceptable physical property database
  - Select appropriate type of relief devices
  - Determine sizes of PRD’s and associated piping to handle the relief flow rates
  - Determine other design parameters: noise, vibration, reaction forces etc.
  - Design codes: ASME, API, ANSI, NFPA etc. plus client specific standards
A Chemical Plant is Born

- Architectural model
  - Plants
  - Units
  - Protected Systems
  - Equipment
  - Overpressure Contingency Scenarios

- Plants are comprised of units and equipment assigned to units (depicted in P&ID’s)
  - Equipment provides protection, requires protection, or neither
  - Equipment has fittings: inlet/outlet
- Units are comprised of protected systems (system sketches)
- Protected systems are comprised linked pieces of equipment
- System sketches portray protected systems
- Overpressure contingencies assigned to protected systems
- Associated documents linked to equipment
A Chemical Plant is Born

Pressure Relief System Design

- Plants are comprised of Units & Units are depicted in many P&ID’s
Pressure Relief System Design

- **Units** are comprised of **Protected Systems** (typically 7 to 10) and are depicted in system sketches and loaded into iPRSM™.

- An isometric drawing of the PRD inlet and outlet piping is loaded into iPRSM™.
Pressure Relief System Design
• **Protected Systems** are comprised of linked equipment, instruments, piping and **PRD’s**

  – Vessels
  – Heat Exchangers
  – Pumps
  – Fittings
  – Piping
  – Control valves
  – **Pressure Relief Valves**
  – Rupture Disks
  – Tank vents
A Chemical Plant is Born

Pressure Relief System Design

• Overpressure Contingencies are assigned to Protected Systems

  – Blocked Outlet
  – Abnormal heat Input
  – Exchanger Tube Rupture
  – Automatic Control Failure
  – reflux Failure
  – Fire
  – Cooling Failure
  – Power Failure
  – Instrument Air Failure
  – Inadvertent Valve Opening
  – Mechanical equipment Failure
  – Series Fractionation
  – Thermal
  – Loss of Quench
  – Chemical Reaction
  – Steam Out

Other...
A Chemical Plant is Built

- Procurement
- Installation and inspection
- Pre start-up PHA*
- Start-up and operating procedures*
- Commissioning and Start-Up

* Imes Engineering Services

May 2004
Changes...Changes...Changes

• Upgrades, improvements, change equipment, change location, temperatures, pressures ............... 

• Unless a design review is made after a change, the protected system must be considered “no longer protected”

• Management of Change documentation (MOC)

MOC is a mandated procedure to ensure that pressure systems remain viable. It requires updated flow sheets, equipment files, revalidated PHA and modified or rechecked relief system.
Historical Background

Union Carbide
Bhopal, India
Pesticide Plant

Methyl Isocyanate Gas (MIC)
• CSChE program typically include 12 major elements (Canada)
• OSHA 1910.119 standard contains 14 elements (US)
• The elements have strong interaction with one another
• It is not possible to meet the requirements of one element without considering its effect on the others, and how they are affected in turn
  1. Accountability: Objectives and Goals
  2. Process Knowledge and Documentation
  3. Capital Project Review and Design Procedures
  4. Process Risk Management
  5. Management of Change
  6. Process and Equipment Integrity
  7. Human Factors
  8. Training & Performance
  9. Incident Investigation
  10. Company Standards, Codes and Regulations
  11. Audits and Corrective Actions
  12. Enhancements of Process Safety Knowledge
## OSHA Citations

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<tr>
<th>PSM Elements</th>
<th>93-94&lt;sup&gt;1&lt;/sup&gt;</th>
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</table>
Typical OSHA Citations

• Operating Procedures
  – Inadequate procedures for emergency shutdown and emergency operations
  – Procedures don’t discuss consequences of deviations from operating limits or steps to correct the deviations

• PSM compliance audits
  – Verify that the procedures and practices in place are adequate and being followed
  Ensure that the audit is conducted by personnel knowledgeable about audit techniques

• Employee participation
  – Failure to have written employee participation plan
  – Failure to consult with employees on conducting PHA’s
  – Failure to obtain employee input on other PSM elements
  – Failure to provide adequate access to PHA’s and process safety information

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Typical OSHA Citations

- **Mechanical Integrity**
  - Poor documentation

- **Collecting/maintaining process safety information**
  - Failure to include safe upper and lower operating limits for processes
  - Failure to document the consequences of deviation from these limits
  - Failure to document process safety information related to safety systems in place

- **Training**
  - Failure to conduct initial training
  - Failure to consult workers about the frequency of refresher training for specific jobs
Management defines the facilities for auditing and the audit schedule

Select Audit team, (internal or external)

Define audit subject areas and audit priorities

Define Audit Scope:
1. Design Basis, codes, regulations
2. Responsibilities for field verification and inspection of existing PRV system

Audit Activities:
1. Data gathering, generating
2. Review previous audit reports and incident history
3. Study the existing PRV maintenance log
4. Overpressure cases analysis and PRV selection
5. Evaluating the existing PRV system
6. Report findings
7. Conclusions, recommendations, and opinions

Documentation including:
1. Report of overpressure case studies
2. Proposal of implementation program
3. Basic require maintenance schedule

Develop a feasible action plan:
1. Resolve the differences between audit team and management
2. Propose a feasible action plan
3. Define a practical item schedule
4. Elect a monitoring team

Follow-up until the next scheduled audit
Customer Requirements

- Engineering Services Needed by PSM & Relief Systems
  - Varies greatly by client
  - Larger firms usually need peak load help or single function help
  - Smaller firms may need up to total resource help
  - Larger firms often act as if no one can know more than they do, and they often micromanage their contractors
  - Smaller firms are usually flexible and delegate more to their contractors

- Software Requirements
  - All companies now have PHA software - usually purchased but some still use in-house tools
  - Relief valve software varies all over the map. One large company still uses an Excel spreadsheet developed in 1993. Others use a variety of software and select the cheapest bidder. Some have selected a software and vendor but usually there is a level of dissatisfaction.
  - iPRSM™ is the most flexible, cost-effective software on the market
Typical Scope of Work

- Update process flow diagrams (PFD’s) with heat and material balances for all operating units
- CAD drawings of all Relief Devices inlet and outlet piping
- CAD drawings of all flare header systems
- Relief load analysis and sizing calculations for all devices
- Pressure drop calculations for all Relief Devices inlet and outlet piping
- Perform mechanical evaluation (acoustic and reaction loads) on applicable devices
- Recommendation for remediation work with cost estimates, if necessary
- Complete documentation including all calculations, drawings, equipment data sheets
- Update P&ID’s with proposed modifications, if necessary
Customer Requirements

Typical Project Execution and Deliverables

- **Project Execution**
  - Phase 1 - Information gathering
  - Phase 2 - Calculations
  - Phase 3 - Documentation

- **Project Deliverables**
  - Discrepancy list of relief device information from field search compared to the master PRD database
  - CAD drawings of all relief devices inlet and outlet piping
  - CAD drawings of all flare header systems
  - Calculations for each relief device
  - Calculations for flare header systems
  - Complete documentation for each relief device

** Refer to handout for complete description **

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Customer Requirements

- Customer driven features for software
  - Multi-user 24/7 access to real time data
    - Access control
    - Multilevel permission authority
    - Concurrency control
    - Web delivered
  - Ease of use
  - Reliable
  - Physical property database accuracy
  - DIERS Benchmark compliance
  - Reactivity
  - Flare header
  - Cost competitiveness
  - Complete files on each tag
  - Customized for client needs
  - Fast track results to meet project or shutdown schedule
Customer Requirements

- **Software Requirements** – all met by iPRSM™.
  - Multi-User Architecture
    - Support collaborative work
    - Support concurrent access
    - Provide groupware tools
    - Easy interface to other software tools
    - Allow multi-tasking
  - Standards Compliance - Requires rigorous compliance with:
    - Engineering standards
    - Concurrent consistency protocols
    - Distributed security standards
  - Workflow Support
    - Supports workflows for every work process
    - Allows selection of reasonable tasks
    - Prevents selection of unreasonable tasks
    - Records signoffs for appropriate tasks
  - History Tracking
    - Records changes and signoffs as they are made
    - Query interface (who changed and who approved what, when & why)
    - Reports for summarizing changes over specified time periods
    - Persistently available archiving in long-life storage format
iPRSM solution

• Developed a multi-disciplined “WEB-enabled” engineering software that fully satisfies the CSChE guidelines for audit req’ts for pressure relief systems (iPRSM)

• iPRSM’s unique web approach addresses the proactive management of relief systems safety compliance according to best-practices principles, including
  – the management of compliance-related as-operating data
  – the ongoing verification of standards-based compliance

• And produces
  – tasks for plant management
  – reports for regulatory purposes

• The net result is
  – safer plants
  – major cost savings due to the elimination of duplication of effort in plant data recording and tracking
iPRSM solution

• iPRSM has been designed to provide the user an all-encompassing solution to auditing or designed safe and effective pressure relief systems. Six major features that differentiates iPRSM from existing solutions:

  – Technology Features
    Web-Enabled Software Application

  – “One Stop Shop” Features
    Centralized Document Repository

  – Unique Architectural Model/Workflow
    Total integration of all processes and equipment

  – Engineering Algorithms and Calculation Functions
    Encompasses all relief load & Inlet-Outlet Pipe Loss calculations

  – Built-In Libraries
    Equipment catalogs, pipe fittings, etc.

  – Deliverables
    Access to complete documentation package including all calculations, documentation, drawings, spec sheets, etc.
PSV Audit using iPRSM

- Protected System Definition
  - P&ID’s
  - PRD List
- Contingency Analysis
- CAD System Sketch
- Equipment Data Collection
  - Equipment List
  - For Protected System
  - Field Data Verification
- PRD Calculations
  - P&ID’s
  - PFD’s
- Audit
- Client Approval
- Completed Package
- Extra Work Item
- Mitigation
- Offsite Engineer (If Needed)

- iPRSM™ Data Entry
- Evaluation
- Completed Tag
- Field Sketch of PRD ISO
- CAD ISO

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“Traditional” Approach

• Relief Device Approach (Old Technology)
  – Each relief device is tracked individually
  – Sizing of relief device is done independent of other equipment or scenarios
  – Most common method used in chemical plants
  – Requires extensive database cross-referencing
  – Uses no advances in database technology
“Protected System” Approach

Protected System Model (iPRSM™)

- Units are comprised of multiple “protected systems”. These systems are portrayed in the system sketches. The basic concept is that any kind of equipment can be linked to a protected system in one of four roles:
  - Protected: Equipment requiring protection (vessel, heat exchangers etc)
  - Protecting: Pressure Relief Devices (PRV’s Rupture Disks, etc)
  - Overpressure Source: Equipment as source of overpressure (pumps, control valves, etc)
  - Ancillary: (Block valves, pipe fittings, etc.)

- All equipment associated with each relief system is listed.
- Includes protected equipment, over-pressure sources, and all equipment considered in the calculations.
- Typically method used for plant design and PHA. Each protected system is a “node” in the PHA. iPRSM™ is the software most easily integrated with PHA.
- Excellent for changes in plant (MOC) due to built in cross-references. A change in any item may quickly be detected and the effect on any relief system calculated.
- Most plants use the relief device method and it can be difficult to convince them to convert
“Protected System” Approach
• P&ID’s have long been an integral part of engineering and design
• Increasingly “intelligent” P&ID’s are entering the plant operations arena
• Inclusions of smart objects allows ease of integration to equipment, calculations, documentation, etc.
Typical PRD Drawing

Pressure Relief Valve Reference Drawing

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<th>PSV Identification</th>
<th>Date Prepared: 2004-02-11 14:28</th>
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Farris

26JA12-120

API Letter | API Area | ASME Area
---|---------|--------|
J | 1.287 m² | 1.430 m²

Size | Rating | Facing
---|--------|-------|
2.5 in | 300 psig | RF
4.3 in | 150 psig | RF

Valve Design

Conventional | Screwed Cap | RF
Max. Box Cap | React. Port | Nozzle
5256 Steel | 974.07 lbf | 113.43 ksi

Material

Body (1) | Bonnet (2)
---|-------|
Carbon Steel | Carbon Steel
Notched (1) | Disc (1)
516.63 lbf | 516.63 lbf
Hubs (2) | Ratings (16)
516.63 lbf | Chromia Alloy
Bolts (1) | N/A
Conclusions

- In an increasingly competitive environment, today’s plants are under enormous pressure to increase productivity, reduce cost and risk, and enhance manufacturing uptime.
- Maintaining comprehensive (safe) models of pressure relief and vapor disposal systems is essential.
- Web-centric technology, allows plant personnel instantaneous and concurrent access and analysis to data on any pressure relief system, from any location that has web connectivity.
- Plant personnel can quickly resolve problems from this ability and it offers the most thorough and systematic approach for the design, analysis, and documentation of new or existing pressure relief systems.
- Today’s innovation is the road to success!