PROCESS SAFETY
IMPLICATIONS FOR LARGE GRASSROOTS PROJECTS

The Life Cycle Approach

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BACKGROUND

• Large capital projects are underway in the Alberta oil sector.
• Engineering shops may not have the skills and experience to make valid scope decisions re. process safety.
• Oil facilities have experienced several major process incidents in recent years.
• Owners must ensure process safety is included in the engineering scope for major projects.
• Author has worked on two major capital projects.
PSM LINKAGE TO LARGE ENGINEERING PROJECTS

• Leadership
• Process Safety Information
• Process Risk Management
• Management of Change
• Capital Project Review and Design Procedures
• Process and Equipment Integrity
• Pre-Startup Safety Review
PSM LINKAGE TO LARGE ENGINEERING PROJECTS

- Leadership ★
- Process Safety Information
- Process Risk Management
- Management of Change ★
- Capital Project Review and Design Procedures
- Process and Equipment Integrity ★
- Pre-Startup Safety Review
LEADERSHIP

• Sets the tone for the project.
• Establishes core values. Process safety and design integrity
• Promotes desired behavior
• Establishes an environment of trust – Reveal errors and commit to fix problems.
• Establishes risk acceptance criteria
• Identities standards to be followed
• Ensures quality systems are in place

Leadership is the single most important PSM element and the key to launching a successful project.
Leadership

A commitment to quality and integrity

May need to spend extra money on safety

Solve problems as they are uncovered

Support established objectives
CORE VALUES

Often combined under Scope

{ SAFETY
  ↓
  ↓
QUALITY
  ↓
SCHEDULE
  ↓
  ↓
  COST
SAFETY AS A CORE VALUE

• Must distinguish process safety from traditional safety. May need to define aggregate risk to stakeholders.
• Concept of criticality must be defined and used sparingly.
• Guidelines for risk based decisions. i.e. risk tradeoff
• Support for those who disclose quality problems or process safety concerns.
RISK MANAGEMENT STRATEGY

- Appoint risk (process safety) engineer
- Update engineering specifications
- Develop and publish risk acceptance criteria
- Issue risk tools to engineering shops
- Spec deviation procedure linked to risk acceptance.
- Risk and safety reviews conducted in conjunction with project milestones.
RISK MANAGEMENT

Must directly link to corporate risk practices BUT

May need to add several safeguards.

Should add at least one safeguard.
<table>
<thead>
<tr>
<th>CONSEQUENCE</th>
<th>FREQUENCY</th>
</tr>
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<tbody>
<tr>
<td>E</td>
<td>Catastrophic</td>
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<tr>
<td>D</td>
<td>Major</td>
</tr>
<tr>
<td>C</td>
<td>Serious</td>
</tr>
<tr>
<td>B</td>
<td>Minor</td>
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</table>

May need to add additional PSM dimension.
FRONT END LOADING

• Approved “Design Basis”
• Conceptual scope definition
• Contract strategy identified
• Do’s and Don’ts clarified
• Process safety (design integrity) a key deliverable
• Project standards identified
• Field safety during construction
• On going dialogue with Operations
• Staged approval system (Gate process) defined.
KEY STRATEGIC ISSUES

- A Process Selection
- B Size of Facility
- C Physical Location
- D Product Conversion
- E Operating Service Factor
- F Utility Tie-Ins and Consumption
- G Mode of Construction

These issues should be formally documented in an approved *Design Basis Memorandum.*
STAGES OF PROCESS SAFETY EVOLVEMENT

• Select process / size of facility
• Establish layout and siting
• Establish grading and drainage
• Establish preliminary process design
• Determine circuit isolation requirements
• Establish strategy for control of ignition sources
• Establish relief and blowdown requirements
• Establish fire protection philosophy
INHERENT SAFETY REVIEW

✓ Can less hazardous materials be used?
✓ Is the process chemistry well understood?
✓ Can working inventories be reduced?
✓ Can major equipment sizes be reduced?
✓ Can elevated equipment be lowered?
✓ Can operating severity be reduced?
✓ Can the mechanical design be simplified?
✓ Is the plot well spaced and is equipment safely oriented?
SIZE / LOCATION / LAYOUT

- Vessels and equipment sized to meet minimum holdup requirements
- Orientation established
- Equipment stacking minimized
- Relative location of equipment on plot
- Layout recognizing staffing and human factors considerations
# PLOT PLAN REVIEWS

<table>
<thead>
<tr>
<th>FOCUS</th>
<th>KEY CONSIDERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot location relative to other units.</td>
<td>Operating logistics.</td>
</tr>
<tr>
<td></td>
<td>Distance from control room.</td>
</tr>
<tr>
<td></td>
<td>Knock-on effects</td>
</tr>
<tr>
<td>Size of plot areas – based on preliminary process designs.</td>
<td>Cost of real estate, site prep</td>
</tr>
<tr>
<td></td>
<td>Elevation considerations</td>
</tr>
<tr>
<td></td>
<td>Access to support systems</td>
</tr>
<tr>
<td>Equipment stand-off distances</td>
<td>Insurance spacing guidelines</td>
</tr>
<tr>
<td></td>
<td>Consequential damage</td>
</tr>
<tr>
<td></td>
<td>Business interruption</td>
</tr>
<tr>
<td>Inner unit layout and congestion</td>
<td>Ease of access</td>
</tr>
<tr>
<td></td>
<td>Operability and maintainability</td>
</tr>
<tr>
<td></td>
<td>Equipment decking and layering</td>
</tr>
</tbody>
</table>
PROCESS AND EQUIPMENT INTEGRITY

- Safe operating envelope established.
- Stability of instrumentation / control scheme
- Equipment failure modes identified and systematically eliminated.
- Piping configuration and layout established.
  - Flanged connections minimized
  - Isolation provided in critical locations
  - Small bore piping exposures minimized
- Metallurgy selection based on run length projections and alternate exposures.
ENGINEERING QUALITY

- Are qualified engineering personnel engaged in all engineering activities?
- Is there a system for mentoring and overseeing the work of less experienced workers in the engineering shops?
- Is there a standard method or protocol for performing engineering in each engineering shop?
- Is there a system for providing Operations or end user input into important engineering decisions?
- Is there a system for evaluating design effectiveness?
- Is there a system to ensure consistent management of spec deviations?

These are sample items from a holistic quality mgmt program.
EXECUTION STRATEGY

DETERMINES HOW WORK WILL GET DONE

• Field vs. shop fabrication of major vessels
• Stick built vs. modular construction
• Post weld heat treatment strategy – in place or spool by spool
• Project staging
• Vendor shop testing vs. field testing
• Erection and hoisting strategy
• In situ service test vs. hydro vs. leak test
THE END RESULT

• Most EPC contracts focus on cost, schedule and functionality.

• Execution strategy flexibilities may lead to congested plant layout that is particularly vulnerable to vapor cloud explosion.

• Design changes may also add to congestion.

• A plant that is not maintenance friendly will encourage short cuts and oversight. Work will default till the next shutdown.
MODULAR CONSTRUCTION

**BENEFITS**
- Better quality work - controlled conditions
- Ease of fabrication
- Ability to transport large scale equipment to plantsite.

**ADVERSE EFFECTS**
- More structural steel
- Higher level of congestion in modules

**LESSON**
- Modular construction should only be used in non critical areas and close to grade applications.
DESIGN REVIEW PROCESS

- Reviews must be scheduled to match key project milestones
- Reviews must have a defined purpose
- Technical reviews must not interfere with safety reviews
- Reviews must be staffed with experts and experienced Operations personnel
- Review findings should trigger follow-up actions.
- Must utilize industry accepted protocols – HAZOPs
- Must reference appropriate codes, standards and current drawings
STAGES OF RISK / SAFETY REVIEWS

- Inherent safety review
- Plot layout reviews – Consequence modeling
- What If Analysis – process safety
- Review against loss prevention standards
  - Grading and drainage
  - Electrical area classification
  - Fire protection
- Guideword HAZOPs
- Global issues risk assessment
- Detail engineering HAZOP or FMEA
HAZARD ASSESSMENT

- “What If” analysis should be conducted on all process designs during EDS engineering.
- Guideword HAZOPs should be conducted during detail engineering.
- Above reviews must involve Operations.
- External facilitators should be used.
- Reviews should utilize corporate risk criteria.

DO NOT ALLOW THESE REVIEWS TO BECOME A CLEANUP EXERCISE FOR ENGINEERING
**SAFEGUARDS**

“Add-on devices to prevent or protect against incidents”

<table>
<thead>
<tr>
<th>ACTIVE</th>
<th>PASSIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure switches</td>
<td>Overflow weirs</td>
</tr>
<tr>
<td>Relief valves</td>
<td>Fireproofing</td>
</tr>
<tr>
<td>Alarms</td>
<td>Upgraded metallurgy</td>
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</tbody>
</table>

Safeguard requirements may be incorporated into risk matrix.
SAFEGUARDS

Remember that the widespread use of safeguards may offset the benefits of classifying certain equipment as critical.

“Overuse leads to abuse.”

Build safety into the design in the first place.
GLOBAL ISSUES

• Global issues that affect the project should be captured and addressed through the risk assessment process.
• High level risks should be documented and communicated to management. Remember, no operating facility is *risk free!*
• Semi-quantitative risk assessment provides a means of evaluating all types of risks.
## INCIDENT RISK PROFILE

<table>
<thead>
<tr>
<th>Incident</th>
<th>Relative Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical power failure</td>
<td>3.6</td>
</tr>
<tr>
<td>Steam boiler outage</td>
<td>1.2</td>
</tr>
<tr>
<td>Product pipeline outage</td>
<td>5.2</td>
</tr>
<tr>
<td>Premature catalyst de-activation</td>
<td></td>
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<tr>
<td>Cooling water restriction</td>
<td></td>
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<tr>
<td>Environmental restriction</td>
<td></td>
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<tr>
<td>Fire on Central piperack</td>
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<tr>
<td>Fire in Control Center</td>
<td></td>
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<tr>
<td>Fire in Hydrotreater (12 weeks)</td>
<td></td>
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<tr>
<td>Fire on Crude unit (12 weeks)</td>
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</tbody>
</table>
OTHER RISK AND SAFETY INITIATIVES

- Management of Change – Scope changes and spec deviations
- Accident case studies to support safety concepts
- Facility siting studies – building placement
- Safety Critical Instrument SIL studies
- Electrical area classification
- Fire protection reviews
- Pre-Startup Safety Review
PRE-STARTUP SAFETY REVIEW

- Two tiered system to ensure that completed facility is ready to support a safe and reliable operation.
- Higher tier examines the physical facility against specs and design intent. Punch list sign off.
- Operational readiness review looks at all the components of a safe startup including people, chemicals, utilities, procedures and conditions elsewhere. Repeated at every startup.
CONCLUSIONS

• Process safety objectives must be incorporated into the engineering contract.

• Process safety must be a front line driver not a back end consideration.

• Risk and safety reviews must be carried out independent of disciplined engineering reviews.

• Process safety and engineering quality must be managed as an on going activity.