Breakthrough Ergonomic Application Tools for the Petrochemical Industry

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Vice President
Agenda Topics

- Review of petroleum and chemical manufacturing issues
- Innovative applications for human performance ergonomics
  - Effective WMSD risk management strategy
  - Managing performance shaping factors with pareto analysis tools
- Success stories
  - Priority valve and petrochemical applications
Historical Perspective

- Petroleum production began with Seeps, Skimming, and Dippers
- 1859 crude oil production began at Oil Creek at Titusville in Northwest Pennsylvania.
- 1st idea of a pipeline to carry crude oil was put forth in Parkersburg, West Virginia, in November 1860
- American Chemical Society formed over 125 years ago
Earliest Mass Production

- Wooden tanks for storing oil
- Group of workers at an oil production site
- Drilling rig and oil well
- Oil refinery and storage facility
Safety Priorities
Injury Statistics

- Amell, Kumar (2001) indicate that 50% of all petrochemical valves are operated manually.
- Parks and Schulz (1998) indicated that 56% of low back injuries and 73% of head, neck and face injuries are associated with industrial valve handwheel actuation.
- At a major petroleum facility 88% of surveyed operators indicated WMSD discomfort attributed to industrial valve handwheel actuation.
Traditional Human Factors Efforts

- PSM Standard 1910.199 (e)(3) (vi) specifies a review of performance shaping factors (PSF) related to operator/equipment interface, manual activities, instrumentation and coding.

- Human-system interaction errors (Type I & Type II) account for nearly 90% of system failure in complex systems (CMA, 1994).
Petrochemical Problematic Areas

- Operator and maintenance errors account for 41% of incidences (CMA)
- Likely incidence areas include
  - Valve turning and control points
  - Maintenance access for pumps, pigs (pipeline), and piping access
  - Control rooms
  - Lab tasks
“Every Organization is Perfectly Designed to Get the Results that they Achieve”
Does your organization have the CC virus?

‘Cause
Barriers to Implementing Ergonomics

- Lack of applied knowledge or resources
- Perceived lack of time
- Check the box PSM audit criteria
- Cultural – “It’s always been that way”
- Suppliers don’t get it and when they do it’s too costly
- Lack of easy-to-use ergonomics assessment tools specific to petrochemical manufacturing industry
When will these ergonomics issues get addressed?
Application Strategy & Goals

- Prioritize the petrochemical job universe
  - Physical forces
  - Function reach requirements
  - Repetition of activities and access control
  - Considerations for environment exposures
  - Consider applications using structured method

- Proactive Hazard Control
  - Highlight valve design/retrofit criteria
  - Support maintenance access
  - Support directed education and participation from petrochemical operators
Nothing Should Stand Between a Worker and Their Right to Take Pride in Workmanship
Simple Process Flow Chart

1. Identify job/tasks
2. Qualitative risk assessment
   - Simple controls available?
     - YES: Implement controls
     - NO: Prioritization needed?
6. Quantitative risk assessment
7. Risk prioritization
   - HIERARCHY: Engineering controls, Administrative controls, Work practices modifications
8. Confirm effectiveness
9. Ensure usage - training - supervision - procedures
Qualitative Risk Assessment

Ergonomics Hit List

» A helpful tool to identify ergonomic issues and job improvements

» The tool is divided into two parts:
  » Find It
  » Fix It
Wash Rag

Shoulder Too High
Shoulder Too Low

Elbows Out

Comfort Zone

Bad Vibes

Nodding Neck
Continuous Improvement Process

Check for Success:
Confirm that Fix It improvements resolve Find It issues (and don’t create additional concerns).

**FORM:** A reminder to share successful improvements with other areas that have similar challenges.
Check for Success

Find It: washrag (awkward posture, thin handle)
Fix It: (extend handle)

Check for Success (Ask the Operator)
Tool/Target

Find It
» Forceful, awkward, and prolonged finger pressing

Fix It
» Attachable spray device
» Cost: $20
Tool/Target

Find It

» Forceful, awkward, and prolonged gripping

Fix It

» Drum handling device
» Cost: $1,800
Hose Support
Jack Bolts “Superbolt”
Eliminate “Cheater Bars”
Mobile Pipe Bending Equipment
Multi-use Valves
Simple Process Flow Chart

1. Identify job/tasks

2. Qualitative risk assessment
   - Simple controls available?
     - YES: Implement controls
     - NO: Quantitative risk assessment

3. Quantitative risk assessment
   - Prioritization needed?
     - YES: Risk prioritization
     - NO: HIERARCHY
       - Engineering controls
       - Administrative controls
       - Work practices modifications

4. Risk prioritization
   - Confirm effectiveness

5. Ensure usage
   - Training
   - Supervision
   - Procedures

What now?
Quantitative Risk Assessment

The Valve assessment tool objectives

- Help plant operations staff determine whether turning force exceeds capabilities
- Assist piping designers with valve layout
- Provide Ergonomic design basis for valve designers
- Prioritize retrofit applications to get the most benefit
Derivative Work

- Manual force to “crack” depends on valve type and its condition. Maximum dynamic forces can be obtained at lower wheel heights with a horizontal wheel in a CCW direction - Schulze, Stanton, Patel and Cheli (1997)

- 100 pounds (444 N) applied to 36” valve wrench opens 93% of valves - Jackson, Osburn, Laughery and Vaubel (1992)

- Most force can be applied from knee to waist height for vertical stems, for horizontal stems the most force can be applied between waist and shoulder - Attwoof, Nicolisch, Doney, Smolar and Swensen (2002)

- Increases in force application can be achieved by zig zag rim designs wheels or the use of spokes - Woldstat (1995)
Valve Assessment Tool Categories

- Breaking/Seating/Turning forces
- Frequency of use
- Clearance/Accessibility/Standing surface

Valve application force also depends on:
- Wheel or handle
- Location of the wheel or handle relative to operator
- Orientation of valve stem
- Wheel diameter and grip interface
## Valve Prioritization Worksheet

### Valve Information
- Unit/Area: Building 78 - Tank 7
- Valve ID Number: 128-CRY
- Valve Type: Wheel
- Date Entered: 16-Aug
- Analyst: JK

### SUMMARY SECTION SCORES

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td></td>
</tr>
<tr>
<td>Less than yearly</td>
<td>0</td>
</tr>
<tr>
<td>Yearly</td>
<td>1</td>
</tr>
<tr>
<td>Monthly</td>
<td>2</td>
</tr>
<tr>
<td>Weekly</td>
<td>3</td>
</tr>
<tr>
<td>Daily</td>
<td>4</td>
</tr>
<tr>
<td>Multiple daily/Emergency</td>
<td>5</td>
</tr>
<tr>
<td>Total Frequency Rating</td>
<td>4</td>
</tr>
<tr>
<td>Seating/Breaking Force</td>
<td></td>
</tr>
<tr>
<td>0 - 70 lb</td>
<td>0</td>
</tr>
<tr>
<td>71 - 80 lb</td>
<td>1</td>
</tr>
<tr>
<td>81 - 90 lb</td>
<td>2</td>
</tr>
<tr>
<td>91 - 100 lb</td>
<td>3</td>
</tr>
<tr>
<td>101 - 110 lb</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 110 lb</td>
<td>5</td>
</tr>
<tr>
<td>Total Seating/Breaking Force</td>
<td>4</td>
</tr>
</tbody>
</table>

### Calculated Prioritization Score

**Priority Score: 68**

**SUBMIT TO DATABASE**
Valve Prioritization Software

Step 1 – ID the Valve

Location and Type is Captured
Step 2 – Determine the frequency of use

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Frequency Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than yearly</td>
<td>0</td>
</tr>
<tr>
<td>Yearly</td>
<td>1</td>
</tr>
<tr>
<td>Monthly</td>
<td>2</td>
</tr>
<tr>
<td>Weekly</td>
<td>3</td>
</tr>
<tr>
<td>Daily</td>
<td>4</td>
</tr>
<tr>
<td>Multiple daily/Emergency</td>
<td>5</td>
</tr>
</tbody>
</table>

Enter Frequency Rating: 4

Valve Use Frequency
Step 3 – Determine the breaking force

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 70 lb</td>
<td>0</td>
</tr>
<tr>
<td>71 - 80 lb</td>
<td>1</td>
</tr>
<tr>
<td>81 - 90 lb</td>
<td>2</td>
</tr>
<tr>
<td>91 - 100 lb</td>
<td>3</td>
</tr>
<tr>
<td>101 - 110 lb</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 110 lb</td>
<td>5</td>
</tr>
</tbody>
</table>

Enter Breaking/Seating Force Rating: 4

Measure the force
How Forces are Measured
### Valve Prioritization Software

#### Step 4 – Determine the turning force

<table>
<thead>
<tr>
<th>Turning Force</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 35 lb</td>
<td>0</td>
</tr>
<tr>
<td>36 - 45 lb</td>
<td>1</td>
</tr>
<tr>
<td>46 - 55 lb</td>
<td>2</td>
</tr>
<tr>
<td>56 - 65 lb</td>
<td>3</td>
</tr>
<tr>
<td>66 - 75 lb</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 75 lb</td>
<td>5</td>
</tr>
</tbody>
</table>

Enter Turning Force Rating: 5

Measure the force
Valve Prioritization Software

Step 5 – Determine the hand wheel height

<table>
<thead>
<tr>
<th>Hand Wheel Height</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>33&quot; - 43&quot;</td>
<td>0</td>
</tr>
<tr>
<td>27&quot; - 49&quot;</td>
<td>1</td>
</tr>
<tr>
<td>21&quot; - 55&quot;</td>
<td>2</td>
</tr>
<tr>
<td>15&quot; - 61&quot;</td>
<td>3</td>
</tr>
<tr>
<td>9&quot; - 67&quot;</td>
<td>4</td>
</tr>
<tr>
<td>3&quot; - 73&quot;</td>
<td>5</td>
</tr>
</tbody>
</table>

Enter Hand Wheel Height Rating: 3

Measure the height
Step 6 – Determine the hand wheel orientation

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical hand wheel facing operator</td>
<td>0</td>
</tr>
<tr>
<td>Horizontal hand wheel facing operator</td>
<td>1</td>
</tr>
<tr>
<td>Vertical hand wheel not facing operator</td>
<td>2</td>
</tr>
<tr>
<td>Horizontal hand wheel not facing operator</td>
<td>3</td>
</tr>
<tr>
<td>Hand wheel grip diameter &lt; 1.5&quot;</td>
<td>Add 1 pt.</td>
</tr>
<tr>
<td>Other safety concern</td>
<td>Add 1 pt.</td>
</tr>
</tbody>
</table>

Enter Hand Wheel Orientation Rating: 5

Determine the position
Step 7 – Determine the clearance/accessibility

<table>
<thead>
<tr>
<th>Clearance/Accessability</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical clearance &gt; 80&quot;, standing width &gt; 24&quot;, adequate hand clearance, and horizontal reach &lt; 16&quot;</td>
<td>0</td>
</tr>
<tr>
<td>One of the afore mentioned criteria incorrect</td>
<td>1</td>
</tr>
<tr>
<td>Two of the afore mentioned criteria incorrect</td>
<td>2</td>
</tr>
<tr>
<td>Three of the afore mentioned criteria incorrect</td>
<td>3</td>
</tr>
<tr>
<td>Four of the afore mentioned criteria incorrect</td>
<td>4</td>
</tr>
<tr>
<td>Other safety concern</td>
<td>Add 1 pt.</td>
</tr>
</tbody>
</table>

Enter Clearance/Accessability Rating: 5

Determine the clearance
Step 8 – Determine the standing surface criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat, stable, high friction, 24&quot; x 25&quot; standing surface</td>
<td>0</td>
</tr>
<tr>
<td>One of the afore mentioned criteria incorrect</td>
<td>1</td>
</tr>
<tr>
<td>Two of the afore mentioned criteria incorrect</td>
<td>2</td>
</tr>
<tr>
<td>Three of the afore mentioned criteria incorrect</td>
<td>3</td>
</tr>
<tr>
<td>Four of the afore mentioned criteria incorrect</td>
<td>4</td>
</tr>
<tr>
<td>Other safety concern</td>
<td>5</td>
</tr>
</tbody>
</table>

Enter Standing Surface Rating: 5

Determine the rating
## SUMMARY SECTION SCORES

<table>
<thead>
<tr>
<th>Factor</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Multiplier</td>
<td>2.40</td>
</tr>
<tr>
<td>Seating/Breaking Force</td>
<td>6.69</td>
</tr>
<tr>
<td>Turning Force</td>
<td>8.36</td>
</tr>
<tr>
<td>Handwheel Height</td>
<td>5.02</td>
</tr>
<tr>
<td>Handwheel Orientation</td>
<td>2.75</td>
</tr>
<tr>
<td>Clearance/Accessability</td>
<td>2.75</td>
</tr>
<tr>
<td>Standing Surface</td>
<td>2.75</td>
</tr>
</tbody>
</table>

### TOTAL VALVE PRIORITIZATION SCORE

- **Priority Score**: 68

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**Submit to Database**
Sort by Key Areas

SORT BY:
- UNIT/AREA
- VALVE ID NUMBER
- VALVE TYPE
- DATE
- ANALYST
- VALVE SCORE
Recommendations

- Maintenance and clean valves to reduce closing/opening torque
- Consider pneumatic actuators
- Gear valves can be used for additional mechanical advantage; the valve bonnet is fitted with manual operated gear heads
Recommendations

- Gear Reduction devices can be used in large diameter and/or high pressure piping systems to reduce the physical exertion required to operate large valves.
Recommendations

- The primary purpose of the chain wheel actuator is to provide ground-level control of overhead valves
- Consider solenoid actuators
Recommendations

- Use directional change couplers
Recommendations

- As application of new technologies force changes in original flow paths, manual valves can become partially or totally obstructed. Through judicious use of compatible components, you can assemble a cost-effective extension system to reach virtually any valve in any location or position.
Recommendations

- Cease reliance on cheater bars as they create many additional hazards
- Use a combination of hard facing on the gate, Teflon® lining in the stem packing and needle thrust bearings
- Improved zig-zag handwheel designs can increase applied torque by up to 54%
- Partial turn (60 degree) butterfly, plug and ball valve designs limit the frequency of turning needed
Questions/Discussion

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