Risk Matrix:

Know when to accept the risk.
Know when to reject the risk.

What’s A Risk Matrix

• A risk matrix is simple graphical tool. It provides a process for combining:
  – The chance for an occurrence of an event (pof) (usually an estimate)
  – The $Consequence if the event occurred (usually an estimate)
  – Put the two together as:
    $Risk = pof \times $Consequence
• Use the tool for everyday $judgments and decisions—it’s easy and it’s quick
Control Of Risk: The Process

• Important decisions in life and business involve risks and how you handle the risk
• Don’t take too little risk—you waste money
• Don’t take too much risk—it’s too expensive
• You’ve got to get it right and you’ve got to make decisions quickly without delays in time
• Use a simple tool such as a risk matrix to help the decision making process

Four Important Questions

• How much $risk can you tolerate?  
  Clue: Look at your signature limit in SAP
• What is the probability of failure (pof*)?  
  Clue: Use good engineering judgment
• What is the consequence of the event?  
  Clue: Say it in money
• How does it go together into one statement?  
  Clue: $Risk = POF*$Consequence

*POF = probability of failure = a number between 0 (never happens) & 1 (happens)
What's Your Risk Tolerance?

Typical Limits In Words.
Zones Of A 5*5 Risk Matrix

- Probability Of Failure
- $ Consequence

Risk Increases In This Direction

Every company (every division?) has a different risk matrix which depends upon their risk aversion or risk acceptance.
**A More Complex Matrix**

Figure 2: Semi-Quantitative Risk Matrix

<table>
<thead>
<tr>
<th>Severity</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>Almost certain it will occur &gt;80% in timeframe</td>
</tr>
<tr>
<td>High</td>
<td>Expected to occur 10% chance in timeframe</td>
</tr>
<tr>
<td>Medium</td>
<td>It could occur &gt;1% chance in timeframe</td>
</tr>
<tr>
<td>Low</td>
<td>Not expected to occur &gt;0.1% chance in timeframe</td>
</tr>
<tr>
<td>Very Low</td>
<td>Almost certain it will occur &lt;0.01% chance in timeframe</td>
</tr>
</tbody>
</table>

![Figure 2: Semi-Quantitative Risk Matrix](image)

Your Head Is Going To Hurt!

Figure 3: Quantitative Risk Matrix

<table>
<thead>
<tr>
<th>Severity</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>Almost certain it will occur &gt;70% in timeframe</td>
</tr>
<tr>
<td>High</td>
<td>50% up to 70% chance to occur in timeframe</td>
</tr>
<tr>
<td>Medium</td>
<td>30% up to 50% chance to occur in timeframe</td>
</tr>
<tr>
<td>Low</td>
<td>10% up to 30% chance to occur in timeframe</td>
</tr>
<tr>
<td>Very Low</td>
<td>Less than 10% chance for an occurrence during the timeframe</td>
</tr>
</tbody>
</table>

![Figure 3: Quantitative Risk Matrix](image)
### One Risk Matrix—Many Uses

<table>
<thead>
<tr>
<th>Probability</th>
<th>Occurrence</th>
<th>Severity</th>
<th>Mitigate</th>
<th>Avoid!</th>
<th>Fix Now!</th>
<th>Avoid!</th>
<th>Avoid!</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 to 0.1</td>
<td>Once/yr</td>
<td>Low/Very Low</td>
<td>Mitigate</td>
<td>Fix Now!</td>
<td>Avoid!</td>
<td>Fix Now!</td>
<td>Avoid!</td>
</tr>
<tr>
<td>0.1 to 0.01</td>
<td>Once/10yr</td>
<td>Low/Very Low</td>
<td>Avoid!</td>
<td>Avoid!</td>
<td>Fix Now!</td>
<td>Avoid!</td>
<td>Fix Now!</td>
</tr>
<tr>
<td>0.01 to 0.001</td>
<td>Once/100yr</td>
<td>Low/Very Low</td>
<td>Avoid!</td>
<td>Avoid!</td>
<td>Fix Now!</td>
<td>Avoid!</td>
<td>Fix Now!</td>
</tr>
<tr>
<td>0.001 to 0.0001</td>
<td>Once/1,000yr</td>
<td>Low/Very Low</td>
<td>Avoid!</td>
<td>Avoid!</td>
<td>Fix Now!</td>
<td>Avoid!</td>
<td>Fix Now!</td>
</tr>
</tbody>
</table>

#### Figure 4: Broad Use Of The Matrix—Memory Joggers

- Ways to express the probability
- People/Health Issues
- Environmental
- Product or Service Quality
- Asset Or Financial Loss
- Local, National, or International Reputation

#### Management Sets The Standard

- Build a risk matrix for your organization
- Train your staff to use the matrix & set limits
- Use the matrix for more consistent and effective results
  - Don’t take too much risk
  - Don’t take too little risk
  - Be decisive and make decisions quickly
- Know when to accept the risk.
- Know when to reject the risks!
A Few Worked Out Examples

- Safety issue
- Environmental issue

Because of presentation time and simplicity, these examples are not intended to represent a complete solution. Rather, the examples are intended to give you ideas about the use of risk matrices.

Relief Valve Safety Issue

- A safety relief value shows erratic performance over many years without any recorded catastrophic events for pressure integrity.
- 10% of the time the valve opens too early (safe side), 20% of the time it opens too late at over pressure, and 5% of the time it will not open at —both unsafe side reasons due to dirty conditions. Number of demands for relief to open is not know, therefore be conservative.
- Catastrophic valve failure could result in: $2MM destruction of equipment, $50MM of business losses, & $30MM of employee lawsuits = $82MM.
- You’re the senior site engineer. It’s your call. What do you recommend?
Facts: Safety Relief Valve

• Hidden valve failure on unsafe side is 25% POF.
• Maximum failure consequence is $82MM
• Your personal risk consequence limit is $10,000.
• Limit the POF to $10000/$82MM=0.000122

However, humans are involved in the issue, and the limit must be less than 0.0001=POF for one person involved or ~0.00001 POF for up to 3 people involved—society sets practical limits.

• ∴ Mitigate high $ consequences immediately!

From Figure 1.16. Acceptable risk criteria, ALARA, as low as reasonably achievable.
From Figure 2.2. Societal risk criterion
Risk Analysis For Process Plant Pipelines And Transport
J. R. Taylor, Chapman & Hall, 1994

Risk Matrix For Our Plant Says

0.25 POF

$ Consequence

Probability Of Failure

$82MM! Take Action! Reduce Risk!

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Safety Relief Valve Alternatives

• Shut down the operation-(first/last alternative)
• Put a human on a manually operated valve until a permanent risk reduction achieved—(think LOPA)
• Add redundant relief valves—How many and what type. Show calculations.
• Brain storm alternatives for a permanent solution—need is urgent because of high risk, do something now!

Add How Many Relief Values?

• POF = 1-Reliability = must be less than 0.00001 as minimum requirement for risk
• Reliability of exposed valve = 0.75. Would require 9 valves in parallel
• Reliability of valve not exposed = 0.99 (assumed) in series with rupture disk at 0.99 (assumed) for a system reliability =0.9801. Would require 3 valves in parallel which are active at any one time
Relief Valve Calculations

<table>
<thead>
<tr>
<th>Relief Valve</th>
<th>unprotected Valve</th>
<th>protected Valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rupture Disk</td>
<td>Actual 0.7500</td>
<td>Assumed 0.9900</td>
</tr>
<tr>
<td>Valve Reliability</td>
<td>0.7500</td>
<td>0.9801</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N</th>
<th>reliability</th>
<th>pof</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.75</td>
<td>0.25</td>
</tr>
<tr>
<td>2</td>
<td>0.9375</td>
<td>0.062500</td>
</tr>
<tr>
<td>3</td>
<td>0.984375</td>
<td>0.015625</td>
</tr>
<tr>
<td>4</td>
<td>0.996094</td>
<td>0.003906</td>
</tr>
<tr>
<td>5</td>
<td>0.999023</td>
<td>0.000977</td>
</tr>
<tr>
<td>6</td>
<td>0.999756</td>
<td>0.000244</td>
</tr>
<tr>
<td>7</td>
<td>0.999939</td>
<td>0.000061</td>
</tr>
<tr>
<td>8</td>
<td>0.999985</td>
<td>0.000015</td>
</tr>
<tr>
<td>9</td>
<td>0.999999</td>
<td>0.000004</td>
</tr>
<tr>
<td>10</td>
<td>0.999999</td>
<td>0.000001</td>
</tr>
</tbody>
</table>

Environmental Issue

- We’re concerned about an environmental issue that may develop—no problems yet—but….
- The issue is a potential release of about a 100 to 500 gallon noxious/smelly liquid which will rapidly convert to a non-poisonous, very smelly, vapor before we can clean it up.
- The smelly odor will escape the plant site and bother the neighbors, some who have called the site manager 21 times to complain about other routine odors.
- You’re the senior site engineer. It’s your call. What do you recommend?
What Are The Odds For Events?

- We estimate the occurrence odds are:
  - 50% chance we'll have one occurrence/yr
  - 30% chance we'll have two occurrences/yr
  - 20% chance we'll have three occurrences/yr

- If the neighbors reach the breaking point during the next year—their actions may be:
  - One occurrence--they call the press
  - Two occurrences--they call EPA + the press
  - Three occurrences—file law suit + the press

What Does Our Risk Matrix Say?

<table>
<thead>
<tr>
<th>Probability Range</th>
<th>Occurrence Frequency</th>
<th>Consequence Severity</th>
<th>Probability of Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>~0.00001</td>
<td>Once/10,000yr</td>
<td>Negligible</td>
<td>Lowest Priority</td>
</tr>
<tr>
<td>~0.0001</td>
<td>Once/100yr</td>
<td>Minor</td>
<td>Lowest Priority</td>
</tr>
<tr>
<td>~0.001</td>
<td>Once/1000yr</td>
<td>Slight</td>
<td>Lowest Priority</td>
</tr>
<tr>
<td>~0.01</td>
<td>Once/10yr</td>
<td>Lost time</td>
<td>Lowest Priority</td>
</tr>
<tr>
<td>~0.50</td>
<td>Once/yr</td>
<td>Total disability/fatality</td>
<td>Lowest Priority</td>
</tr>
</tbody>
</table>

Take action to reduce the probability of an occurrence too less than 0.01% chance which is risk reduction of 4 orders of magnitude, i.e. no releases!
Risk Matrix Summary

• Use the risk matrix idea to be decisive, non-argumentative, and action oriented
• Develop a risk matrix for your organization. Match it to the organization’s appetite for risk
• Use examples from your plant to indoctrinate your organization on how to use the method
• Work to know when to accept risk and know when to reject risk—be decisive
• Don’t accept risk by default—work the numbers!

Reference Material

• See references at http://www.barringer1.com/nov04prb.htm for details from both ASME and API
• You can also download this presentation from the same address.