

# Risk Matrix:

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

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## 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:  
 **$\$Risk = pof * \$Consequence$**
- Use the tool for everyday \$judgments and decisions—**it's easy and it's quick**

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## 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**

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## Four Important Questions

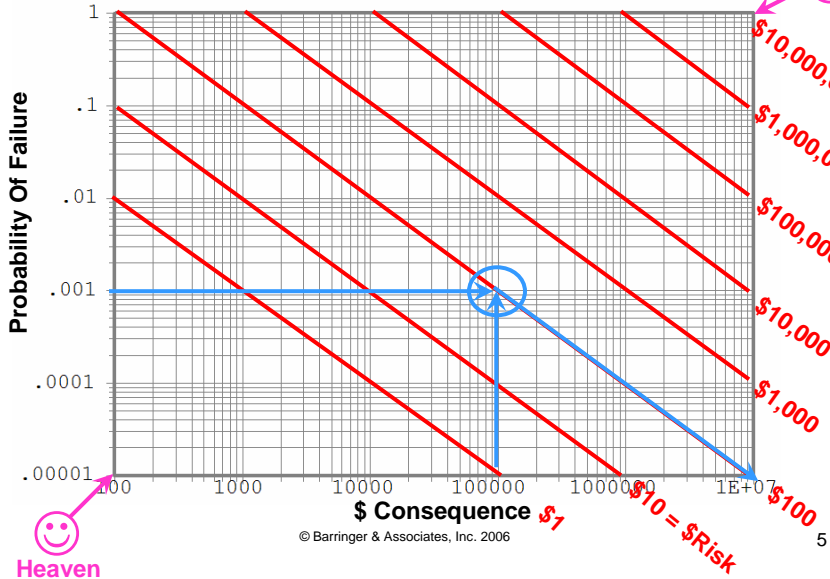
- How much **\$risk** can you tolerate?  
**Clue:** Look at your signature limit in SAP
- What is the **probability of failure (pof\*)**?  
**Clue:** Use good engineering judgment
- What is the **\$consequence** of the event?  
**Clue:** Say it in money
- How does it go together into one statement? 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

\*POF = probability of failure = a number between **0** (never happens) & **1** (happens)

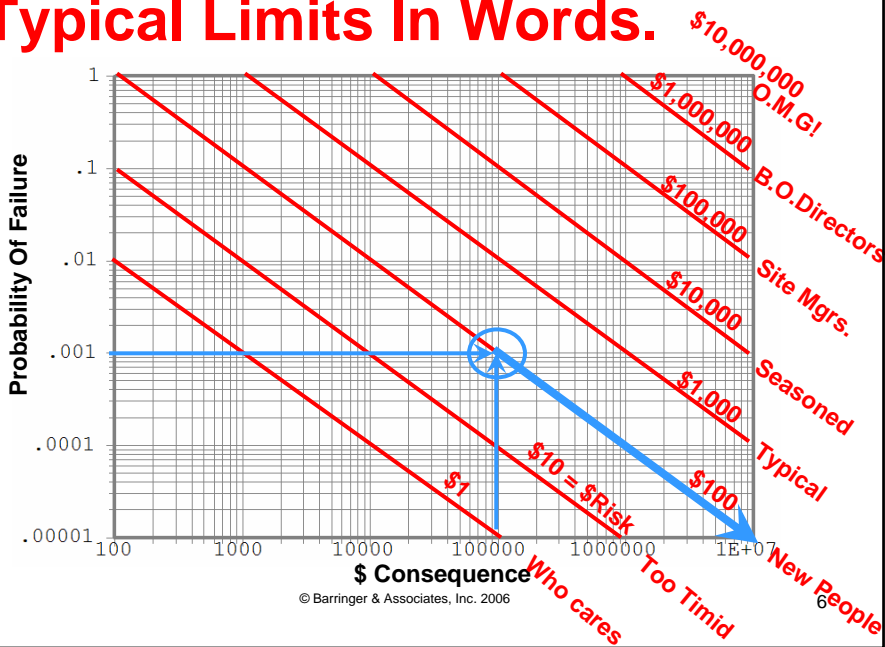
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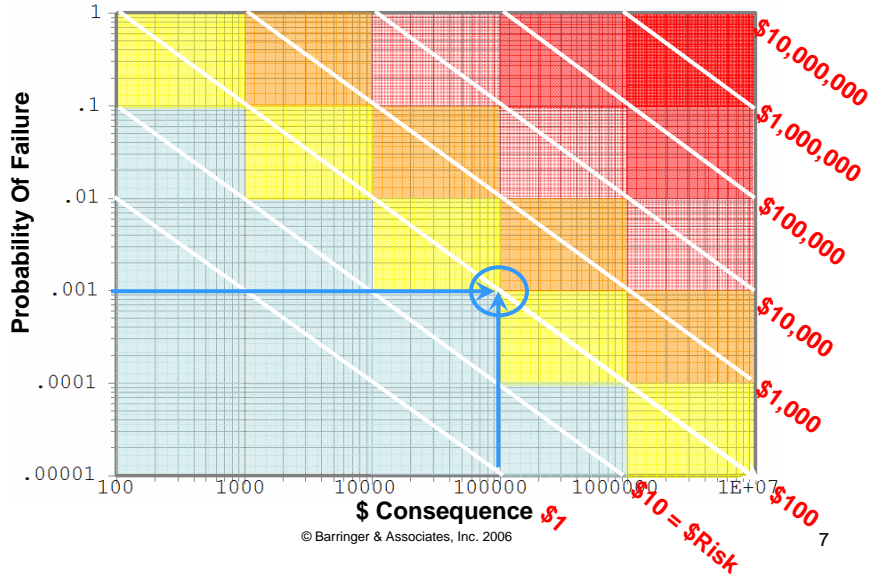
# What's Your Risk Tolerance? Hell ☹️



# Typical Limits In Words.

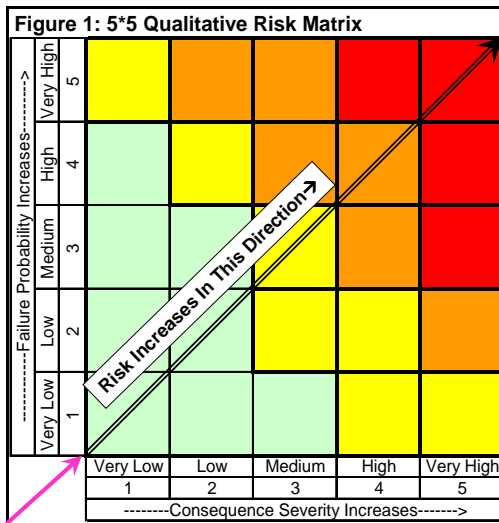


# Zones Of A 5\*5 Risk Matrix



# A Simple Risk Matrix

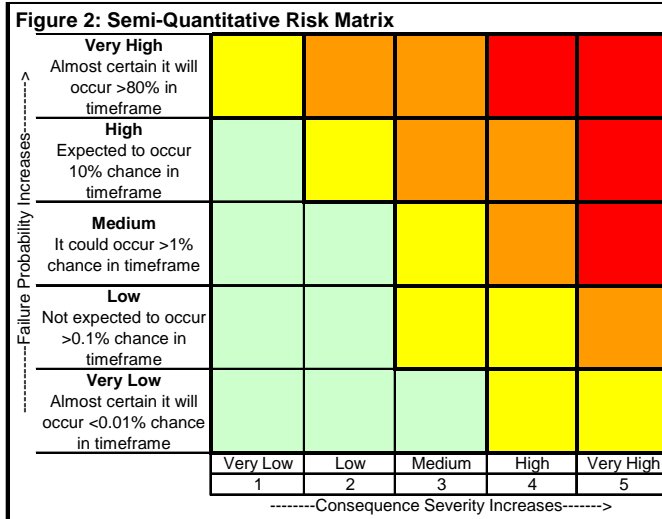
Every company (every division?) has a different risk matrix which depends upon their risk aversion or risk acceptance.



Heaven ☺

Hell ☹

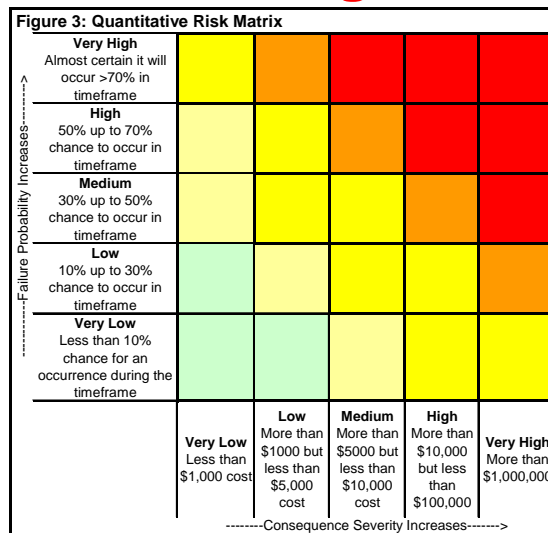
# A More Complex Matrix



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# Your Head Is Going To Hurt!



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# One Risk Matrix—Many Uses

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

Ways to express the probability					Consequence Severity Increases				
1.0 to 0.1	Once/yr to Once/10yr	Occurs several times/yr	It will happen!	Mitigate	Fix Now!	Avoid!	Avoid!	Avoid!	
0.1 to 0.01	Once/10yr to Once/100yr	Occurs in 10 to 100 years	It may happen	Lower Priority	Mitigate	Fix Now!	Avoid!	Avoid!	
0.01 to 0.001	Once/100yr to Once/1,000yr	May occur within company	Would be unusual if it occurred	Lowest Priority	Lower Priority	Mitigate	Fix Now!	Avoid!	
0.001 to 0.0001	Once/1,000yr to Once/10,000yr	Occurs within our industry	We can conceive it occurring	Lowest Priority	Lowest Priority	Mitigate	Mitigate	Fix Now!	
Less than 0.0001	Less Than Once/10,000yr	Never heard of occurring	We can't conceive it occurring	Lowest Priority	Lowest Priority	Lowest Priority	Mitigate	Mitigate	

Consequences in Various Regimes		Consequence Severity Increases				
People/Health Issues-->	No health/injury risks	First aid case or slight health problem	Lost time injury or potential health problem	Partial disability or major health problem	Total disability/fatality(s) severe health problem	
Environmental-->	Negligible effect confined to implant grounds/ environment	Minor effect neighbors adjacent to plant complain	Localized release makes local TV coverage newspapers	Major release makes national TV coverage newspapers	Massive damage makes international TV coverage/newspapers	
Product or Service Quality-->	Some product or service fails to meet standards	Several customers complain verbally	Several customers complain in writing	Important/ major customers cancel orders	Loss of substantial market share for problem(s)	
Asset Or Financial Loss-->	Slight damage is less than \$10,000	Noticeable damage exceeds \$10,000	Large damage exceeds \$0.1 million	Major damage exceeds \$1 million	Severe damage exceeds \$10 million	
Local, National, or International Reputation-->	Slight to moderate impact	Loss of community reputation	Loss of state reputation	Loss of national reputation	Loss of international reputation	

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1. Management values a process such as provided by a risk matrix
2. Follow the process in an unemotional manner to control risks
3. Know your limits.
4. When risks exceed your limits, get sign-off for exceedances
5. Use the matrix as a communication tool.
6. Do the right thing for the right reason.

# 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!

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## 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 matrixes.

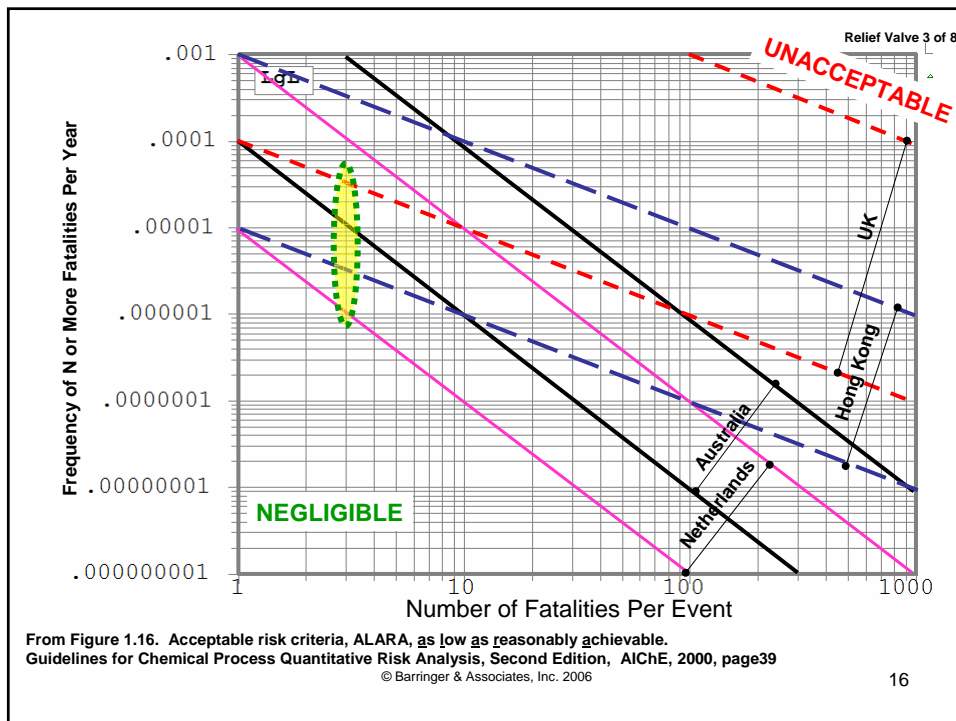
## Relief Valve Safety Issue

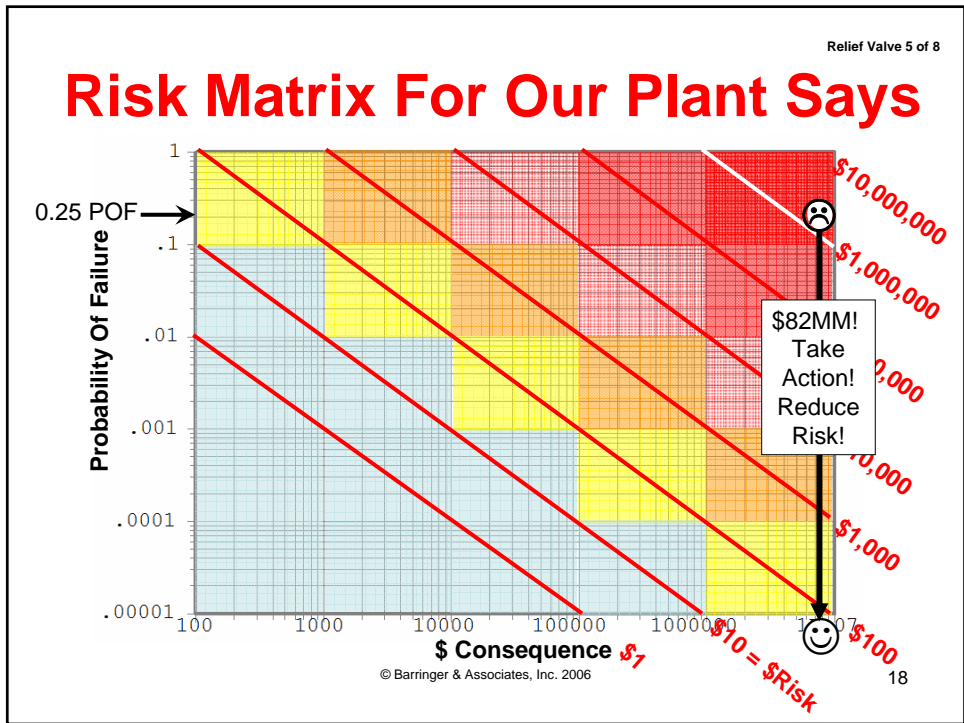
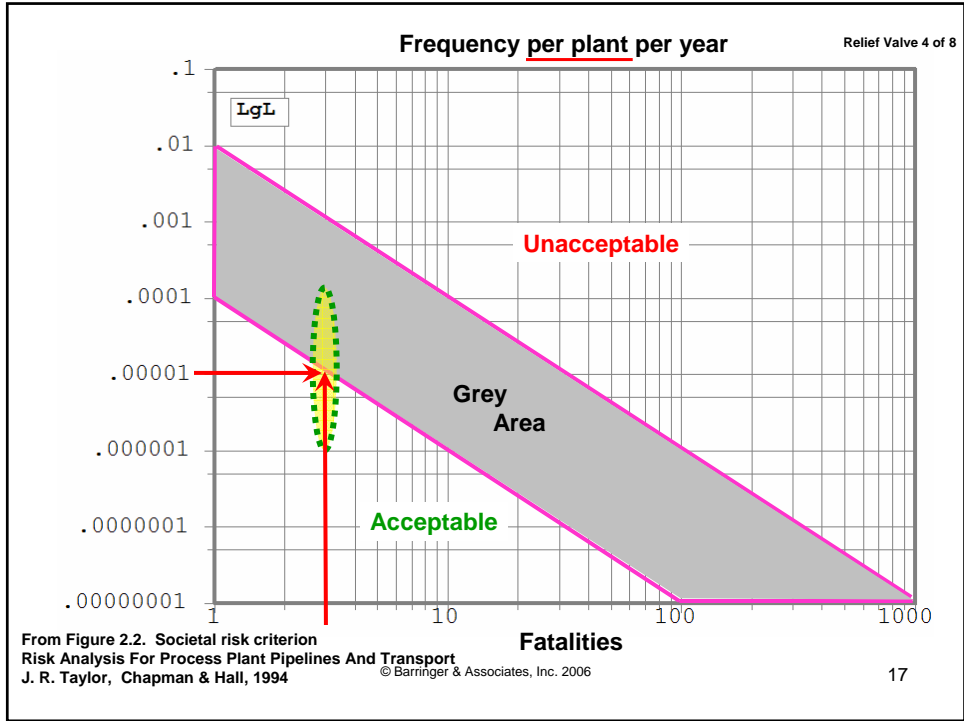
20%  
+5%  
25% = pof

- 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  $\$10000/\$82\text{MM}=0.000122$   
However, humans are involved in the issue, and the limit must be less than  $0.0001=\text{POF}$  for one person involved or  **$\sim 0.00001$  POF** for up to 3 people involved– society sets practical limits.
- $\therefore$  Mitigate high \$ consequences **immediately!**





## 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?

- $POF = 1 - \text{Reliability} = \text{must be less than } 0.00001$  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

Unprotected Valve			Protected Valve		
Relief Valve	0.7500	Actual	0.9900	Assumed	
Rupture Disk	-		0.9900	Assumed	
Valve Reliability	0.7500		0.9801		A Single Protected System Reliability

Calculated System Reliability			Calculated System Reliability		
N	Reliability	pof	N	Reliability	pof
1	0.75	0.25	1	0.98010000	0.0199
2	0.9375	0.062500	2	0.99960399	0.000396
3	0.984375	0.015625	3	<b>0.99999212</b>	<b>0.000008</b>
4	0.996094	0.003906	4	0.99999984	0.000000
5	0.999023	0.000977	5	1.00000000	0.000000
6	0.999756	0.000244	6	1.00000000	0.000000
7	0.999939	0.000061	7	1.00000000	0.000000
8	0.999985	0.000015	8	1.00000000	0.000000
9	<b>0.999996</b>	<b>0.000004</b>	9	1.00000000	0.000000
10	0.999999	0.000001	10	1.00000000	0.000000

Nine Systems In Parallel →

Three Systems In Parallel ←

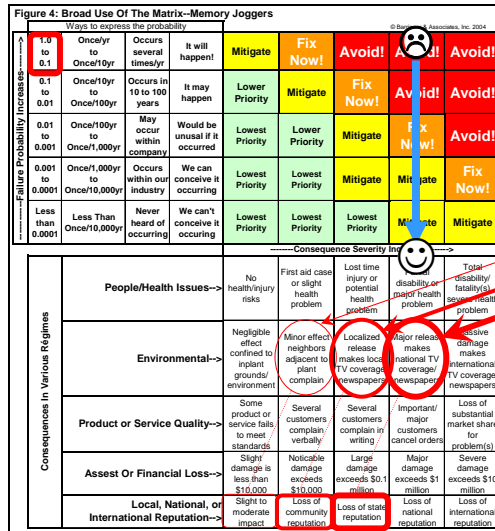
# Environmental Issue

- 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 manger 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?



50% chance → ~\$5,000  
 30% chance → ~\$30,000  
 20% chance → ~\$200,000  
 ~\$235,000

**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!

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## 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.

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