

## Quantifying Process Safety with Expert Judgment



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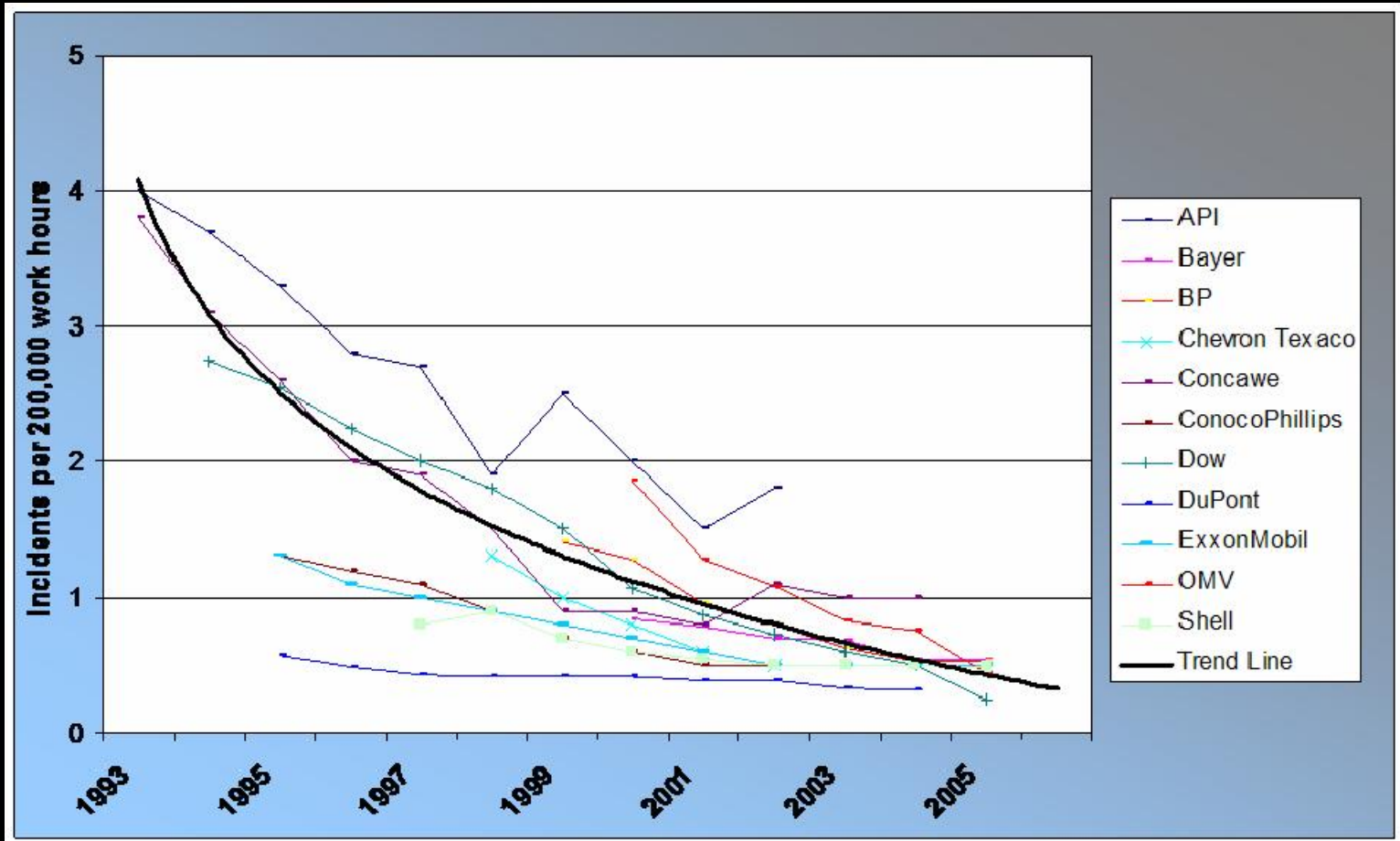
# Outline

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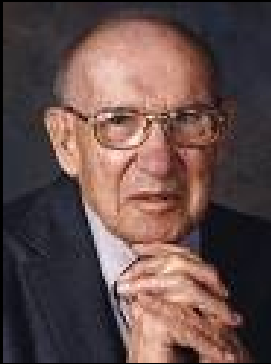
1. Need for quantification of PSM
2. Examine existing approaches: strengths and limitations
3. Present an approach using expert judgment

# Occupational Safety Quantification



# Process Safety Quantification

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**What gets measured gets done**

*Peter Drucker. 1909 - 2005*

- What is our current status?
- Where are we most vulnerable?
- How are we progressing?
- How do we compare to others?
- PSM experts often have a technical/numerical background

# Quantification of Process Safety

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Two tracks:

1. Engineering standards and codes
  1. API
  2. ASME
  3. . . . .
2. Models supported by failure rate data
  1. Fault tree analysis
  2. Fire and explosion models

# Difficulties with Quantifying PSM

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There are three kinds of people: those who can count and those who can't count.

- Lack of consistent terminology
  - Lack of baseline
  - Lack of consistency across facilities
- Lack of correlation with occupational safety
- Assumptions
  - Location of a leak
  - Its size
  - Its likelihood
  - Its duration
  - Effectiveness of operator response
  - Rigor with which regulations are enforced
- Abstraction
- Risk is fundamentally subjective

## Terminology – Defining a Process-Related Incident (CCPS 2007/2008)

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- It must involve a chemical or have chemical process involvement;
- It must be above a minimum reporting threshold;
- It must occur at a process location; and
- The release must be acute, *i.e.*, it must occur over a short period of time.

# Risk Perception

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A truth ceases to be a truth as soon as two people perceive it.

Oscar Wilde (1854 – 1900)

- No two people have the same "world view"
- Hence, there is no "common sense"
- Engineering tends to go the other way: data and algorithms are objective
- But subjectivity is inherent in process safety
- Slovic: There is no 'real risk' or 'objective risk'
- What is "high level"?
  - Major spill to the environment
  - Minor, contained loss

# Public Perception

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- Degree of control
- Familiarity with the hazard
- Direct benefit
- Personal impact
- Natural vs man-made risk
- Recency of events
- Effect of consequence term

# Risk Equation

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$$\text{Risk}_{\text{Hazard}} = \text{Consequence} * \text{Predicted Frequency}$$

Risk can never be zero; there are always hazards, consequence and likelihoods.

The only way of *eliminating* risk is to remove the hazard. Reducing consequence or predicted frequency only *reduces* risk.

# Subjectivity

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$$\text{Risk}_{\text{Hazard}} = \text{Consequence}^n * \text{Predicted Frequency}$$

where  $n > 1$

High consequence / low frequency events are less acceptable than low consequence / high frequency events, even if the objective risk is the same.

# The Titanic

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*They [scientists and engineers] tend to argue with facts, formulas, simulations, and other kinds of sweet reason. These don't work well. What does work well are shameless appeals to emotion - like political cartoons. Like baby seals covered in oil. And always, always, casualty lists. Best of all are individual stories of casualties, to make the deaths real. We only learn from blood.*

Brander

# Use of Expert Judgment

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- Traditional problem-solving expert systems
- Design review/analysis
- Management system
- Develop a system that
  - Identifies management issues
  - Can handle abstraction
  - Is not dependent on the occurrence / non-occurrence of events
  - Is not an audit
  - Incorporates expertise
  - Is quantitative and consistent
  - Retains institutional memory

# Economic Background

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*Globalization has left only one sustainable route to profitability for firms operating in high-wage nations: basing their competitive advantage on exceptional human capital management (HCM).*

*Lauri Bassi, 2008*

# Institutional Memory

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Organizations don't have memories — only people do.

*Trevor Kletz*

# Management by Bumper Sticker

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There's no substitute  
for knowing what  
you're doing.

# From OSHA (1992) to CCPS (2007)

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1. Employee Participation
2. Process Safety Information
3. Process Hazards Analysis
4. Operating Procedures
5. Training
6. Contractors
7. Prestartup Safety Review
8. Mechanical Integrity
9. Hot Work
10. Management of Change
11. Incident Investigation
12. Emergency Planning and Response
13. Compliance Audits
14. Trade Secrets

1. Process Safety Culture
2. Compliance
3. Competence
4. Workforce Involvement
5. Stakeholder Outreach
6. Knowledge Management
7. Hazard Identification / Risk
8. Operating Procedures
9. Safe Work Practices
10. Asset Integrity / Reliability
11. Contractor Management
12. Training / Performance
13. Management of Change
14. Operational Readiness
15. Conduct of Operations
16. Emergency Management
17. Incident Investigation
18. **Measurement and Metrics**
19. Auditing
20. Management Review

# Management Elements Assessment

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- Develop thousands of assessment questions based on expert judgment
- Each question is "obvious"
- Develop a baseline, trendline and outliers
- Can use process safety elements
- Checklist question supported by discursive information

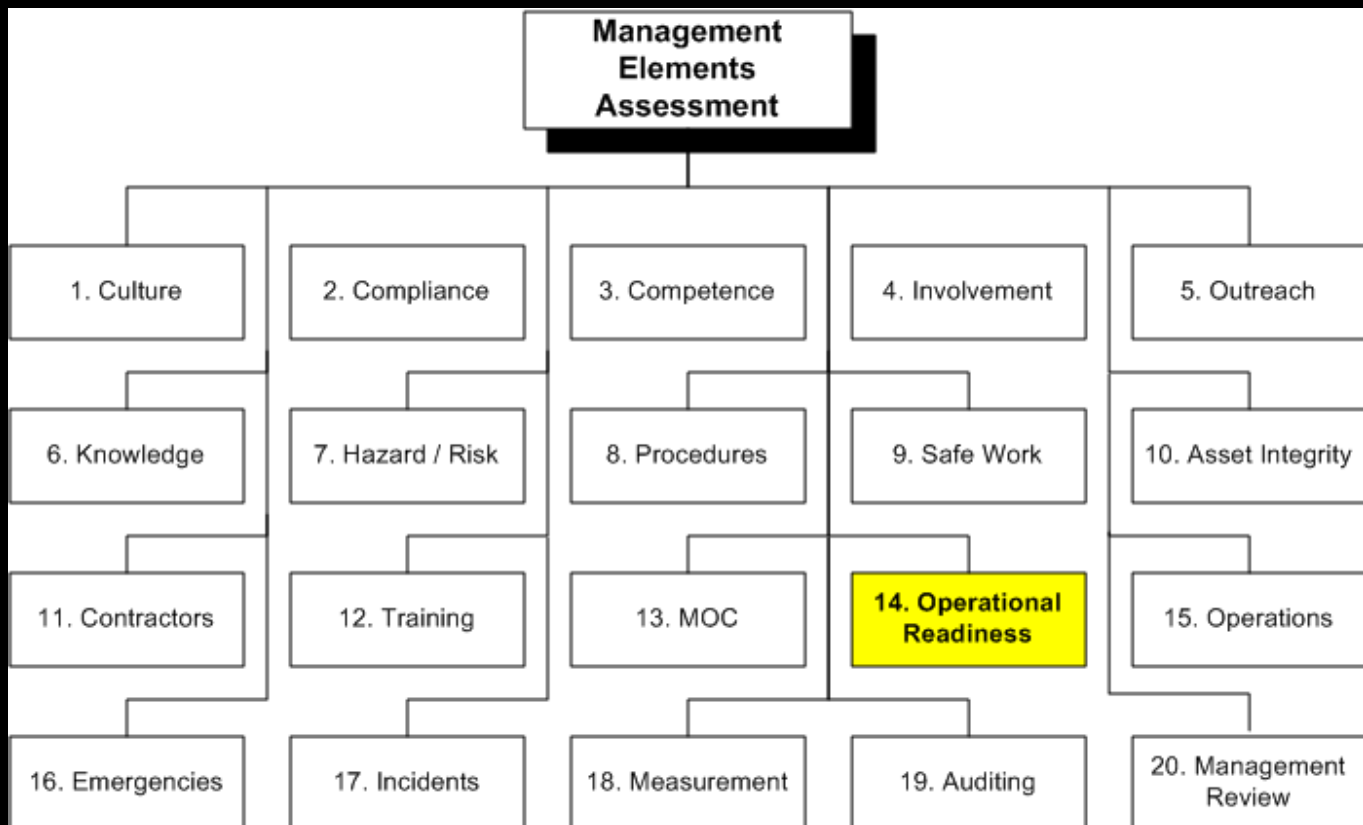
# Advantages

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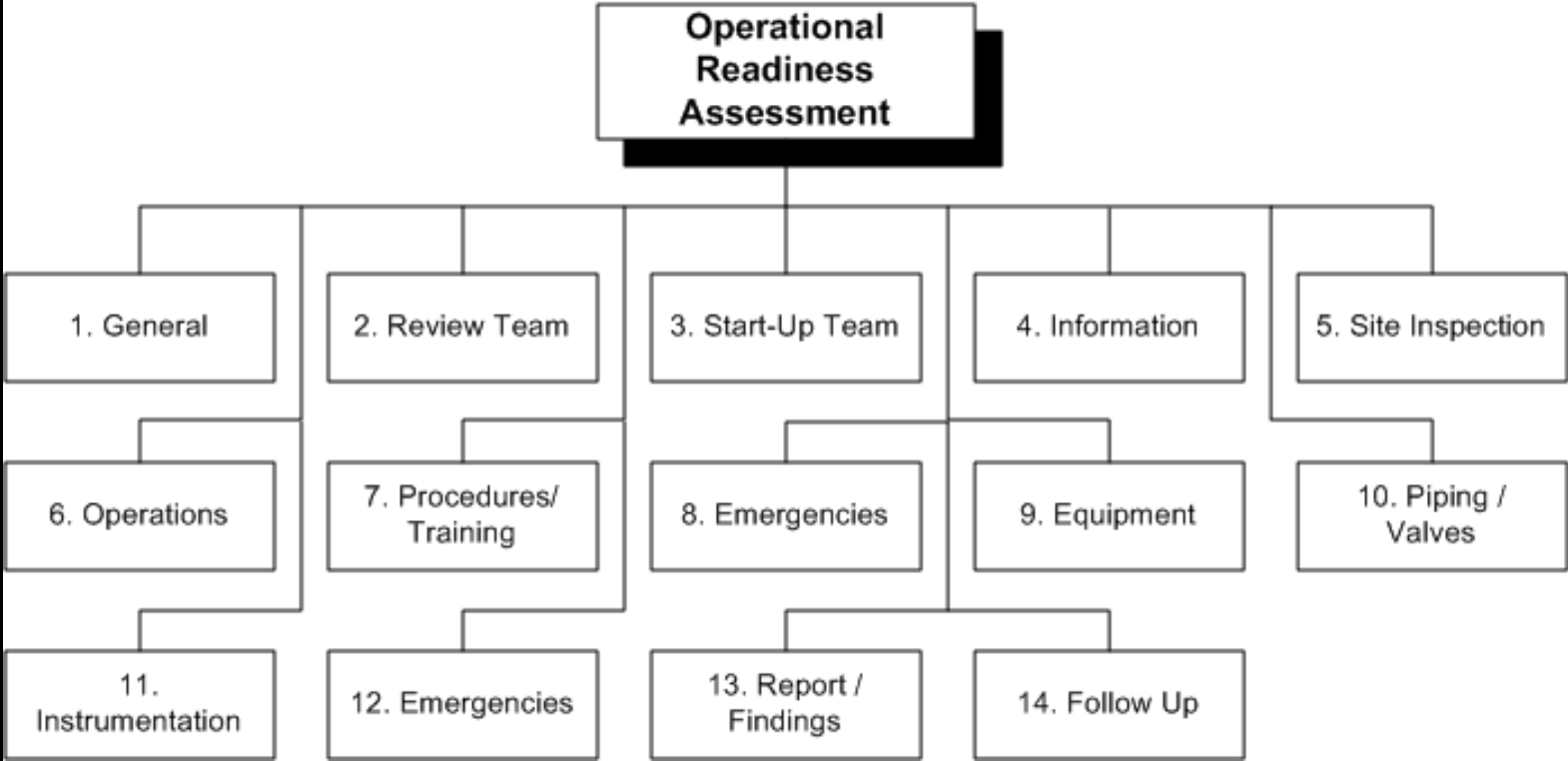
- Does not depend on actual events or near misses
- Large number of questions smoothes out data
- Results quite objective yet incorporate subjectivity (part of all risk assessments)
- Not an audit
  - Audits are prescriptive
  - Audits are qualitative
  - Audits are inherently adversarial

# Overall Structure

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# Operational Readiness Example



	A	B	C	D	E	
1	<b>Process Risk Management</b>					
2						
3	<a href="#">home</a>		<b>Sheets</b>	<b>Questions</b>	<b>Score</b>	
4		<a href="#">1. Process Safety Culture</a>	18	81	62	
5		<a href="#">2. Compliance</a>	5	26	74	
6		<a href="#">3. Competence</a>	2	14	71	
7		<a href="#">4. Workforce Involvement</a>	4	69	40	
8		<a href="#">5. Stakeholder Outreach</a>	2	12	33	
9		<a href="#">6. Knowledge Management</a>	13	146	76	
10		<a href="#">7. Hazard Identification / Risk</a>	22	171	58	
11		<a href="#">8. Operating Procedures</a>	8	71	74	
12		<a href="#">9. Safe Work Practices</a>	37	500	72	
13		<50: Unacceptable	<a href="#">10. Asset Integrity / Reliability</a>	15	150	52
14		50-75: Acceptable	<a href="#">11. Contractor Management</a>	3	33	70
15		>75: Excellent	<a href="#">12. Training / Performance</a>	6	22	58
16			<a href="#">13. Management of Change</a>	5	71	45
17			<a href="#">14. Operational Readiness</a>	14	189	63
18			<a href="#">15. Conduct of Operations</a>	31	365	69
19			<a href="#">16. Emergency Management</a>	11	73	61
20			<a href="#">17. Incident Investigation</a>	6	31	59
21			<a href="#">18. Measurement and Metrics</a>	2	4	75
22			<a href="#">19. Auditing</a>	3	30	80
23			<a href="#">20. Management Review</a>	4	15	44
24		<b>Overall</b>	<b>211</b>	<b>2073</b>	<b>62</b>	
25						
26	<b>Overall Rank</b>	<b>Acceptable</b>				

C24

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## 14. Operational Readiness



Sheet Number	Questions	Score
14.1 General	51	52
14.2 Team	13	56
14.3 Information	4	81
14.4 Field Inspection	2	63
14.5 Operations	7	43
14.6 Procedures/Training	7	68
14.7 Job Site	11	36
14.8 Construction	23	45
14.9 Equipment	10	65
14.10 Piping / Valves	25	67
14.11 Instrumentation	14	96
14.12 Emergencies	13	81
14.13 Report / Findings	3	83
14.14 Follow Up	6	46
<b>Total</b>	<b>189</b>	<b>63</b>

&lt;50: Unacceptable

50-75: Acceptable

&gt;75: Excellent

Microsoft Excel - 14\_readiness.xls

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B10 Is there a person responsible for readiness reviews oversight

	A	B	C	D
1	<b>14.2</b>	<b>Readiness: Team</b>	<b>Score</b>	
2	<b>This sheet to be used?</b>		<b>Y</b>	
3	14.2.1	Is the readiness reviews conducted by a team?	2	
4	14.2.2	Are the roles and responsibilities of the start-up/operations Management Team defined?	3	
5	14.2.3	Has a staffing plan for commissioning activities been developed and communicated to affected personnel?	2	
6	14.2.4	Is contingency resource planning (i.e. contractors, vendors or others) in place?	1	
7	14.2.5	Are plans in place to provide technical support during off-hours?	4	
8	14.2.6	Is the point of transition between the startup and run and maintain organization defined?	2	
9	14.2.7	Does the readiness reviews team have a mix of different disciplines and departmental representatives?	3	
10	14.2.8	Is there a person responsible for readiness reviews oversight and coordination?	4	
11	14.2.9	Does the readiness reviews team leader have plenty of time to organize the readiness reviews?	1	
12	14.2.10	Is the readiness reviews team provided with a structured analysis process?	1	
13	14.2.11	Does the team sign off on the readiness reviews?	1	
14	14.2.12	Are the findings systematically recorded?	2	
15	14.2.13	Are the team's findings effectively conveyed to the project management team?	3	
16	<b>Normalized Total</b>		<b>56</b>	
17				
18	0: missing / ineffective			
19	1: poor			
20	2: adequate			
21	3: good			
22	4: complete / excellent			
23	N/A: not applicable			

Microsoft Excel - 14_templates.xls	
File Edit View Insert Format Tools Data Window Help	
A4 = Are plans in place to provide technical support dur	
A	B
1	<b>14. Operational Readiness: Templates</b>
2	
3	<b>14.2.5</b>
4	<b>Are plans in place to provide technical support during off-hours?</b>
5	<b>Score</b>
6	<b>Discussion</b>
6	0: <i>missing / ineffective</i> Plans do not exist, or their quality is unacceptable.
7	1: <i>poor</i> Plans do exist, but they are of poor quality.
8	2: <i>adequate</i> The plans exist, and should be satisfactory if no unusual conditions arise.
9	3: <i>good</i> The plans are complete and thorough.
10	4: <i>complete / excellent</i> The plans cover all possible contingencies.
11	<i>N/A: not applicable</i> Plans for technical support are not needed because process conditions have not changed.
12	
13	<b>Notes</b>
14	During the start-up technical support may be required in order to address unexpected issues as they arise. The technical support team will generally consist of:
15	
16	A process or facilities engineer;
17	An instrument engineer, and
18	Operations specialists.
19	
20	Depending on the scale of the project work and the complexity of the start-up it may be necessary to have a team of people representing the above disciplines working on a 24 hour shift cycle until the facility is properly lined out.
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22	Even if 24 hour coverage is not considered necessary, discipline specialists should be available on call.
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# Scoring Template

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<b>Are plans in place to provide technical support during off-hours?</b>	
Score	Discussion
<i>0: missing / ineffective</i>	Plans do not exist, or their quality is unacceptable.
<i>1: poor</i>	Plans do exist, but they are of poor quality.
<i>2: adequate</i>	The plans exist, and should be satisfactory if no unusual conditions arise.
<i>3: good</i>	The plans are complete and thorough.
<i>4: complete / excellent</i>	The plans cover all possible contingencies.
<i>N/A: not applicable</i>	Plans for technical support are not needed because process conditions have not changed.

# Background Information

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## **Are plans in place to provide technical support during off-hours?**

During the start-up technical support may be required in order to address unexpected issues as they arise. The technical support team will generally consist of:

- A process or facilities engineer;
- An instrument engineer; and
- Operations specialists.

Depending on the scale of the project work and the complexity of the start-up it may be necessary to have a team of people representing the above disciplines working on a 24 hour shift cycle until the facility is properly lined out.

Even if 24 hour coverage is not considered necessary, discipline specialists should be available on call.

# Conclusions: Benefits of Elements Assessment Approach

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- Independent of events
- Handle management systems
- Smoothing of results
- Objectivity
- Yet incorporate subjectivity
- Incorporate expert knowledge