Integrating RBI into the Oil and Gas Industry – Authority Perception and Roles

Department of Occupational Safety and Health, Malaysia

Objective

- To outline the Authority perception towards RBI
- To outline the Roles of the Authority to assist the Oil and Gas Industry in Implementing RBI

Why RBI?

- To enable industry to forego the Time-based Inspection System
- In-line with the International trend of conducting Statutory Inspection

WHY RBI?

- To replace the current practices of extending certificate of fitness of Pressurized machinery
- As outlines by the Factories and Machinery (Special Scheme of Inspection) (Risk-based Inspection) Regulations, 200X

Risk Based Inspection (RBI) - Introduction

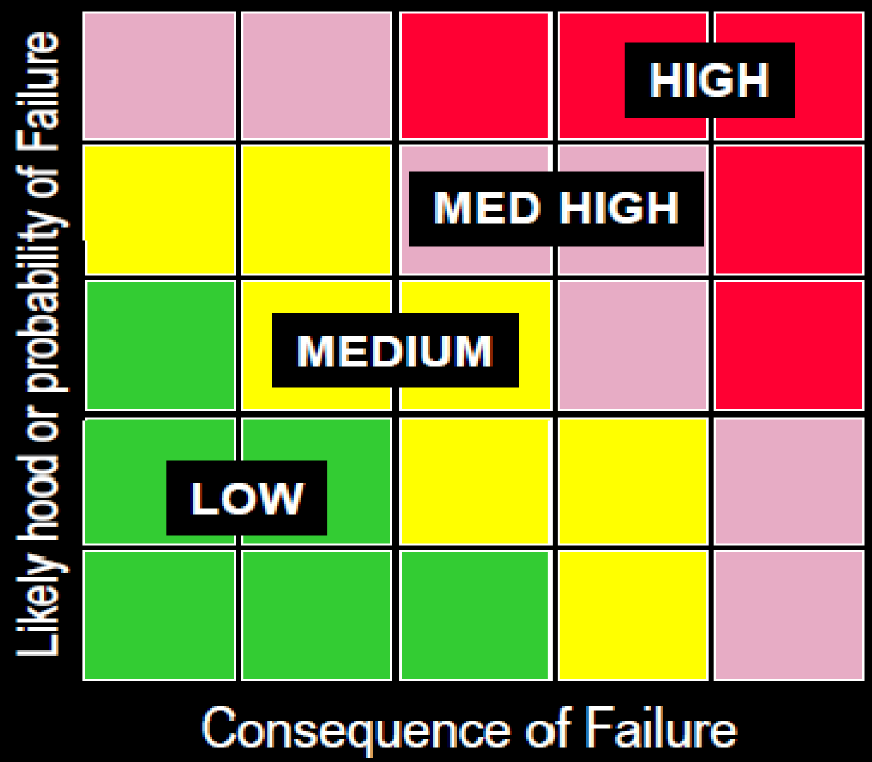
- The RBI methodology provides the basis for managing risk by making an informed decision on inspection frequency, level of detail and types of NDT.
- In most plants , a large percent of the total unit risk will be concentrated in a relatively small percent of the equipment items.
- Hence, with RBI, inspections will continue to be conducted as defined in existing working documents but priorities and frequencies would be guided by RBI procedures.

What is RBI

Risk = Probability of Failure X Consequence of Failure

- ✓ Method for prioritising equipment for inspection based on risk
- ✓ Determines risk associated with operation of specific items of equipment
- ✓ Identifies the key issues driving the risk
- ✓ Decision making tool for Inspection Planning

RISK MATRIX



Probability Ranking

- Very High (1+ per yr.)
- High (10^{-1} per yr.)
- Moderate (10^{-2} per yr.)
- Low (10^{-3} per yr.)
- Very Low (10^{-4} or less per yr.)

Consequence Ranking

- Catastrophic ($\$10^{7}$)
- Very Serious ($\$10^{6}$)
- Serious ($\$10^{5}$)
- Significant ($\$10^{4}$)
- Minor ($\$10^{3}$)

RBI – Authority Perception

- “Risk-based Inspection” is an inspection system where its inspection interval is scheduled based on the category of risk associated with each pressurized machinery

Benefit of Integrating RBI into the Oil & Gas Industry

- Reduce downtime due to unnecessary statutory inspection by Authority
- Reduce both risk and direct operating costs by eliminating unproductive work.
- Result in an increase in direct costs with a corresponding benefit of reduced downtime by a reduction in the occurrence of and consequences of unplanned failures.

Integrating RBI – Industry Tasks & Roles

- ✓ Industry to :
  1. implement RBI,
  2. collect data;
  3. identify the common degradation mode,
  4. determine the likelihood & consequence of failure of machinery; and
  5. rank it based on category of risk
- ✓ to prepare an inspection plan based on the risk associated with each pressurized machinery
- ✓ to submit to the Chief Inspector for approval

Integrating RBI – Authority Roles

1. Authority to approve the proposed RBI
   a) Review the documents
   b) Carry out Audit and validate data
   c) grant maximum inspection interval to the successful application
2. Chief Inspector to issue RBI Approval certificate;
3. Inspector at state office to issue certificate of fitness

Extending C/F – Disadvantages of Current Practices

- DOSH Experienced
  - No proper legal procedures
  - Time consuming
  - Decision made not based on technical reasons

Extending C/F – Disadvantages of Current Practices

- Industry Experienced
  1. May lose Competitiveness Edge with foreign companies
  2. Companies are not making profit
  3. May affect Nation's economy

The Need For A New Legislations on RBI

"Factories and Machinery (Special Scheme of Inspection)(Risk-based Inspection) Regulations, 200X"

The Needs of SSI-RBI Regulations

- To improve “Delivery System” of DOSH
- Reduce industries cost of operation and maintenance
- Support industry to be more competitive in global market

The Needs of SSI-RBI Regulations

- To encourage Risk Based Inspection which is recognized as industrial best practice and latest technology to ensure machinery safety in lieu of Time based inspection
- To introduce and promote RBI technology to industries and JKKP officers
- To overcome issues relating to extension / exemption application

Enabling & Related Provisions

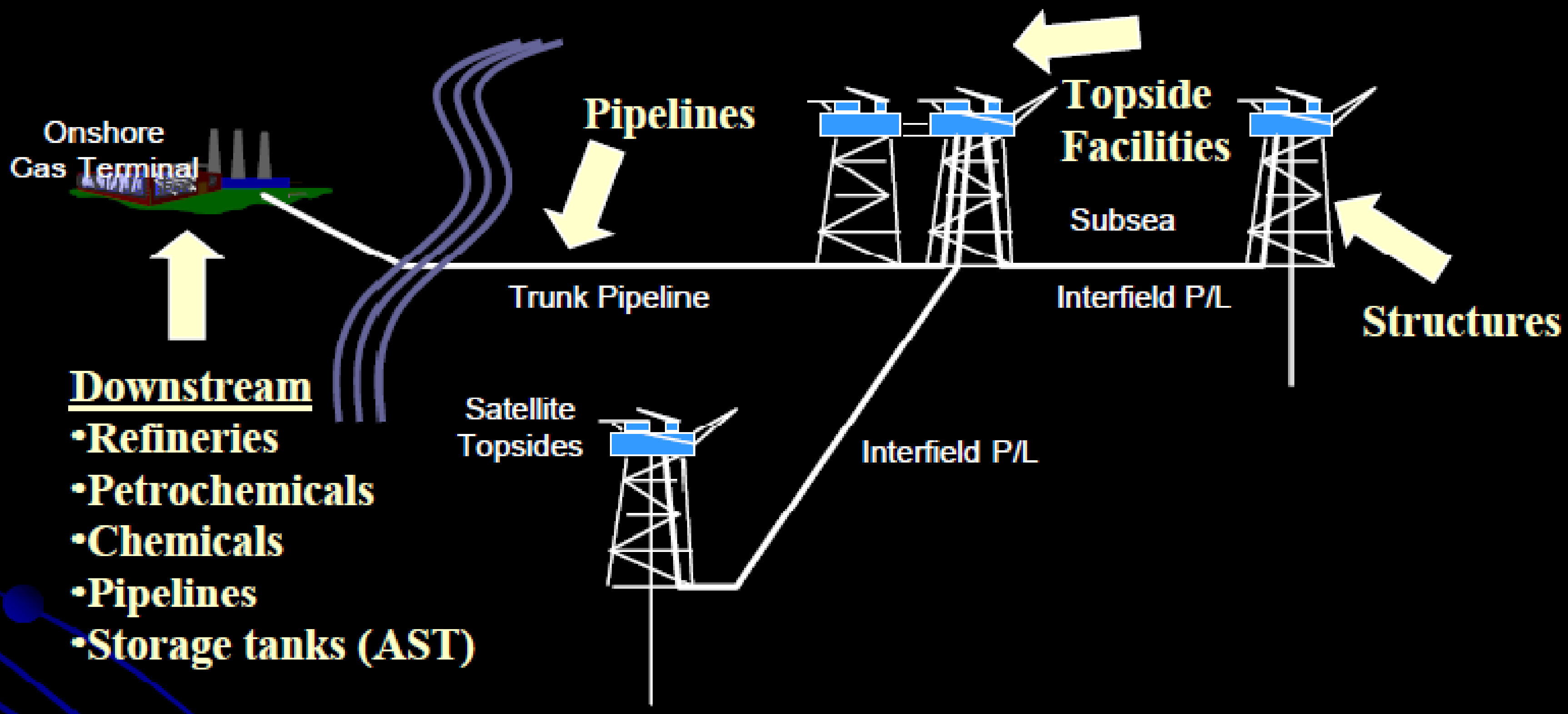
Factories and Machinery Act, 1967

- Section 56 (ga) conferred power for the Minister to make regulations

Enabling & Related Provisions

Related clauses:

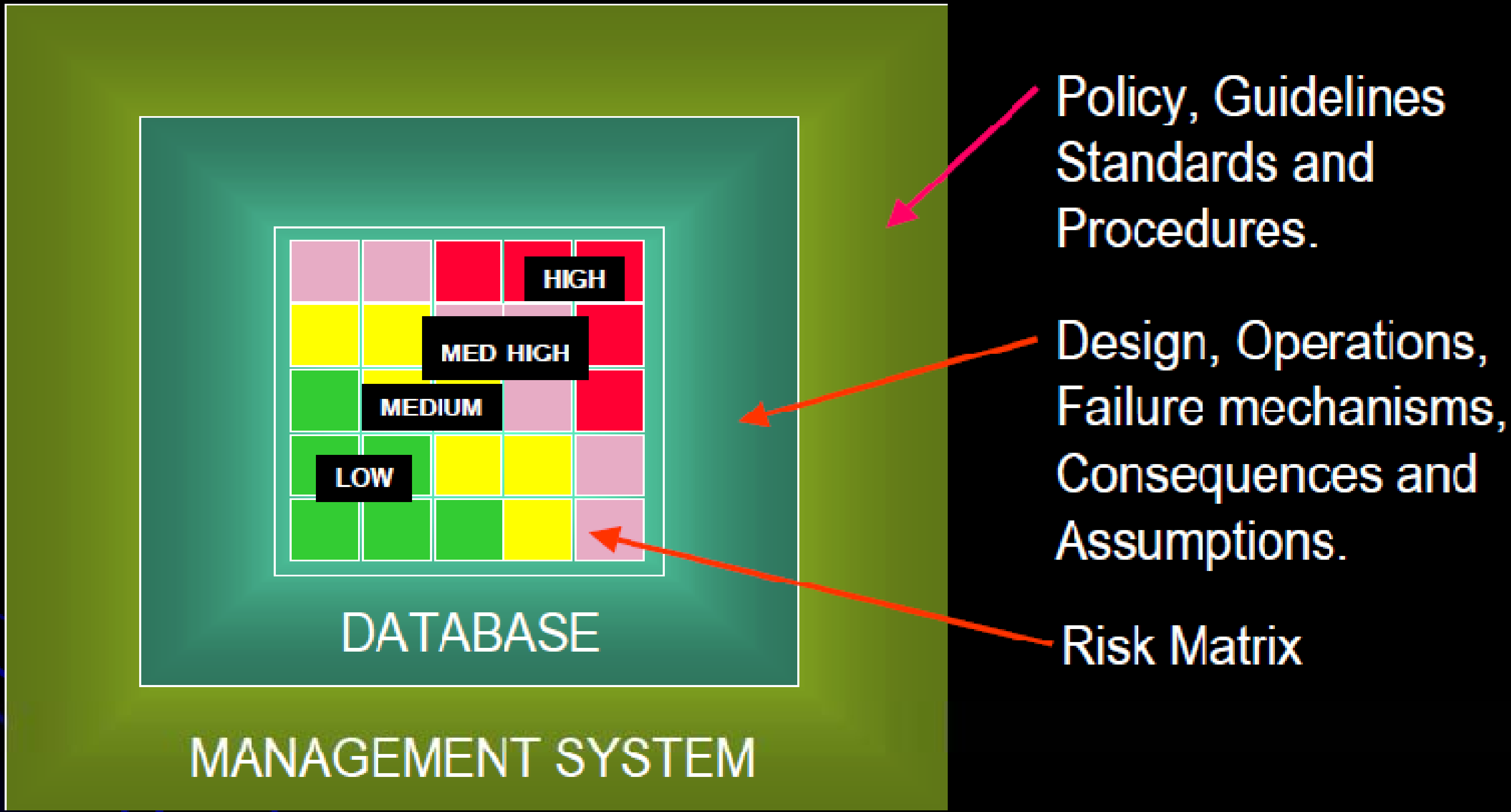
- Periodical inspection - Section 40 of the Factories and Machinery Act, 1967;
- 40 (1) "All machinery and factories shall be inspected by an inspector or other such person as may be approved in writing by the Minister, at *such periods and in such manner as may be prescribed"*
- 40 (5) "Any factory owner or occupier may apply to Chief Inspector for approval for a special scheme of inspection."



Downstream

- Refineries
- Petrochemicals
- Chemicals
- Pipelines
- Storage tanks (AST)

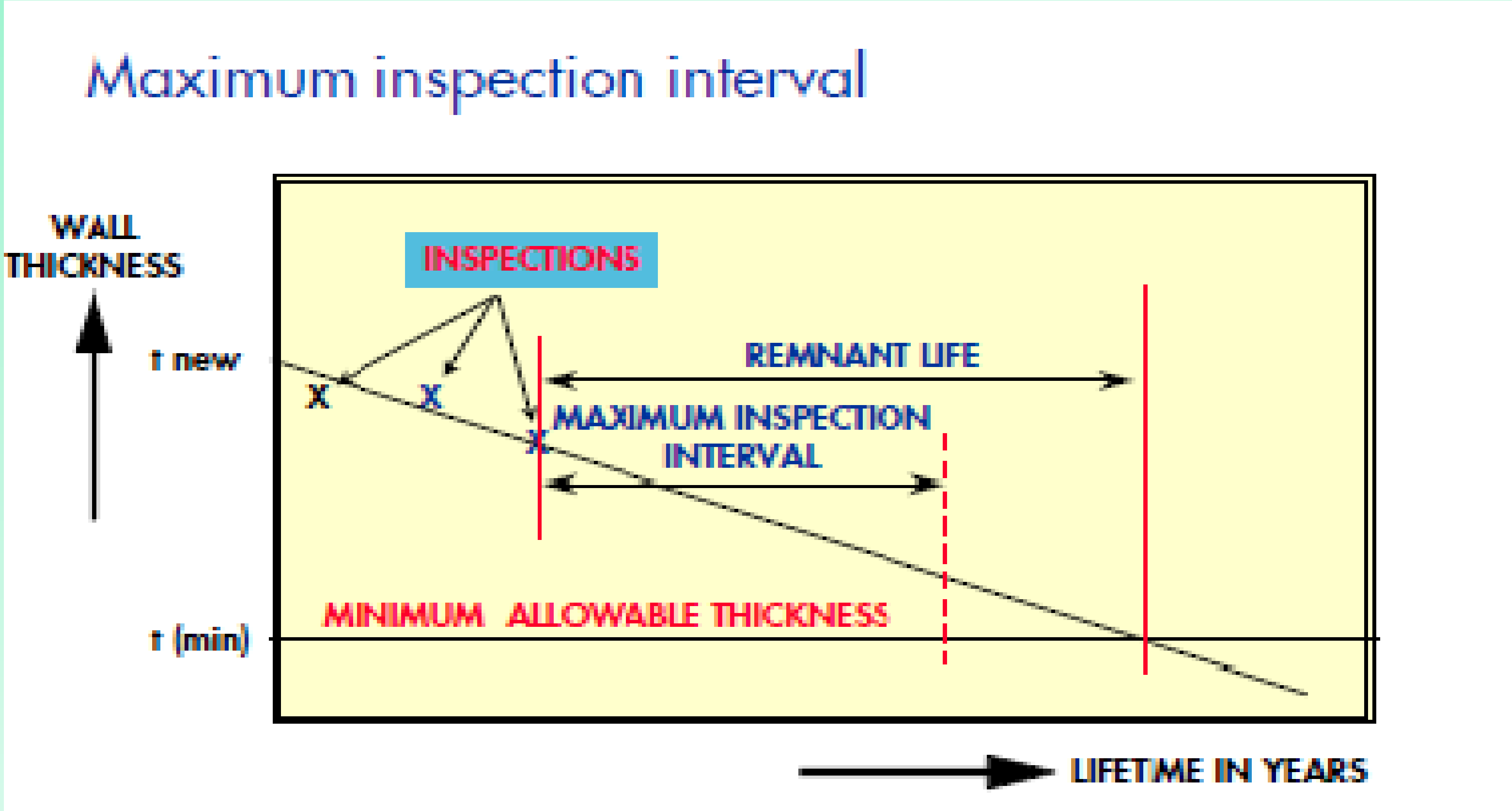
Main elements of RBI



Risk Based Inspection (RBI) – Basic Elements

- A fully integrated Risk Based Inspection system should contain the following steps
  - a)Plant database
  - b)Risk based prioritization
  - c)Inspection planning
  - d)Inspection results
  - e)Fitness for service
  - f)Inspection updating
  - g)System audit

Inspection Interval Based on RBI

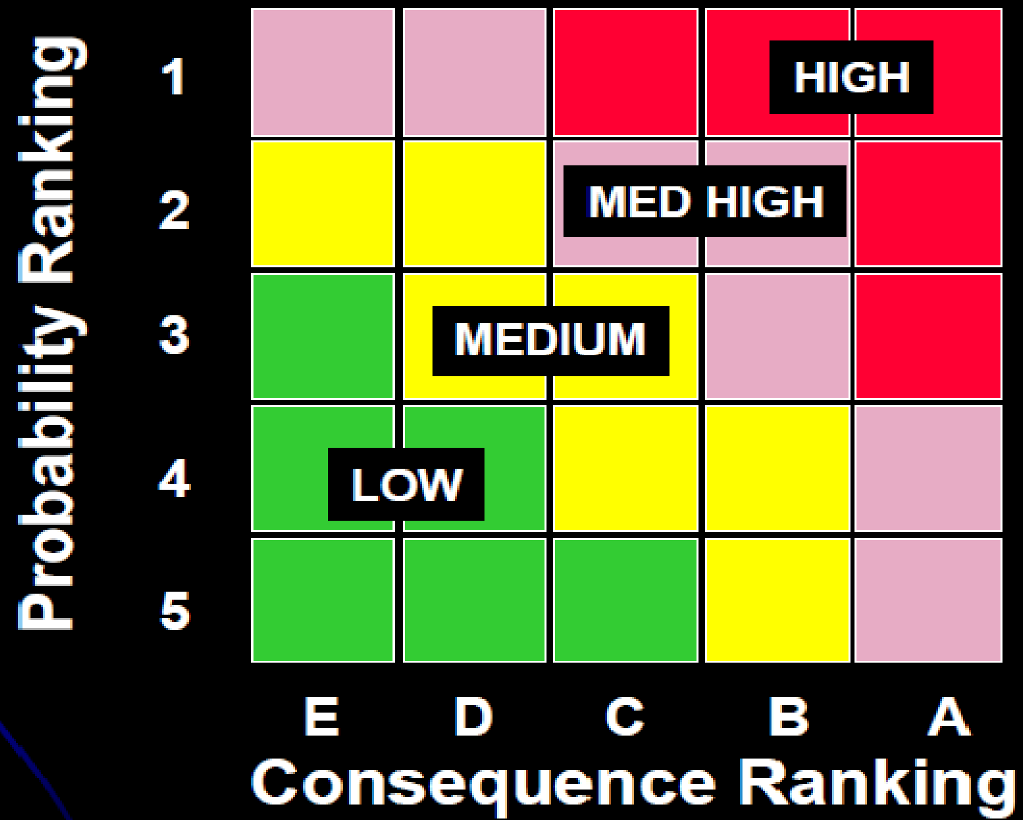


Qualitative and Quantitative Approaches

QUALITATIVE	QUANTITATIVE
• Ease of implementation	• Data intensive
• Less costly	• Sensitive to data quality
• Require suitable expertise	• Costly
• Difficult to audit results	• Able to audit
• Sensitive to expert view	• Carried out as part of large exercise

- Hence, a semi quantitative RBI is most commonly utilized.

Criticality Rating Matrix



Consequence
A-Catastrophic
B-Very Serious
C-Serious
D-Significant
E-Minor

Probability
1-Very High
2-High
3-Moderate
4-Low
5-Very Low

Required Data for Assessing Risk
Internal Corrosion

- Internal diameter
- Initial wall thickness
- Material
- Allowable stress
- Inspection number and confidence
- Date of last inspection
- Design pressure
- Design temperature
- Years in current service
- Corrosion type and rate

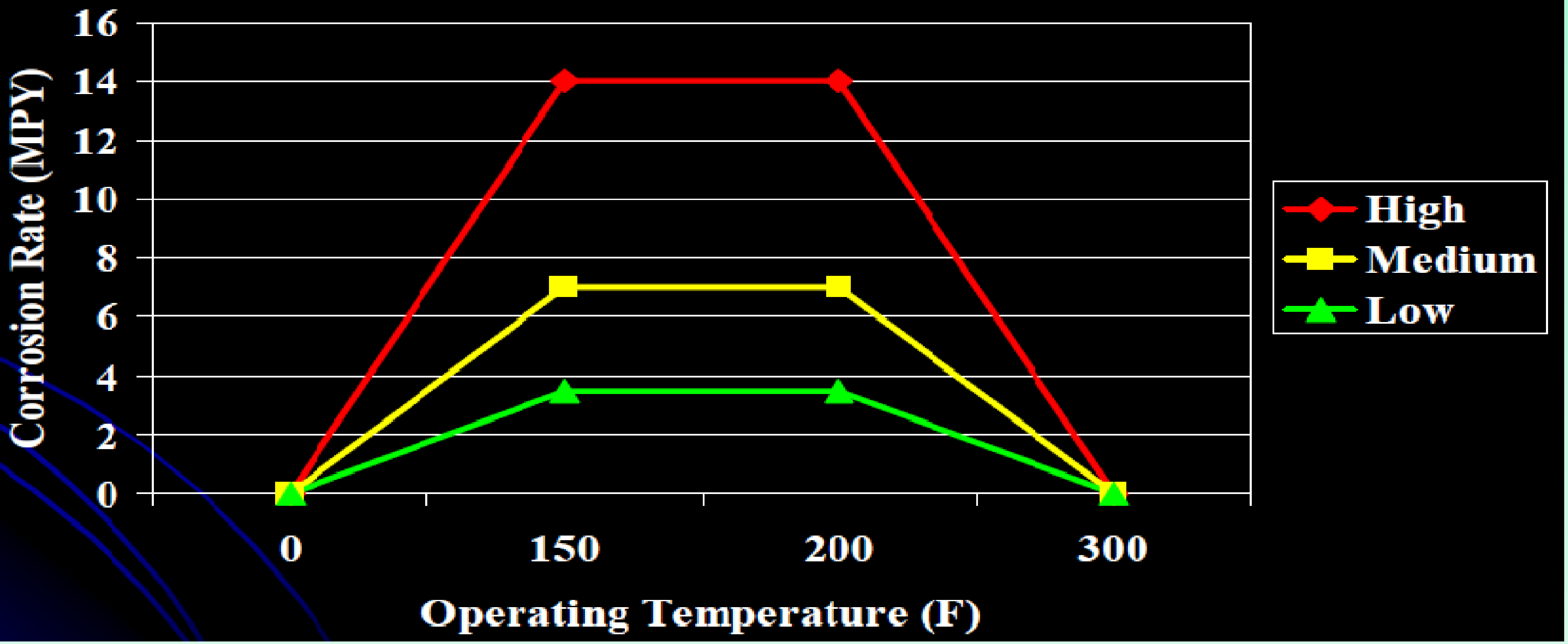
Criticality Rating for Fixed Equipment Internal Corrosion

- Estimate or evaluate the corrosion rate
- Identify number of years in the current service
- Calculate the wall loss and remaining wall
- Calculate the minimum wall thickness (Structural or pressure)
- Calculate the wall ratio (remaining wall / min wall)
- Select number and confidence of inspections
- Calculate fraction wall loss (wall loss/initial wall)
- Look up corrosion factor
- Calculate internal corrosion probability category
- Calculate inspection interval

Criticality Rating for Fixed Equipment External Corrosion

- Insulated? Area humidity? Paint?
- Calculate corrosion rate and adjust for humidity
- Calculate “external age”
- Calculate the wall loss and remaining wall
- Calculate the minimum wall thickness
- Calculate the wall ratio (remaining wall / min wall)
- Number / confidence of external inspections
- Calculate fraction wall loss (wall loss/initial wall)
- Calculate corrosion factor
- Calculate external corrosion probability category

External Corrosion CUI Corrosion Rate by Temperature and Humidity



Other Damage Mechanisms

- Brittle Fracture
- Carburization
- Creep
- Erosion
- Graphitization
- Hot Hydrogen Attack
- Hydrogen Embrittlement
- Liquid Metal Embrittlement
- Lining Failure
- Mechanical Fatigue
- Phase Change Embrittlement
- Thermal Fatigue
- Temper Embrittlement

Environmental Cracking Analysis

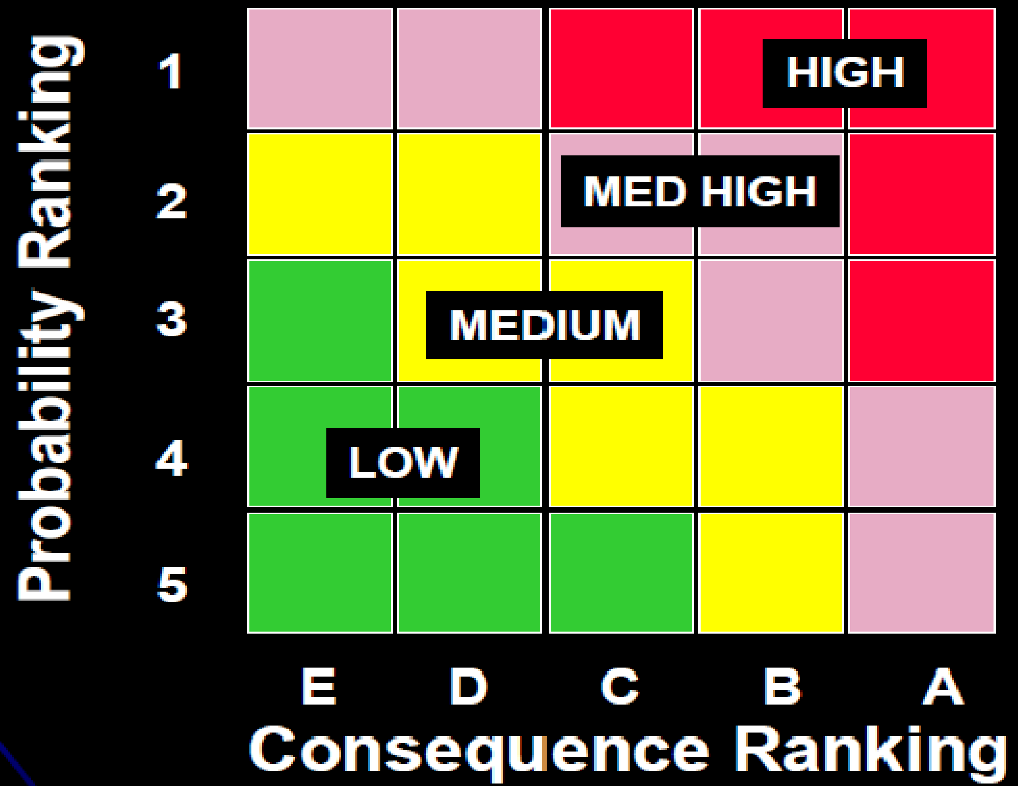
- Materials properties
  - PWHT?, HIC resistant?, Sensitized?, Stable Scale?
- Potential cracking agents
  - concentration, water present
- Initial potential for cracking damage
- Number and confidence of cracking inspections
- Damage at last inspection
- Combine Internal Corrosion / External Corrosion / Environmental Cracking / Other Mechanisms probability categories

Combined Probabilities

- Take the highest of all mechanisms
  - internal corrosion
  - external corrosion
  - cracking
  - others
- If two are the same
  - two or more 2s make a 1
  - two or more 3s make a 2
  - two or more 4 make a 4 (no change)
  - two or more 5s make a 5 (no change)

Criticality Rating Matrix

Probability
- 1-Very High
- 2-High
- 3-Moderate
- 4-Low
- 5-Very Low



Consequence
- A-Catastrophic
- B-Very Serious
- C-Serious
- D-Significant
- E-Minor

- Consequence Analysis
  - Safety
    - flammable
    - toxic
    - reactive
  - Environmental – cleanup costs
  - Production Loss – user input

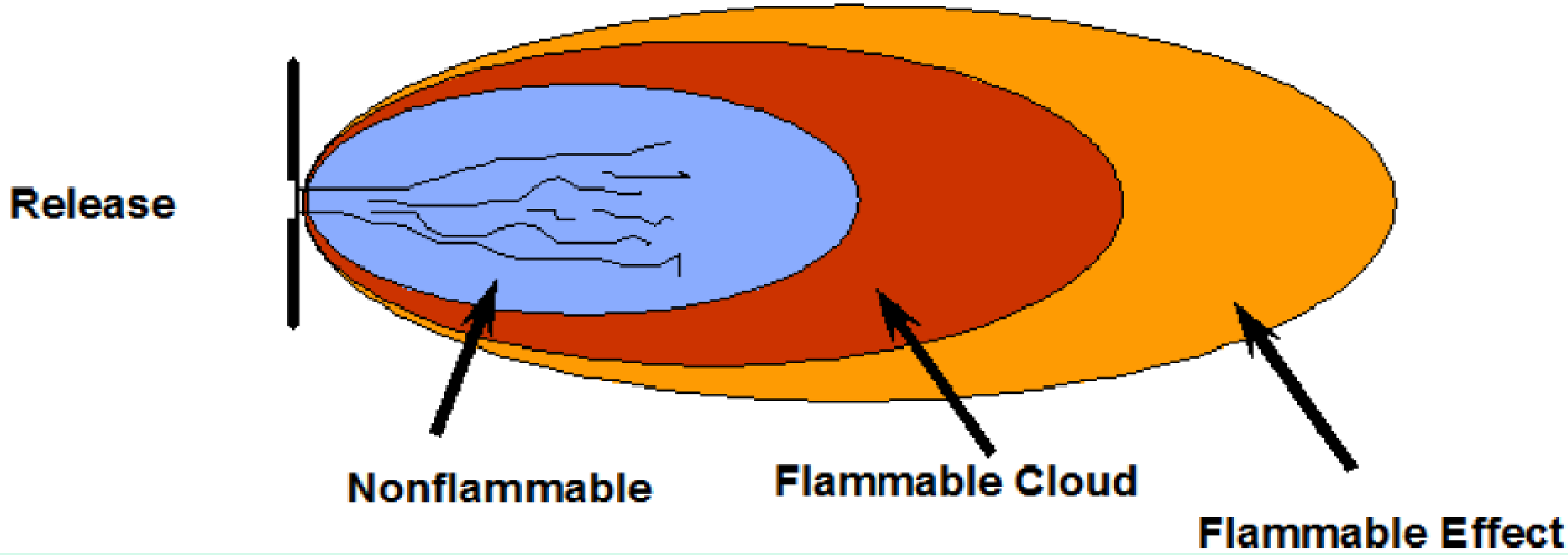
Required Data for Consequence Analysis

- **Fluid**
  - Rep. fluid, operating temperature, operating pressure
  - Initial state (gas or liquid)
  - Percent toxic
- **Available Inventory**
  - Default inventory for liquid = 40,000 lbs
  - Default inventory for gas = 10,000 lbs
  - Check inventories of large vessels
- **Mitigation**
  - Detection & Isolation time
  - Diked Area for liquids

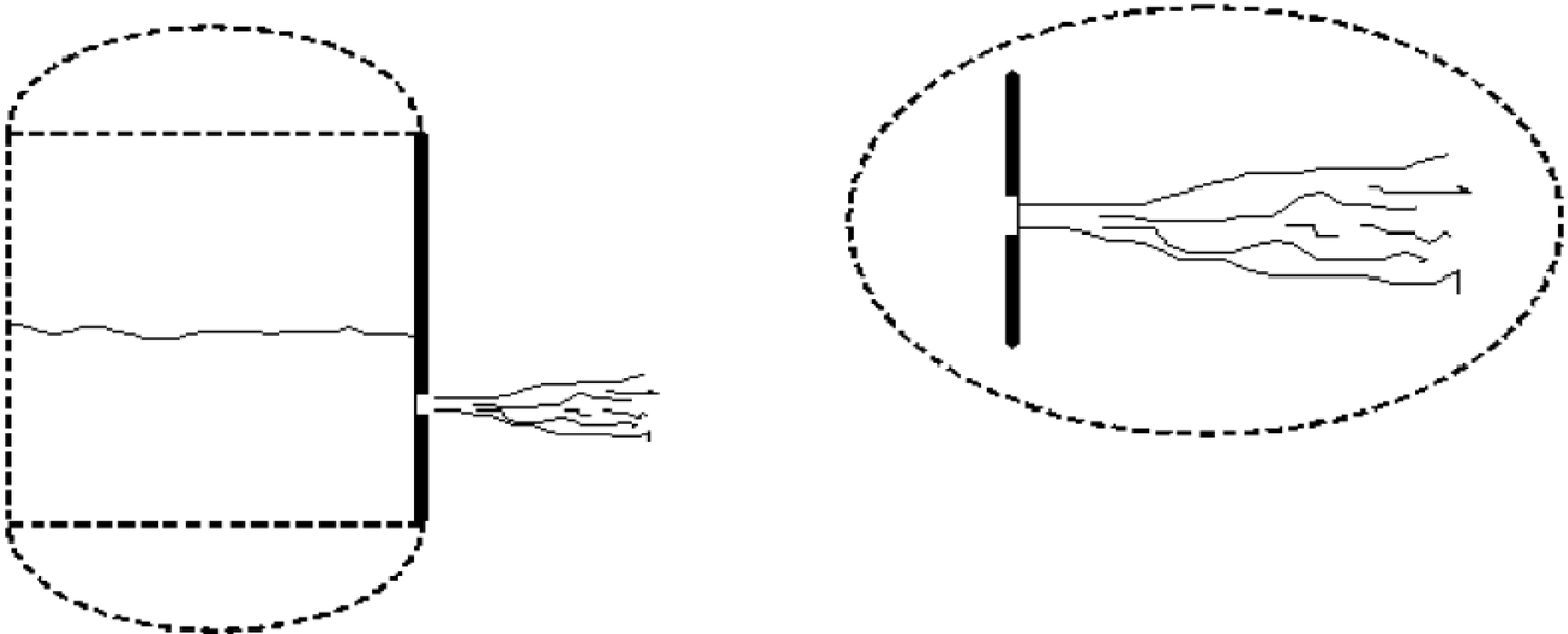
Consequence Analysis Overview

- Estimate available inventory
- Set representative fluid and initial phase
- Calculate leak rate
- Set leak duration
- Calculate leak quantity
- Set final fluid phase
- Apply flammable or toxic model
  - Liquids assumed to make pool size based on liquid depth of 1 cm.
- Calculate affected area

Criticality Rating for Fixed Equipment Flammable Cloud Model



Criticality Rating for Fixed Equipment
Leak Rate Model



Probability of Ignition

- The probability of ignition is a function of the representative fluid being considered for release and its operating temperature.

$$P_{IG} = P_{IGF} + \left[\left(\frac{T_{OP} - T_{FL}}{T_{AUTO} - T_{FL}} \right) * (1 - P_{IGF}) \right]$$

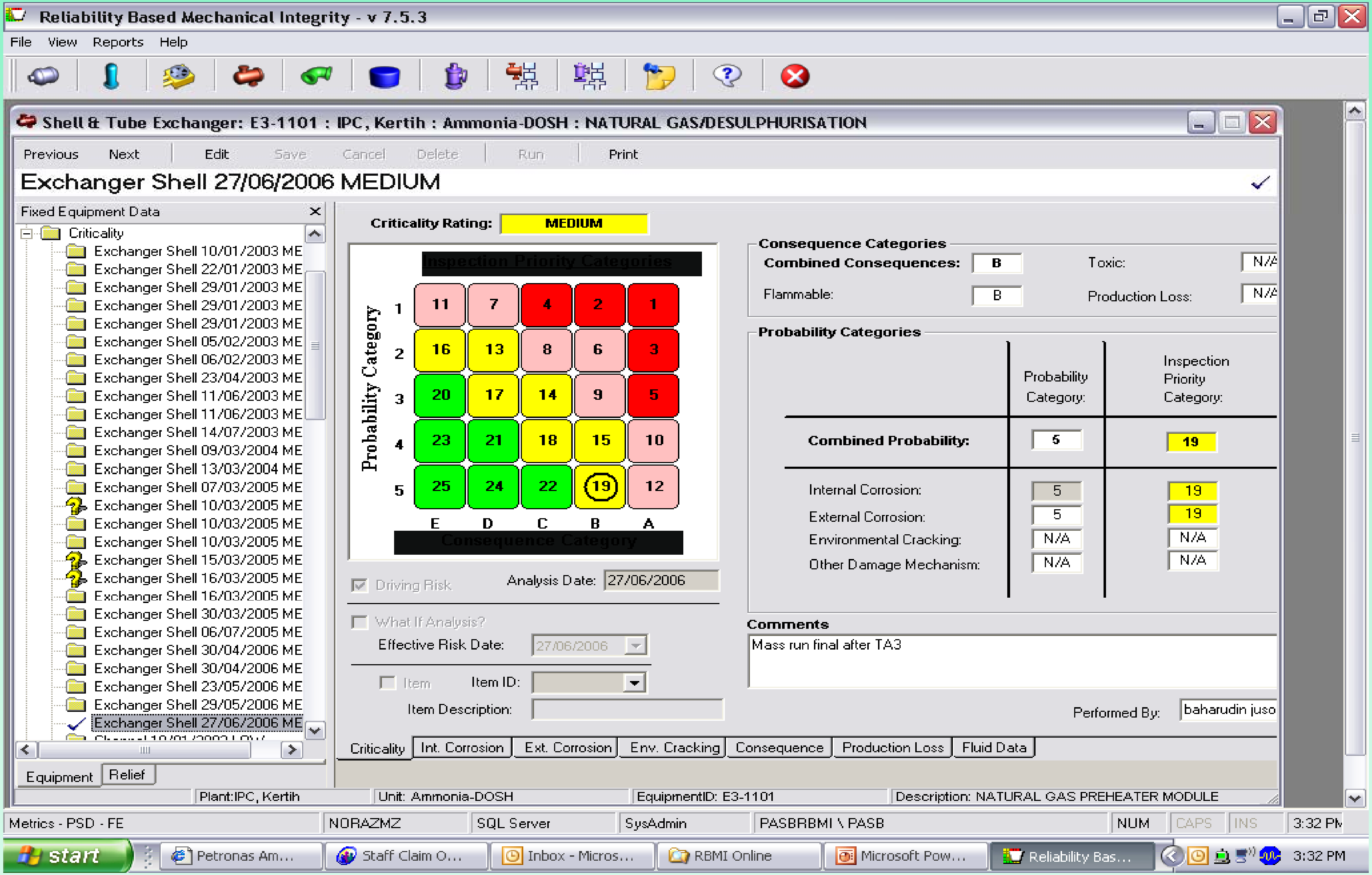
P_{IG} = Probability of Ignition
T_{OP} = Operating Temperature (ºF)
T_{FL} = Flash Point (ºF)
T_{AUTO} = Auto-ignition Temperature (ºF)
P_{IGF} = Probability of Ignition at the Flash Point Temperature (0.5 for C1 – C3)

Flammable Affected Area

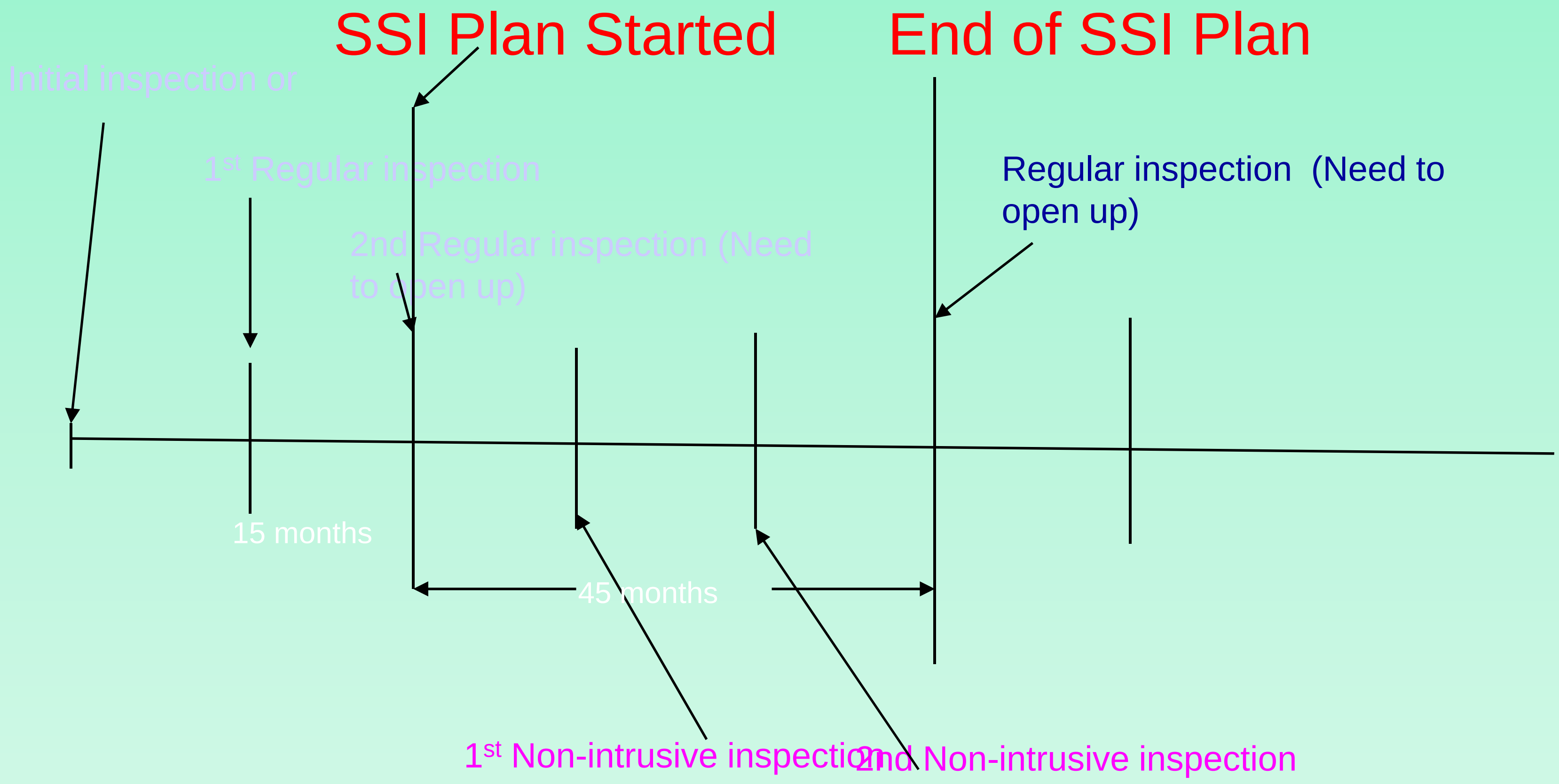
- The distance to the flammable endpoint is converted to a Flammable Affected Area using the following equation:

$$FAA = P_{IG} * \pi D^2$$

FAA is Flammable Affected Area (ft^2)
P_{IG} = Probability of Ignition
D = Distance to flammable endpoint (ft)


Reliability Based Mechanical Integrity - v 7.5.3
File View Reports Help
Shell & Tube Exchanger: E3-1101 : IPC, Kertih : Ammonia-DOSH : NATURAL GAS/DESULPHURISATION
Previous Next Edit Save Cancel Delete Run Print
Exchanger Shell 27/06/2006 MEDIUM
Fixed Equipment Data
Criticality
Exchanger Shell 10/01/2003 ME
Exchanger Shell 22/01/2003 ME
Exchanger Shell 29/01/2003 ME
Exchanger Shell 29/01/2003 ME
Exchanger Shell 29/01/2003 ME
Exchanger Shell 05/02/2003 ME
Exchanger Shell 06/02/2003 ME
Exchanger Shell 23/04/2003 ME
Exchanger Shell 11/06/2003 ME
Exchanger Shell 11/06/2003 ME
Exchanger Shell 14/07/2003 ME
Exchanger Shell 09/03/2004 ME
Exchanger Shell 13/03/2004 ME
Exchanger Shell 07/03/2005 ME
Exchanger Shell 10/03/2005 ME
Exchanger Shell 10/03/2005 ME
Exchanger Shell 10/03/2005 ME
Exchanger Shell 15/03/2005 ME
Exchanger Shell 16/03/2005 ME
Exchanger Shell 16/03/2005 ME
Exchanger Shell 30/03/2005 ME
Exchanger Shell 06/07/2005 ME
Exchanger Shell 30/04/2006 ME
Exchanger Shell 30/04/2006 ME
Exchanger Shell 23/05/2006 ME
Exchanger Shell 29/05/2006 ME
Exchanger Shell 27/06/2006 ME
Equipment Relief
Criticality Rating: MEDIUM
Inspection Priority Categories
Probability Category
1 11 7 4 2 1
2 16 13 8 6 3
3 20 17 14 9 5
4 23 21 18 15 10
5 25 24 22 19 12
E D C B A
Consequence Category
Driving Risk
Analysis Date: 27/06/2006
What If Analysis?
Effective Risk Date: 27/06/2006
Item Item ID:
Item Description:
Consequence Categories
Combined Consequences: B
Toxic: N/A
Flammable: B
Production Loss: N/A
Probability Categories
Probability Category:
Inspection Priority Category:
Combined Probability: 5 19
Internal Corrosion: 5 19
External Corrosion: 5 19
Environmental Cracking: N/A N/A
Other Damage Mechanism: N/A N/A
Comments
Mass run final after TA3
Performed By: baharudin juso
Criticality Int. Corrosion Ext. Corrosion Env. Cracking Consequence Production Loss Fluid Data
Plant:IPC, Kertih Unit: Ammonia-DOSH EquipmentID: E3-1101 Description: NATURAL GAS PREHEATER MODULE
Metrics - PSD - FE NORAZMZ SQL Server SysAdmin PASBRBMI \ PASB NUM CAPS INS 3:32 PM
start Petronas Am... Staff Claim O... Inbox - Micros... RBMI Online Microsoft Pow... Reliability Bas... 3:32 PM

Arrangement of a Non-Intrusive Inspection for Boiler/Fired PV

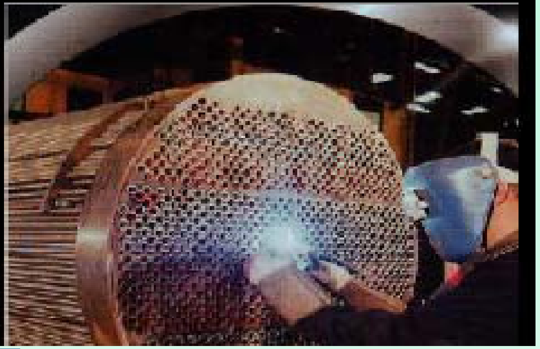


Benefits of RBI

- Benefits of an RBI to the plant/end users:
  - It provides the capability to define and measure risk, creating a powerful tool for managing many of the important elements of a process plant.
  - It allows management to review safety in an integrated, cost-effective manner.
  - It systematically reduces the likelihood of failures by making better use of the inspection resources.

AND

  - It improves the reliability of plant equipment.



Benefits of RBI

- The change to ‘non-intrusive’, ‘on-line’ methods of inspection instead of the traditional ‘off-line’ methods has resulted in shorter and possibly less frequent shutdowns, reducing direct inspection related costs and minimising lost production costs, with associated reduction in permanent inspection manning.
- A structured assessment utilising generic and historical data and sound engineering basis for the revision of the companies inspection philosophy, providing a fully auditable process reflecting regulatory compliance

THANK YOU