September 5th, 2023

Lecture Theater (3rd floor), House of Creativity, Katahira-Campus, Tohoku University

Lectures for Young Researchers and Engineers

Introduction to Risk–based Inspection

Advanced Mechanical Systems Maintenance Engineering

September 5th, 2023

Advanced Mechanical Systems Maintenance Engineering

(機械システム保全学特論)

Introduction

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Tohoku University

September 5th, 2023

Introduction to Risk–based Inspection

ELyTSchool 2023 , August 31st – September 9th

ELyTSchool

	September 5 (Tue.)	6 (Wed.)	7 (Thu.)
8:50 | 10:20	1. Introduction (1) T. Uchimoto N. Mary	6. Fundamentals of Electromagnetic Nondestructive Testing G. Sebald	11. Project Work
10:30 | 12:00	2. Introduction (2) G. Feuillard	7. Application of Nondestructive Testing T. Uchimoto	12. Application of ultrasounds to medicine and material characterization G. Feuillard
13:00 | 14:30	3. Degradation & Damage S. Dancette	8. Fundamental of ultrasonic waves G. Feuillard	13.Degradation& Damage Nicolas Mary
14:40 | 16:10	4. Degradation & Damage N. Mary	9. Generation and detection of ultrasonic waves: piezoelectric ultrasonic transducers G. Feuillard	13. Wrap-up Presentations by Students All lecturers
16:20 | 17:50	5. Project work	10. Project Work	

TFC-SSI

Doctoral Course Lecture

Introduction

1. What is Maintenance ?
2. Guideline of this course

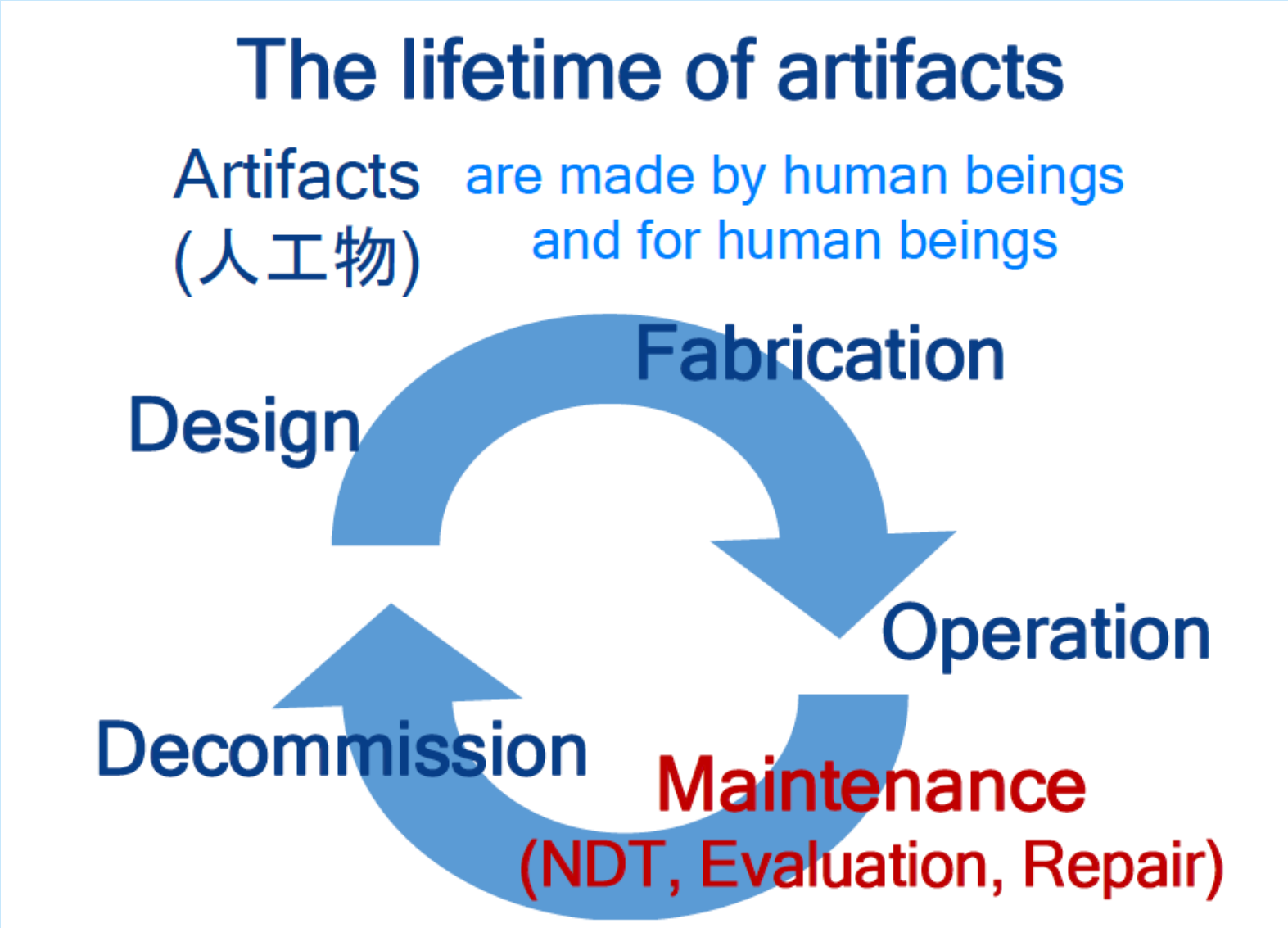
Motivation of Maintenance

High-speed train derailment accident in Germany (1998.6.3)

Mississippi River Bridge Collapse in US (2007.8.1)

Pipe breakage accident in Mihama power plant in Japan (2004.8.9)

When is the maintenance?



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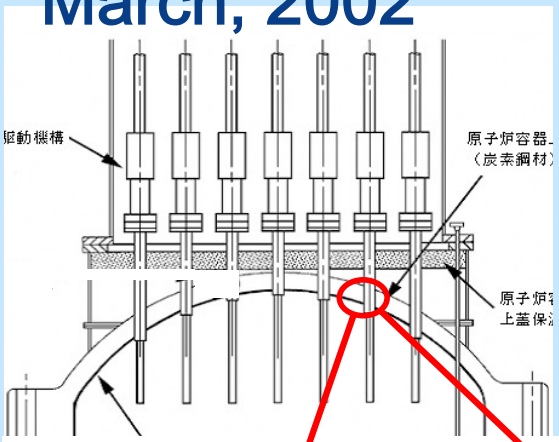
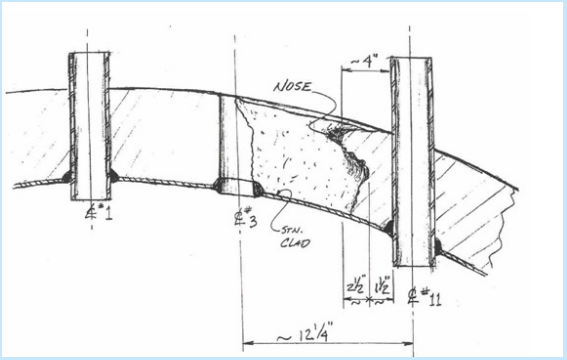
What is maintenance?

Why is maintenance needed?

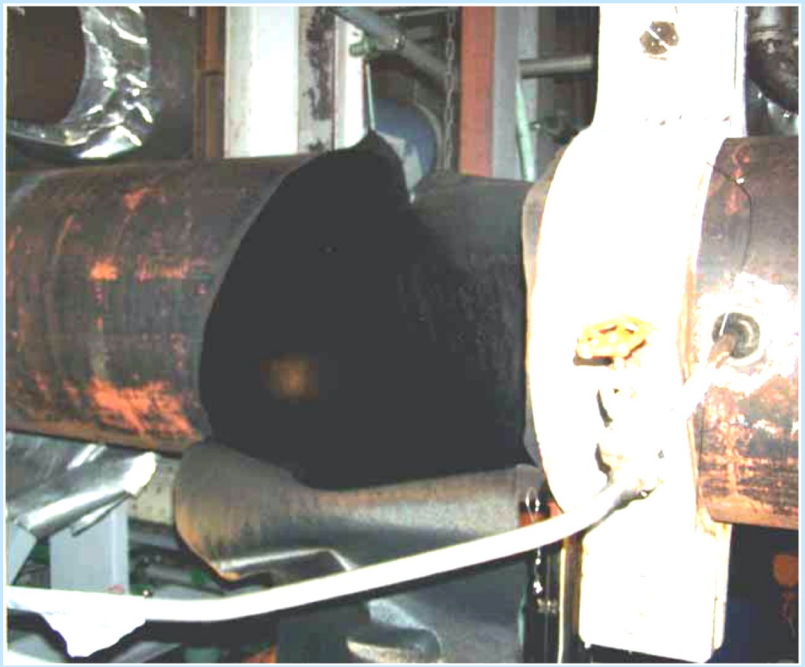
Significant degradation was found at the reactor vessel head of Davis-Besse NPP(US) in March, 2002





PWSCC at the J-weld induced this significant corrosion

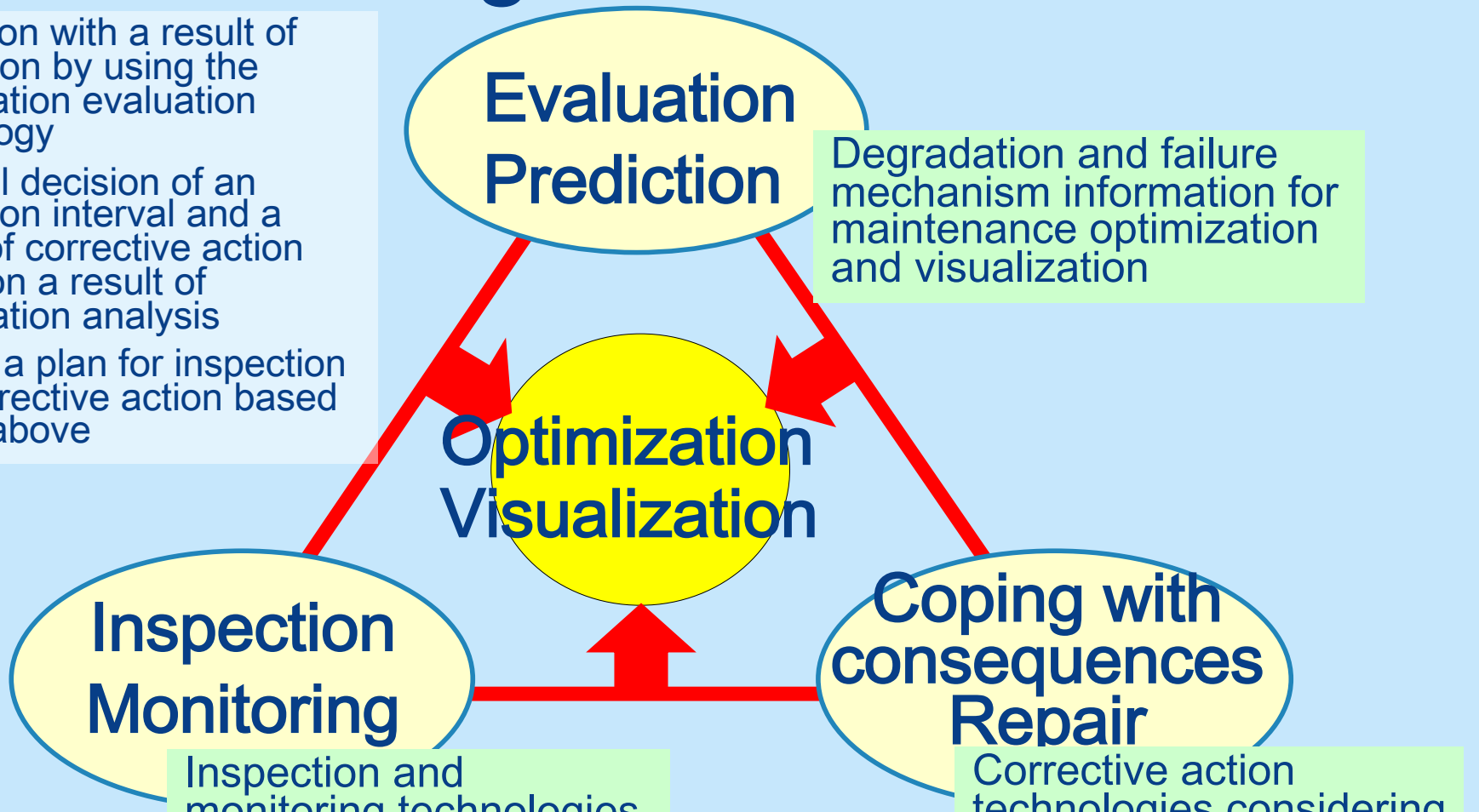
Pipe rapture occurred at the condensate system of Mihama 3 NPP (Japan) in August, 2004



Wall thinning phenomena induced this unstable fracture.

Optimization by Three Major Technologies of Maintenance

- ✓ Prediction with a result of inspection by using the degradation evaluation technology
- ✓ Rational decision of an inspection interval and a timing of corrective action based on a result of degradation analysis
- ✓ Making a plan for inspection and corrective action based on the above



Effectively making good use of the three technologies is required for maintenance optimization.

Lecture Plans

Tuesday, September 5, 2023

8:45 – 08:50 Opening remarks
Tetsuya Uchimoto (Tohoku University), Nicolas Mary (INSA Lyon)

08:50 – 09:30 Introduction of risk–based Inspection
Tetsuya Uchimoto (Tohoku University)

09:30 – 10:20
Nicolas Mary (INSA–Lyon)
Introduction of damage and degradation to be evaluated in maintenance

10:20 – 10:30 Break

10:30 – 12:00
Guy Feuillard (INSA Centre Val de Loire)
Introduction of ultrasonic characterization of materials: Principles and applications

12:00 – 13:00Lunch

Lecture Plans

Tuesday, September 5, 2023

13:00 – 14:30 Introduction to Fracture and Fatigue Behavior of Materials
Sylvain Dancette (ELyTMaX, Tohoku University / CNRS)

14:30 – 14:40 Break

14:40 – 16:10 The Study of Corrosion. Basic Knowledges
Nicolas Mary (INSA–Lyon)

16:10 – 16:20 Break

16:20 – 17:50Project Work 1 (Onsite participants only)

Lecture Plans

Wednesday, September 6, 2023

08:50 – 10:20 Fundamentals of Electromagnetic Nondestructive Testing
Gael Sebald (ELyTMaX, Tohoku University / CNRS)

10:20 – 10:30 Break

10:30 – 12:00 Application of Nondestructive Testing
Tetsuya Uchimoto (Tohoku University)

12:00 – 13:00 Lunch

13:00 – 14:30 Fundamental of ultrasonic waves
Guy Feuillard (INSA Centre Val de Loire)

14:30 – 14:40 Break

14:40 – 16:10 Generation and detection of ultrasonic waves: piezoelectric ultrasonic transducers
Guy Feuillard (INSA Centre Val de Loire)

16:10 – 16:20 Break

16:20 – 17:50 Project Work 2 (Onsite participants only)

Lecture Plans

Thursday, September 7, 2023

08:50 – 10:20 Project Work 3 (Onsite participants only)

10:20 – 10:30 Break

10:30 – 12:00 Application of ultrasounds to medicine and material characterization
Guy Feuillard (INSA Centre Val de Loire)

12:00 – 13:00 Lunch

13:00 – 14:30 Material Degradation. Mitigation Strategies
Nicolas Mary (INSA–Lyon)

14:30 – 14:40 Break

14:40 – 16:10 All Lecturers
Wrap–up and presentations by onsite participants

16:10 – 16:15Closing remarks
Tetsuya Uchimoto (Tohoku University), Nicolas Mary (INSA Lyon)

Risk Based Maintenance

安全とは何か

What is safety ?

安全とは (Safety)

safety (Concise Oxford Dictionary, 9th edition)

1 The condition of being safe; freedom from danger or risk.

2 Designating any of various devices for preventing injury from machinery. Designating items of protective clothing.

Safety (ISO/IEC Guide 51)

freedom from risk which is not tolerable

Guidelines for their inclusion in **standards**.

安全とは (Safety)

Safety (ISO/IEC Guide 51*)

freedom from risk which is not tolerable

Reliability

Degree to which a system, product or component performs specified functions under specified conditions for a specified period of time.

* Guidelines for the inclusion of safety concept in **standards**.

ハザード (Hazard) とリスク(Risk)

Hazard： Potential source of harm (危害）

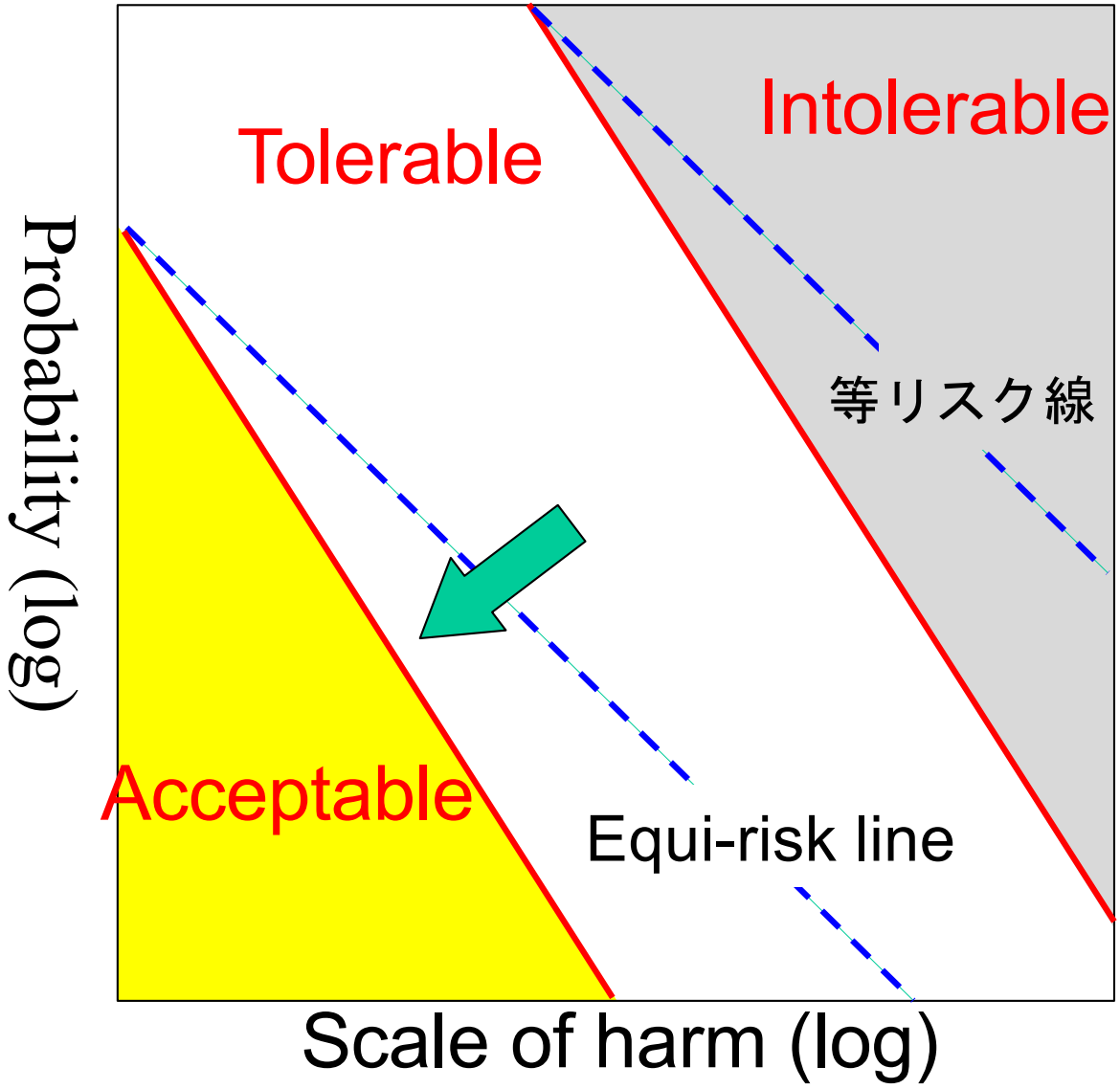
fire, heat, water(flood), pressure, animals, electricity, etc.

Risk is decided by the balance between hazard and protection.

リスクとは (Risk)

Risk is the combination of the probability of an event and its consequence

(危害の発生確率及びその危害の程度の組合せ) (ISO/IEC Guide 51 ）



Risk-based Maintenance

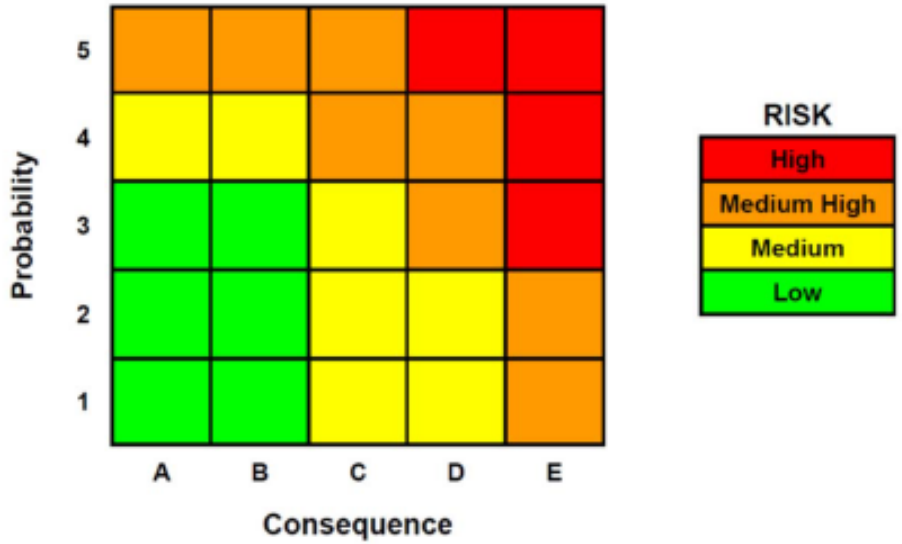
Risk Based Maintenance in CPI

i. Definition of risk

ii. Trend of RBM and remaining problems for applying RBM

iii. Cases of Risk Based Inspection

Risk=Consequence of Failure x Likelihood of Failure



Related Technical Standards

- American Petroleum Institute (API)
  - API 580, Risk Based Inspection, Recommended Practice, First Edition(2002)
  - API 581, Risk-Based Inspection Methodology, Recommended Practice, Third Edition (2016)
  - API 571, Damage Mechanisms Affecting Fixed Equipment in the Refining Industry, Recommended Practice, First Edition (2003)

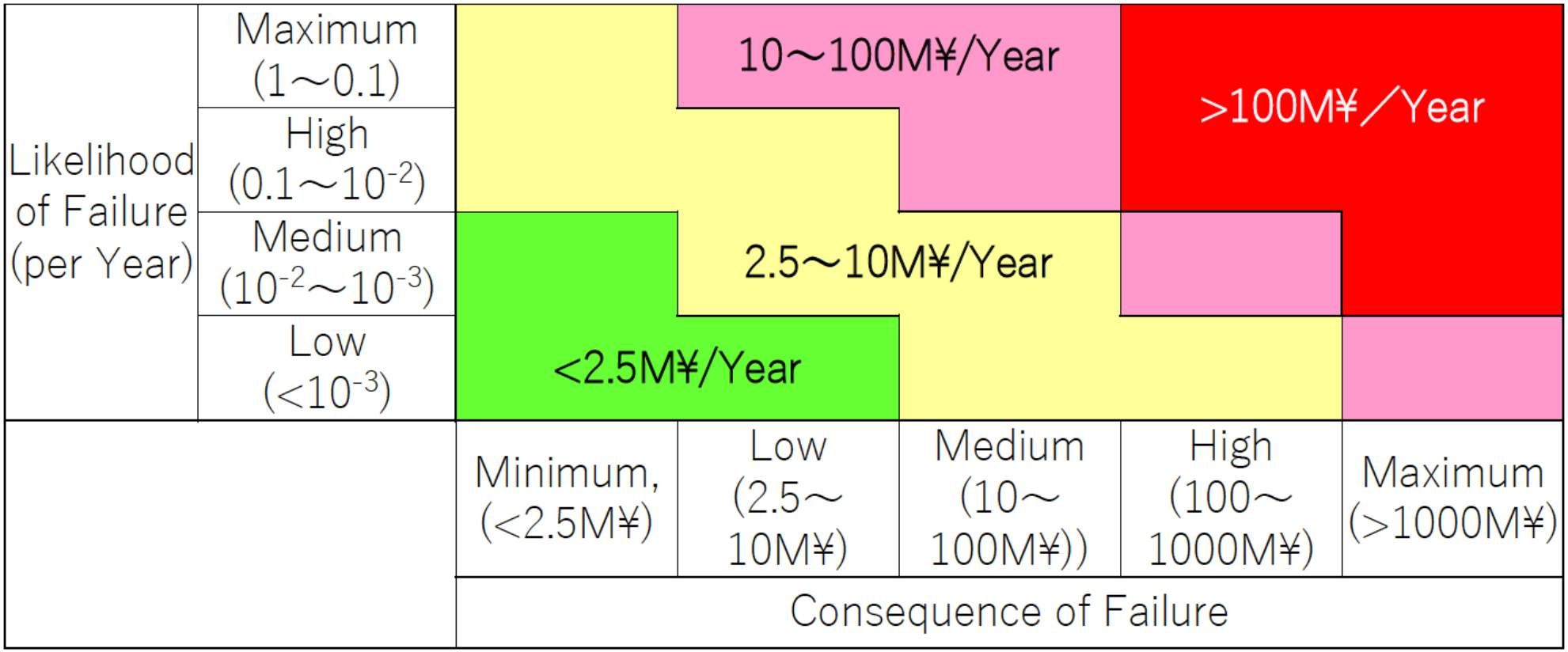
Example of rank of Consequence of Failure

Level (point)	Safety/ Human Health	Fire or Explosion (direct cost)	Potential Chemical Impact	Environment Impact	Community
1 (27)	Some fatalities	More than 1000M¥	Some fatalities	More than 250M¥	National media coverage
2 (9)	One fatality	100~1000M¥	One fatality at off-site	100～250M¥	
3 (3)	Time off from work	10~100M¥	Emission at on-site	Less than 250M¥	Local media coverage
4 (1)	Emergency response	2.5～10M¥	Emission within the limit	Short range measurement	No coverage
5 (0.3)	Less than level 4	Less than 2.5M¥	Less than level 4	Less than level 4	

Rank of Likelihood of Failure

	Maximum	Large	Medium	Small
Probability (per Year)	$> 10^{-1}$	$10^{-1} \sim 10^{-2}$	$10^{-2} \sim 10^{-4}$	$< 10^{-4}$
MTBF or Remaining life	< 2 Years	2～10 Years	10～50 Years	> 50 Years
Qualitative	Very high possible	High possible	Medium possible	Low possible

Quantitative Image of Risk



Risk Countermeasures
(risk avoidance, reduction, transfer, and retention)