MANAGING RISK DNV

Risk Based Inspection for Offshore Facilities (RBI)

海上设施的基于风险的检验(RBI)

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Module 1

Topics of Presentation

- Introduction - why RBI？ 为什么需要 RBI?
- What is RBI? 什么是RBI?
- Principles of RBI RBI的主要理论
- RBI Benefit RBI的作用

Introduction - why RBI？
介绍 - 为什么需要 RBI?

Module

1

Trends – Enablers for Change 趋势—促使改变

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- Ageing offshore installations/ pipelines, or drive to extend life-time
- 海上设施/管线的老化,或延长使用寿命
- **Time-dependent degradation mechanisms** have become more important
- 与时间有关的退化机理已经越来越显现
  - Corrosion 腐蚀
  - Erosion 冲蚀
  - Fatigue 疲劳
- Limited budgets to spend on maintenance and inspection – need to prioritise
- 用于维护和检验的预算有限—需要优化
- Operation Condition Changes compared with the Design Condition
- 实际操作条件件发生了变化，已与设计状态有了很大的不同

Pitting corrosion in stainless steel 不锈钢点腐蚀

CO_2 corrosion in flowline
流体管道中的CO2腐蚀

How Important is Mechanical Failure
机械失效的严重性

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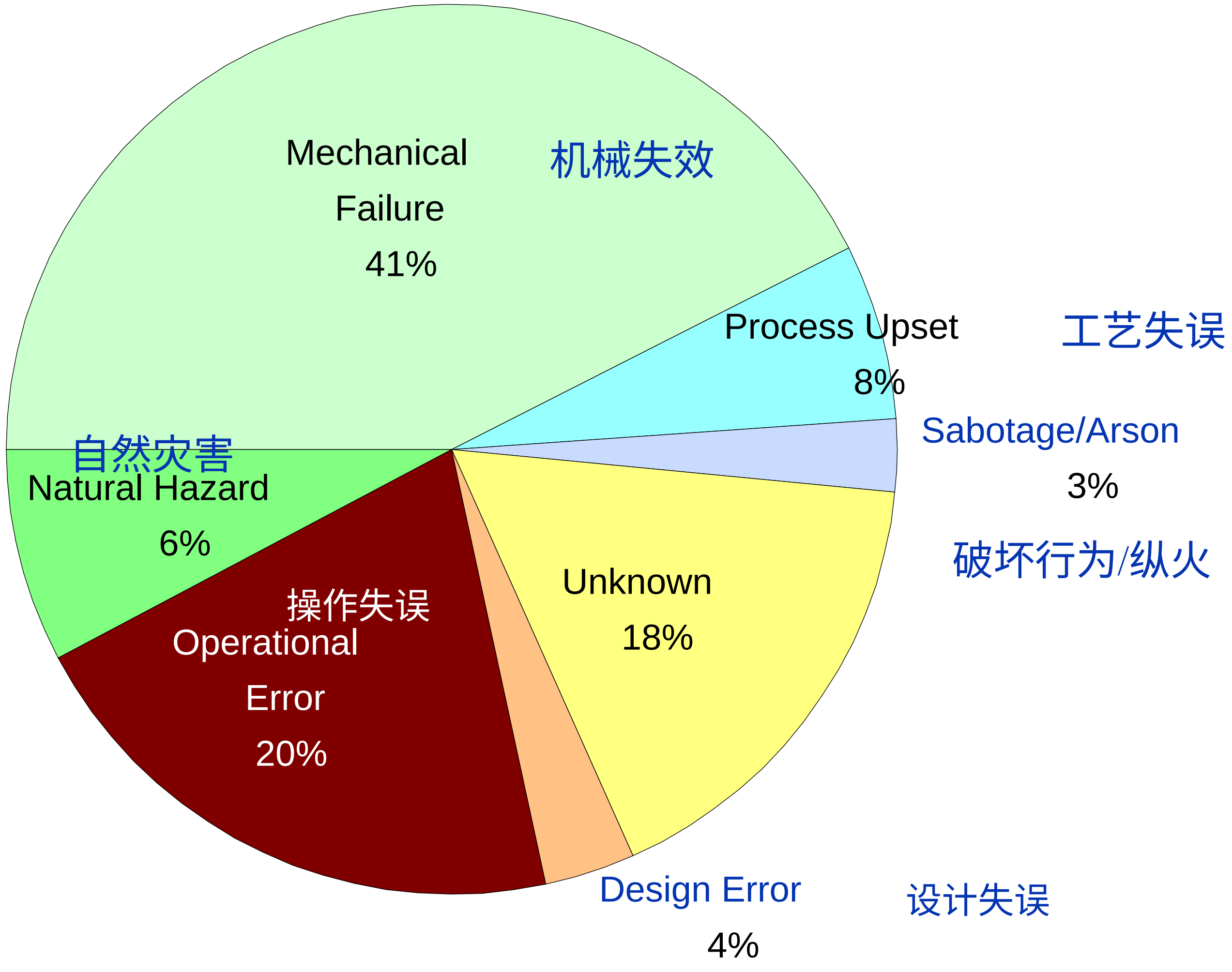
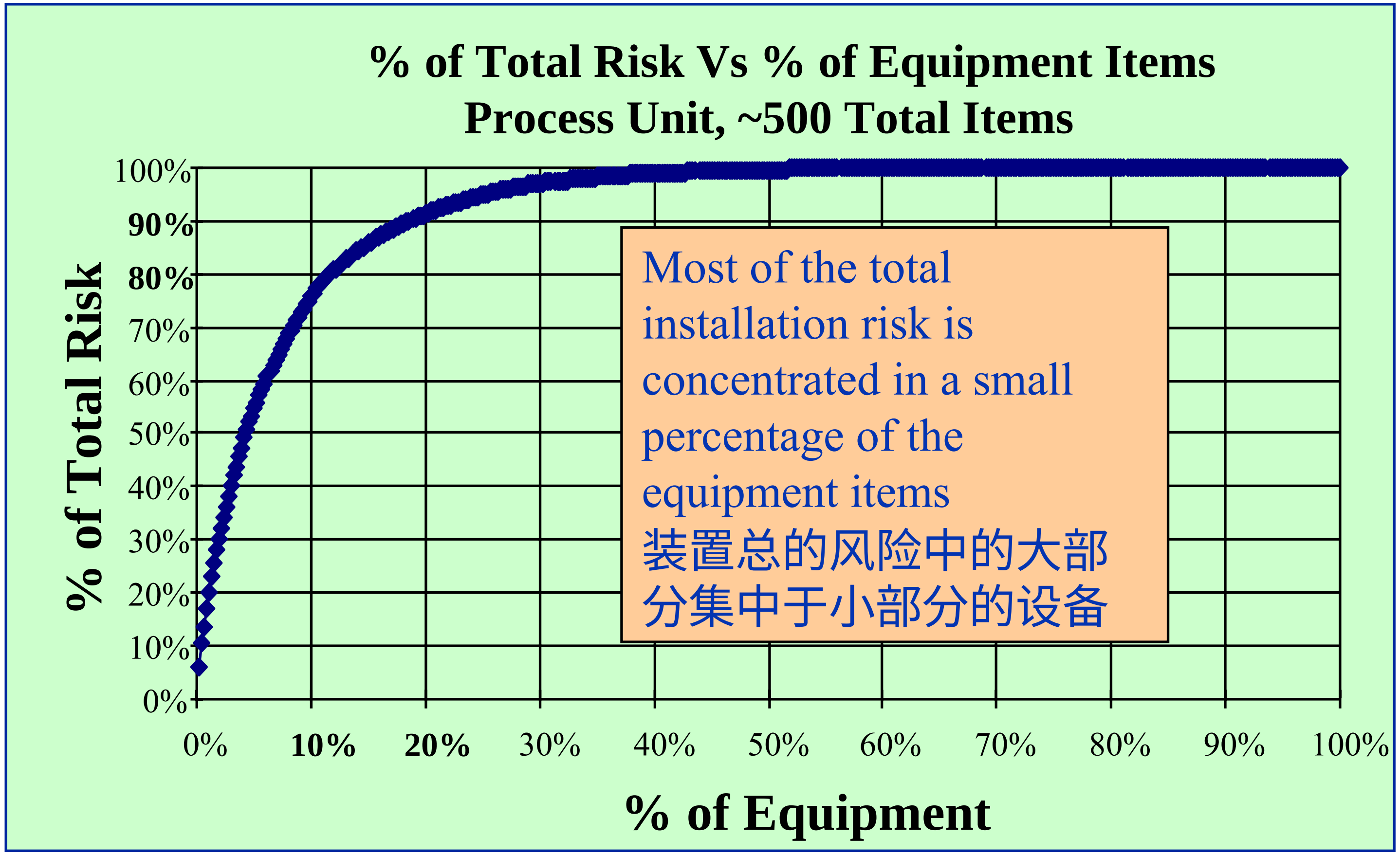
~ Half of losses are related to loss of mechanical integrity - can be influenced by inspection/ maintenance management

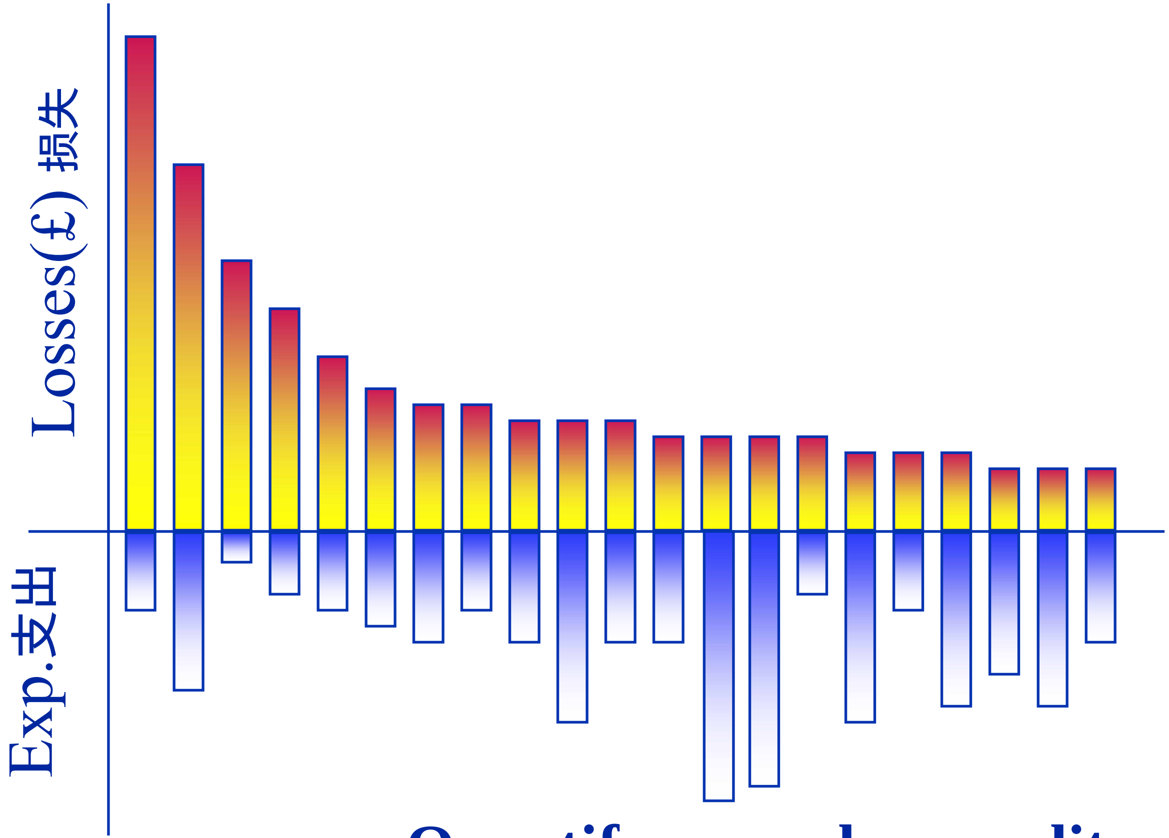
一半的损失与机械完整性损失有关—可以通过检验/维护管理改变



Risk Ranking of Equipment
设备的风险排序



Reviewing Risk Control
评估及控制风险



- Inspection
- Maintenance

Quantify annual expenditure to avoid losses

量化每年的支出以避免损失！

Reduce Risk Exposure
降低所承受的风险

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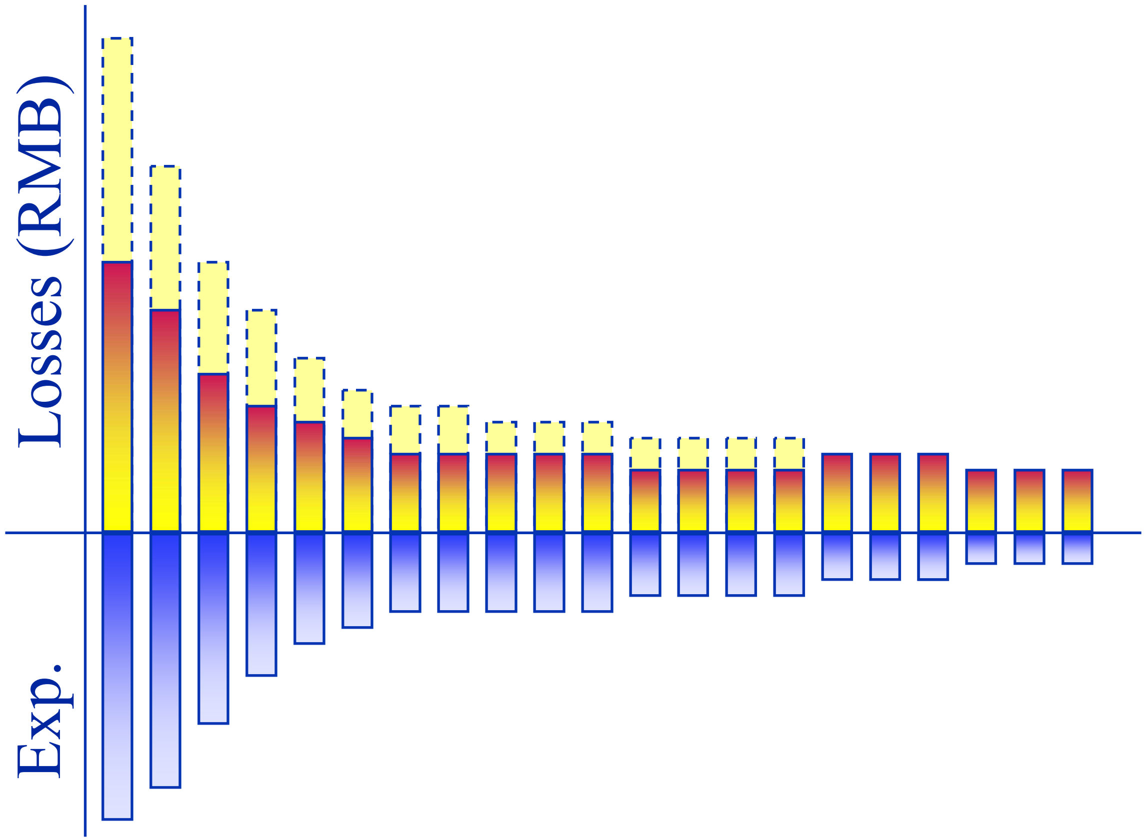

Optimize expenditure to reduce losses

充分運用支出以減少損失！

What is RBI ?
什么是RBI ？

Module 1

Risk Based Inspection (RBI)

- RBI is a risk-based methodology, scientific and systematic...

  RBI 是一种科学地、系统地基于风险的评价方法…
- to identify degradation mechanisms in equipment/piping …

  通过确认设备/管线的损伤机理…
- and the consequences upon the failure…

  和失效所造成的后果…
- which together will give a risk...

  进而计算出其风险大小…
- that can be effectively managed & reduced through material selection, corrosion management & preventative inspection/monitoring

  通过有针对性地选材、腐蚀管理、预防性检验/维护监控及工艺监控来有效地管理风险和降低风险

Risk Based Inspection (RBI)
基于风险检验的概念

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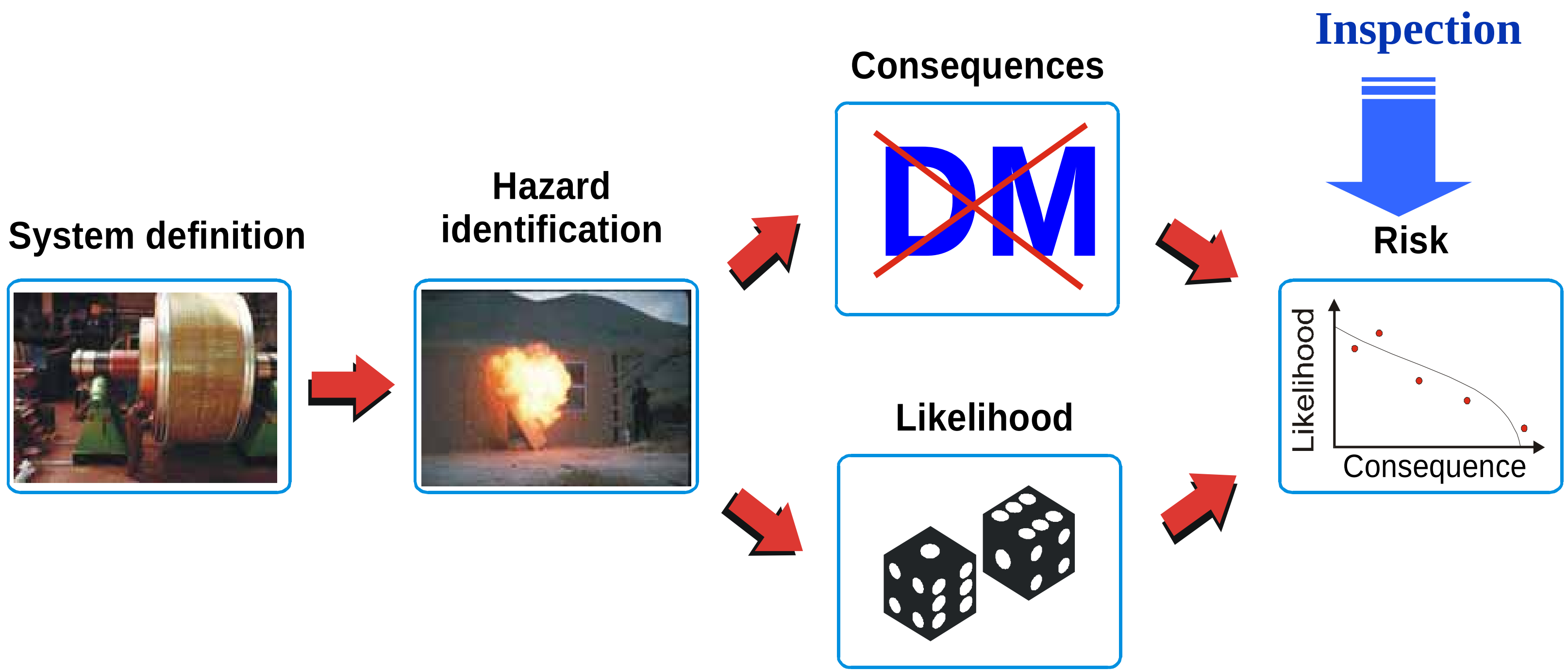

Risk = Likelihood of Failure × Consequence of Failure
= PoF × CoF

风险=失效可能性 × 失效后果

RBI Offshore Background
海上RBI的发展背景

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- RBI practices for refinery industry and other onshore plant developed during last decade (API 580 & 581)

  近10年开发了应用于炼油工业和其他陆上工厂的RBI方法(API 580 & 581)
  - DNV heavily involved in this development
  - DNV为此开发的主要参与者
- Identified need for similar practices offshore

  识别海上相似的需要
- Desire to establish industry “best practice”: 希望建立行业“最佳方法”
  - DNV collaborate with industry in a Joint Industry Project
    DNV与同行业合作设立“联合行业项目”
- Sponsors:赞助商:
  - BP/Amoco, Hydro, Phillips, Saga, Statoil, DNV
- Norwegian Petroleum Directorate: 挪威石油理事会:
  - Endorses DNV RBI in codes 规范认可DNV RBI

RECOMMENDED PRACTICE
DNV-RP-G101

RISK BASED INSPECTION OF OFFSHORE TOPSIDES STATIC MECHANICAL EQUIPMENT

JANUARY 2002

上部模块静设备RBI方法

DET NORSKE VERITAS

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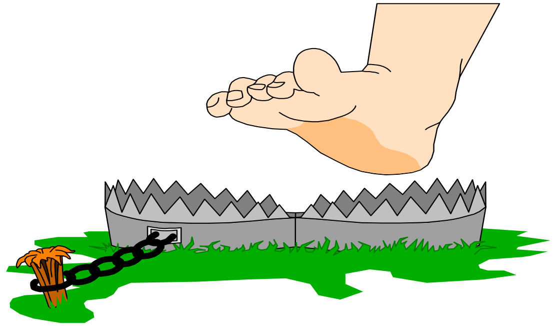
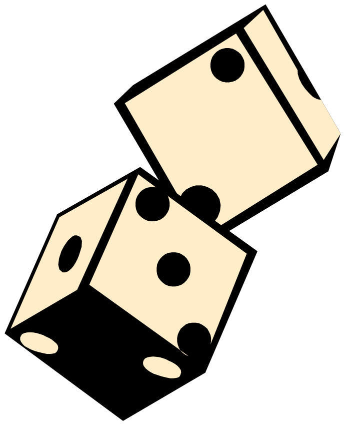
Principles of RBI
RBI的原理

Module
1

Definition of Risk
风险的定义



Risk = Probability of failure X Consequence of failure
风险 =失效概率 X 失效后果



Calculation of Probability of Failure
失效概率的计算

Degradation Mechanism 损伤机理 → **Damage (+ Model) 破坏(模型)** + **Loads *v.* Strength 载荷 强度** → **Failure Mode 失效模式** → **Limit States 极限状态** → **PoF**

Degradation Mechanism 损伤机理
- Corrosion 腐蚀
- Fatigue
- 疲劳
- Erosion
- 冲蚀
- …..

Damage (+ Model) 破坏(模型)
- Pitting
- 点蚀
- Cracks
- 裂纹
- Wall loss
- 壁厚减薄
- …..

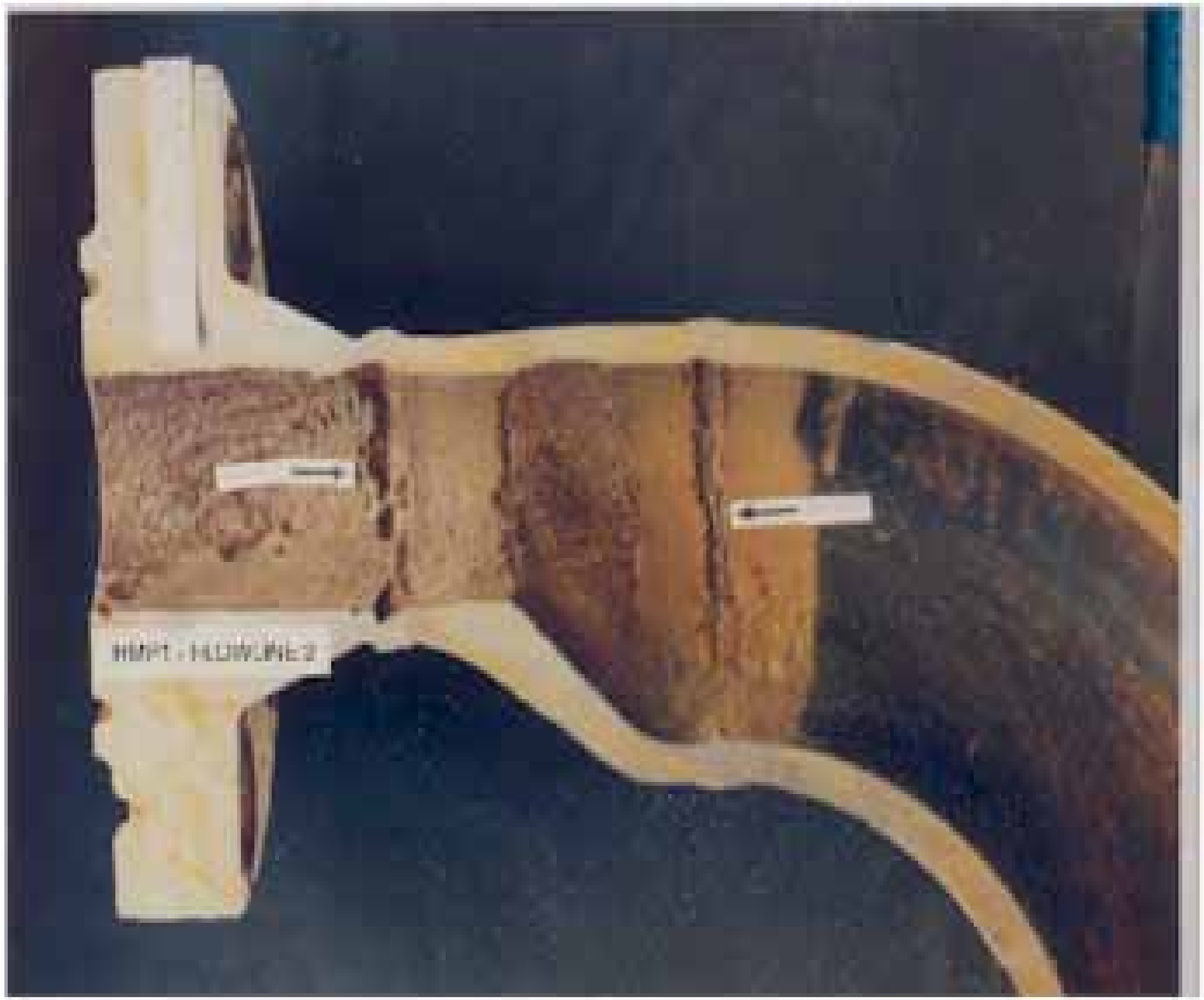
Loads *v.* Strength 载荷 强度
- Geometry形状
- Material type 材料种类
- Stress intensity 应力集中
- Remaining wall 剩余壁厚

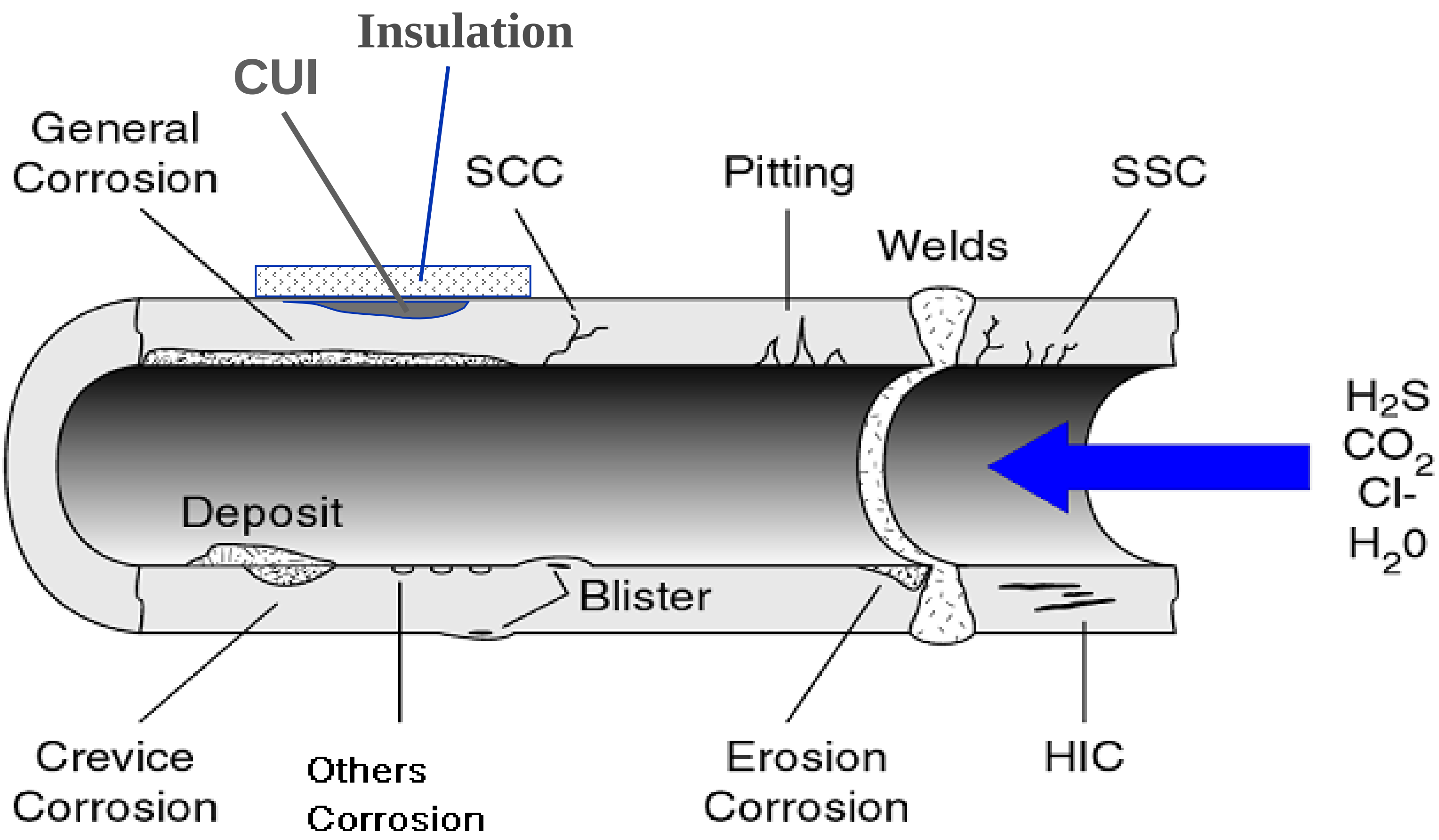
Failure Mode 失效模式
- Pinhole leak 小孔泄漏
- Brittle fracture 脆性断裂
- Burst爆炸
- …..

Limit States 极限状态

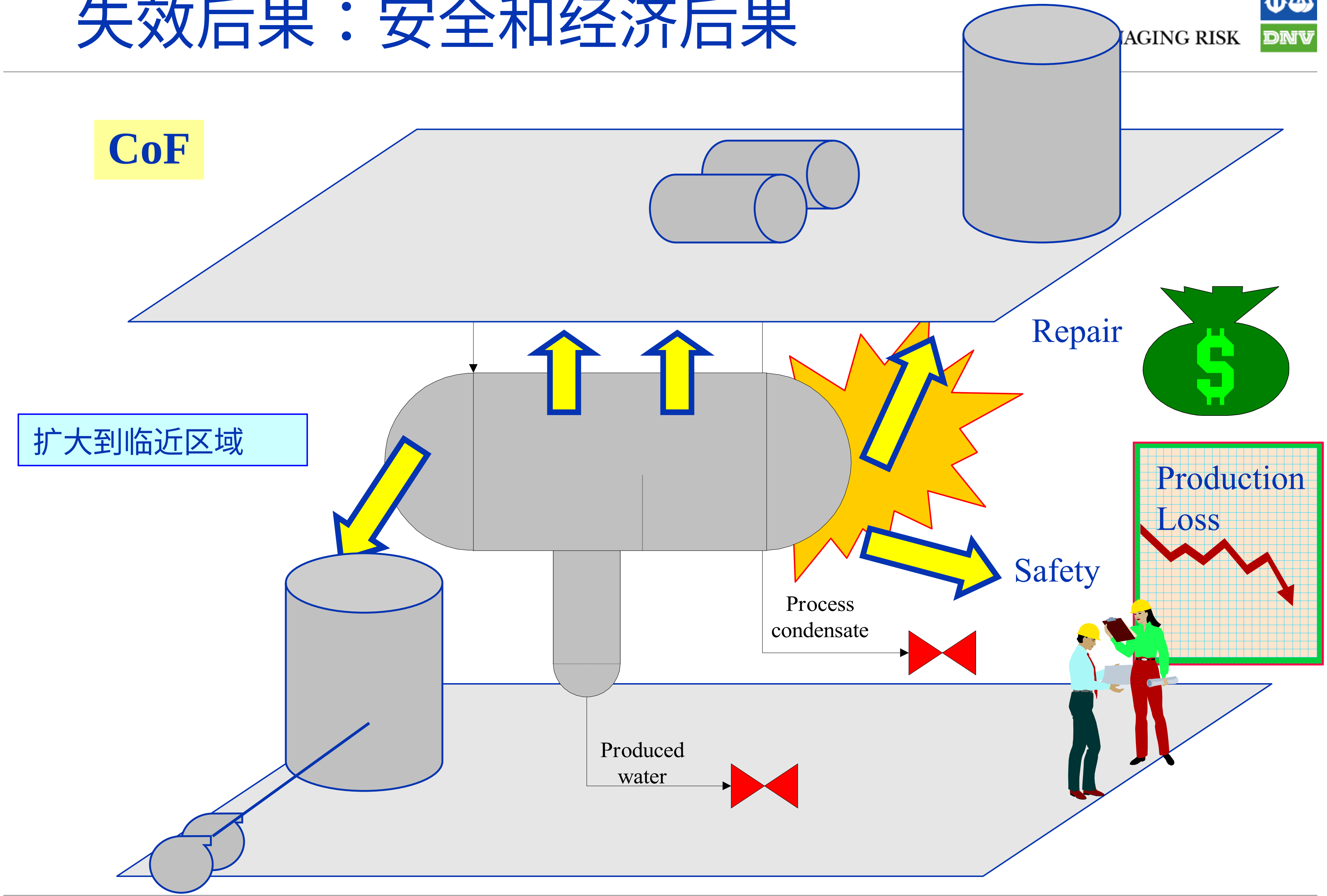
PoF

CO_2 Corrosion




Insulation
CUI
General
Corrosion
SCC
Pitting
SSC
Welds
Deposit
Blister
H_2S
CO_2
Cl-
H_20
Crevice
Corrosion
Others
Corrosion
Erosion
Corrosion
HIC

失效后果：安全和经济后果



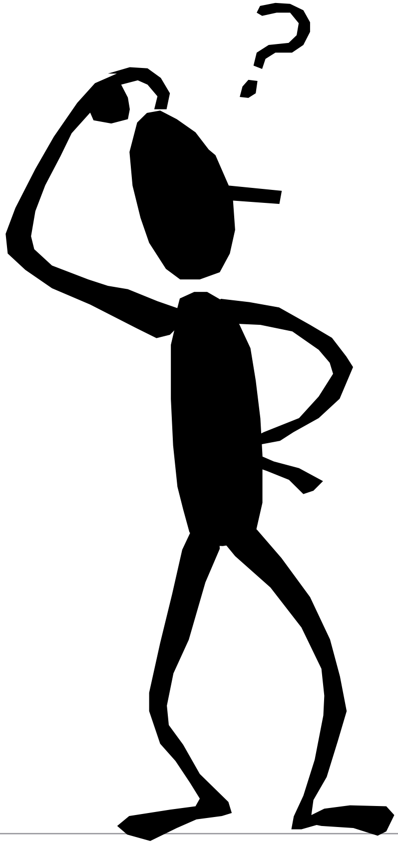
Financial Consequences财务后果

- Damage requires <u>repair</u> (costs + strategy)

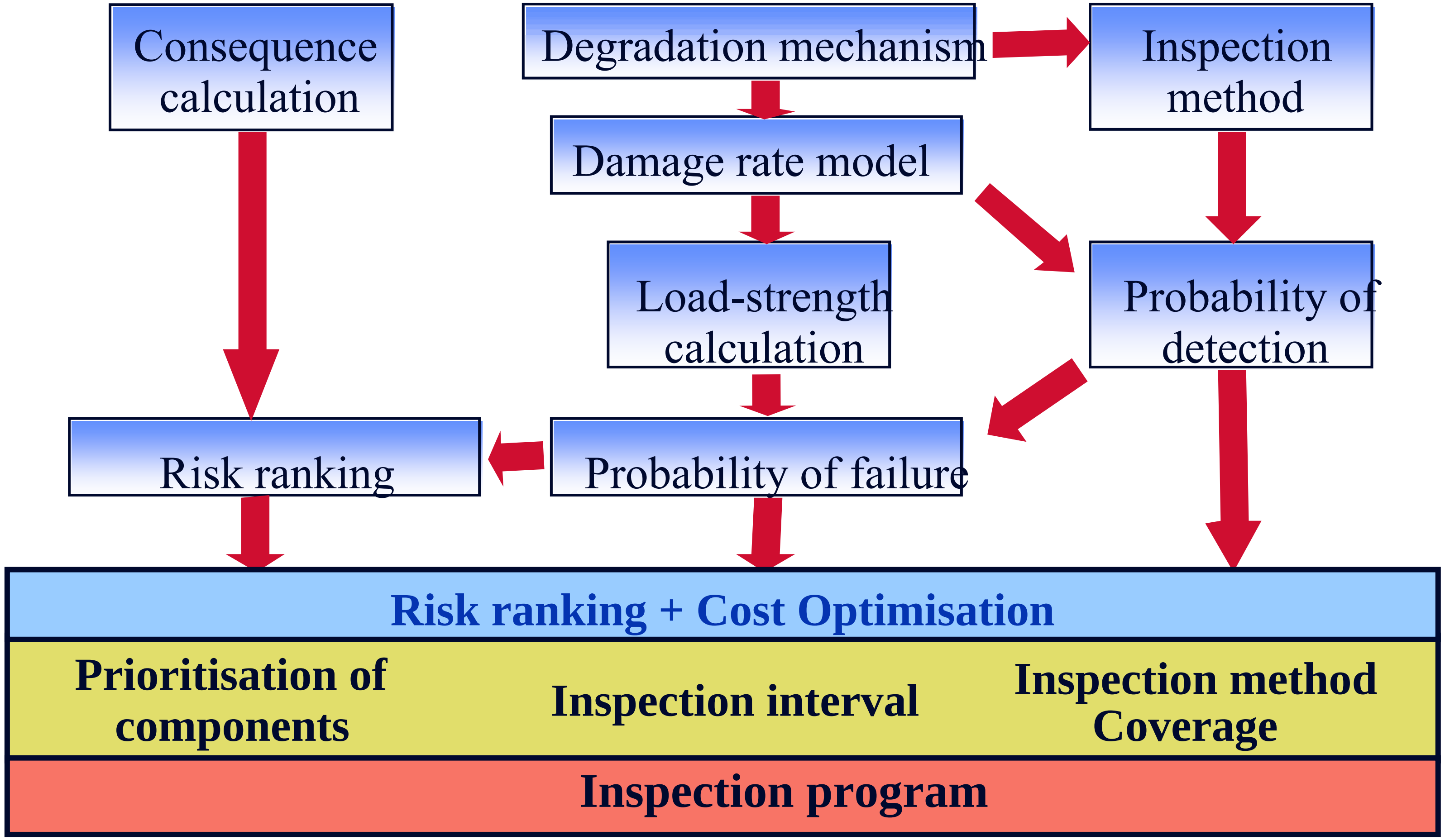
  损坏需要修理(成本+策略)
  - **Equipment** damage 设备损坏
  - **Module** damage after escalation 延伸至模块损坏
  - **Installation** damage after escalation损坏
- <u>Production loss</u> 生产损失
  - Due to **equipment** damage 由设备损坏引起
  - Due to **module** damage after escalation由延伸至模块损坏引起
  - Due to **installation** damage after escalation 由延伸至装置损坏引起

Inspection Planning <-> Risk ?

检验计划<-> 风险?



Main Principles of Offshore RBI
海上RBI的主要原理



item	NDT Technique	Abbreviation	Skill
1	Visual Testing	VT	Low
2	Radiography	RT	Medium
3	Radiography Profile	RT Profile	Medium
4	Ultrasonic Wall THK	UT-WT	Low
5	Ultrasonic detection	UT-WT	Medium
6	Corrosion Mapping	VT Mapping	High
7	Time of Flight Diffraction	ToFD	High
8	Long Range Ultransonic	LRUT	High
9	Guide Wave UT	GWUT	High
10	Dimensional Measurement	DM	Low
11	Pit Depth Guage	PDG	Low
12	Eddy Current Testing	ET	High
13	Pulsed Eddy Current	PEC	High
14	Remote Field Eddy Current	RFED	High
15	IRIS	IRIS	High
16	Penetrant Testing	PT	Low
17	Magnetic Testing	MT	Medium
18	Magnetic Flux Leaking	MFL	Medium
19	Felectic Magnetic Testing	EMAT	High
20	Thermography	TT	High
21	Acoustic Emission	AE	High
22	He, N_2, H_2, Leak detection	LT	Medium
23	Positive Material Identification	PMT	Medium

使用UT检验点蚀概率

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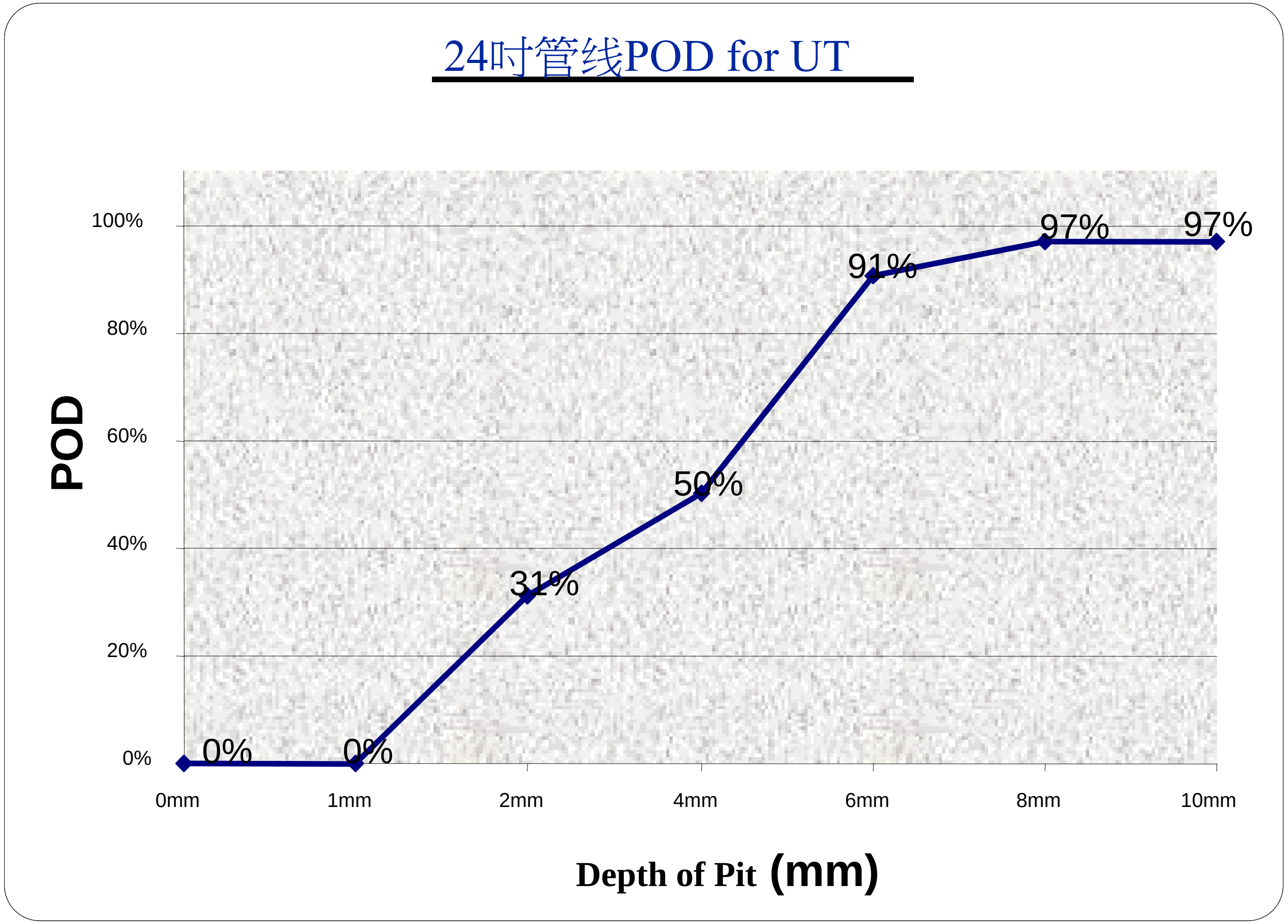

Two Vessels: Same degradation
两个容器：相同的退化机理

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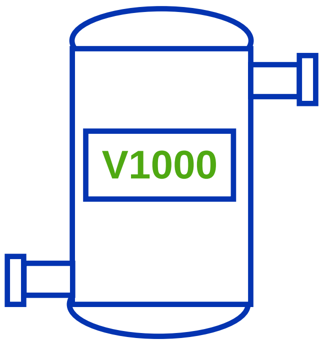
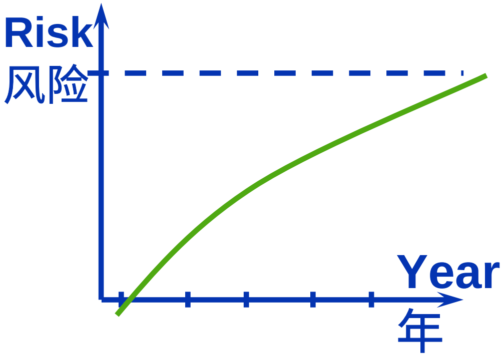


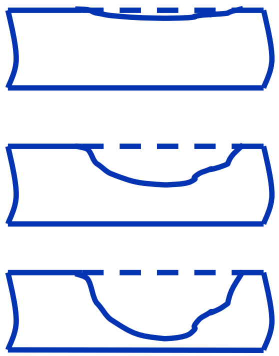
Contents: water

Production Effect: None

内容物： 水

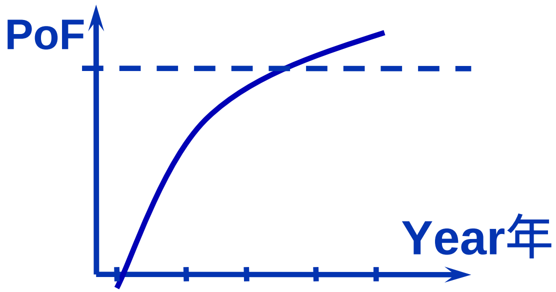
生产影响：无

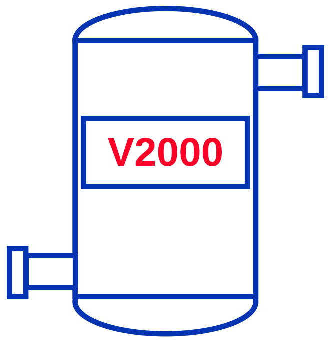




Failure probability increases in time

失效可能性随时间增加



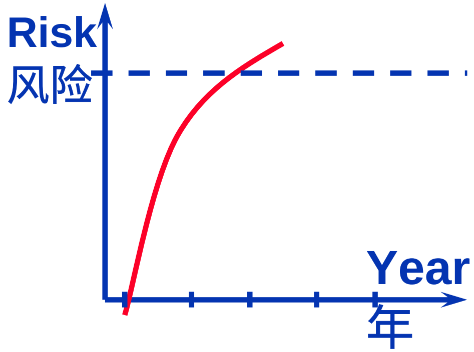


Contents: toxic, flammable

Production Effect: Stop

内容物： 毒性介质，易燃

生产影响：停产



检验计划的优化

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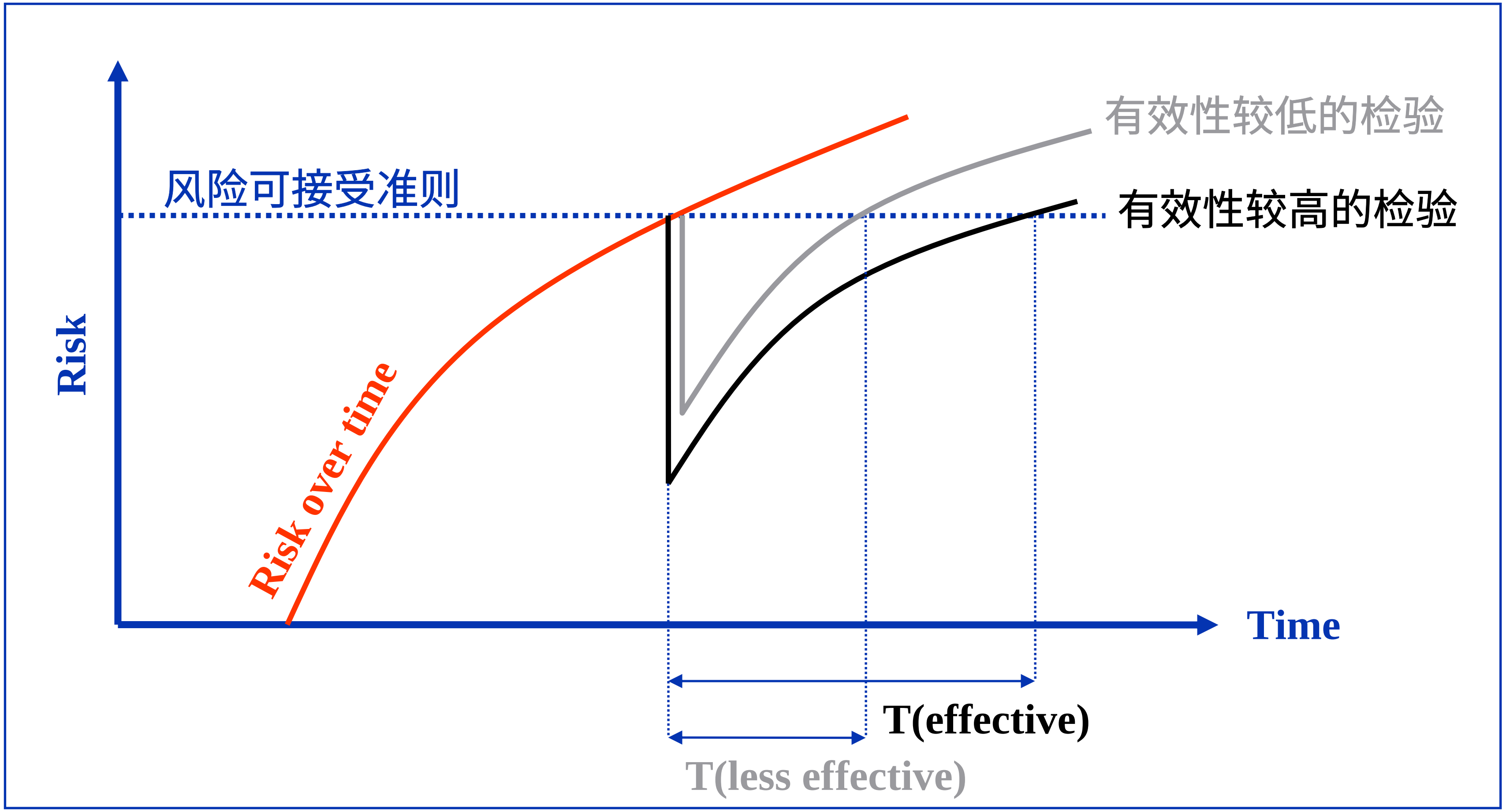
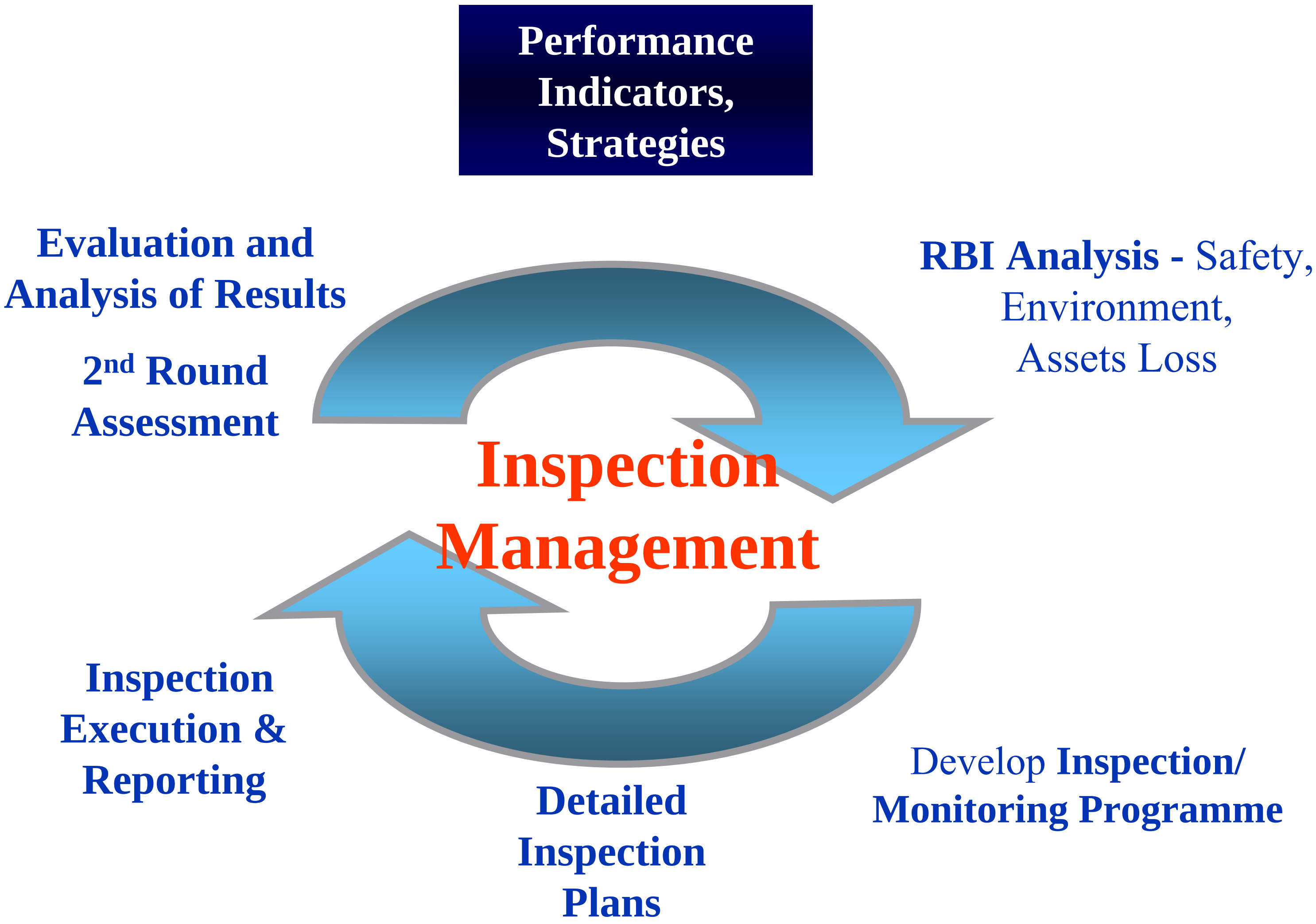
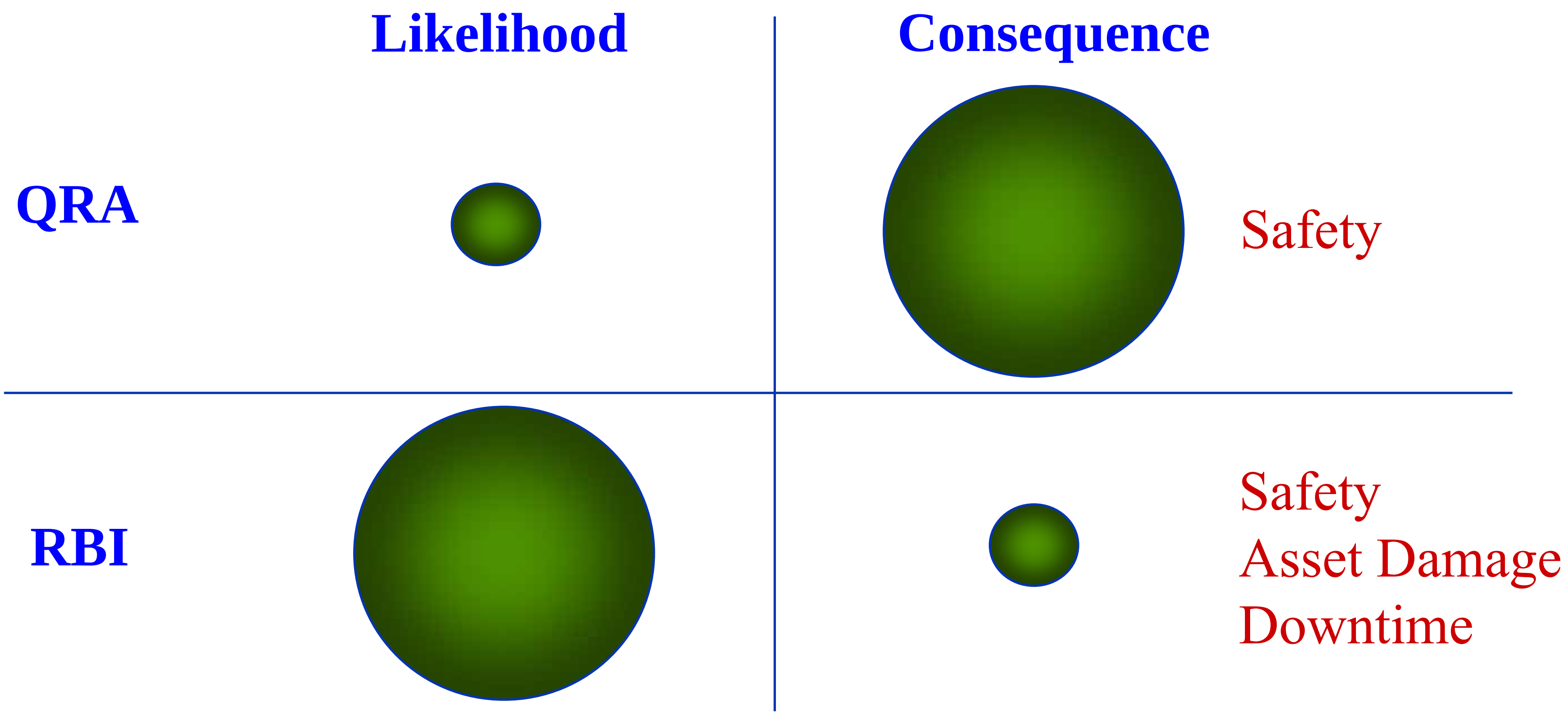


Risk-Based Inspection Management



Amount of Effort RBI/QRA



Cost Comparison

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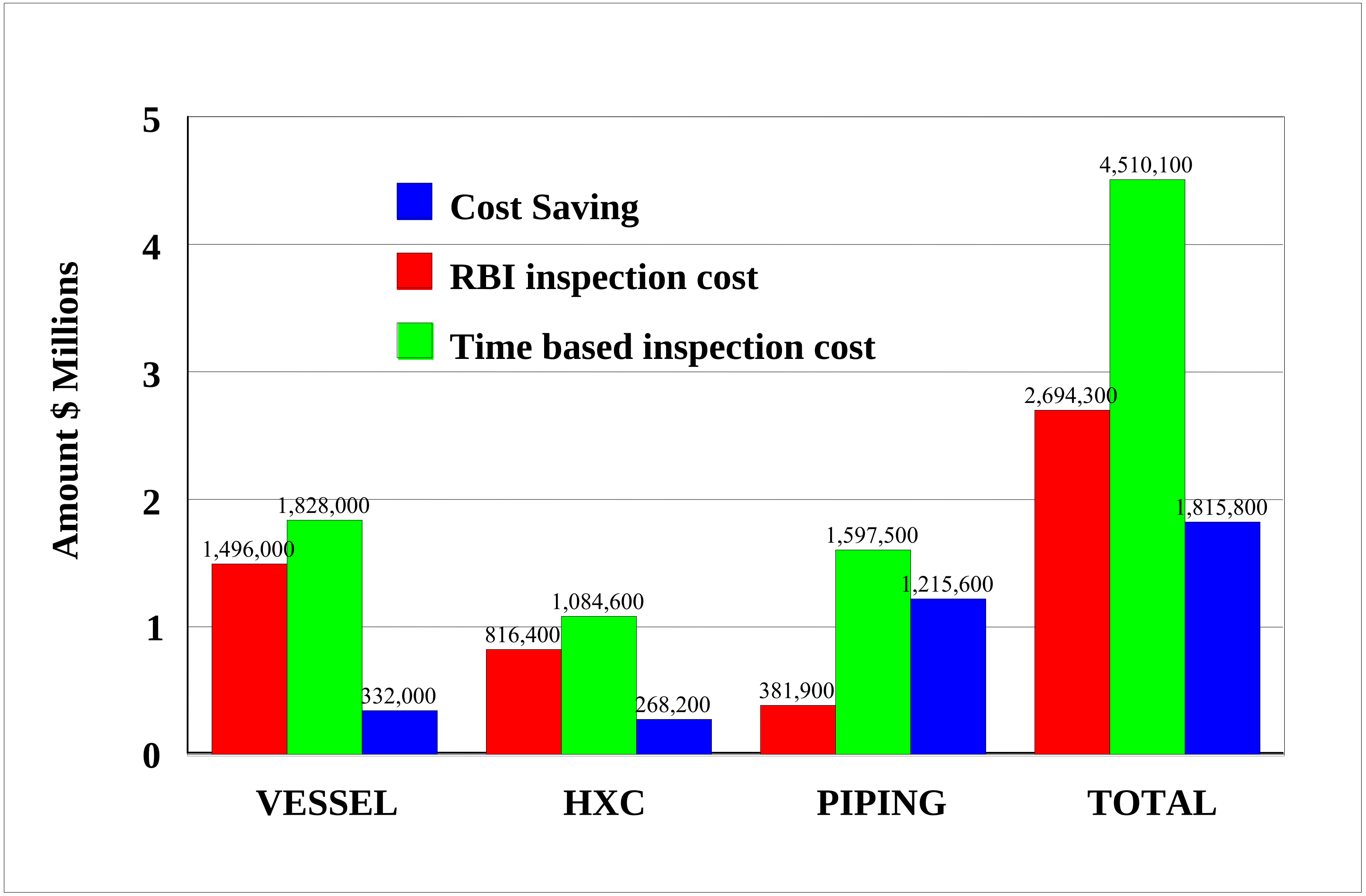

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RBI Case Study
RBI案例

Module
1

Two Step Process 2步

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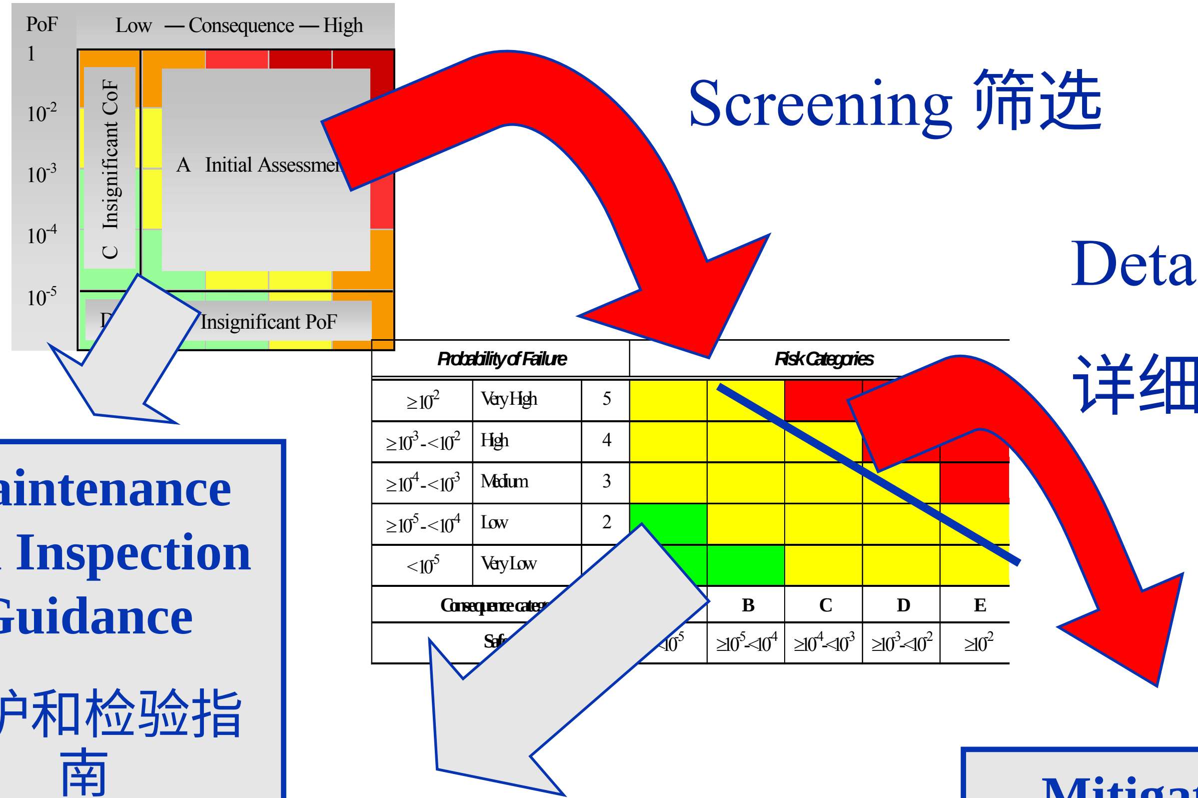


Screening 筛选

Detailed Assessment

详细评估

Maintenance and Inspection Guidance

维护和检验指南

Inspection Plan Guidelines

检验计划

Mitigation Plan

减轻计划

Screening Analysis Results 筛选结果: Equipment设备

失效概率	Risk Categories 风险分类	
High高	纠正性维护 9	详细评估 25
Low低	最低监护 9	预防性维护 42

失效后果	Low 低	High 高

静设备筛选结果

风险类别	设备	百分比
详细评估	25	29.4
预防性维护	42	49.4
纠正性维护	9	10.6
最低监护	9	10.6

合　计	89	100

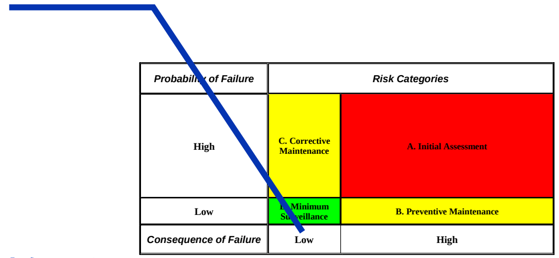
管线筛选结果的风险矩阵

失效概率	Risk Categories风险分类	
High高	纠正性维护 72	详细评估 435
Low低	最低监护 355	预防性维护 211
失效后果	Low 低	High 高

风险类别	管线	百分比
详细评估	435	40.5
预防性维护	211	19.7
纠正性维护	72	6.7
最低监护	355	33.1
合　计	1073	100

MIG - Minimum Surveillance 最低监护

Ex: Fresh Water Tank



- Both low PoF and low CoF 低失效概率和低失效后果
- Not expected to fail and no significant effect on safety, production and environment in case of failure.
- 未预期发生失效并且失效对安全和生产、环境没有严重影响
- Repair or replacement can be carried out upon failure.
- 失效后进行返修或更换
- General Visual Inspection (GVI) only: provided that assumptions in assessment are maintained.
- 仅需要一般目视检验

MIG - Preventive Maintenance预防性维护

Ex: Corrosion Inhibitor Tank

Probability of Failure	Risk Categories	
High	C. Corrective Maintenance	A. Initial Assessment
Low	D. Minimum Surveillance	B. Preventive Maintenance
Consequence of Failure	Low	High

- Low PoF and high CoF低失效概率和高失效后果
- Not expected to fail.未预期发生失效
- Close Visual Inspection (CVI) is only required provided that the assumptions are maintained throughout the assessment.
  仅需要近距离目视检验
- Any occurrences of failure are critical and routine maintenance shall be carried out as per PPM in order to maintain low PoF.
  任何失效的发生均是危急的,应该采用预防性维护计划进行日常维护以保持低失效概率

MIG - Corrective Maintenance 纠正维护

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Ex: Open Drain Tank

Probability of Failure	Risk Categories	
High	C. Corrective Maintenance	A. Initial Assessment
Low	D. Minimum Surveillance	B. Preventive Maintenance
Consequence of Failure	Low	High

- High PoF and low CoF高失效概率和低失效后果
- Expected to fail, but no significant effect on safety, production and environment
  预计会失效,但对安全、生产和环境没有重大影响
- Inspection is not required. Repair or replacement can be carried out upon failure. Failure analysis can be carried out upon failure.
  不要求检验。失效后进行返修或更换， 并进行失效分析.
- Repeated failures may present some inconvenience to the operator. If so, alternative solutions are sought such as revising designs, materials selection or suppliers.
  重复性的失效可能对操作者带来不便.如果是这样,可以寻找改变方法,如改变设计,材料选择或供应商.

High Risk Items: Detailed Assessment Required 详细评估

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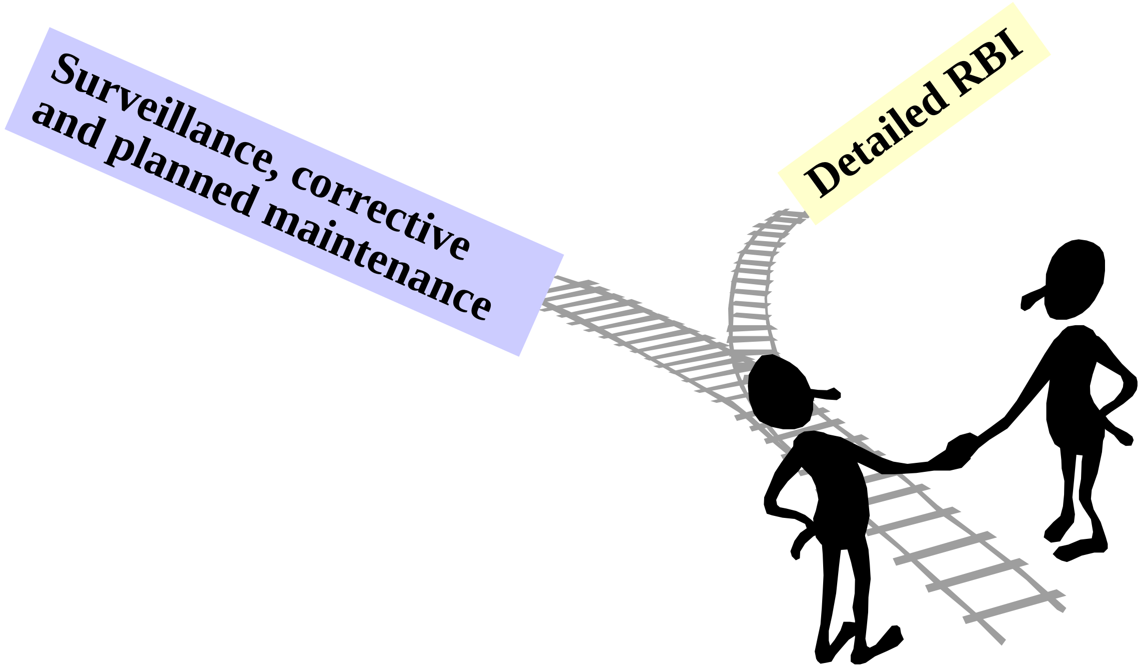
Ex: Production Separator

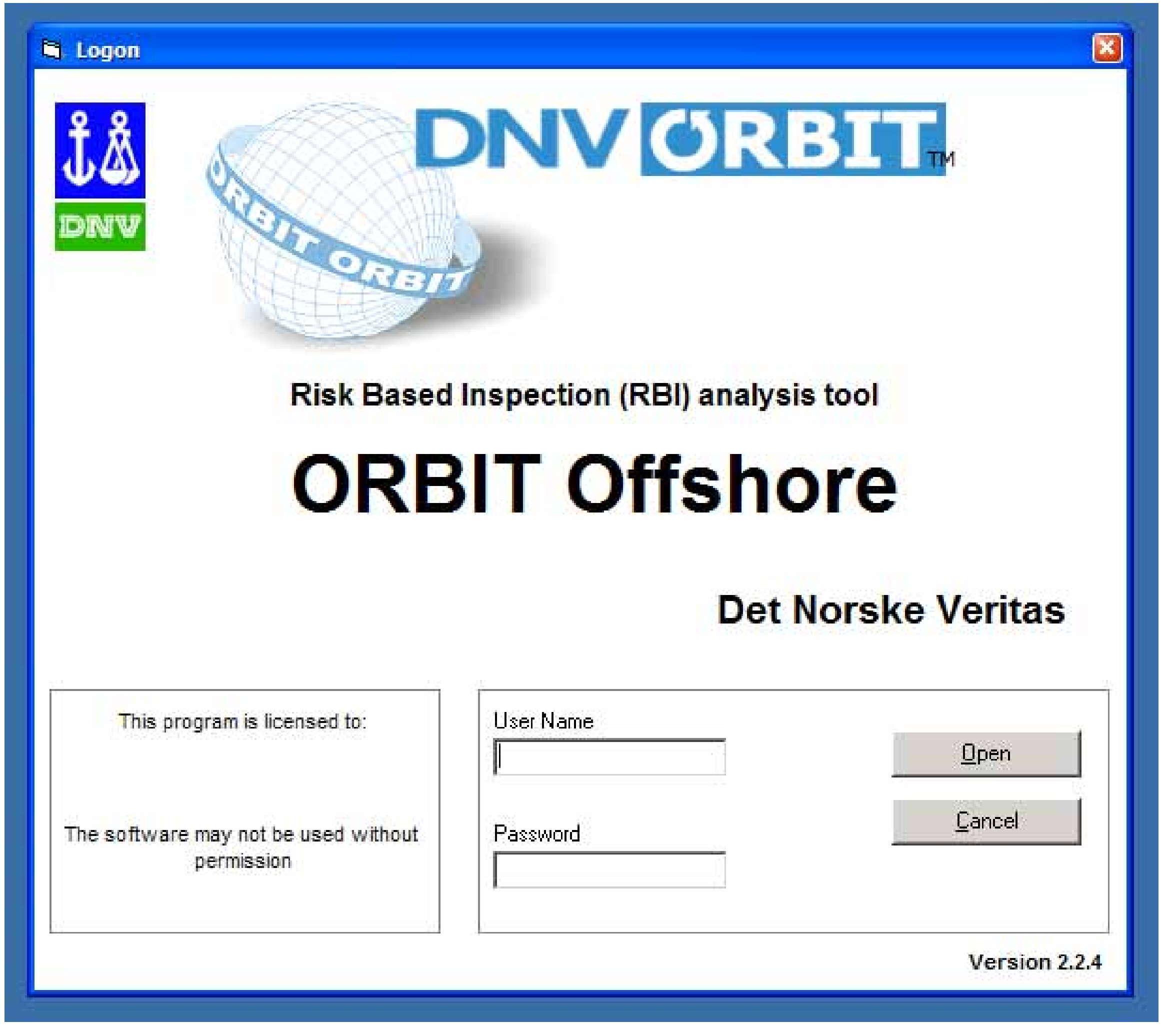
Probability of Failure	Risk Categories	
High	C. Corrective Maintenance	A. Initial Assessment
Low	D. Minimum Surveillance	B. Preventive Maintenance
Consequence of Failure	Low	High

- Remaining equipment and piping for detail Assessment
- 剩余设备和管道要求详细的评估
- More data required
- 需要更多的资料
- Analysis in software to prepare detailed and specific Inspection Plan Guidance (IPG)
- 用软件进行分析以编制详细和明确的检验计划

Up to 50% of items were screened for detailed RBI assessment
50%以上的项目进行RBI的详细评估



Offshore Risk Based Inspection Tool



Safety Risk Matrix 安全风险矩阵

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Probability of Failure			*Risk Categories*				
≥ 10^{-2}	Very High	5	>10^{-8}	>10^{-7}	>10^{-6}	>10^{-5}	>10^{-4}
≥ 10^{-3} - < 10^{-2}	High	4	>10^{-9}	>10^{-8}	>10^{-7}	>10^{-6}	>10^{-5}
≥ 10^{-4} - < 10^{-3}	Medium	3	>10^{-10}	>10^{-9}	>10^{-8}	>10^{-7}	>10^{-6}
≥ 10^{-5} - < 10^{-4}	Low	2	>10^{-11}	>10^{-10}	>10^{-9}	>10^{-8}	>10^{-7}
< 10^{-5}	Very Low	1	>10^{-12}	>10^{-11}	>10^{-10}	>10^{-9}	>10^{-8}
Consequence category			**A**	**B**	**C**	**D**	**E**
Safety (PLL)			<10^{-5}	≥10^{-5}-<10^{-4}	≥10^{-4}-<10^{-3}	≥10^{-3}-<10^{-2}	≥10^{-2}

Very High (VH) | High (H) | Medium (M) | Low (L) | Very Low (VL)

Safety Acceptance Risk Limit as Potential Loss Life (PLL) of 10^{-6} per part per year.

安全接受风险极限为每年的潜在生命损失(PLL) 10-6

Economic Risk Matrix经济风险矩阵

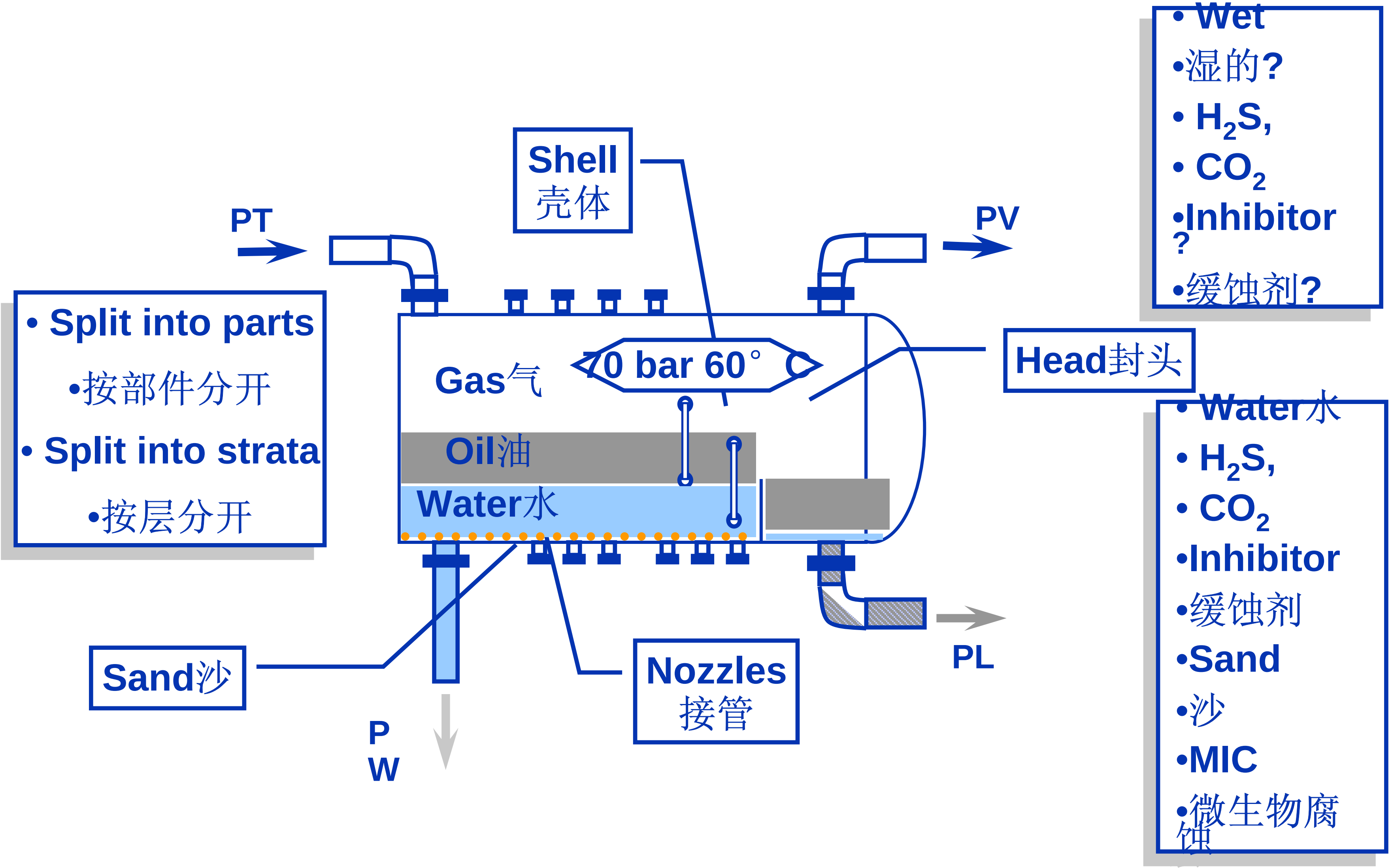
Probability of Failure			*Risk Categories*				
$\geq 10^{-2}$	Very High	**5**	>100	>1,000	>10,000	>100,000	>1,000K
$\geq 10^{-3}$ - $< 10^{-2}$	High	**4**	>10	>100	>1,000	>10,000	>100,000
$\geq 10^{-4}$ - $< 10^{-3}$	Medium	**3**	>1	>10	>100	>1,000	>10,000
$\geq 10^{-5}$ - $< 10^{-4}$	Low	**2**	>0.1	>1	>10	>100	>1,000
$< 10^{-5}$	Very Low	**1**	>0.01	>0.1	>1	>10	>100
Consequence category			**A**	**B**	**C**	**D**	**E**
Economic $			$<10^5$	$\geq 10^5$-$<10^6$	$\geq 10^6$-$<10^7$	$\geq 10^7$-$<10^8$	$\geq 10^8$

Very High (VH)	High (H)	Medium (M)	Low (L)	Very Low (VL)

Economic Acceptance Risk Limit as economic loss of $3,000 per part per year.

可接受经济风险极限为每年的经济损失**$3,000**

Separator分离器



Outputs – Inspection Plan Guidelines
检验计划指南

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- The output of Detailed Assessment:
  - what, when to inspect
    检验内容、时间
  - where and how to inspect for each part of equipment and piping. 每 个设备部件和管线的检验位置、方法

详细评估后静设备经济风险的风险矩阵

失效概率			风险类别				
$>10^{-2}$	很高	5	1	0	2	0	0
10^{-3}～10^{-2}	高	4	0	2	1	0	0
10^{-4}～10^{-3}	中	3	2	2	0	0	0
10^{-5}～10^{-4}	低	2	1	0	1	0	0
$<10^{-5}$	很低	1	0	0	0	0	0
后果类别			A	B	C	D	E
经济 USD			$<3\times10^{4}$	3×10^{4}～3×10^{5}	3×10^{5}～3×10^{6}	3×10^{6}～3×10^{7}	$>3\times10^{7}$

风险类别	小　计	百　分　比
非常高	0	0%
高	2	16.7%
中	4	33.3%
低	5	41.7%
很低	1	8.3%
合　计	12	100%

详细评估后静设备安全风险矩阵

失效概率			风 险 类 别				
$>10^{-2}$	很高	5	0	0	0	1	2
10^{-3}～10^{-2}	高	4	0	0	2	0	1
10^{-4}～10^{-3}	中	3	0	0	0	2	2
10^{-5}～10^{-4}	低	2	2	0	0	0	0
$<10^{-5}$	很低	1	0	0	0	0	0
后果类别			A	B	C	D	E
安全　（PLL）			$<10^{-5}$	10^{-5}～10^{-4}	10^{-4}～10^{-3}	10^{-3}～10^{-2}	$>10^{-2}$

风险类别	小　计	百 分 比
非常高	2	16.7%
高	4	33.3%
中	4	33.3%
低	0	0%
很低	2	16.7%
合　计	12	100%

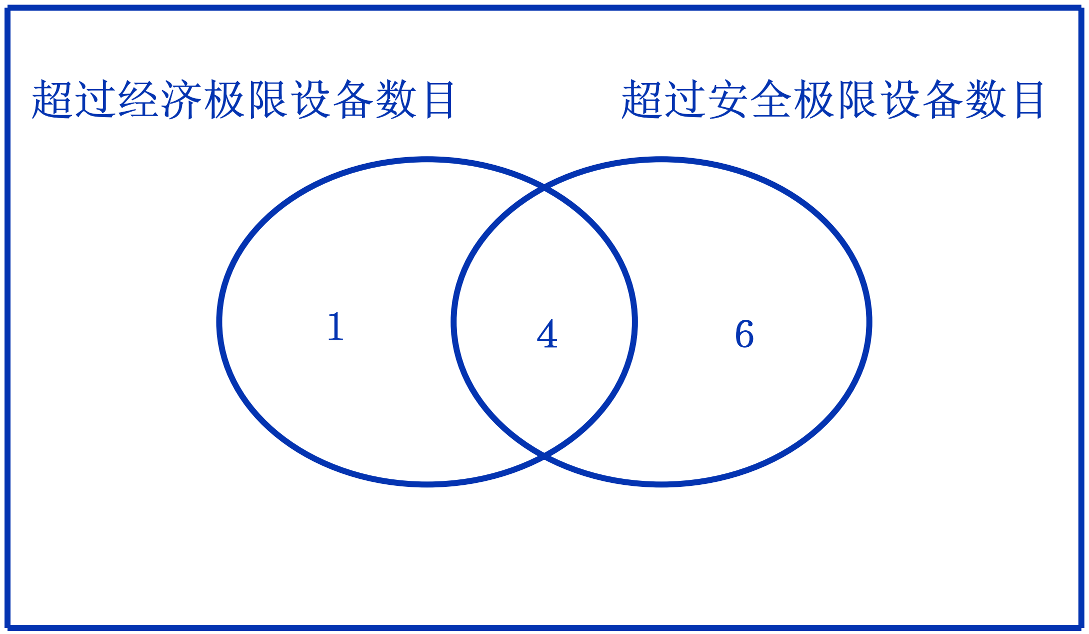

超过经济极限设备数目
超过安全极限设备数目
1
4
6

图-6 详细评估后管线经济风险的风险矩阵

失效概率			风险类别				
$>10^{-2}$	很高	5	200	5	4	0	0
010^{-3}～10^{-2}	高	4	8	10	0	0	0
10^{-4}～10^{-3}	中	3	2	1	0	0	0
10^{-5}～10^{-4}	低	2	21	73	0	0	0
$<10^{-5}$	很低	1	18	32	0	60	0
后果类别			A	B	C	D	E
经济 USD			$<3\times10^{4}$	3×10^{4}～3×10^{5}	3×10^{5}～3×10^{6}	3×10^{6}～3×10^{7}	$>3\times10^{7}$

经济风险类别	小　计	百 分 比
非常高	0	0%
高	4	1%
中	216	50%
低	144	33%
很低	71	16%

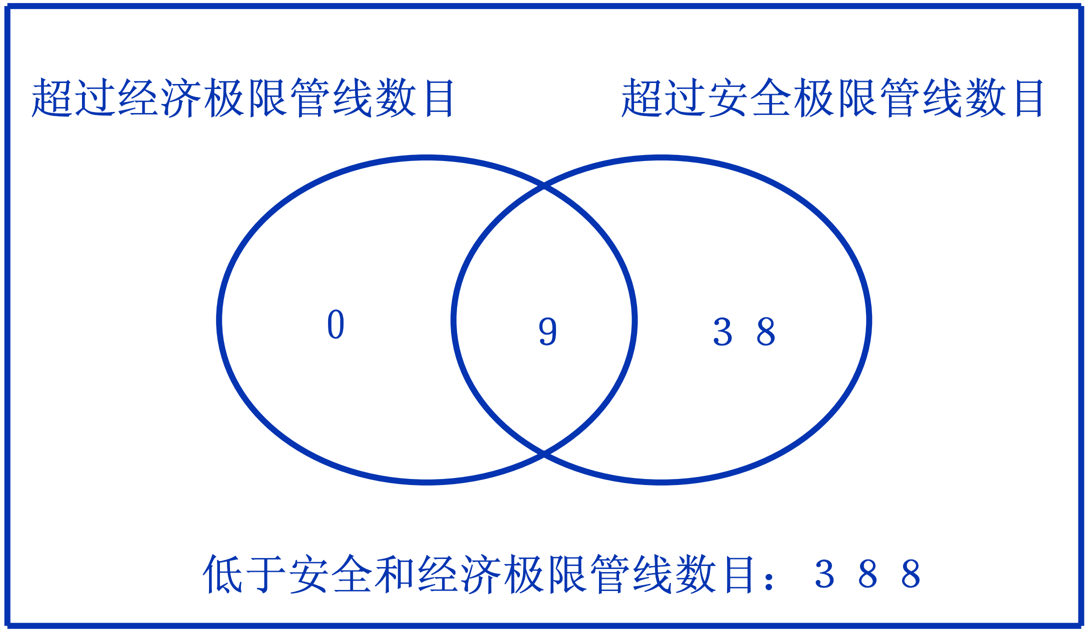
合　计	435	100%

详细评估后管线安全风险的风险矩阵

失效概率			风险类别				
>10^{-2}	很高	5	200	0	0	0	9
10^{-3}～10^{-2}	高	4	9	0	6	3	0
10^{-4}～10^{-3}	中	3	2	0	1	0	0
10^{-5}～10^{-4}	低	2	10	0	55	12	17
<10^{-5}	很低	1	21	0	5	2	82
后果类别			A	B	C	D	E
安全 （PLL）			<10^{-5}	10^{-5}～10^{-4}	10^{-4}～10^{-3}	10^{-3}～10^{-2}	>10^{-2}

安全风险类别	小　计	百 分 比
非常高	9	2. 1%
高	3	0. 7%
中	319	73. 3%
低	73	16. 8%
很低	31	7. 1%
合　计	435	100%

经详细评估结果表明，总共435条详细评估的管线中有47条超出了经济、安全可接受准则。



Object: ***F-V-103 (Type: Separator) - Production Separator***

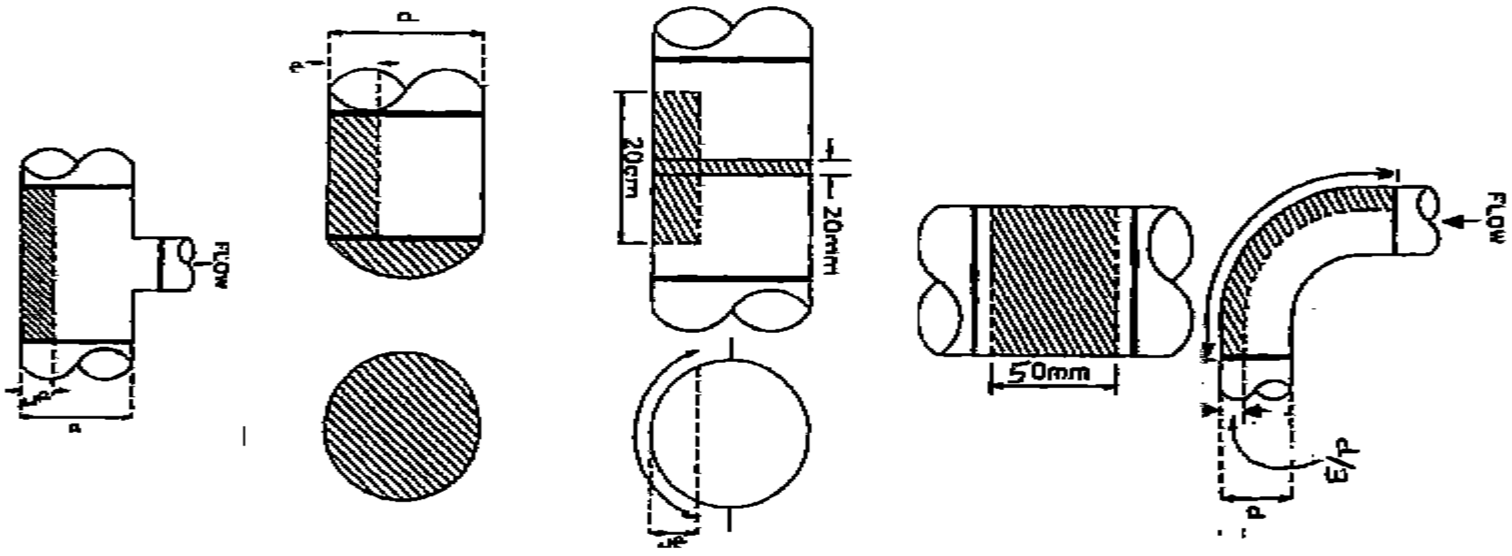
Part Name	Reference	Material	External Coating	Insulation	Internal Lining	Installation Year	Service Code	Degradation Mechanism	Wall Thick/ Diam [mm]	Corr. Rate [mm/yr]	St. Dev [mm/yr]	CoF Cat Safety	CoF Cat Econ.			PoF Cat	Risk Category Safety	Risk Category Econ	Insp. Year	Inspection Task	
Nozzle N10A Closed Drain	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	CR	CO2-Uniform	5.54 60.30	0.03	0.04	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	1 4 1	M H M	L M L	2006	**PET50**	Pulsed Eddy Current 50%
	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	CR	CO2-Local	5.54 60.30	0.07	0.07	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	4 5 1	H VH M	M H L	2004	**PET100**	Pulsed Eddy Current 100%
	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	CR	CUI-CS	5.54 60.30	0.03	0.29	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	1 5 1	M VH M	L H L	2004	**PET50**	Pulsed Eddy Current 50%
Nozzle N10B Closed Drain	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	CR	CO2-Local	5.54 60.30	0.07	0.07	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	4 5 1	H VH M	M H L	2004	**PET100**	Pulsed Eddy Current 100%
	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	CR	CO2-Uniform	5.54 60.30	0.03	0.04	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	1 4 1	M H M	L M L	2006	**PET50**	Pulsed Eddy Current 50%
	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	CR	CUI-CS	5.54 60.30	0.03	0.29	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	1 5 1	M VH M	L H L	2004	**PET50**	Pulsed Eddy Current 50%
Nozzle N2 Crude Oil Outlet	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	CR	CO2-Uniform	12.70 219.08	0.03	0.04	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	1 1 1	M M M	L L L	>10yrs	**PET50**	Pulsed Eddy Current 50%
	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	CR	CUI-CS	12.70 219.08	0.03	0.29	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	1 5 1	M VH M	L H L	2004	**PET50**	Pulsed Eddy Current 50%
	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	CR	CO2-Local	12.70 219.08	0.07	0.07	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	1 1 1	M M M	L L L	2011	**PET100**	Pulsed Eddy Current 100%
Nozzle N3 Gas Outlet	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	PG	CUI-CS	10.97 168.28	0.03	0.29	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	1 5 1	M VH M	L H L	2004	**PET50**	Pulsed Eddy Current 50%
	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	PG	CO2-Uniform	10.97 168.28	0.53	0.43	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	5 5 5	VH VH VH	H H H	2004	**PET50**	Pulsed Eddy Current 50%
	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	PG	CO2-Local	10.97 168.28	1.33	0.60	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	5 5 5	VH VH VH	H H H	2004	**PET100**	Pulsed Eddy Current 100%
Nozzle N4 Water Outlet	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	CR	CO2-Local	7.62 88.90	0.07	0.07	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	4 4 1	H H M	M M L	2004	**PET100**	Pulsed Eddy Current 100%
	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	CR	CO2-Uniform	7.62 88.90	0.03	0.04	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	1 1 1	M M M	L L L	2012	**PET50**	Pulsed Eddy Current 50%
	DWG-FPU-PR-0104	SA 106 GR B SMLS PP (ASMEB1)	Coating System c1	HT	Internal Lining	1989	CR	CUI-CS	7.62 88.90	0.03	0.29	E	C	Current Status: Status w/o insp: Status with insp:	2004 2009 2009	1 5 1	M VH M	L H L	2004	**PET50**	Pulsed Eddy Current 50%

现场验证

- 对平台的7条超出经济、安全可接受风险的管线实施内、外腐蚀的现场检测。
- 现场检测的数据表明：其中2″-FG-40604-A2-H管线的腐蚀速率已超出设计值的3倍。

Inspection Procedures检验程序

- Inspection effectiveness:检验有效性:
  - Relevant to degradation mechanism and damage morphology与退化机理和损坏形态相关
    - Inspection technique chosen, e.g. UT, RT, VI, ...
      检验技术的选择
    - Location 位置
    - Area covered 覆盖区域



RBI目的和作用

RBI关键目的在于应用风险评估、可靠性理论、材料、腐蚀和设备管线知识优化检验和防腐策略：

- WHAT： 要检查哪些设备和管线？ 要检测何种类型的缺陷？
- WHERE：检验哪里？缺陷的位置/可接近性？
- HOW： 能发现缺陷的最佳检验技术？缺陷形式(减薄，裂纹等)
- WHEN： 从风险和经济性角度确定最佳检验时间？

以避免

- 检验不足
- 检验无效
- 过度检验

RBI enables Sensitivity analysis： RBI方法还可以进行敏感性分析

Change of operating conditions, fluid composition
操作情况,物料的变化对设备的影响
Material, coating etc. selection 材料,衬里的选择
Corrosion Monitoring 腐蚀监控

Cost/Benefit analysis 检验/维护成本效益分析

与传统检验的比较

- 不清楚特种设备失效模式，失效机理 ⟶ 检验不足
  盲目追求"全面"
- 不清楚失效发生的可能部位 ⟶ 检验无效，过度检查
- 装置、设备的重要度划分考虑因素较少重点不突出
- 检验周期确定依据不足 ⟶ 过频或过长

满足国家与社会需求，促进社会经济发展

国家的需求：

- 用先进的风险工程学理念，处理安全与经济的关系；
- 加入WTO → 提高企业国际竞争力。

企业管理层的需求：

- 管理层需要一个系统、完善的管理体系来规划、监控风险、制定严格有效的风险应对计划来降低风险带来的影响。

管理人员的需求：

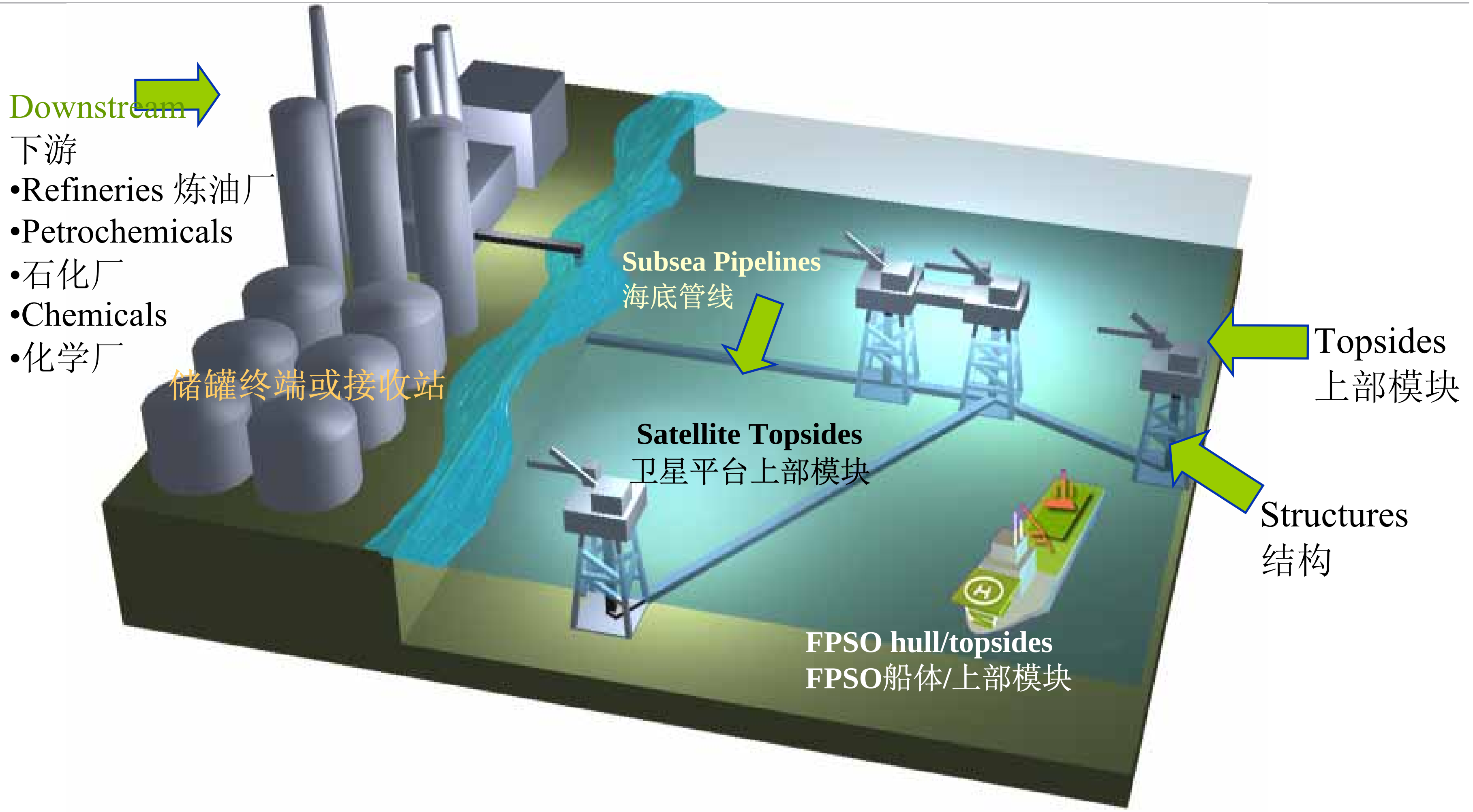
- 全面的信息库
- 集工艺、设备、腐蚀、安全等跨部门的知识核心小组，改变了以往各个部门间知识不流通的状况。
- 经验的传承
- 工作的指导

经济效益需求：

- 确保安全 → 最根本的效益保证
- 国外：降低成本
- 国内：短期成本可能会上升，长期降低成本

Application of RBI RBI的应用

MANAGING RISK DNV



MANAGING RISK DNV

资产完整性管理技术介绍

Module
1

DNV 引领技术潮流

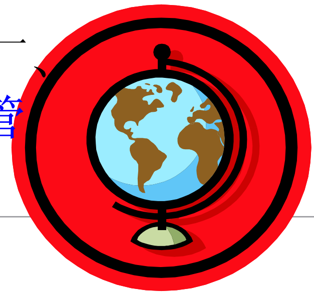
MANAGING RISK DNV

海上**RBI**规范的制定者
美国石油协会（**API 581 RBI)**项目领导成员

欧洲工业基于风险的检验及维护规程
(RIMAP)项目领导成员

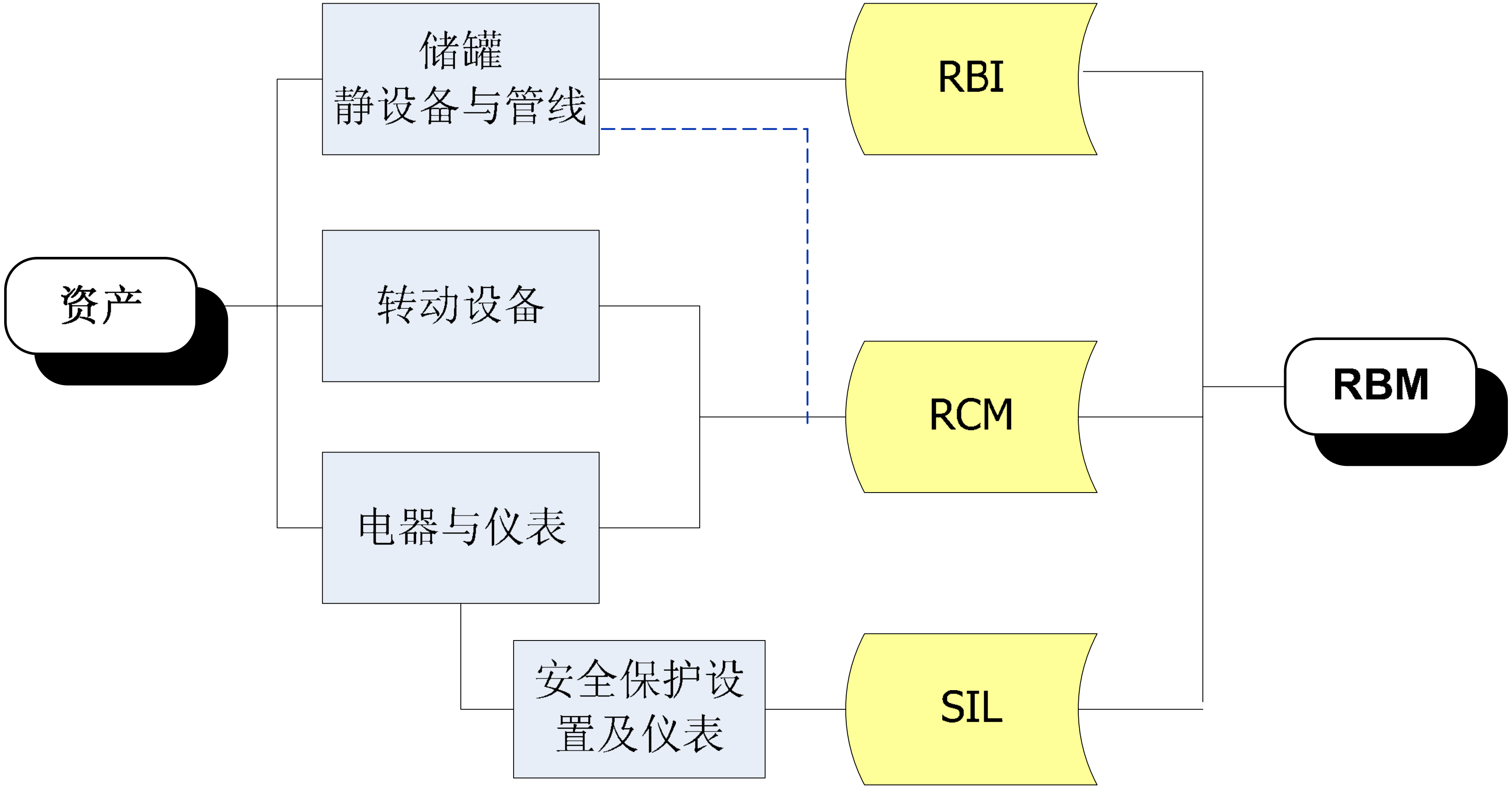
不仅具备前瞻性知识和技术并拥有全球的业务及工作经验

DNV在全世界完成超过**310**个以上的项目，包括不同的炼油厂、化工厂、海上石油平台及输油管线、FPSO等。这些例子显示应用资产完整性管理，能为石油天然气行业帶來实质重大的效益.

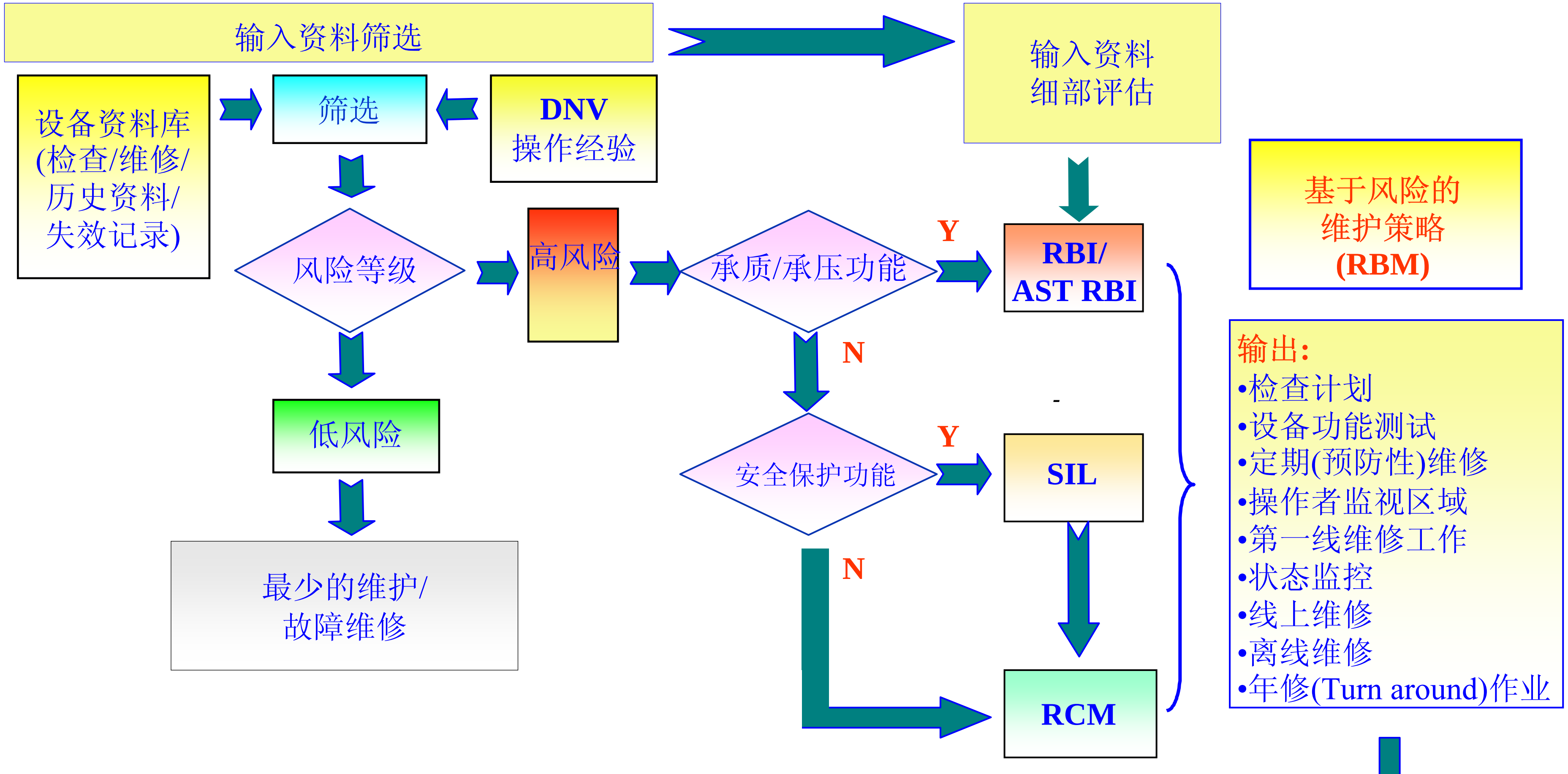


Risk Based Asset Integrity Management
基于风险的资产完整性管理技术方法

MANAGING RISK



RBM Strategy 基于风险的维护策略

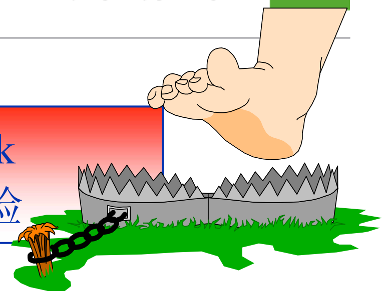


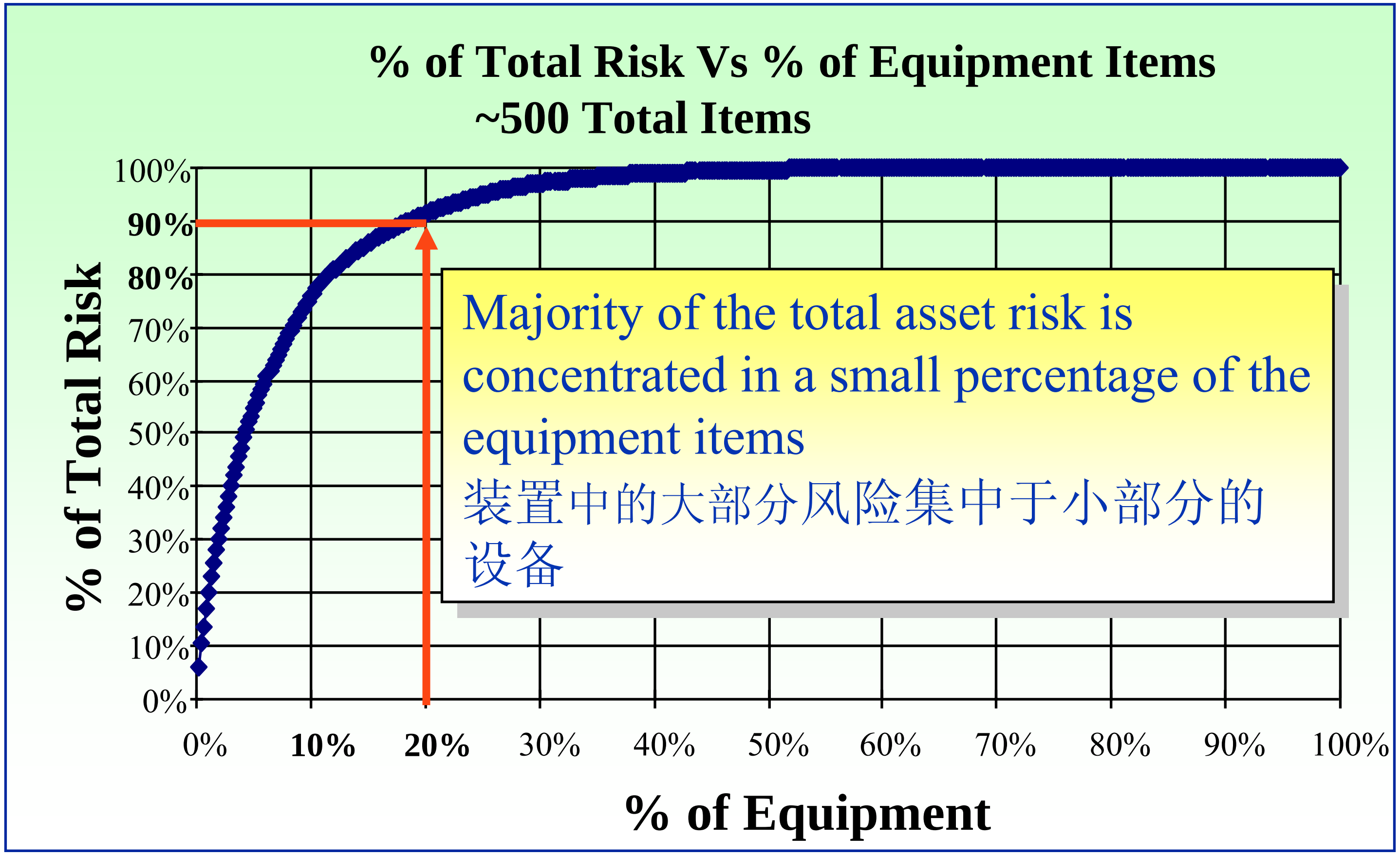
RBI: 基于风险的检验
SIL: 安全完整性等级评估
RCM: 以可靠性为中心的维修
CMMS: 电脑化维修管理

Detailed RBM analysis principles
RBM分析原理

MANAGING RISK

Probability of Failure 失效可能性	X	Consequence of Failure 失效后果	QRA/FHA ⇨	Risk 风险





Risk Based Inspection (RBI)

MANAGING RISK DNV

- RBI is a risk-based methodology, scientific and systematic...

  RBI 是一种科学地、系统地基于风险的评价方法…
- to identify degradation mechanisms in equipment/piping …

  通过确认设备/管线的损伤机理…
- and the consequences upon the failure…

  和失效所造成的后果…
- which together will give a risk...

  进而计算出其风险大小…
- that can be effectively managed & reduced through material selection, corrosion management & preventative inspection/monitoring

  通过有针对性地选材、腐蚀管理、预防性检验/维护监控及工艺监控来有效地管理风险和降低风险

Reliability Centred Maintenance
以可靠性为中心的维护

MANAGING RISK DNV

- Through FMEA & RCFA, the maintenance strategy and task package is developed to mitigate the failure causes / root causes identified.

  通过FMEA 故障模式影响分析、RCFA 失效根本原因分析制定维护策略和维护任务包，以降低失效原因/根本原因的发生

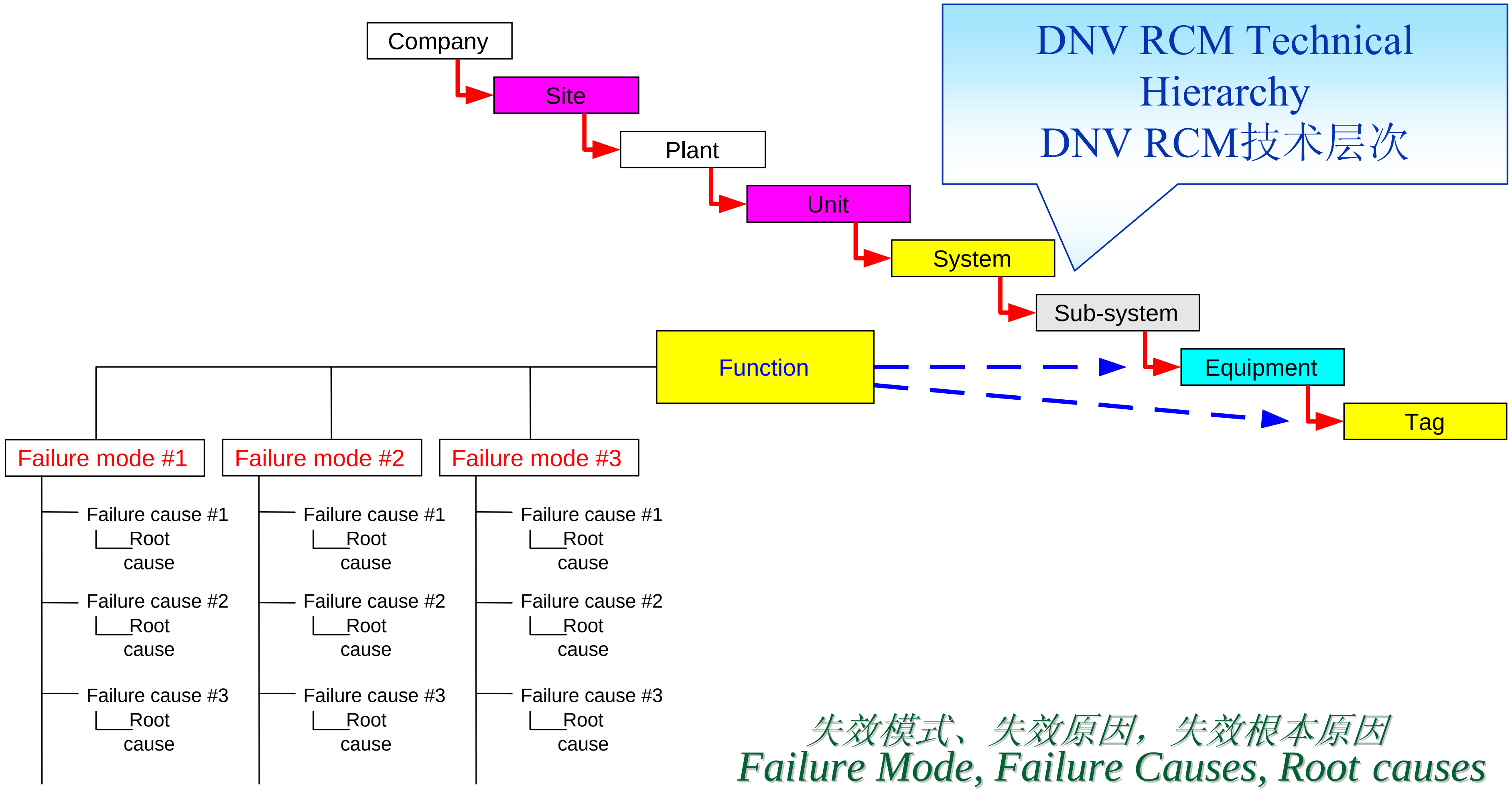
- Through Risk Calculation/Analysis, Maintenance requirements are related to Production, Safety, environment and Cost

  通过风险分析和计算使维护的要求与生产、安全、环境和成本相连接

- A systematic approach to create an accurate, well targeted and optimised maintenance package that aims at achieving optimum reliability for a facility.

  一个系统的方法、用于建立一个准确的、适于目标的和优化的维护工作包，目标在于优化装置的可靠性

DNV RCM Methodology
DNV RCM 方法

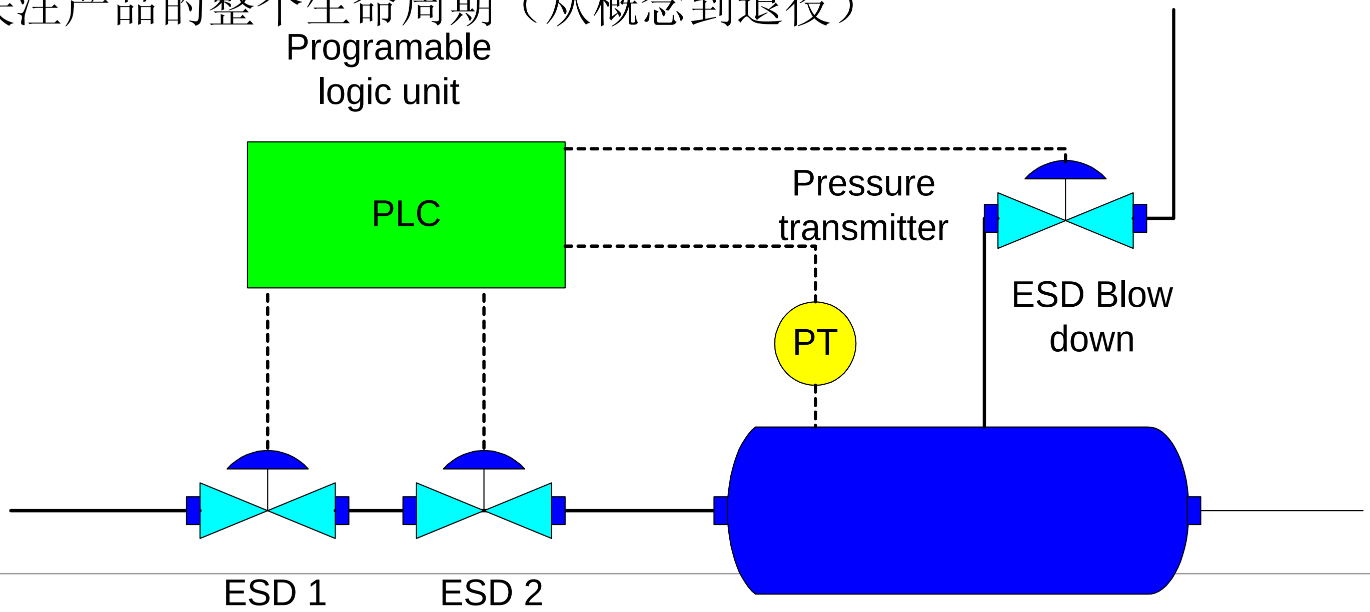


Safety Integrity Level Assessment (SIL)
安全完整性等级评估（SIL）

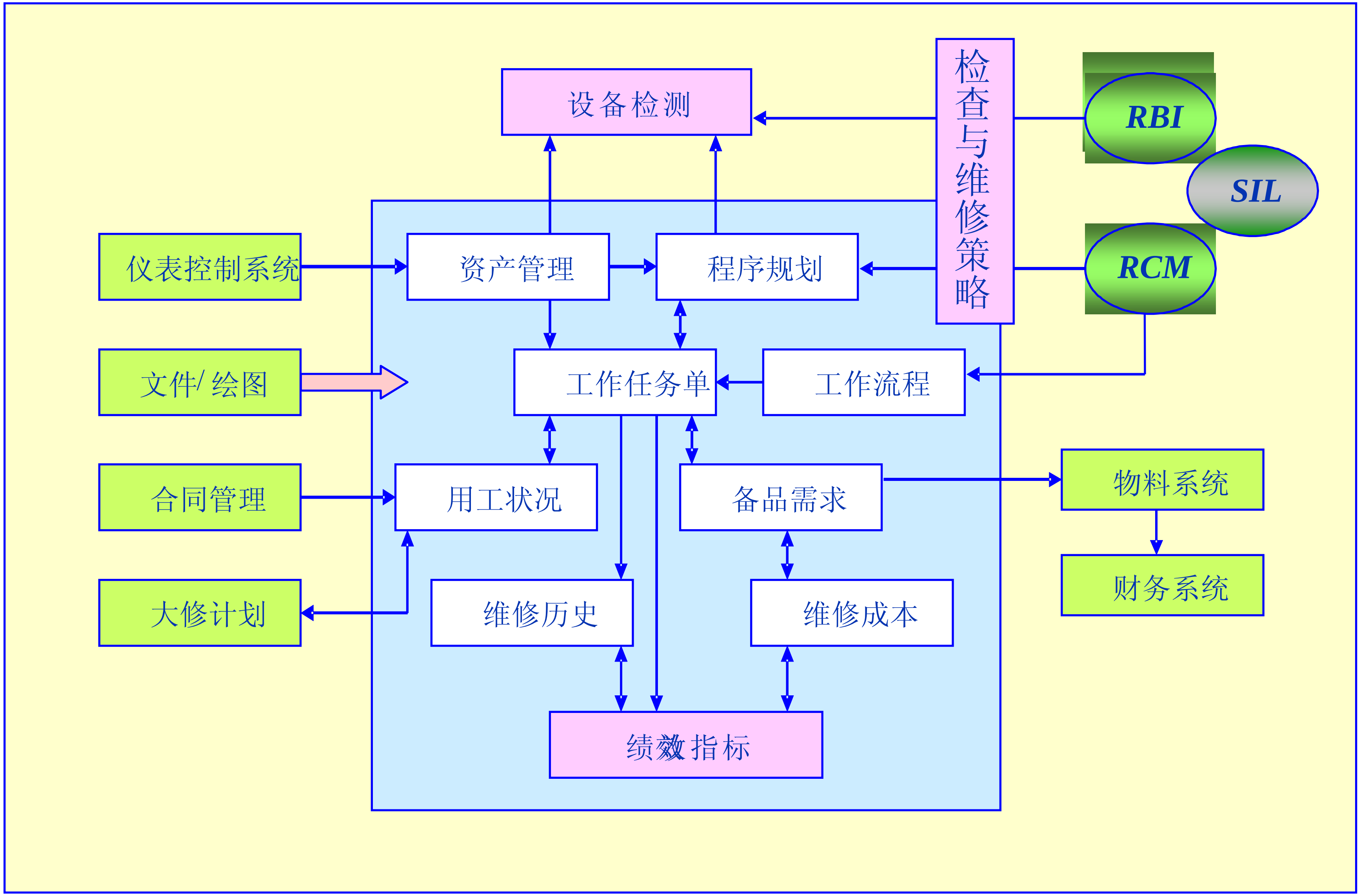
MANAGING RISK DNV

- Safety systems 安全系统
  - System reliabilities 系统可靠性
  - Risk cost optimization 风险成本优化
- Focus on Technology and Processes关注技术和过程
- Focus on Hardware and Software关注技术和软件
- Focus on the whole Product Lifecycle (concept → decommissioning)

关注产品的整个生命周期（从概念到退役）



RBM 系统整合模式


设备检测
检查与维修策略
RBI
SIL
RCM
仪表控制系统
资产管理
程序规划
文件/ 绘图
工作任务单
工作流程
合同管理
用工状况
备品需求
物料系统
财务系统
大修计划
维修历史
维修成本
绩效指标

风险管理 (RBM) 可达到的效益

RBI

- 降低工厂安全风险
- 了解工厂危险等级
- 找出设计或操作不当之所在

RCM

- 以可靠度为中心的维护
- 降低非计划性停车
- 缩短维修时间
- 找出设计或操作不当之所在

CMMS

- 提供标准化及效率化作业流程
- 建立绩效指标及审核改善数据

有效地管理安全


THANK YOU