رویکردهای تعیین زمان بازرسی در صنعت نفت، گاز و پتروشیمی

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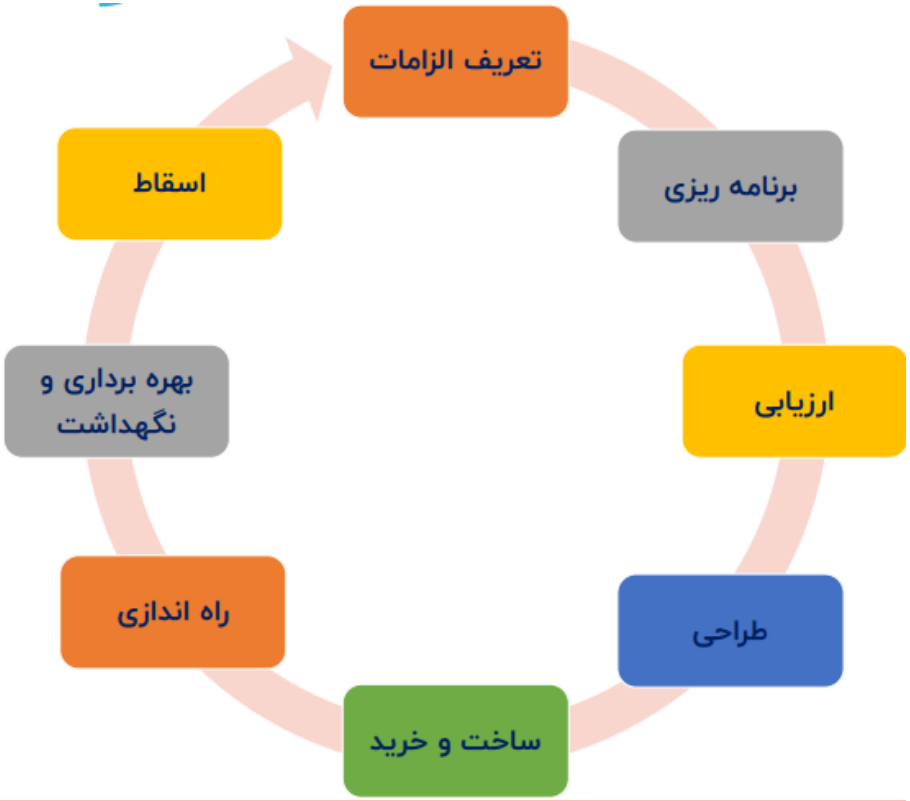
امید میلانی فرد، رضا آزادگان

چرخه عمر مدیریت دارایی‌های فیزیکی



هزینه‌های مستقیم نگهداشت به کل هزینه بهره‌برداری

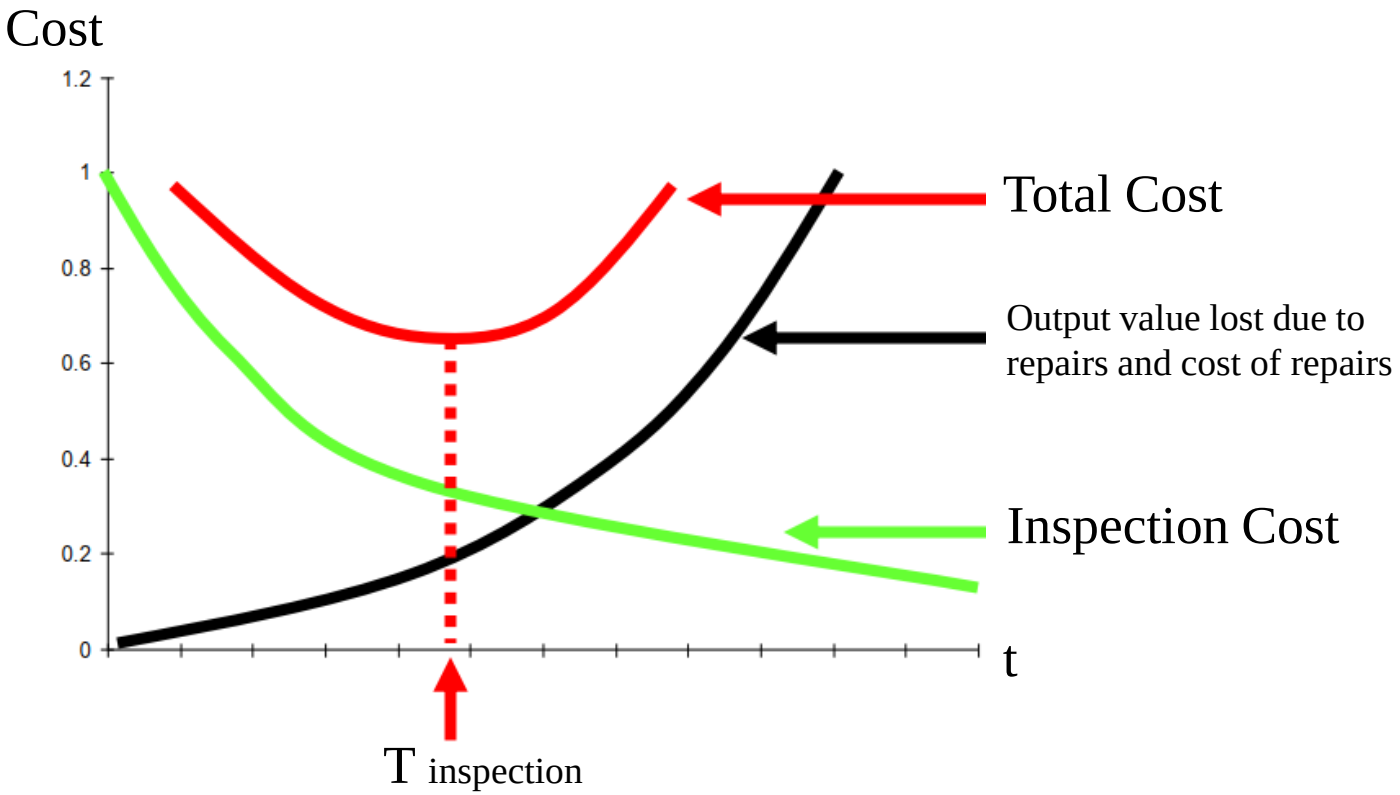
حوزه صنعت	درصد هزینه‌های مستقیم نگهداشت به کل هزینه بهره‌برداری
معدن	20-50
نفت و گاز	30-45
تولید فلزات	15-25
لوازم برقی	15-25
تولیدی	5-15
فراوری	3-15
منسوجات و مونتاژ	3-5

From Uptime

سه رویکرد تعیین زمان بازرسی

- Time-Based
- Condition-Based
- Risk-Based

Time-Based Inspection



Time-Based Inspection

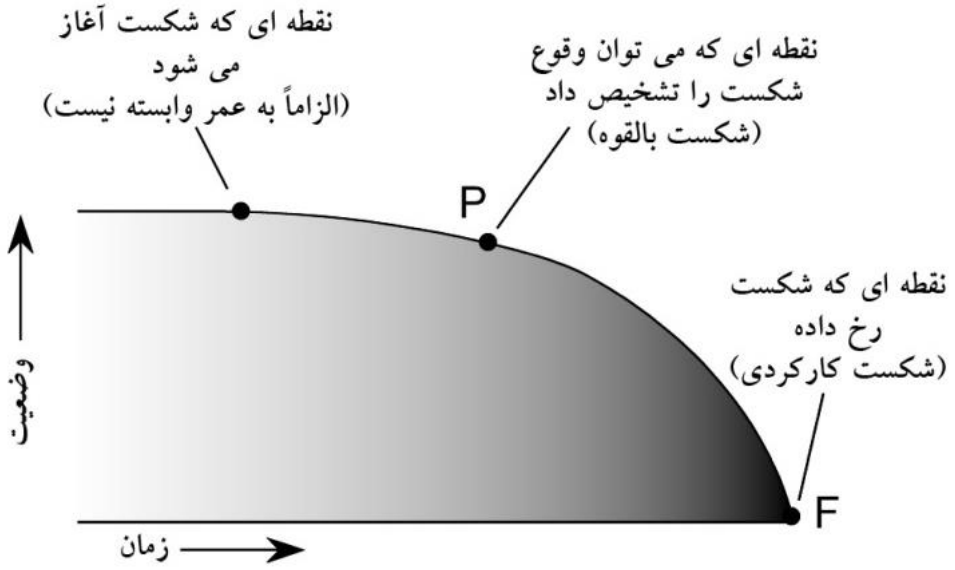
- استاندارد API 570

Table 1—Recommended Maximum Inspection Intervals

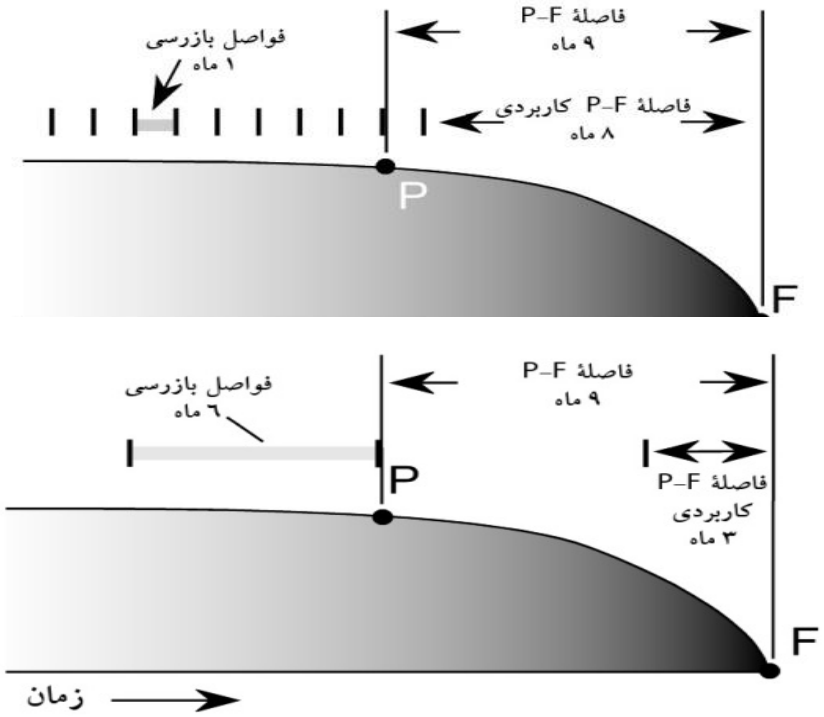
Type of Circuit	Thickness Measurements	Visual External
Class 1	5 years	5 years
Class 2	10 years	5 years
Class 3	10 years	10 years
Class 4	Optional	Optional
Injection points [a]	3 years	By class
Soil to Air Interfaces [b]	—	By class

Condition-Based Inspection

- در زمانی که رخداد یک شکست آغاز می شود چه اتفاقاتی رخ می دهد؟



Condition-Based Inspection



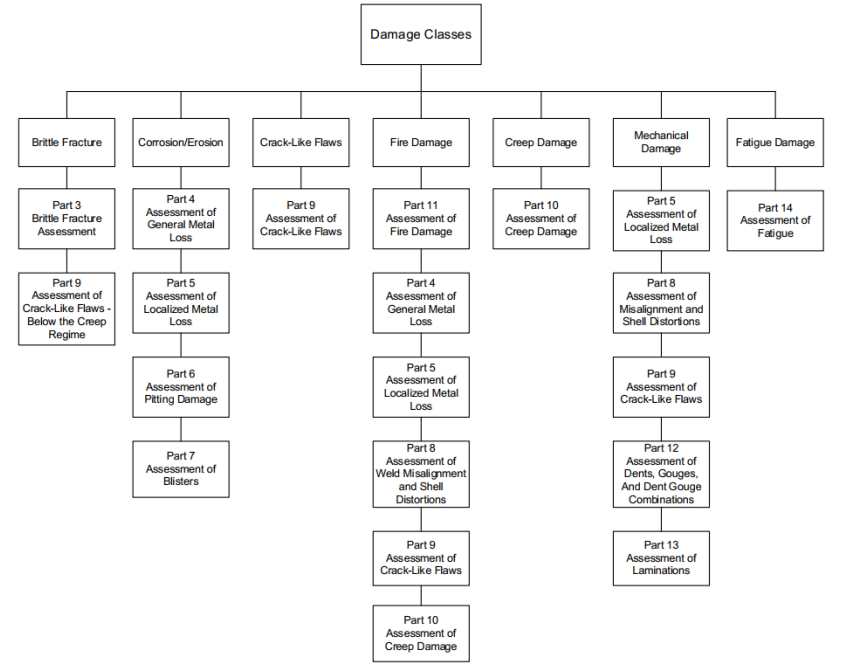
- فاصلهٔ P-F
- تغییر فاصلهٔ P-F

برحسب روش CM مورد استفاده

Condition-Based Inspection

- ارزیابی مناسب بودن برای سرویس دهی

API 579/ASME FFS (Fitness for Service)



$$\text{Remaining life (years)} = \frac{t_{actual} - t_{required}}{\text{corrosion rate [inches (mm) per year]}}$$

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Risk-Based Inspection

- **بازرسی مبتنی بر ریسک (Risk Based Inspection)**
- احتمال وقوع حادثه
- پیامدهای آن **حادثه**
- API580/581-DNV-RP-G101
- به سه روش کیفی(Qualitative) ، کمی (Quantitative) و نیمه کمی (Semi-Quantitative)

Risk-Based Inspection

$$Risk = POF \times COF$$

Risk-Based Inspection

	Damage Mechanisms	Descriptions
1	Thining DF	Internal General or localized corrosion damages
2	Component Lining DF	Damages to any internal Organic or Inorganic lining
3	Stress Corrosion Cracking (SCC) DF-Caustic Cracking	Carbon or low Alloy steel exposed to caustic at any concentration
4	Stress Corrosion Cracking (SCC) DF- Amine Cracking	Carbon or low Alloy steel exposed to lean Amine solutions
5	Stress Corrosion Cracking (SCC) DF-Sulfide Stress Cracking (SSC)	carbon or low Alloy steel exposed to wet H2S environment at any concentration
6	SCC DF—Hydrogen-induced Cracking and Stress-oriented Hydrogen-induced Cracking (HIC/SOHIC-H2S)	carbon or low Alloy steel exposed to wet H2S environment at any concentration
7	SCC DF—Alkaline Carbonate Stress Corrosion Cracking (ACSCC)	carbon or low Alloy steel exposed to water at pH> 7.5
8	SCC DF—Polythionic Acid Stress Corrosion Cracking (PASCC)	Austenitic S.S or Ni-alloys exposed to Sulfur-bearing compunds
9	SCC DF—Chloride Stress Corrosion Cracking (ClSCC)	Austenitic S.S exposed to aqueous chloride solutions at 2.5<=pH<=10.5
10	SCC DF—Hydrogen Stress Cracking in Hydrofluoric Acid (HSC-HF)	carbon or low Alloy steel exposed to HF at any concentration
11	SCC DF—Hydrogen-induced Cracking and Stress-oriented Hydrogen-induced Cracking (HIC/SOHIC-HF)	carbon or low Alloy steel exposed to HF at any concentration

Risk-Based Inspection

	Damage Mechanisms	Descriptions
12	External Corrosion DF—Ferritic Component	Uninsulated Carbon or low alloy steels subjected to corrosive atmosphere
13	Corrosion Under Insulation (CUI) DF—Ferritic Component	insulated Carbon or low alloy steels subjected to corrosive atmosphere
14	External Chloride Stress Corrosion Cracking (ExtClSCC) DF—Austenitic Component	Uninsulated Austenitic S.S subjected to chloride containing medium
15	External CUI ClSCC DF—Austenitic Component	Insulated Austenitic S.S subjected to chloride containing medium
16	High Temperature Hydrogen Attack (HTHA) DF	Carbon or C-Mo low alloy steel exposed to High pressure Hydrogen at high temperatures
17	Brittle Fracture DF	Carbon or low Alloy steels Operating at or Below MDMT or MAT
18	Low Alloy Steel Embrittlement Damage Factor	Low Alloy Cr-Mo containig steels operating between 343 and 577 C
19	885 °F Embrittlement DF	High Cr Ferritic steels operating between 371 and 566 C
20	Sigma Phase Embrittlement DF	Austenitic S.S operating between 593 and 927 C
21	Piping Mechanical Fatigue DF	Piping exposed to vibration

Risk-Based Inspection

- Probability Of Failure

- $P_f(t) = gff \times F_{MS} \times D_f(t)$
  - Generic failure frequency
  - Management system factor
  - Damage factor

- Weibull Analysis for PRD and Tube bundle

Risk-Based Inspection

API

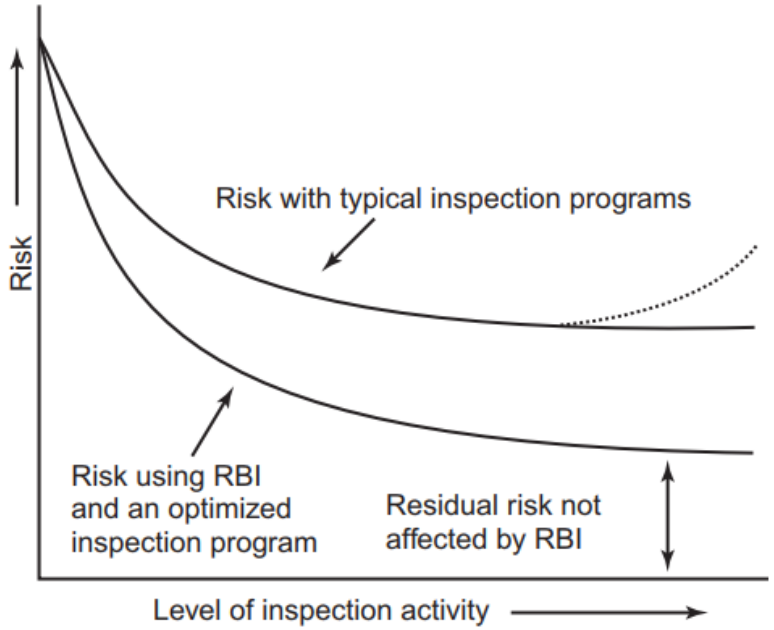
- Consequence Of Failure

- Area Based Consequence
- Financial Consequence

- Flammable
- Toxic
- Non-flammable Non-toxic

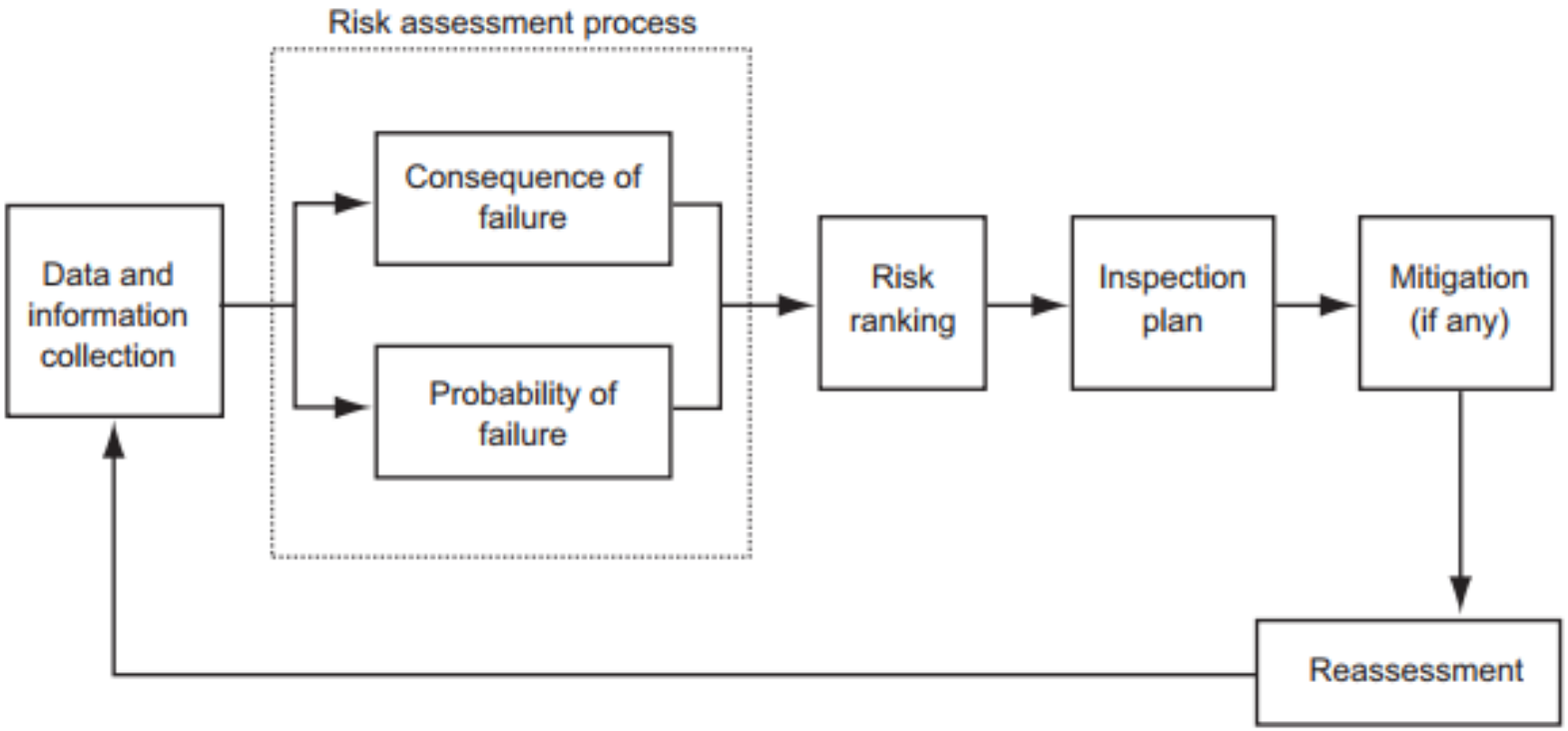
Risk-Based Inspection

- نقش بازرسی مناسب در کاهش ریسک



From API 580/581

Risk-Based Inspection



From API 580/581

Risk-Based Inspection

- **WHAT** to inspect
- **WHEN** to inspect
- **WHERE** to inspect
- **HOW** to inspect
- **WHAT** to report

Risk-Based Inspection

WHAT to inspect	Prioritization of high-risk components
WHEN to inspect	Determination of inspect intervals
WHERE to inspect	Expected damage mechanisms
HOW to inspect	Selection of best inspection method
WHAT to report	Data requirements for continuous improvement

Risk-Based Inspection

Category	Probability Category [a, b, c]		Consequence Category [d]	
	Probability Range	DF Range	Category	Range (ft^2)
1	$P_f(t,I_E) \leq$ 3.06E-05	$D_{f\text{-}total} \leq 1$	A	$CA_f^{flam} \leq 100$
2	3.06E-05 < $P_f(t,I_E) \leq$ 3.06E-04	$1 < D_{f\text{-}total} \leq 10$	B	$100 < CA_f^{flam} \leq 1{,}000$
3	3.06E-04 < $P_f(t,I_E) \leq$ 3.06E-03	$10 < D_{f\text{-}total} \leq 100$	C	$1{,}000 < CA_f^{flam} \leq 10{,}000$
4	3.06E-03 < $P_f(t,I_E) \leq$ 3.06E-02	$100 < D_{f\text{-}total} \leq 1{,}000$	D	$10{,}000 < CA_f^{flam} \leq 100{,}000$
5	$P_f(t,I_E) >$ 3.06E-02	$D_{f\text{-}total} > 1{,}000$	E	$CA_f^{flam} > 100{,}000$

From API 581

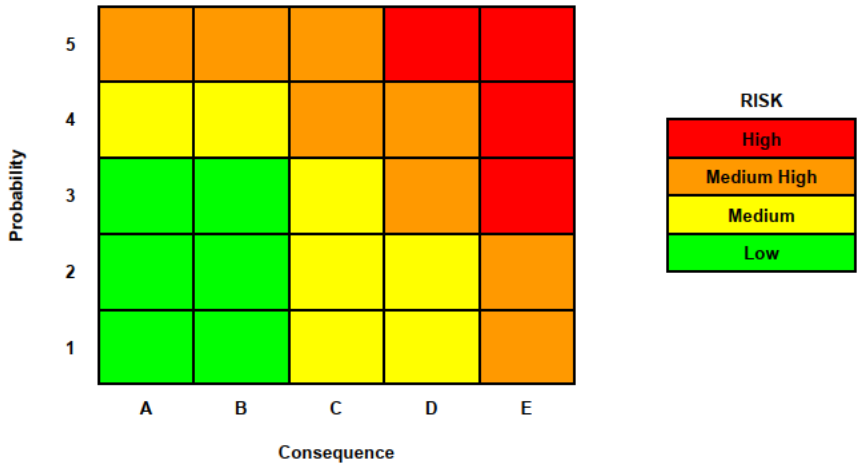
Risk-Based Inspection

Category	Probability Category [a, b, c]		Consequence Category [d]	
	Probability Range	DF Range	Category	Range ($)
1	$P_f(t,I_E) \leq$ 3.06E-05	$D_{f\text{-}total} \leq 1$	A	$CA_f^{fin} \leq$ 10,000
2	3.06E-05 < $P_f(t,I_E) \leq$ 3.06E-04	1 < $D_{f\text{-}total} \leq 10$	B	10,000 < $CA_f^{fin} \leq$ 100,000
3	3.06E-04 < $P_f(t,I_E) \leq$ 3.06E-03	10 < $D_{f\text{-}total} \leq 100$	C	100,000 < $CA_f^{fin} \leq$ 1,000,000
4	3.06E-03 < $P_f(t,I_E) \leq$ 3.06E-02	100 < $D_{f\text{-}total} \leq 1000$	D	1,000,000 < $CA_f^{fin} \leq$ 10,000,000
5	$P_f(t,I_E) >$ 3.06E-02	$D_{f\text{-}total} > 1000$	E	$CA_f^{fin} >$ 10,000,000

From API 581

Risk-Based Inspection

Risk Matrix and Risk Target

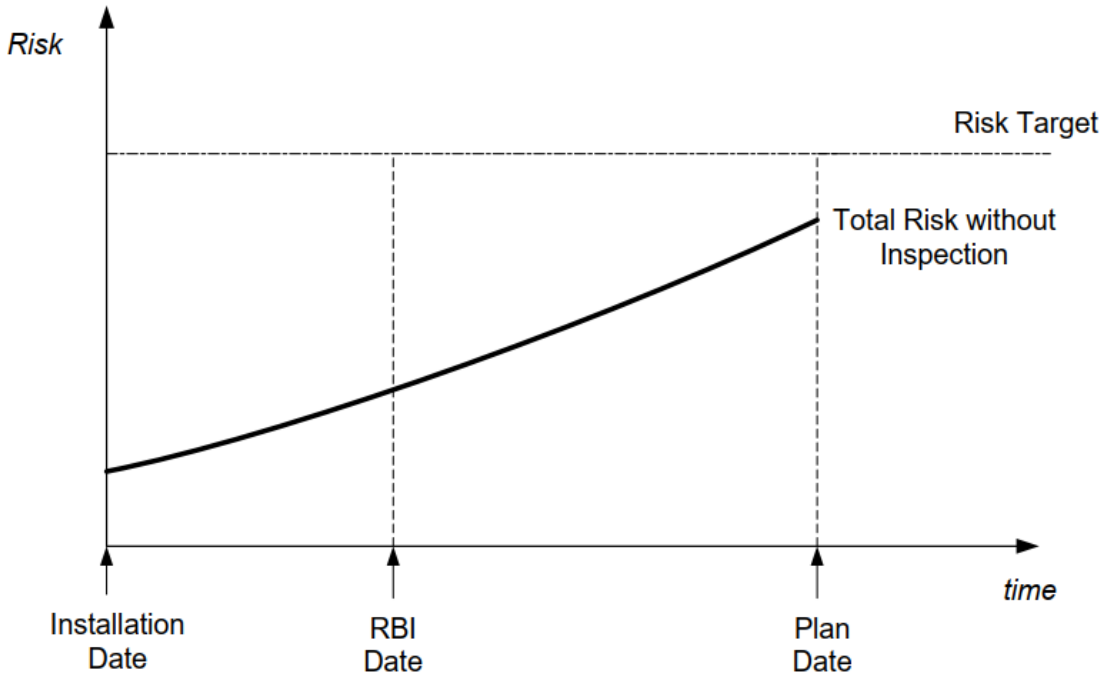


API 581

PoF Ranking	PoF Description	A	B	C	D	E
5	(1) In a small population, one or more failures can be expected annually. (2) Failure has occurred several times a year in the location.	YELLOW	RED	RED	RED	RED
4	(1) In a large population, one or more failures can be expected annually. (2) Failure has occurred several times a year in operating company.	YELLOW	YELLOW	RED	RED	RED
3	(1) Several failures may occur during the life of the installation for a system comprising a small number of components. (2) Failure has occurred in the operating company.	GREEN	YELLOW	YELLOW	RED	RED
2	(1) Several failures may occur during the life of the installation for a system comprising a large number of components. (2) Failure has occurred in industry.	GREEN	GREEN	YELLOW	YELLOW	RED
1	(1) Several failures may occur during the life of the installation for a system comprising a large number of components. (2) Failure has occurred in industry.	GREEN	GREEN	GREEN	YELLOW	YELLOW
CoF Types	Safety	No Injury	Minor Injury Absence < 2 days	Major Injury Absence > 2 days	Single Fatality	Multiple Fatalities
	Envirnoment	No pollution	Minor local effect. Can be cleaned up easily.	Significant local effect. Will take more than 1 man week to remove.	Pollution has significant effect upon the surrounding ecosystem (e.g. population of birds or fish).	Pollution that can cause massive and irreparable damage to ecosystem.
	Business	No downtime or asset damage	< € 10.000 damage or downtime < one shift	< € 100.000 damage or downtime < 4 shifts	< € 1.000.000 damage or downtime < one month	< € 10.000.000 damage or downtime one year
CoF Ranking		A	B	C	D	E

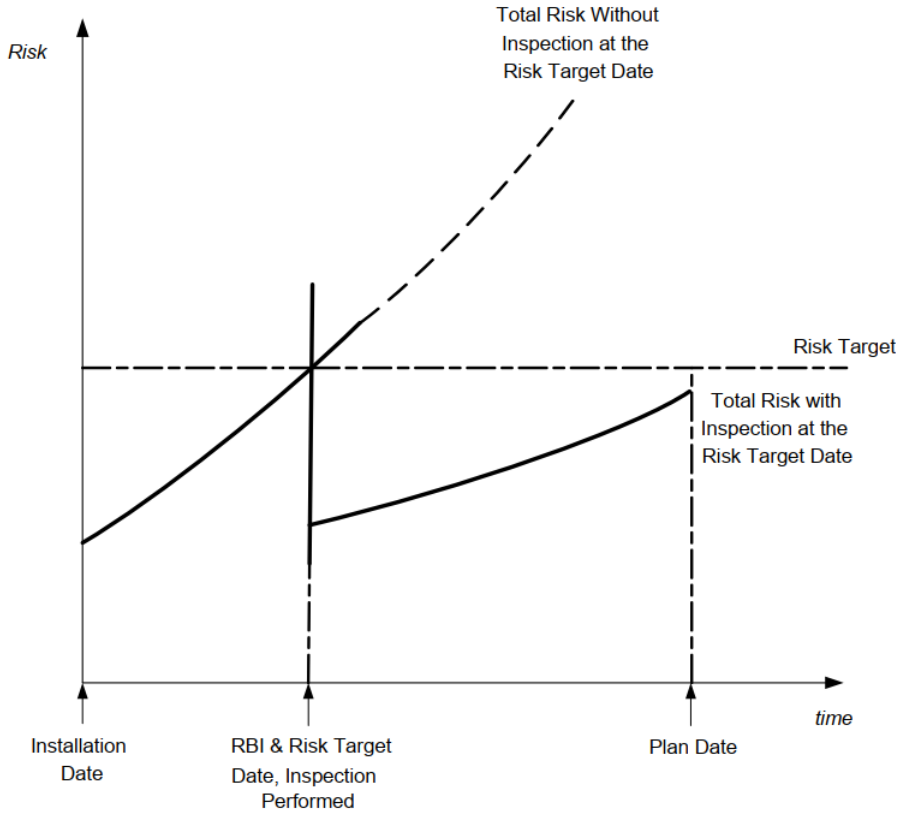
DNVGL-RP-G101

Risk-Based Inspection



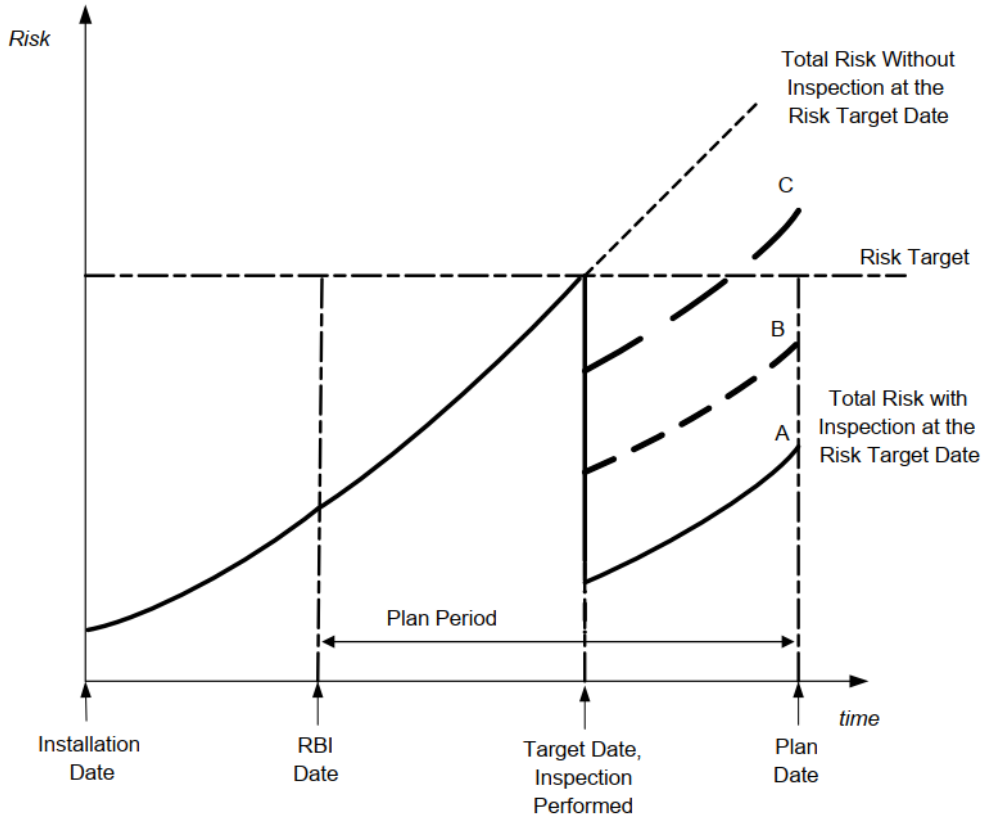
From API 581

Risk-Based Inspection



From API 581

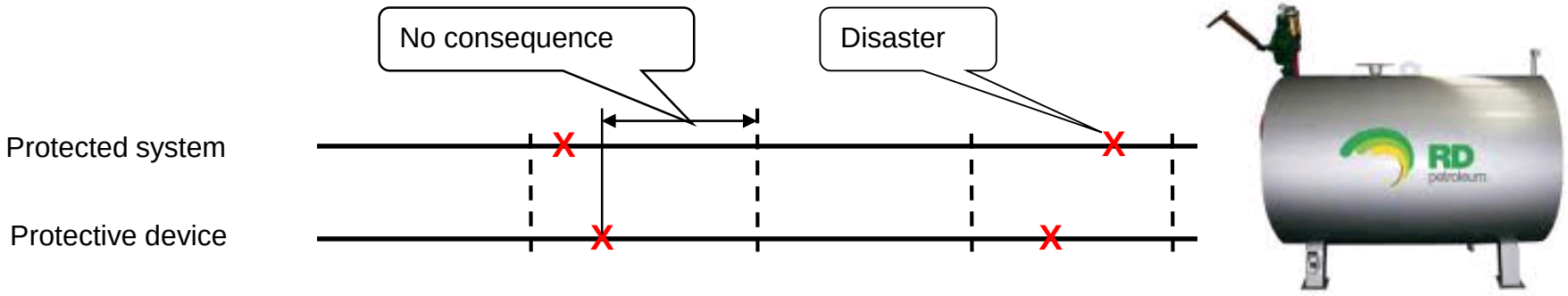
Risk-Based Inspection



From API 581

Risk-Based Inspection

- Multiple Failure: Hidden failure of a protective device does not have any consequence until a failure of the protected function (system) occurs.



$$FFI = \frac{2 \times M_{TIVE} \times M_{TED}}{M_{MF}}$$

سه رویکرد تعیین زمان بازرسی براساس اولویت

- Risk-Based
- Condition-Based
- Time-Based

تشکر از توجه شما

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