

RBI(Risk-based Inspection -

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by Lynne Kaley, P.E.

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RBI

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(JIP – Joint Industry Project)

API RBI c 1996 .

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API 580 API 581

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API 580/581

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Equity Engineering



- - 1 2 API 581
 - 2 API 580
 - API 580 581
 - RBI
 - RBI
- - API RBI User Group Joint Industry Project ()
 - API 580
 - API 581
 - API 510, 570, 653
 - API 571
 - API RBI



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API 580
API 581

API RBI



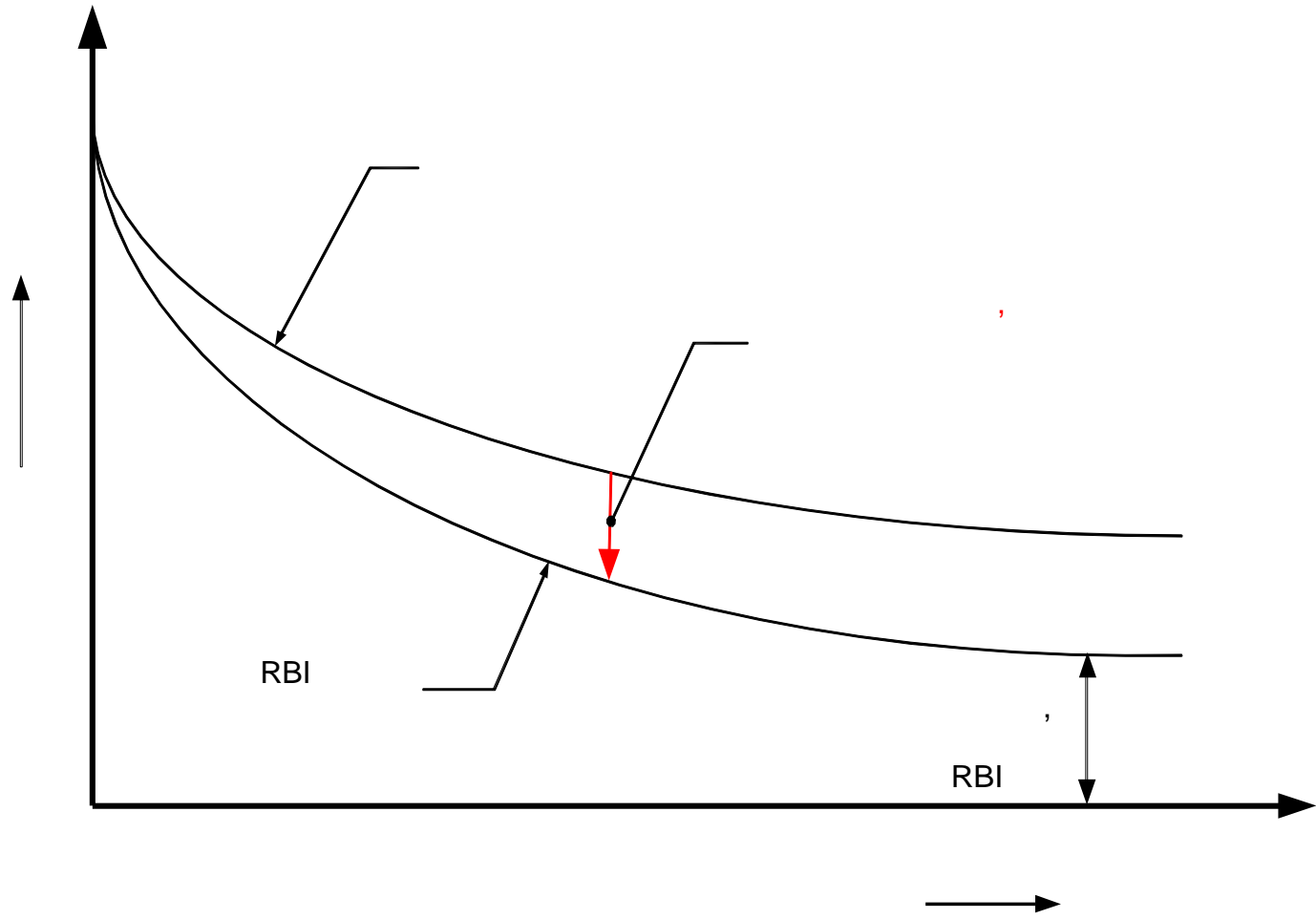
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API RBI

(JIP-Joint

- API RBI (1992 , Industry Project)

- API 580 Risk-Based Inspection - (1 , 2002)

- RBI

- 2 2009 .

- API 581 Base Resource Document - (1 , 2000)

- RBI

- API 581 API RBI (2 2008 .)

- 1: RBI
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API 580

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API RP 580

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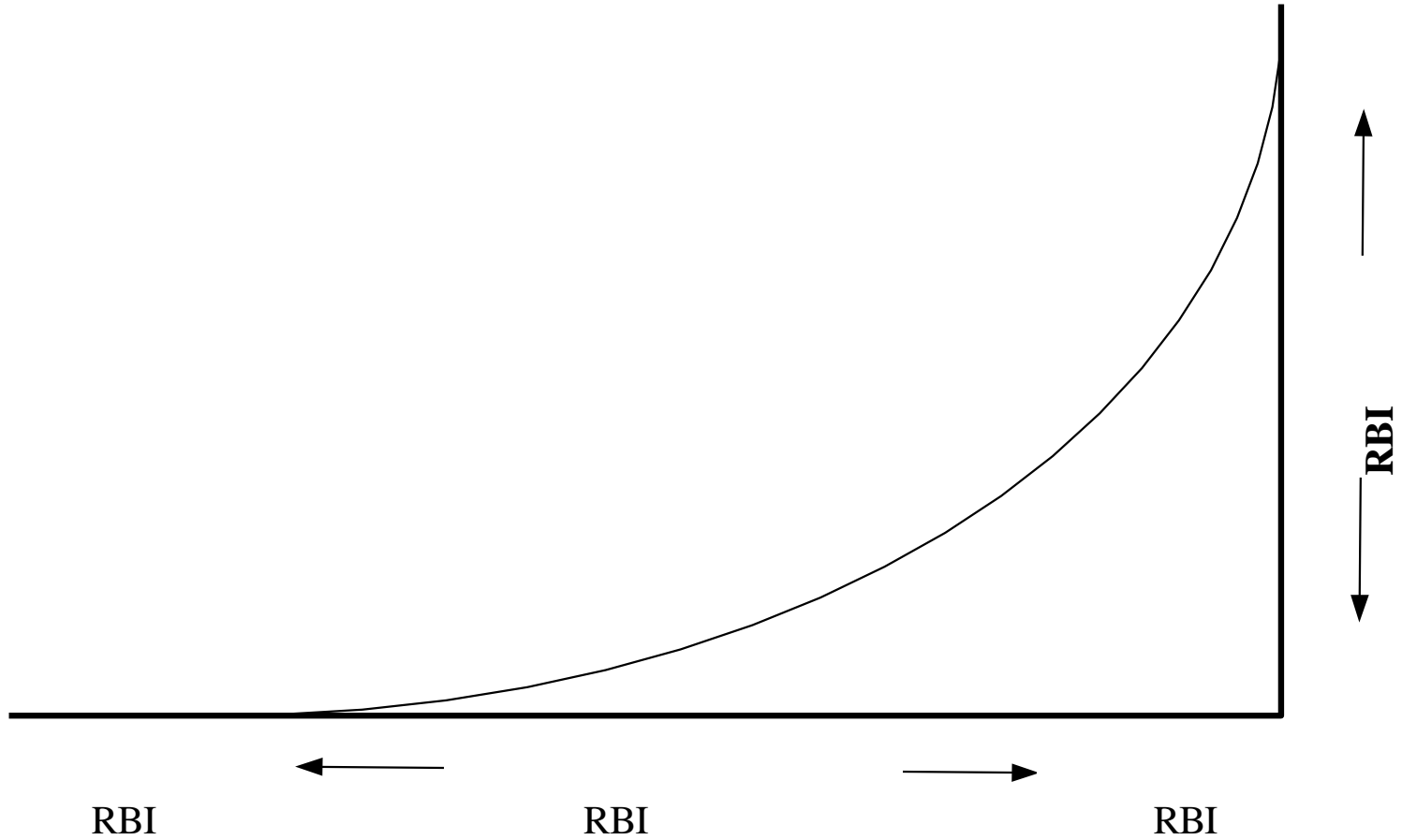
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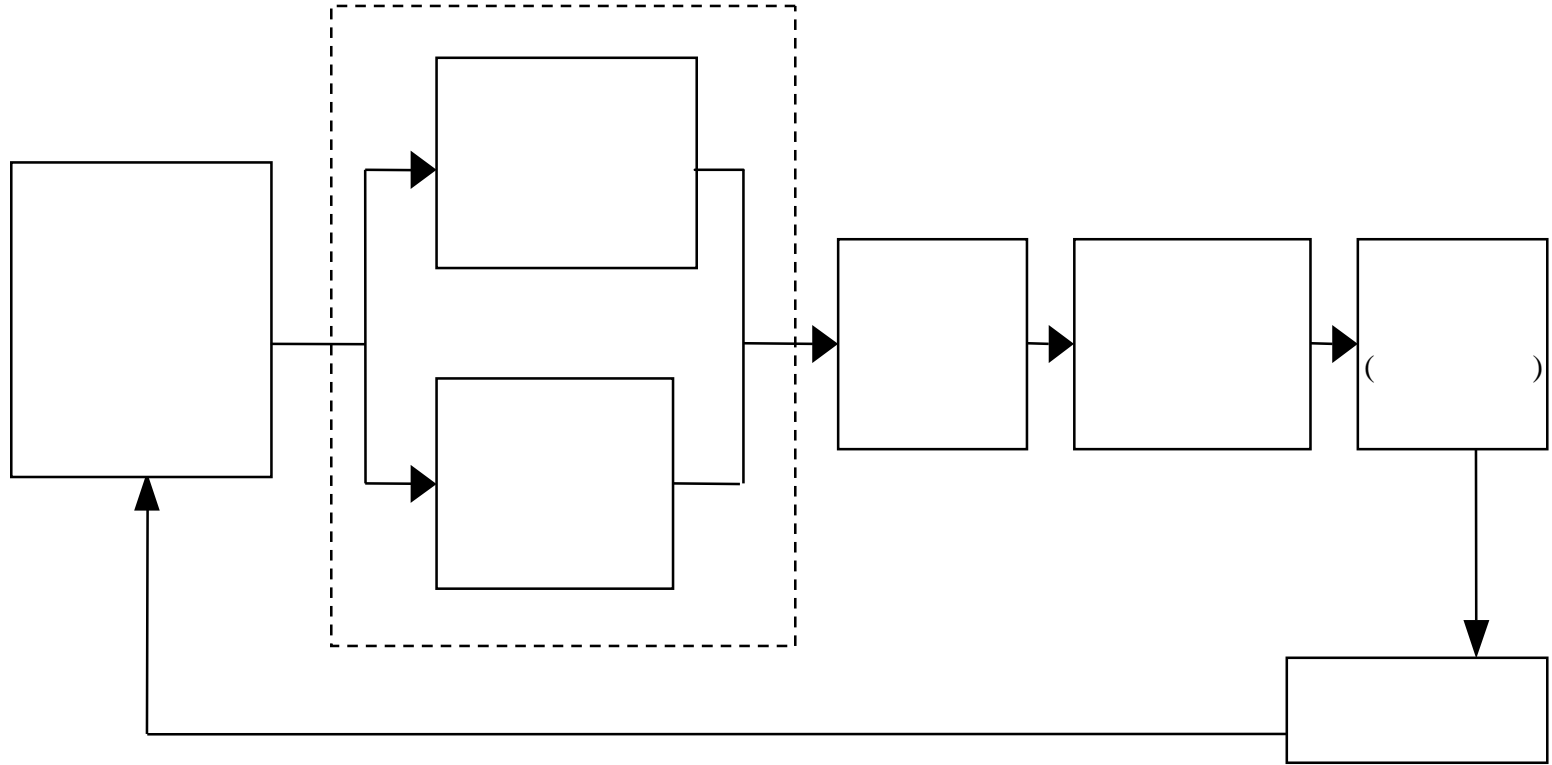
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(MOC - maintenance on
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API 510, 9

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API 510, 9

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API 580

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- maintenance on condition)
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API 581

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API RBI 581 2

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RBI

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$$(t) = (t) \bullet$$

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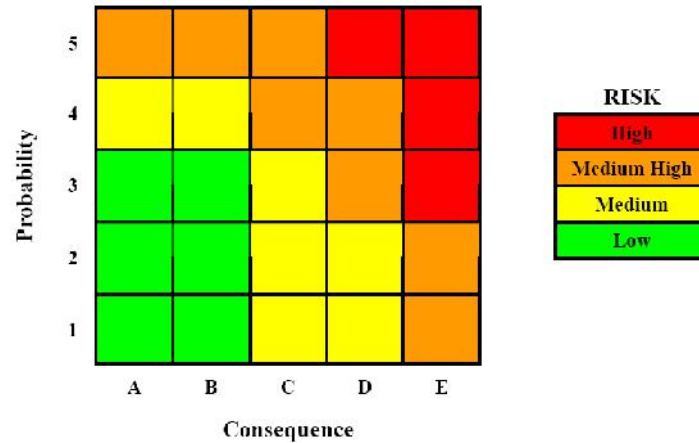
• API RBI

$$(t) = (t) \bullet ($$

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$$(t) = (t) \bullet -$$

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Numerical Values Associated with Consequence and Probability Categories in API RBI

Probability Category (1)		Consequence Category (2)	
Category	Range	Category	Range
1	$D_{f-total} \leq 2$	A	$CA \leq 100$
2	$2 < D_{f-total} \leq 20$	B	$100 < CA \leq 1000$
3	$20 < D_{f-total} \leq 100$	C	$1000 < CA < 3000$
4	$100 < D_{f-total} \leq 1000$	D	$3000 < CA \leq 10000$
5	$D_{f-total} > 1000$	E	$CA > 10000$

Notes:

- In terms of the total damage factor.
- In terms of maximum component consequence area.

$$CA = \max [CA_{cmd}, CA_{inj}]$$

- API RBI :

$$POF_t = gff \cdot D_f \cdot F_{MS}$$

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POF_t -
(Probability of Failure)

gff - (general failure
frequency)

D_f - (Damage
factor)

F_{MS} - (Management factor)

- RBI

- A_{rt} , основной материал без
 ого сл :

$$A_{rt} = \max \left[\left(1 - \frac{t_{rd} - C_{r,bm} * age}{t_{min} + CA} \right), 0.0 \right]$$

где

A_{rt} – коэффициент

t_{rd} – толщина з

$C_{r,bm}$ – скорость

age – время, пр

t_{min} – минимал

CA – допуск

A_{rt} 5.11

В

5.11 –

A_{rt}													
	E	1				2				3			
		D	C	B	A	D	C	B	A	D	C	B	A
0.02	1	1	1	1	1	1	1	1	1	1	1	1	1
0.04	1	1	1	1	1	1	1	1	1	1	1	1	1
0.06	1	1	1	1	1	1	1	1	1	1	1	1	1
0.08	1	1	1	1	1	1	1	1	1	1	1	1	1
0.10	2	2	1	1	1	1	1	1	1	1	1	1	1
0.12	6	5	3	2	1	4	2	1	1	3	1	1	1
0.14	20	17	10	6	1	13	6	1	1	10	3	1	1
0.16	90	70	50	20	3	50	20	4	1	40	10	1	1
0.18	250	200	130	70	7	170	70	10	1	130	35	3	1
0.20	400	300	210	110	15	290	120	20	1	260	60	5	1
0.25	520	450	290	150	20	350	170	30	2	240	80	6	1
0.30	650	550	400	200	30	400	200	40	4	320	110	9	2
0.35	750	650	550	300	80	600	300	80	10	540	150	20	5
0.40	900	800	700	400	130	700	400	120	30	600	200	50	10
0.45	1050	900	810	500	200	800	500	160	40	700	270	60	20
0.50	1200	1100	970	600	270	1000	600	200	60	900	360	80	40
0.55	1350	1200	1130	700	350	1100	750	300	100	1000	500	130	90
0.60	1500	1400	1250	850	500	1300	900	400	230	1200	620	250	210
0.65	1900	1700	1400	1000	700	1600	1105	670	530	1300	880	550	500

• t_{min}

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ЗНАЧАТ
ОБРАТНОСТЬ ЗАВИСИМОСТИ

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$$t_{min}^c = \frac{PR_c}{SE - 0,6P}$$

где

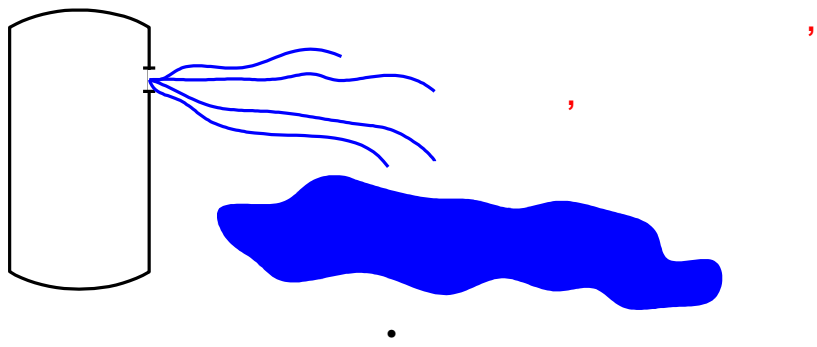
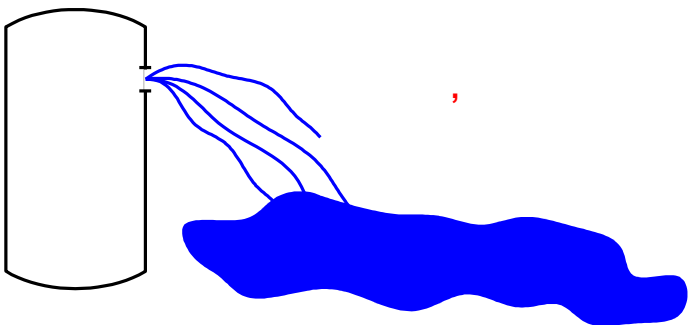
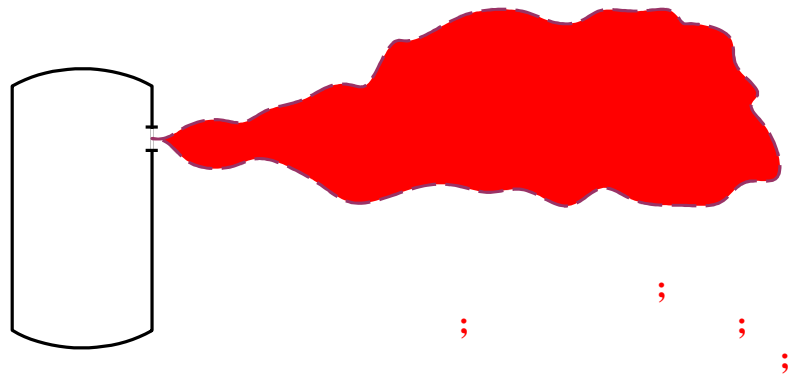
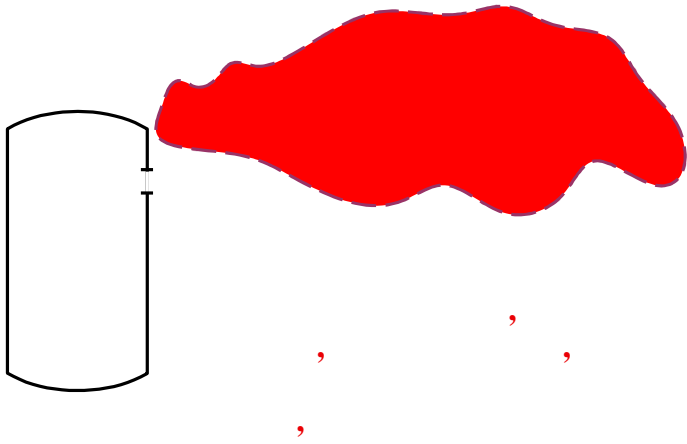
t_{min}^c -

P - n_f

R_c - pa

S - $доп.$

E - $коэф.$



- **ые последствия:** определяются как средневзвешенное по вероятности для каждого отдельного события-й ситуации

$$CA_{flam} = p * CA_{pool} + p * CA_{jet} + p * CA_{VCE}$$

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- API RBI

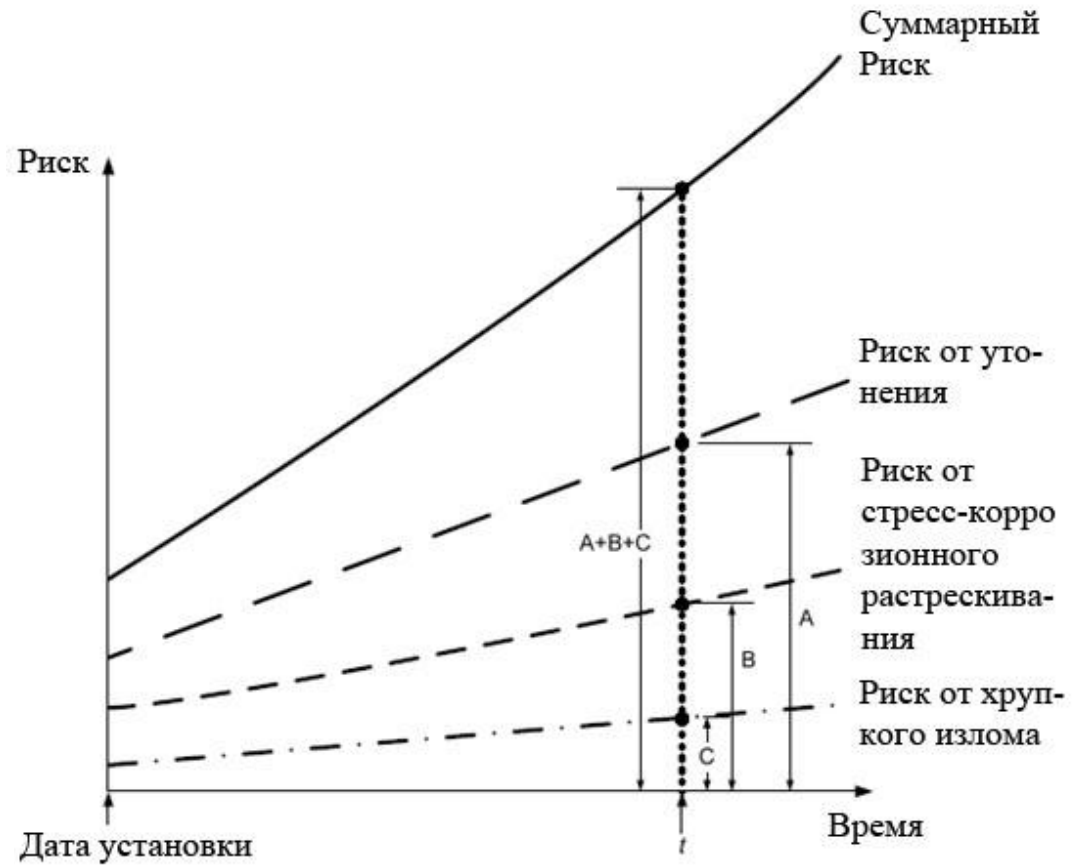


Рисунок 5 - Принцип суперпозиции для расчета Риска в API RBI

RBI

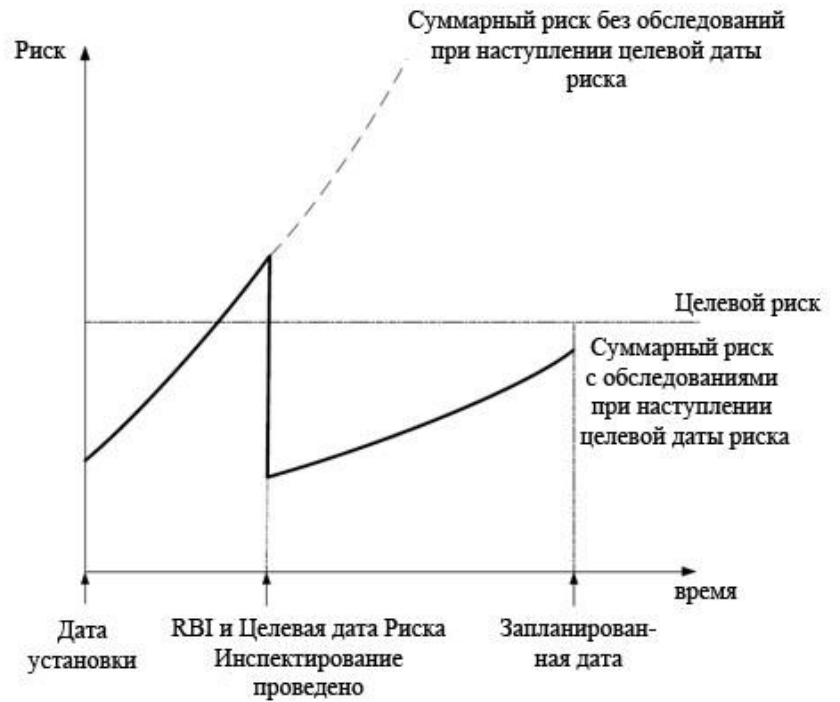


Рисунок 8 - случай 2: Планирование инспектирования когда целевой риск превышен до наступления даты RBI

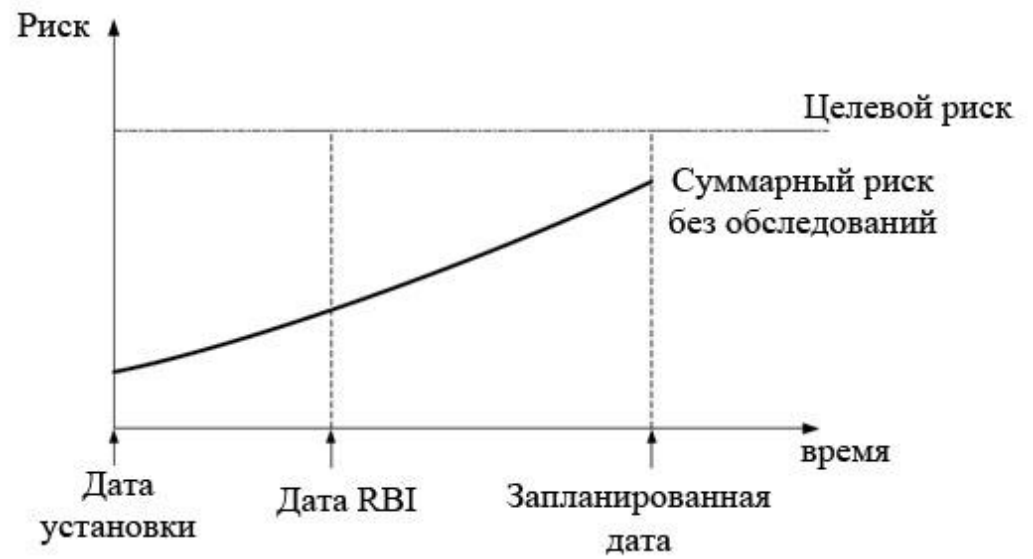


Рисунок 9 - Случай 3: Планирование инспектирования когда целевой риск не превышен до наступления запланированной даты

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API RBI

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API RBI

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API. , 47 ,
- RBI(API 581)
Standards Committee API Committee
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RBI
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- API RP 581 2008 .
- API RP 580

(H₂S)

200,000 \$/

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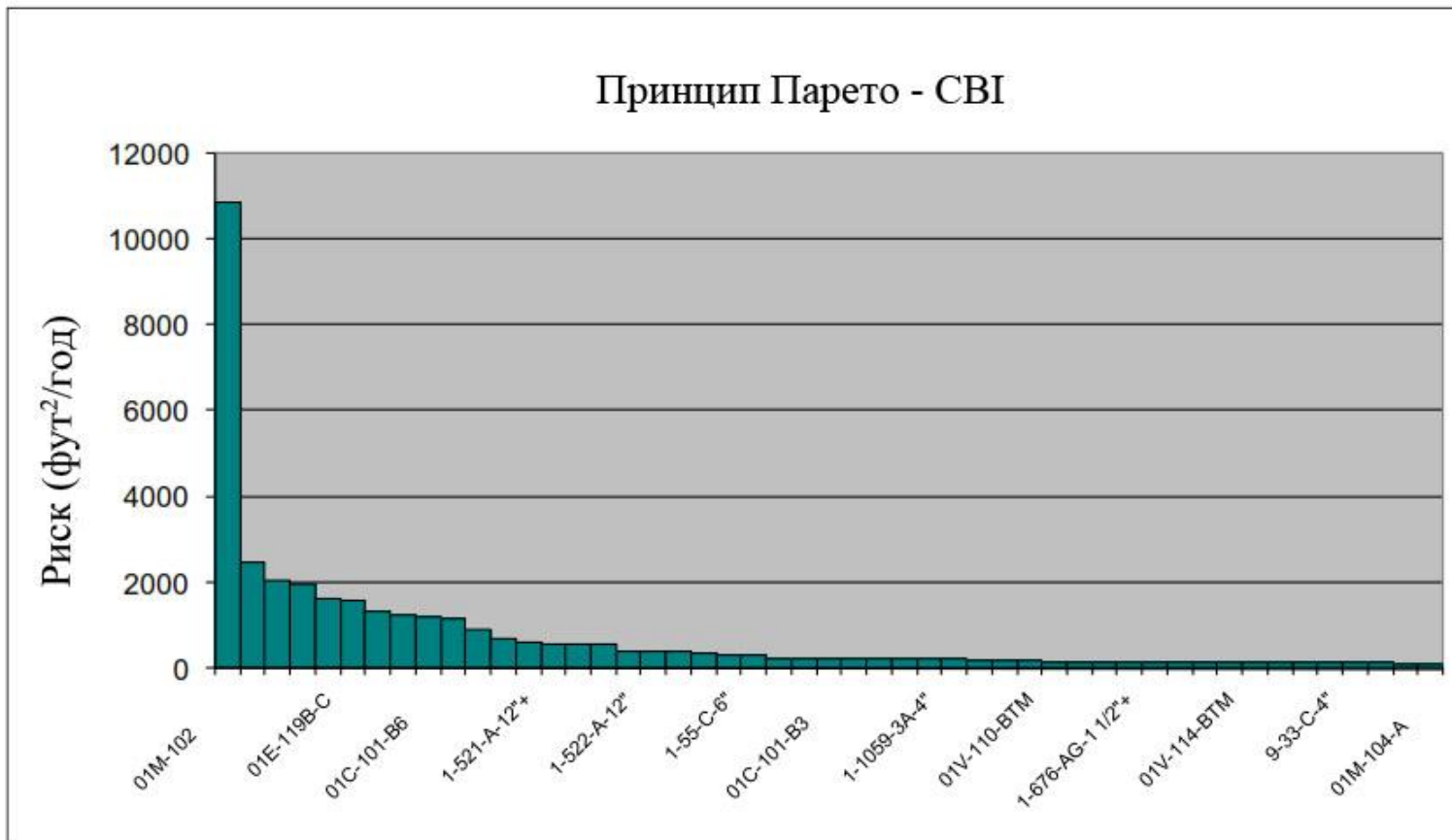
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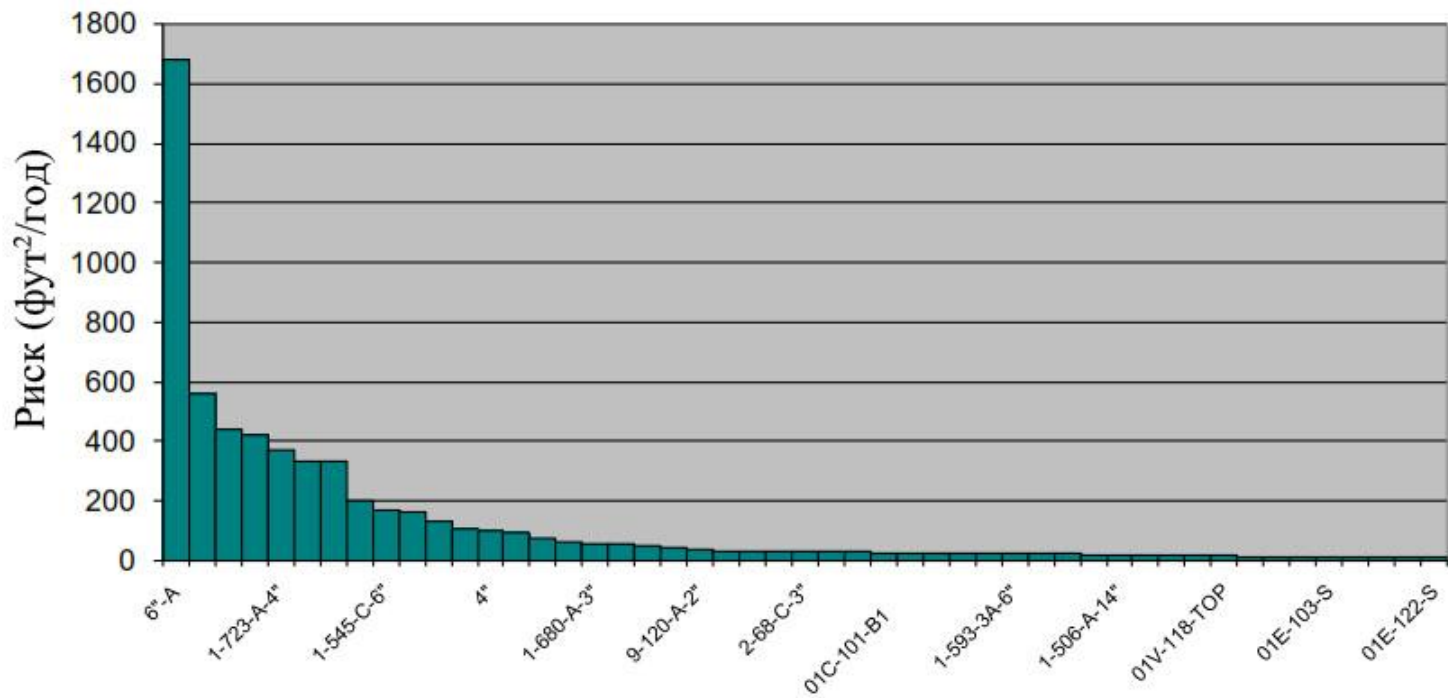
RBI

(CBI - Condition or Interval-Based inspection)
(RBI - Risk-based inspection)

Принцип Парето - СВІ



Принцип Парето RBI



- CBI = 16.5%
- RBI = 85.8%

291,500 \$
RBI 22,500 \$

-

	CBI	RBI
, ^{2/}	45,743.7	45,743.7
, ^{2/}	38,179.5	6,493.3
, ^{2/}	7,564.1	39,250.3
	16.5%	85.8%
, \$	US\$ 1,846,220	US\$ 1,554,720
, \$	US\$ 264,381,947	US\$ 264,381,947
, \$	US\$ 218,106,985	US\$ 38,571,428
	17.5%	85.4%
= /	25.1	145.2

		CBI (%)	RBI (%)	(%)
431	DIB/Deprop	11	85	74
866	Heavy HDS	2	50	48
867	SRU	21	93	72
231	Gulfiner	22	50	28
531	Amine	30	68	38
8733	SWS	30	83	53
137	Crude	4	6	2
210B	Crude	53	91	38
210C	Vac	40	68	28
865	Kero HDS	9	49	40
860	Reformer	35	91	56
862	LERU	17	85	68
864	Unifiner	10	63	53
210A	Crude	32	74	42
868	FCC	4	66	62
869	Sulfuric Alky	16	60	44

RBI

(FCC)

15,000 \$/

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API 510,

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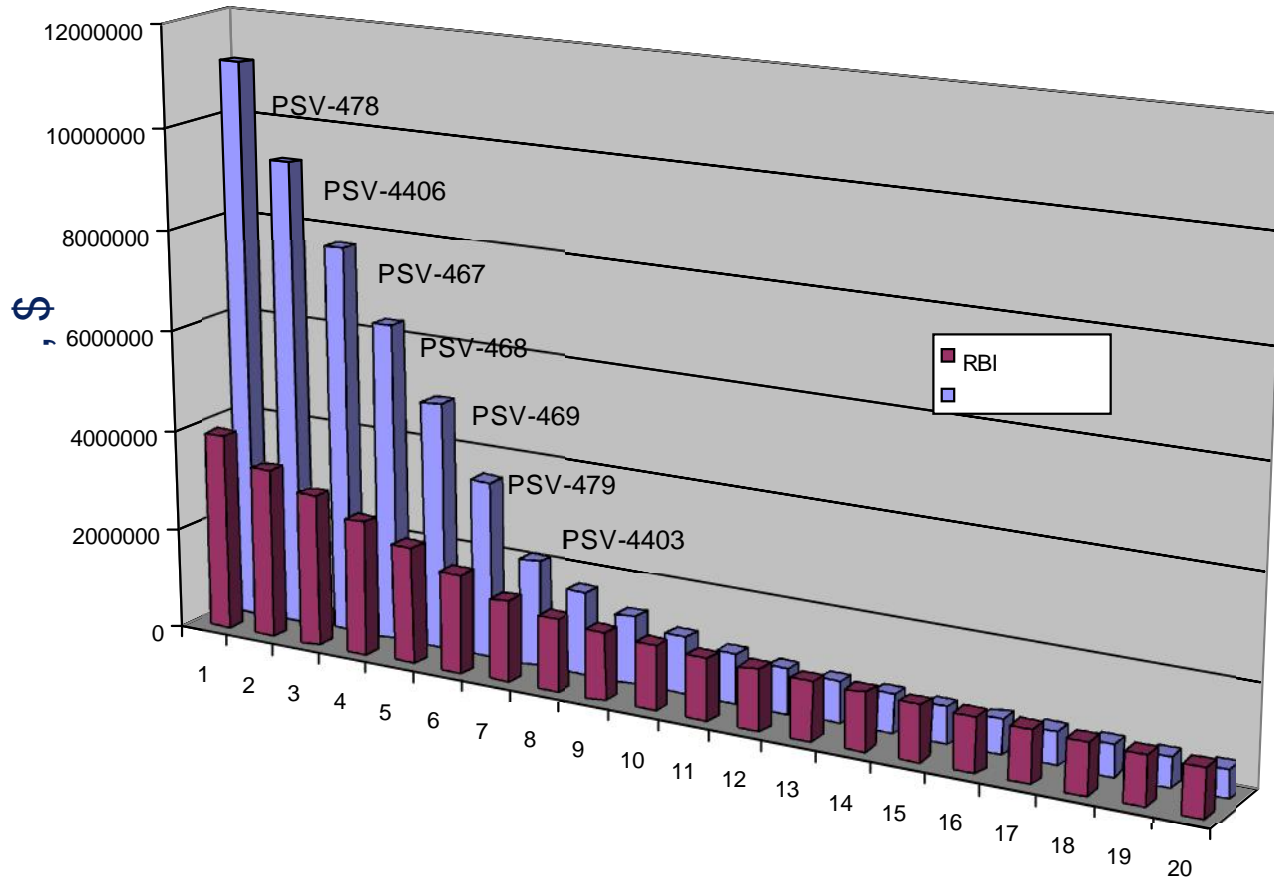
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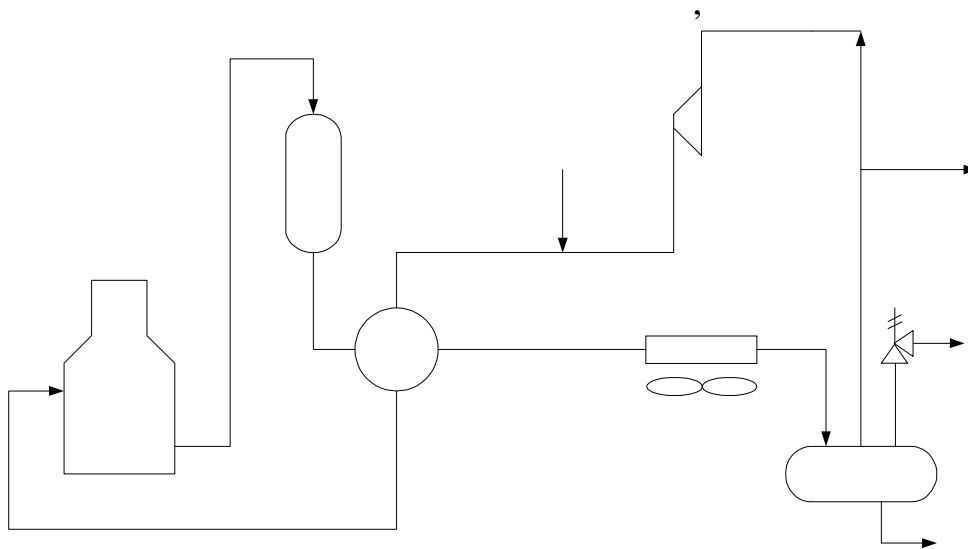
69 97

65%,

1: FCC/VRU



RBI



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- API RBI
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- , MTTF
- (mean time to failure -)
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Inspection Planning

Inspection Plan Option **PLAN**

Component **011-E-005-T2**

Crude Charge/Naptha Product Exchanger

General **CBA**

Replacement Frequency

Planned Replacement (\$/Day)	22.04
Unplanned Failure (\$/Day)	5.76
Total Cost (\$/Day)	27.79
Optimal Replacement Frequency (Yrs)	9.276031

Optimal Bundle Replacement Frequency



Decision Analysis

Turnaround Date 1 (yyyy-mm-dd)	2008-03-01
Turnaround Date 2 (yyyy-mm-dd)	2014-03-01
POF Between Turnaround Dates	0.057240085831

	Inspection	Replacement
Bundle Maintenance Cost (\$)	30000	30000
Bundle Inspection / Replacement (\$)	2000.0	44996.77
Total Cost (\$)	32000.0	74996.76999999999
Hurdle Cost (\$)	32000.0	74996.77
Incremental Risk (\$)	209958.45	209958.45
Recommendation	Inspect	Replace

Save

Help

Delete

View Plots

Recommendations

Calculate

Inspection Report

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- 60-80 %
- 10-20 %
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