

Risk Assessment

Pump Mechanical Seals in Hazardous Services

A case study on risk awareness



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Are you compliant with API-RP 751?

Are you addressing all 3 Initiating Events?

Do your Protection Layers truly constitute a Control Barrier?

Are your Recovery Measures part of your risk assessment?

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Risk assessment

Tolerability of pump seals in hazardous service

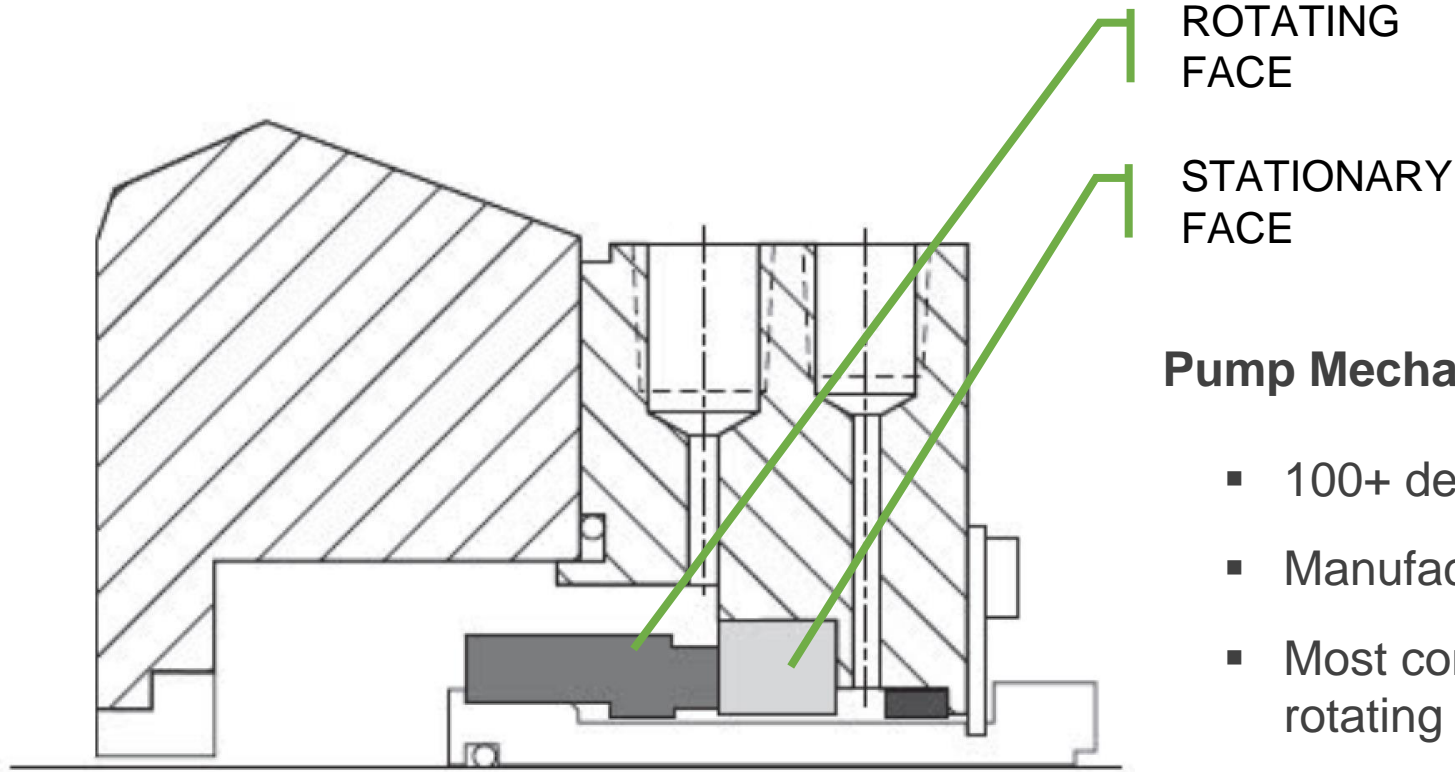


Methodology Assessment and Gap Analysis.

Provide a technical opinion and gap analysis on the current risk assessment methodology including a review of site risk assessment practices and risk matrix/model.

Risk assessment

Tolerability of pump seals in hazardous service



Pump Mechanical Seals

- 100+ designs
- Manufactured to the millionths of an inch
- Most complex design standard in all of rotating equipment (API 682)

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THREAT TO LIFE (hazardous services)

Acute Toxic (i.e. HF Acid, Benzene)

Auto-Ignition. Hydrocarbons with an operating temperature at the pump that is equal to or above the fluid auto-ignition temp

Flashing. Hydrocarbons with a specific gravity equal to or above 0.72 at ambient conditions or any flammable hydrocarbon that will readily boil in a loss of containment release to atmosphere

Risk assessment

Tolerability of pump seals in hazardous service

Meet the team...



LaKeshia Taylor
Reliability Lead



Bob Jelley
Machinery SME



Seth Tate
Machinery Lead



Ray Hinske
Process Safety SME



Chuck Lickteig
Machinery SME

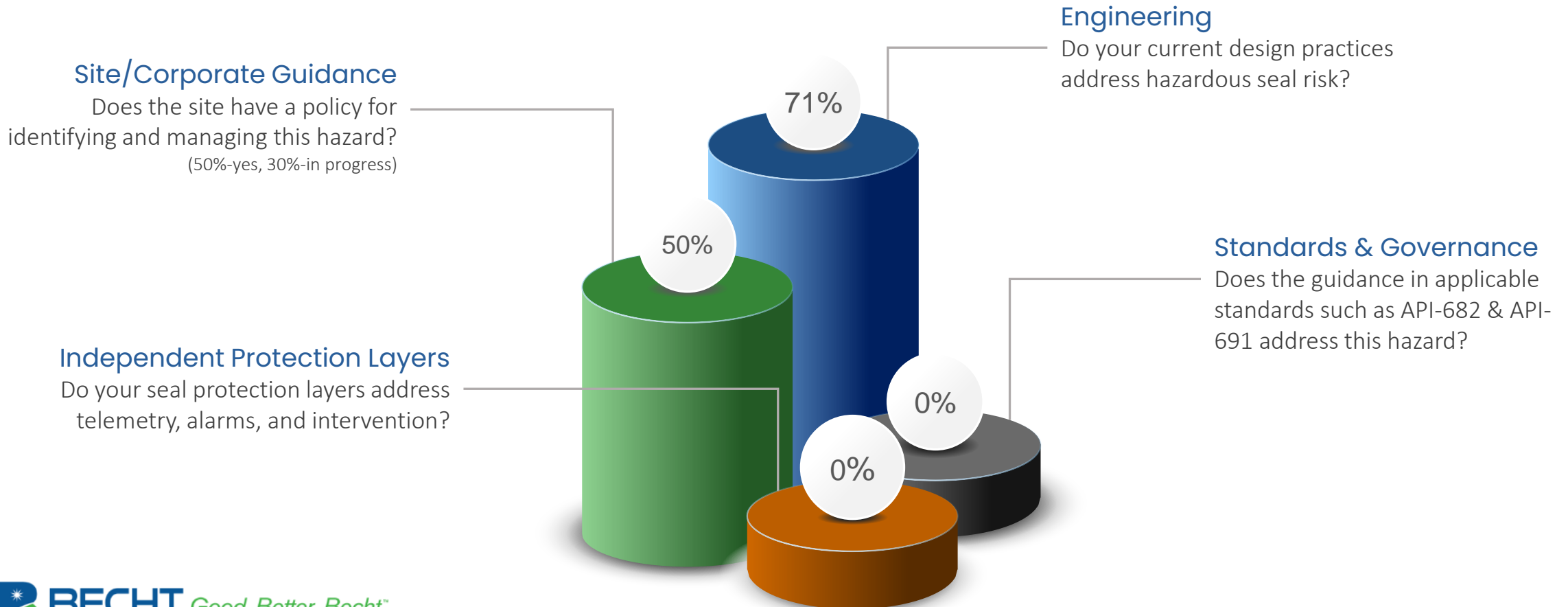


Patrick Williams
Process SME

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Tolerability of pump seals in hazardous service

Becht reached out to several refiners to learn what proactive measures are currently in place and what actions are being taken on pumps in hazardous service.



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Tolerability of pump seals in hazardous service

METHODOLOGY

RESPONSE

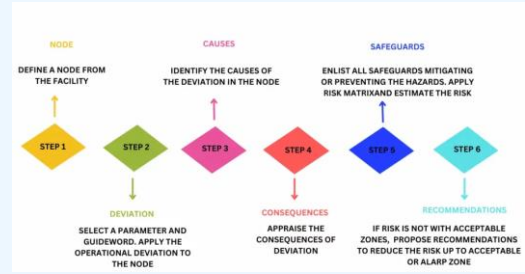
Checklist For Assessment of Different Type of Risks - (Sample Checklist)
(A) Product Size Risks
 Following generic risks are associated with the product size

Sr.	Check Point / Defect Statement	Check Mark (If the Appropriate Criteria)	
		Yes	No or N/A
1)	Estimated size of the product in LOC or FP?		
2)	Degree of confidence in estimated size estimate?		
3)	Estimated size of product in number of programs, files, transactions?		
4)	Percentage deviation in size of product from average for previous products?		
5)	Size of database created or used by the product?		
6)	Number of users of the product?		
7)	Number of projected changes to the requirements for the product? Before delivery? after delivery?		
8)	Amount of reused software?		

Note: In each case, the information for the product to be developed must be compared to past experience. If a large percentage deviation occurs or if numbers are similar, but past results were considerably less than satisfactory, risk is high.

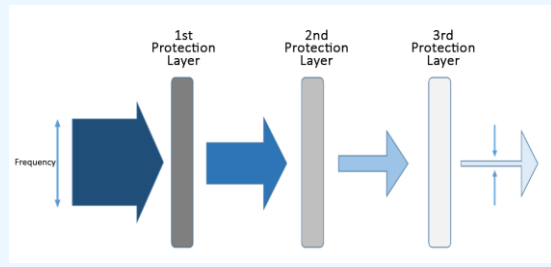
CHECKLIST

common



HAZOP

rare



LOPA

rare

Quantitative	Qualitative	1	2	3	4	5
Frequency	8 Almost Certain	High	High	High	High	High
	4 Probable	Medium	Medium	Medium	High	High
	2 Possible	Low	Medium	Medium	Medium	High
	1 Unlikely, but possible to occur during product life	Low	Low	Medium	Medium	Medium
Severity	5 Catastrophic	High	High	High	High	High
	4 Major	High	High	High	High	High
	3 Significant	High	High	High	High	High
	2 Minor	High	High	High	High	High
Safety	5 Fatal or permanent disability	High	High	High	High	High
	4 Serious injury or exposure	High	High	High	High	High
	3 Moderate injury	High	High	High	High	High
	2 Negligible	High	High	High	High	High
Environment	5 Environmental impact in short term and regional release no long-term consequences	High	High	High	High	High
	4 Environmental impact in short term, significant release with site, no long-term consequences	High	High	High	High	High
	3 Environmental impact in short term, significant release with site, no long-term consequences	High	High	High	High	High
	2 Environmental impact in short term, significant release with site, no long-term consequences	High	High	High	High	High

COF/POF

Commonly connected to HAZOP & LOPA

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Interesting findings...

HIDDEN THREATS

- Misrepresented initiating events
- **Catastrophic bearing failures**
- Dead-heading
- Overestimated value of control barriers

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CREDIT WITHOUT CONTEXT

- **Dual seals**
- Deluge
- Gas detection
- Vibration monitoring

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LACK OF GRANULARITY

- Effective operator activities
- **Effective recovery measures**
- Process temperature profile
- Vibration monitoring program
- Combined primary event (LoC) with secondary event (Exposure)

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CREDIT WITHOUT CONTEXT

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OVERCONSTRAINED

- Vibration monitoring must be wired, continuous
- **MCSF requirement vs MCTF**
- Acute toxic threats are all the same

Risk assessment

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Interesting findings...

DUAL SEALS
solve everything

Use this specific seal design
by this mfg with this specific
seal system arrangement
(i.e. John Crane 48LP with
Plan 53A)

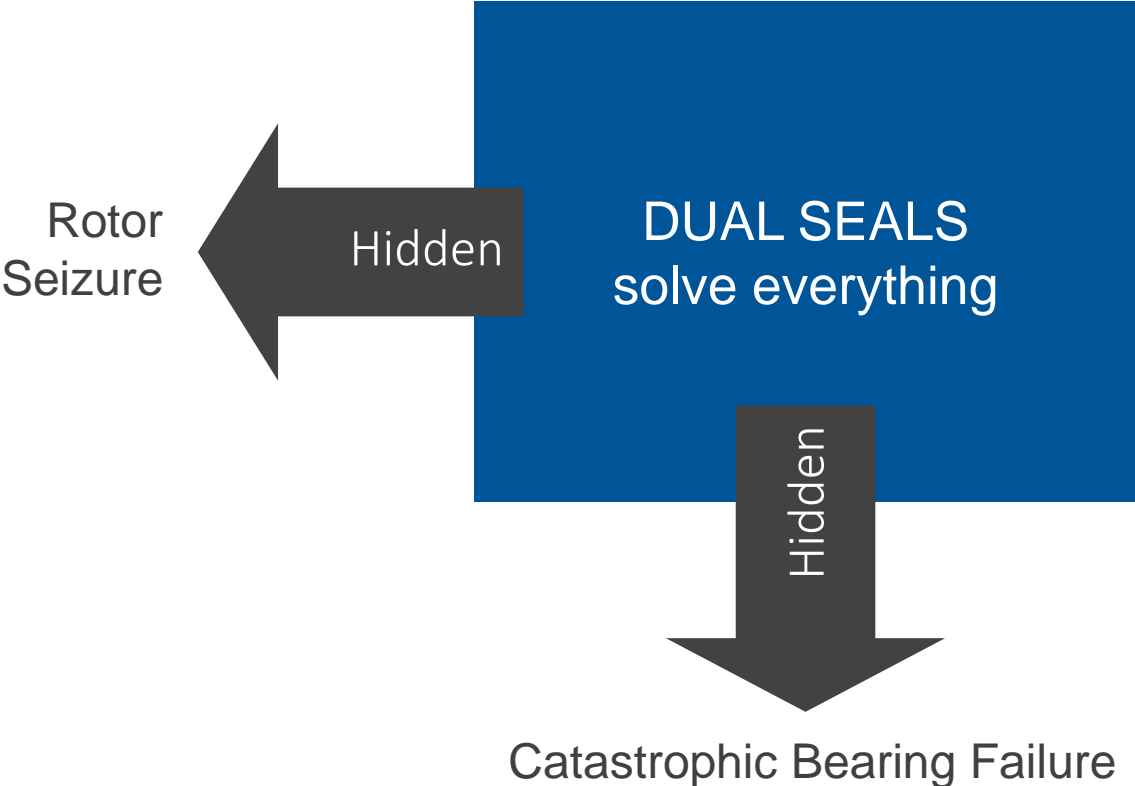
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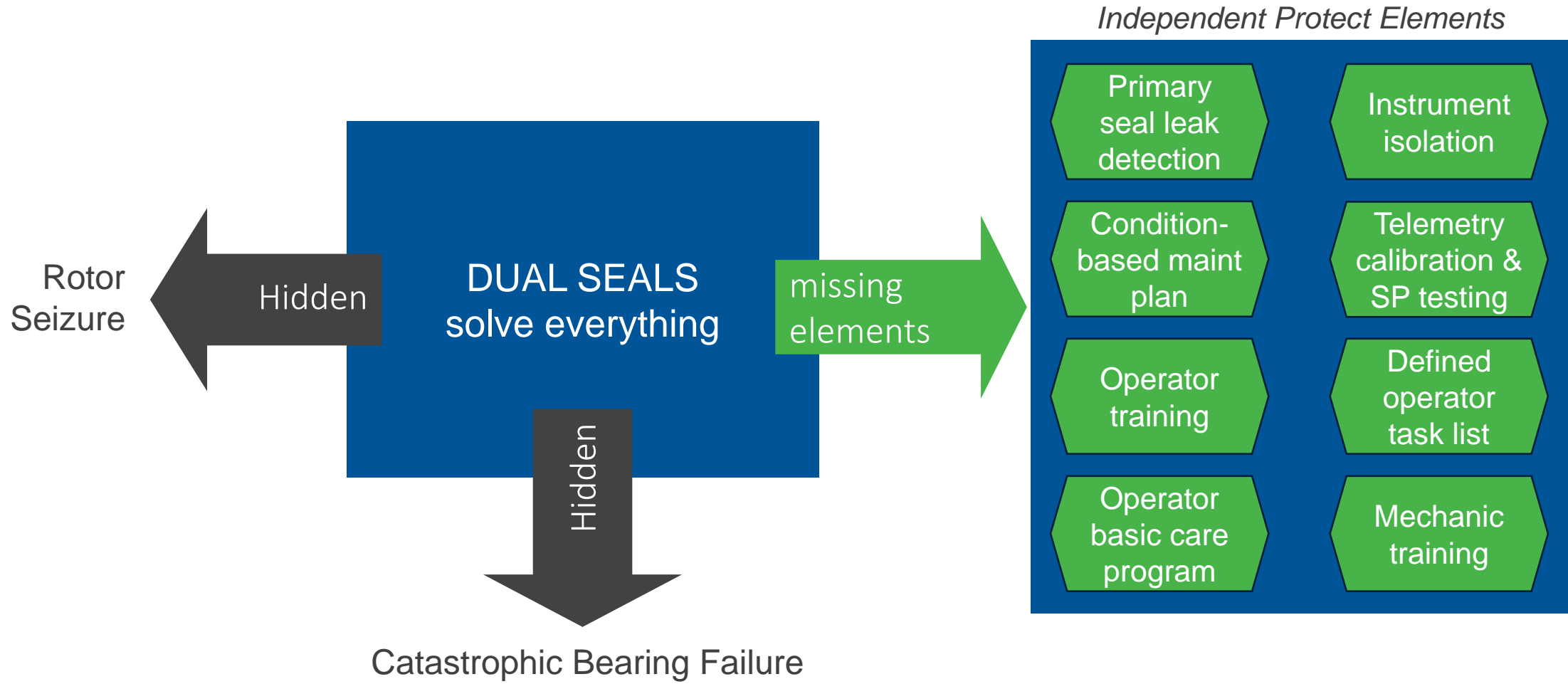
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API RP 751: Safe Operation of Hydrofluoric Acid Alkylation Units

Hidden in the language is a checklist of relevant practices:

LOSS OF CONTAINMENT PROTECTION

- Dual seals or sealless design
- Primary seal leak detection
- 7 seal effectiveness elements

- Vibration monitoring
- 7 bearing protection elements

- 13 rotor protection element

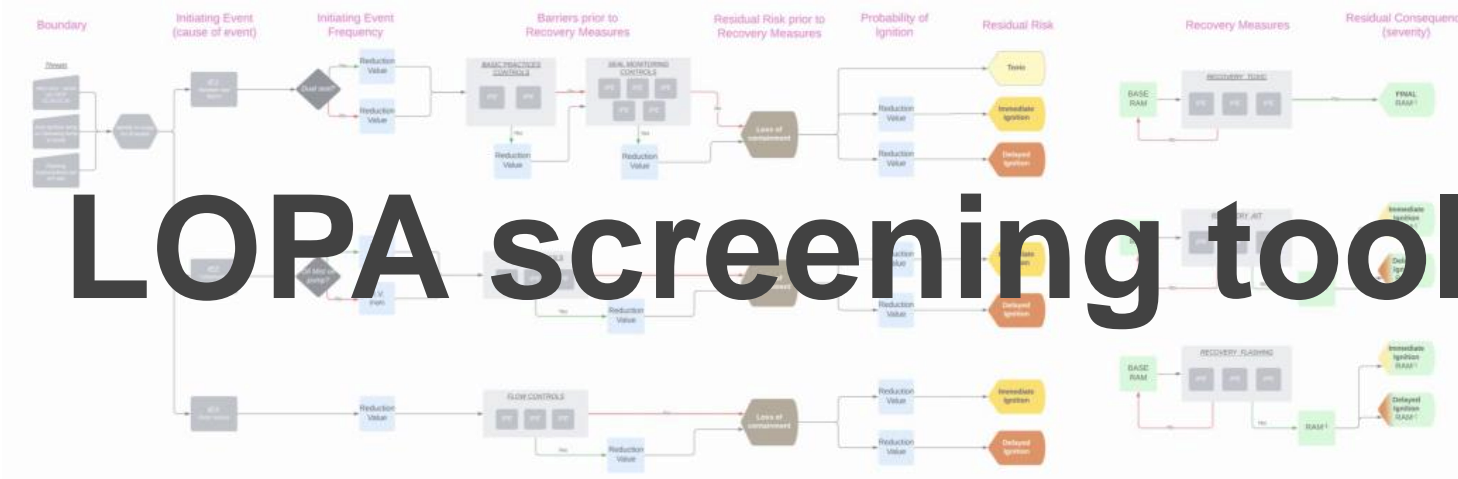
RECOVERY MEASURES

- Deluge mitigation or equivalent
- 6 recovery measure elements

- HF detectors
- 8 recovery measure elements

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LOPA screening tool



REVISION 1 JUNE 2016		RELIABILITY TECHNOLOGY MANUAL				
PAGE 1 of 1		BECHT ENGINEERING RISK MATRIX Appendix A				
Risk Levels	4 = Low Risk	Some Risk Levels will have an associated delegation of authority requirement. These requirements – if not established - are made during the ERP preparation. Typically, Level 4 is accepted without approval				
	3 = Medium Low	Level 1 is unacceptable				
	2 = Medium High	Levels 2 and 3 would require different types of approval, notifications or monitoring to accept				
	1 = High					
Probability	A	3	2	1	1	1
	B	4	3	2	1	1
	C	4	4	3	2	1
	D	4	4	4	3	2
	E	4	4	4	4	3
		V	IV	III	II	I
		Consequence →				

THREATS

Acute Toxic
Auto-Ignition
Flashing

INITIATING EVENTS

Random Seal Failure
Catastrophic Bearing Failure
Rotor Seizure

CONTROL BARRIERS

Comprised of a set of applicable Independent Protection Elements

RECOVERY MEASURES

Those activities that mitigate consequence after the primary event

RESIDUAL RISK

Quantified valuation of existing risk after control barrier and recovery measure credit is applied

HYBRID, QUANTIFIED LOPA

SITE COF/POF

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CONSIDERATIONS FOR ACTIONS

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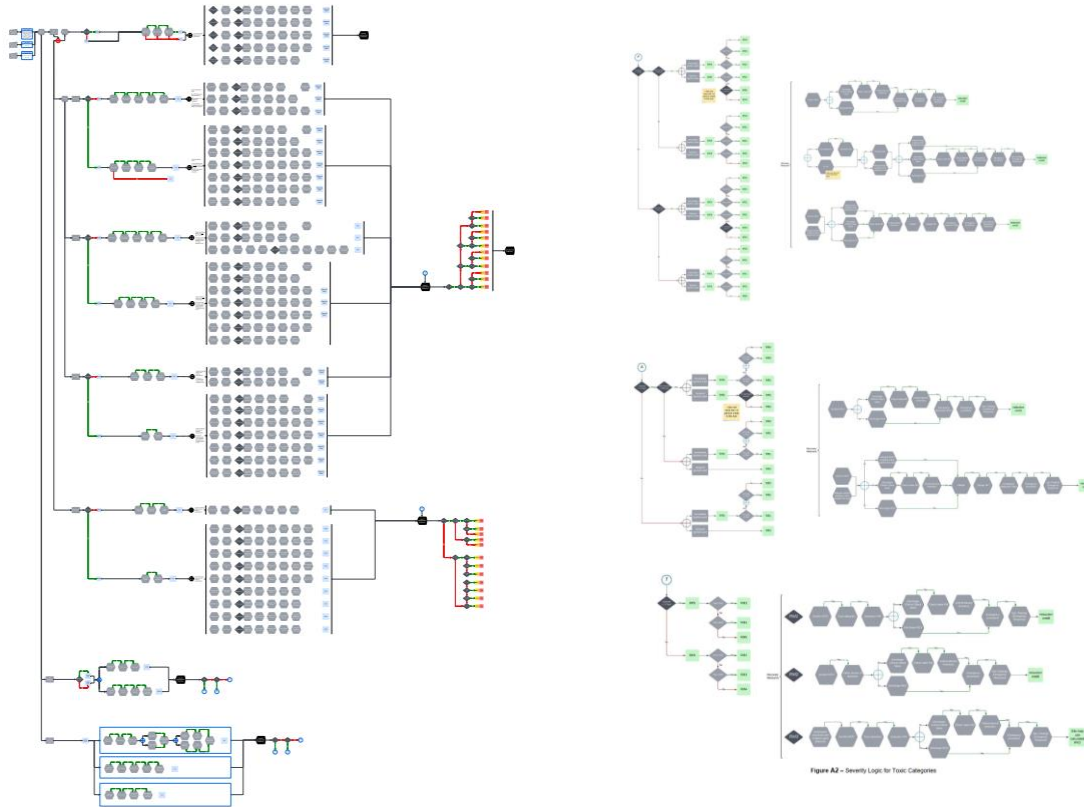
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APPENDIX

Risk assessment

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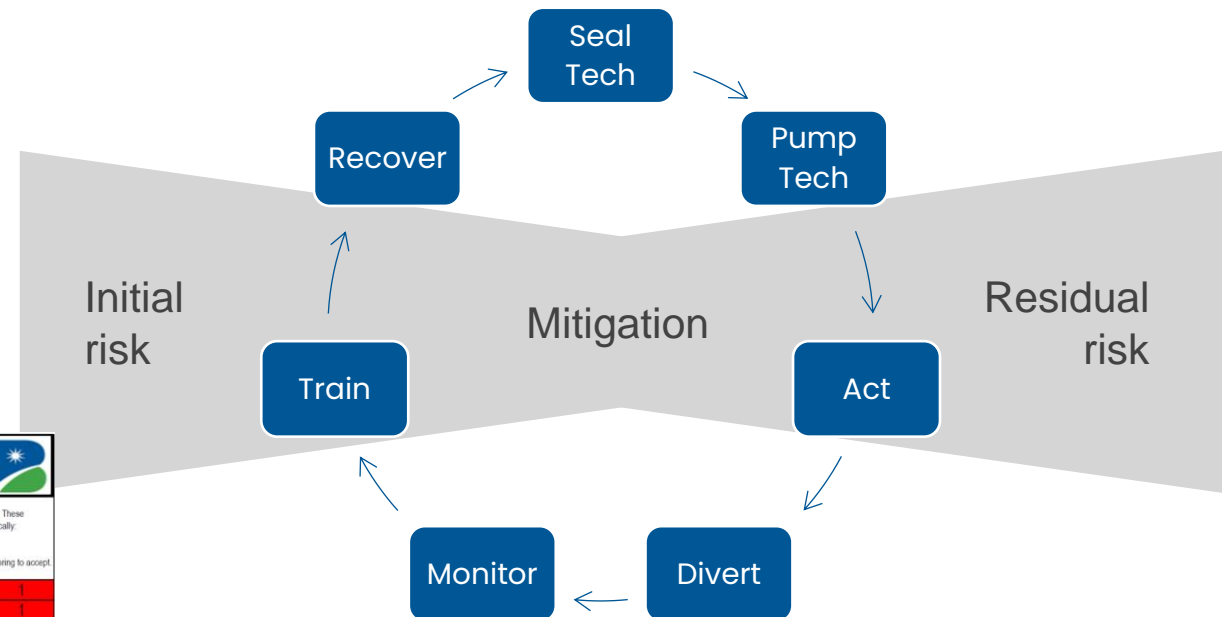
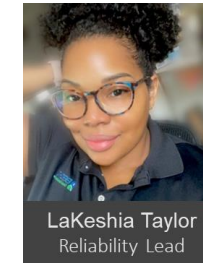
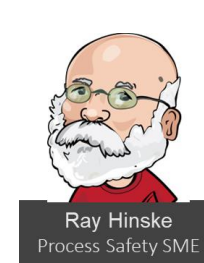
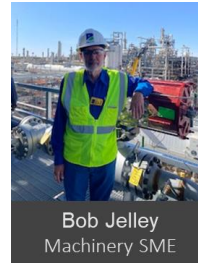
- Granularity to be flexible
- Readily accessible data
- Conclusions based in Machinery, Process, and PSM expertise
- Tool designed to turn on/off different IPEs to uncover effective options for mitigation

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Backed by industry leading expertise and guidance

1. CCPS Publication Guidelines For Determining The Probability Of Ignition Of A Released Flammable Mass
2. Health & Safety Executive (HSE) Failure Rate and Event Data for use within Risk Assessment
3. Institute of Chemical Engineers Risk-Based Approach to Centrifugal Pump Seal Selection, Symposium Series No. 161, Hazard 26
4. API Standard 610 Centrifugal Pumps for Petrochemical and Natural Gas Industries.
5. API Standard 682 Pumps-Shaft Sealing Systems for Centrifugal and Rotary Pumps.
6. API Standard 691 Risk-based Machinery Management.



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		Consequence				

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Pump Seal Risk & Remediation

? HAZOP is requiring an evaluation of our pump seal risk. Can Becht review and provide recommendations?

BECHT SOLUTION

Risk Evaluation, Remediation Recommendations, and Project Optimization

After assessing the current site methodology, Becht proposed an industry aligned, co-created LOPA based screen process specifically designed for pump seals in hazardous services (i.e. acute toxic, AIT, flammable).

CLIENT OUTCOME

Reduced remediation cost and quantified priority.

Guided by API-691, API-682, API-610, OREDA, CCPS, and HSE (UK), a new risk assessment provided flexibility while controlling common mistakes in pump seal risk analysis.



Projected cost reduction
for tolerable risk: \$24MM
(67 pumps vs 312 pumps)



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