Risk Assessment

Pump Mechanical Seals in Hazardous Services

A case study on risk awareness

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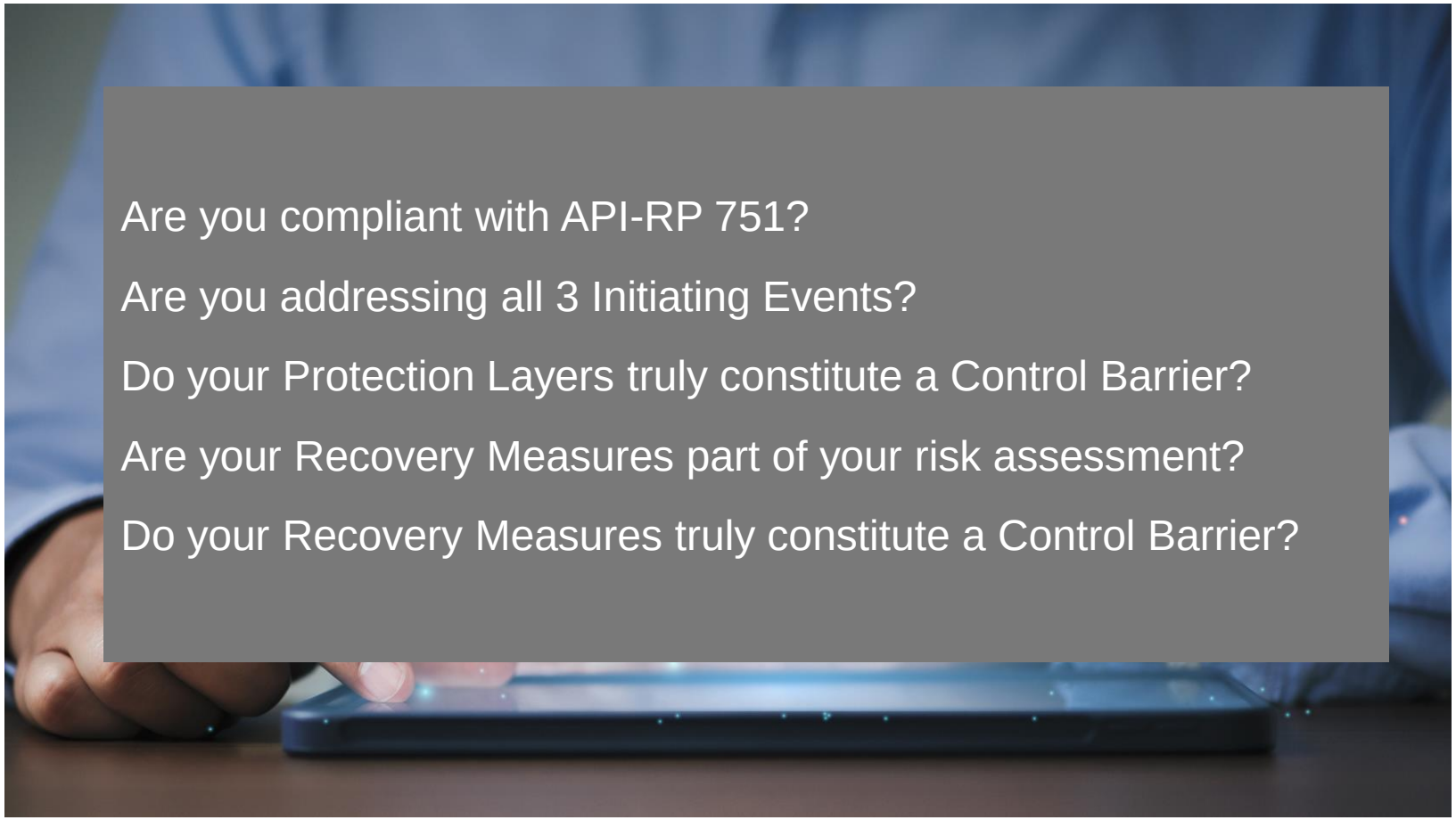


Risk assessment

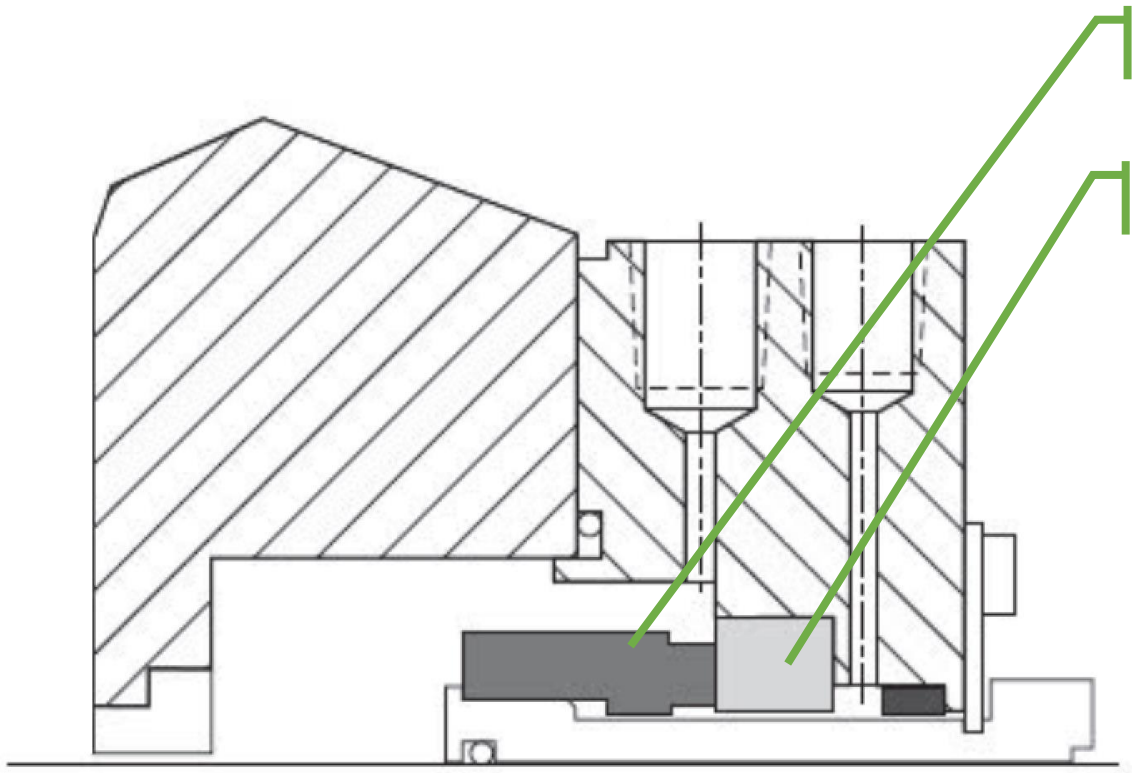
Tolerability of pump seals in hazardous service

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)

Risk assessment

Tolerability of pump seals in hazardous service

THREAT TO LIFE
(hazardous services)

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

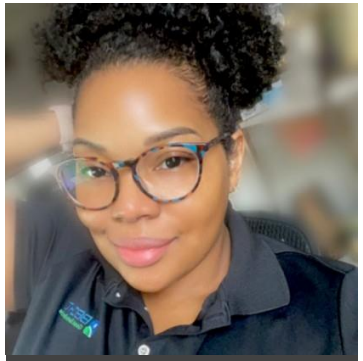
Auto-Ignition. Hydrocarbons with an operating temperature at the pump that is equal to or above the fluid auto-ignition temp

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

Risk assessment

Tolerability of pump seals in hazardous service

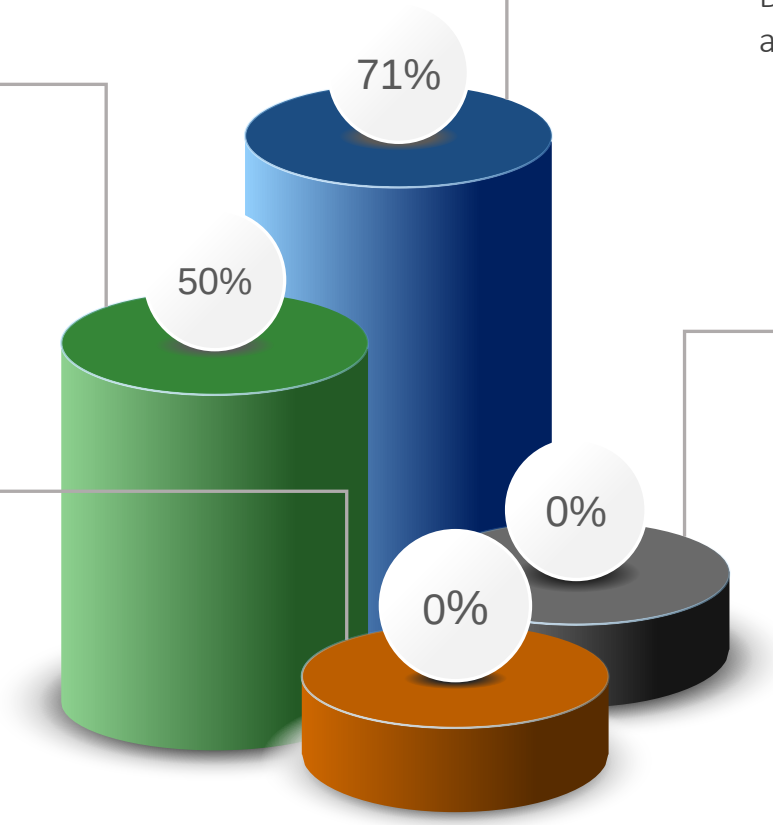
Becht reached out to several refiners to learn what proactive measures are currently in place and what actions are being taken on pumps in hazardous service.

Site/Corporate Guidance

Does the site have a policy for identifying and managing this hazard?
(50%-yes, 30%-in progress)

Engineering

Do your current design practices address hazardous seal risk?



Standards & Governance

Does the guidance in applicable standards such as API-682 & API-691 address this hazard?

Independent Protection Layers

Do your seal protection layers address telemetry, alarms, and intervention?

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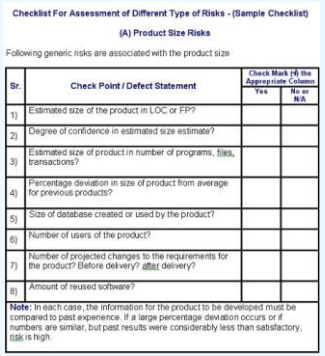
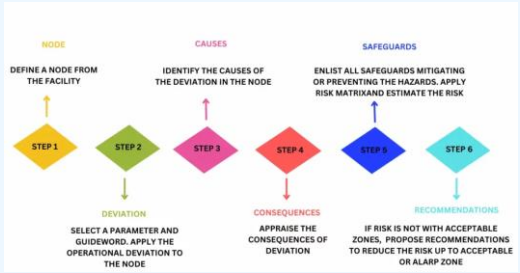
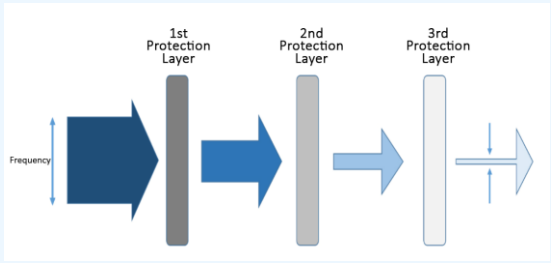
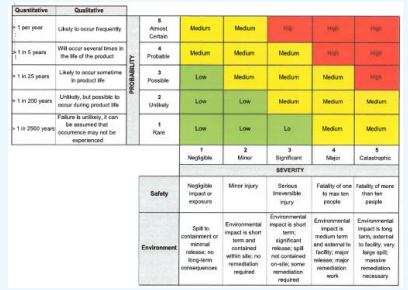
Risk assessment

Tolerability of pump seals in hazardous service

METHODOLOGY	CHECKLIST	HAZOP	LOPA	COF/POF
				
RESPONSE	common	rare	rare	Commonly connected to HAZOP & LOPA

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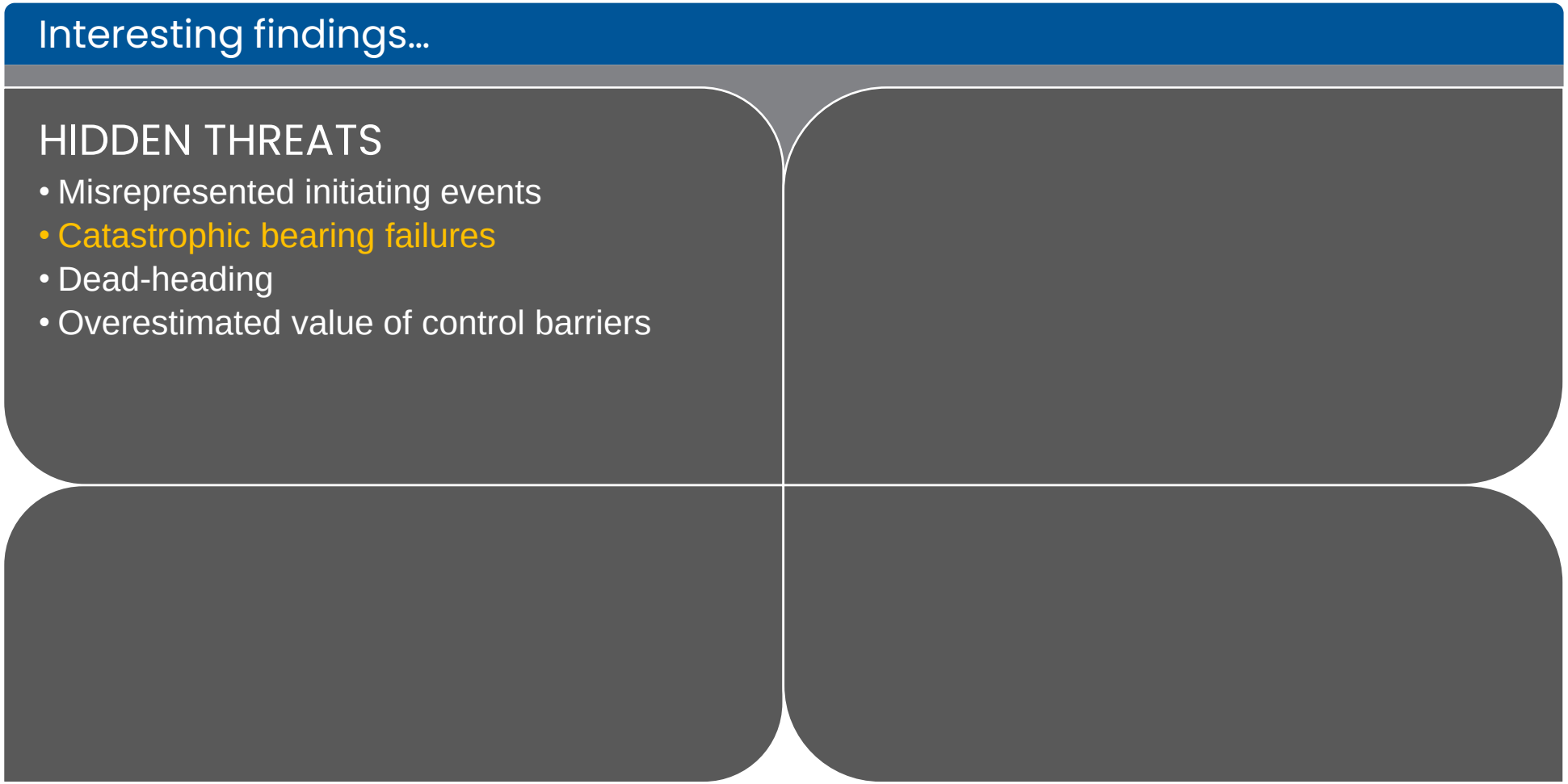
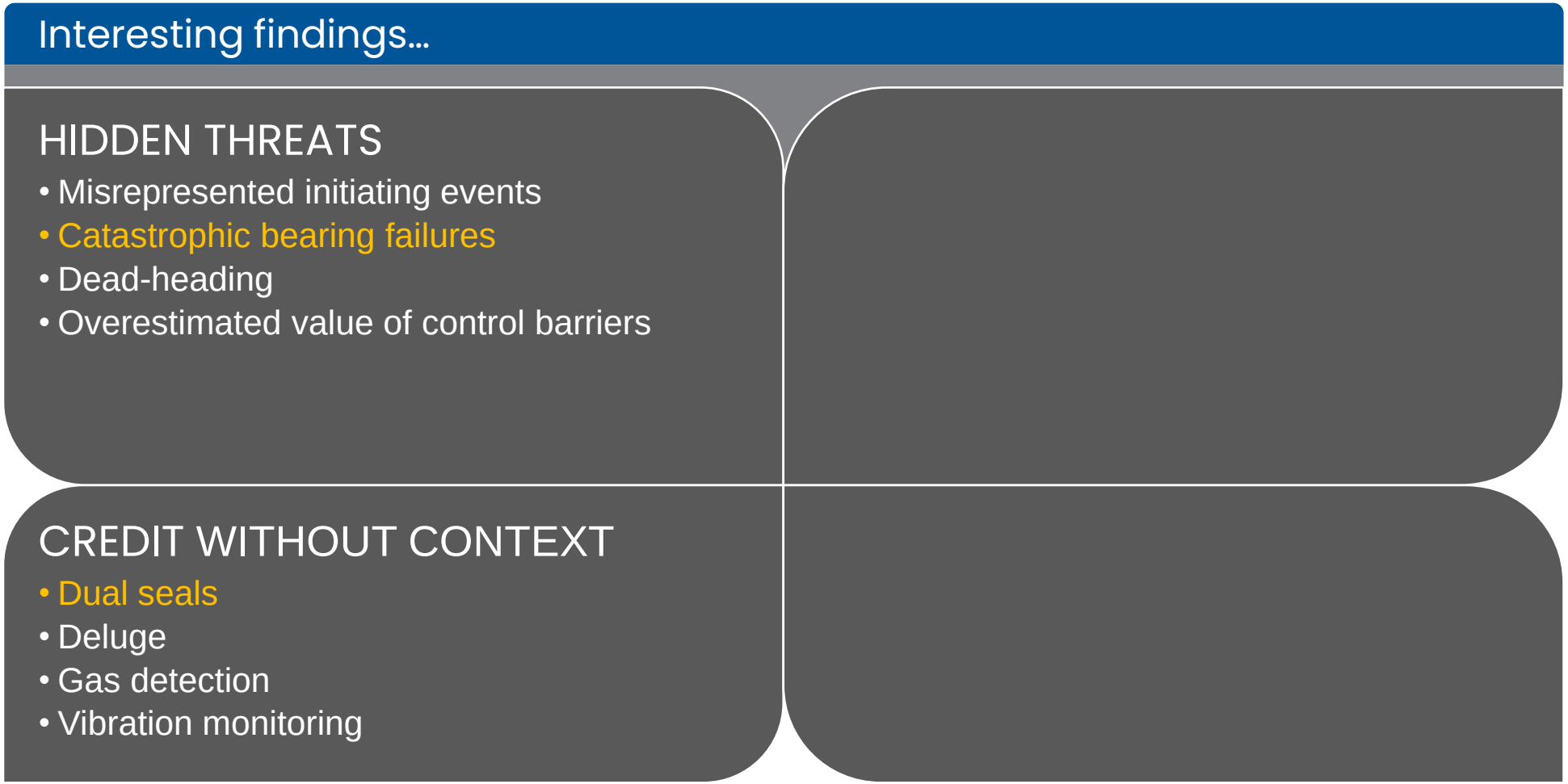
Tolerability of pump seals in hazardous service



Risk assessment

Tolerability of pump seals in hazardous service



Risk assessment

Tolerability of pump seals in hazardous service

Interesting findings...

HIDDEN THREATS

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

LACK OF GRANULARITY

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

CREDIT WITHOUT CONTEXT

- Dual seals
- Deluge
- Gas detection
- Vibration monitoring

Risk assessment

Tolerability of pump seals in hazardous service

Interesting findings…

HIDDEN THREATS

- Misrepresented initiating events
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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 (Ignition)

CREDIT WITHOUT CONTEXT

- Dual seals
- Deluge
- Gas detection
- Vibration monitoring

OVERCONSTRAINED

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

Risk assessment

Tolerability of pump seals in hazardous service

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)

Risk assessment

Tolerability of pump seals in hazardous service

DUAL SEALS
solve everything

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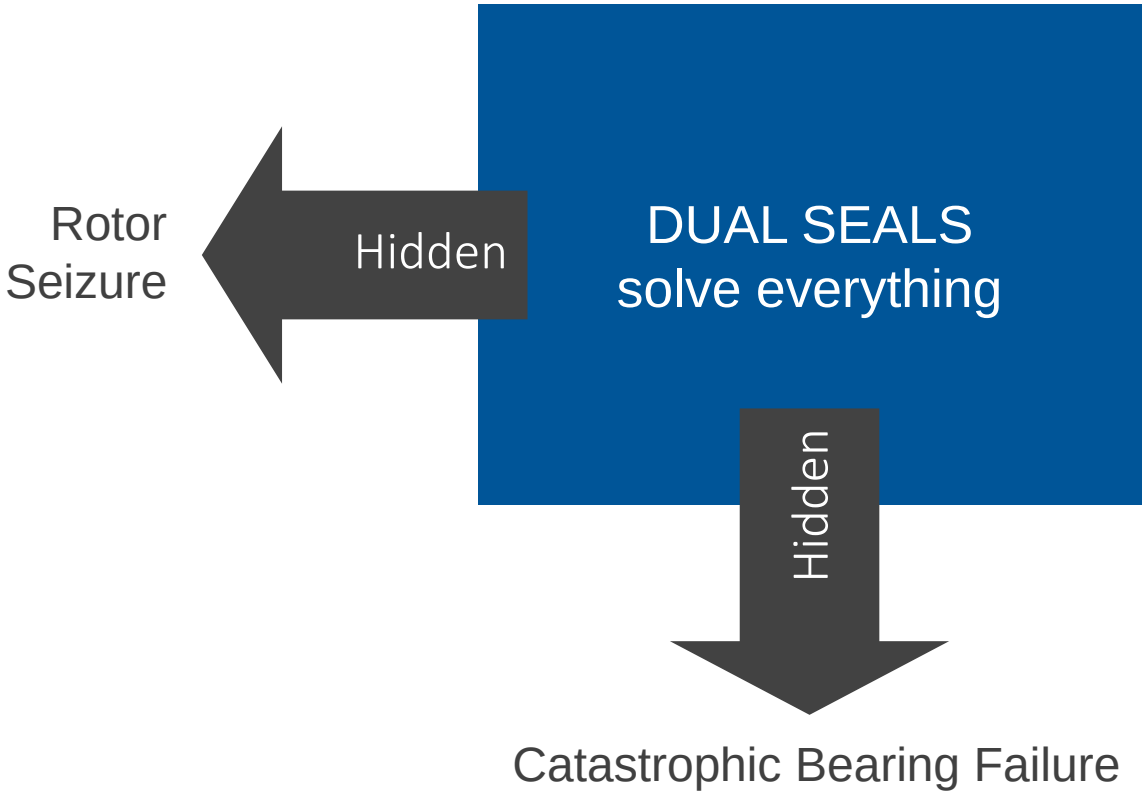
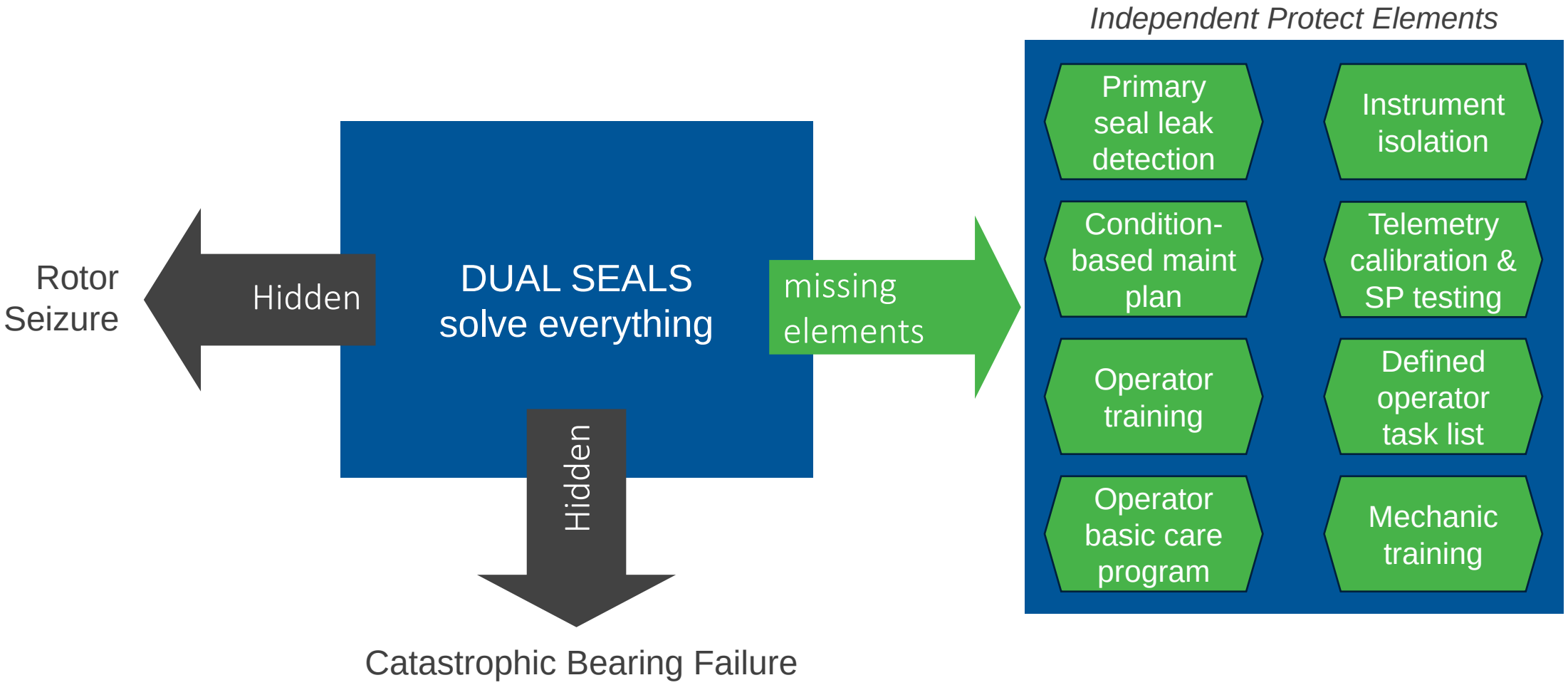


Risk assessment

Tolerability of pump seals in hazardous service



Risk assessment

Tolerability of pump seals in hazardous service

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

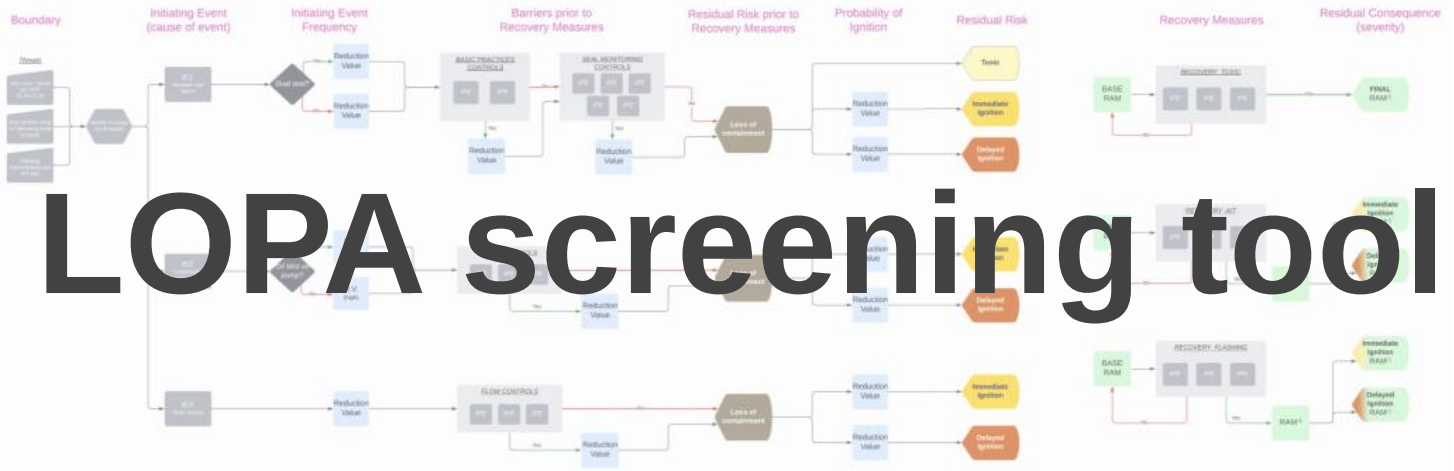
RECOVERY MEASURES

- Deluge mitigation or equivalent
- 6 recovery measure elements

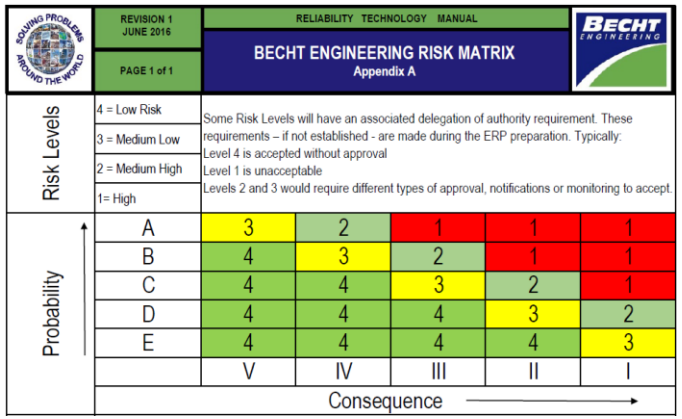
- HF detectors
- 8 recovery measure elements

Risk assessment

Tolerability of pump seals in hazardous service



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					
	2 = Medium High	Level 1 is unacceptable				
	1= High	Levels 2 and 3 would require different types of approval, notifications or monitoring to accept.				
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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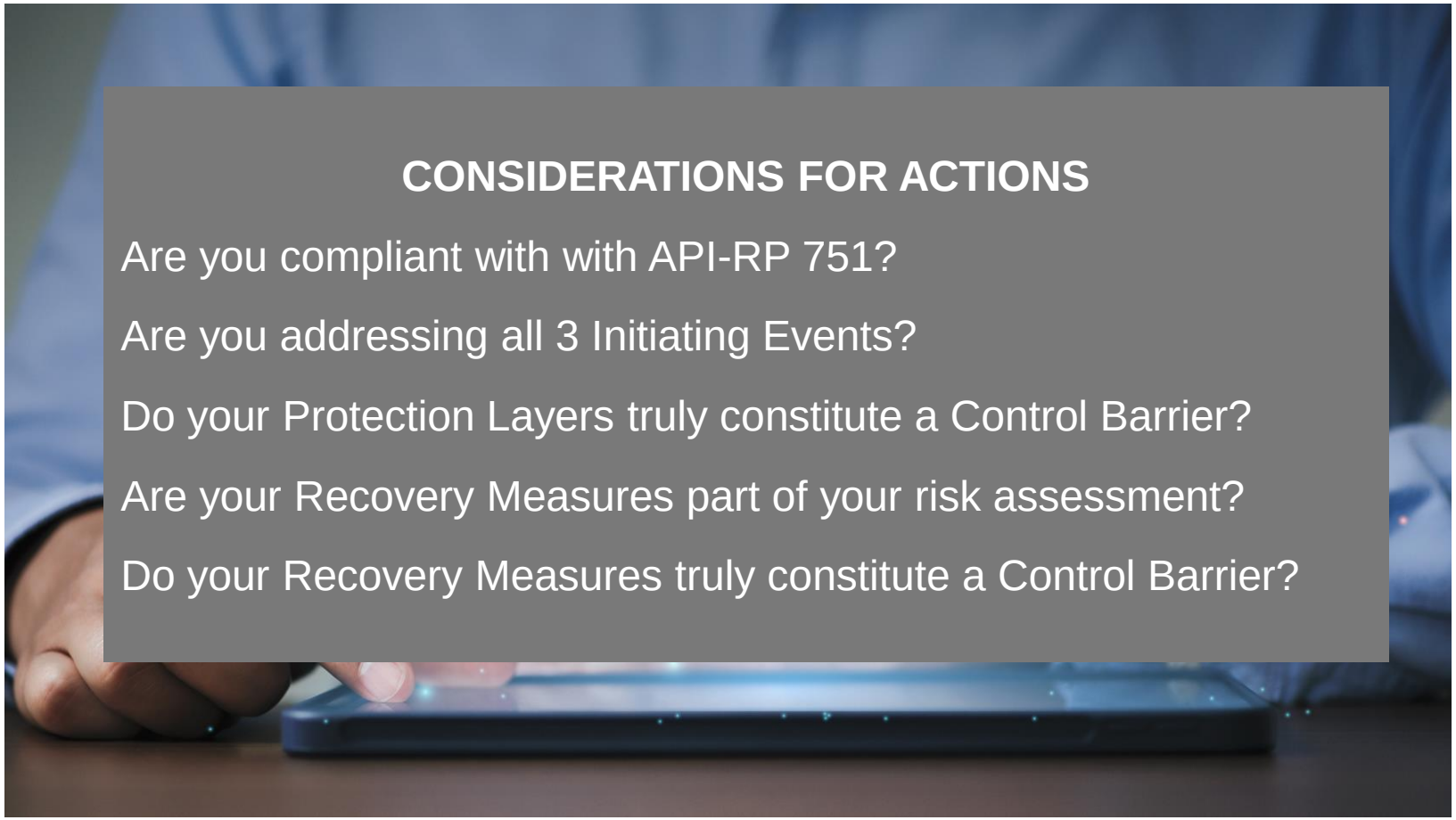

APPENDIX

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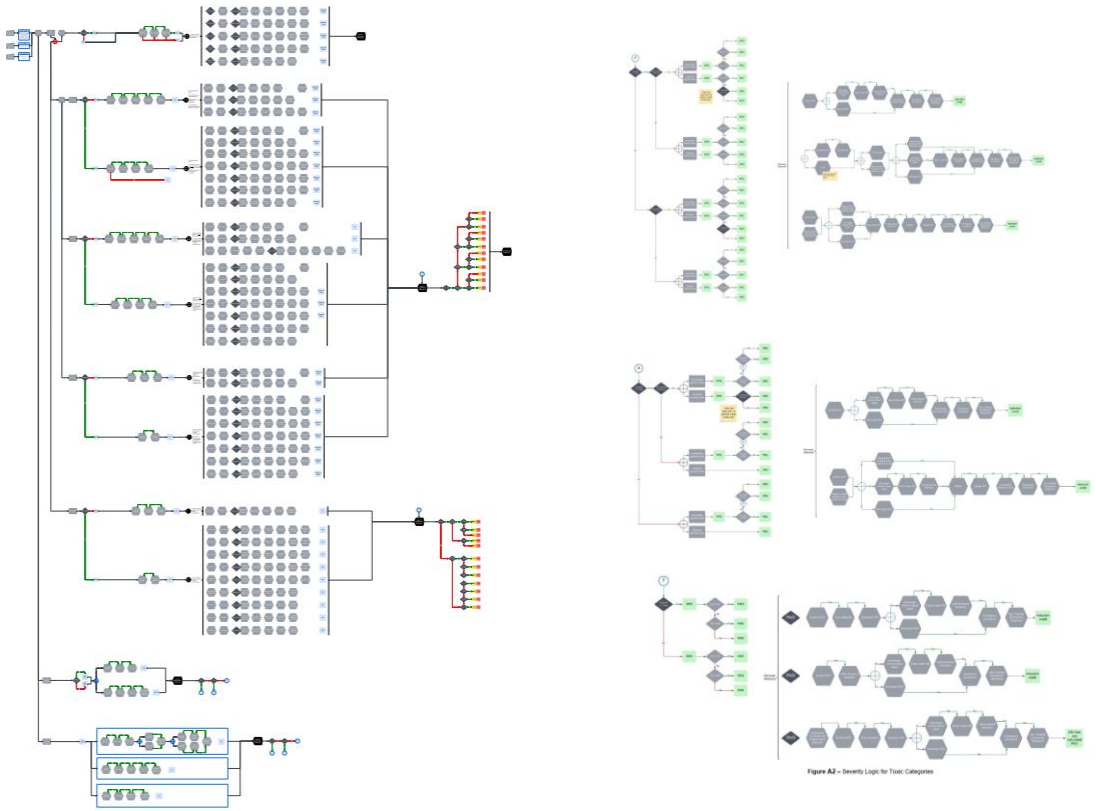


- Granularity to be flexible
- Readily accessible data
- Conclusions based in Machinery, Process, and PSM expertise
- Tool designed to turn on/off different IPEs to uncover effective options for mitigation

Risk assessment

Tolerability of pump seals in hazardous service

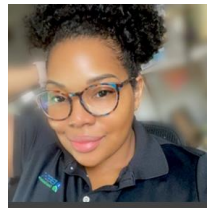
Backed by industry leading expertise and guidance


Bob Jelley
Machinery SME


Chuck Lickteig
Machinery SME

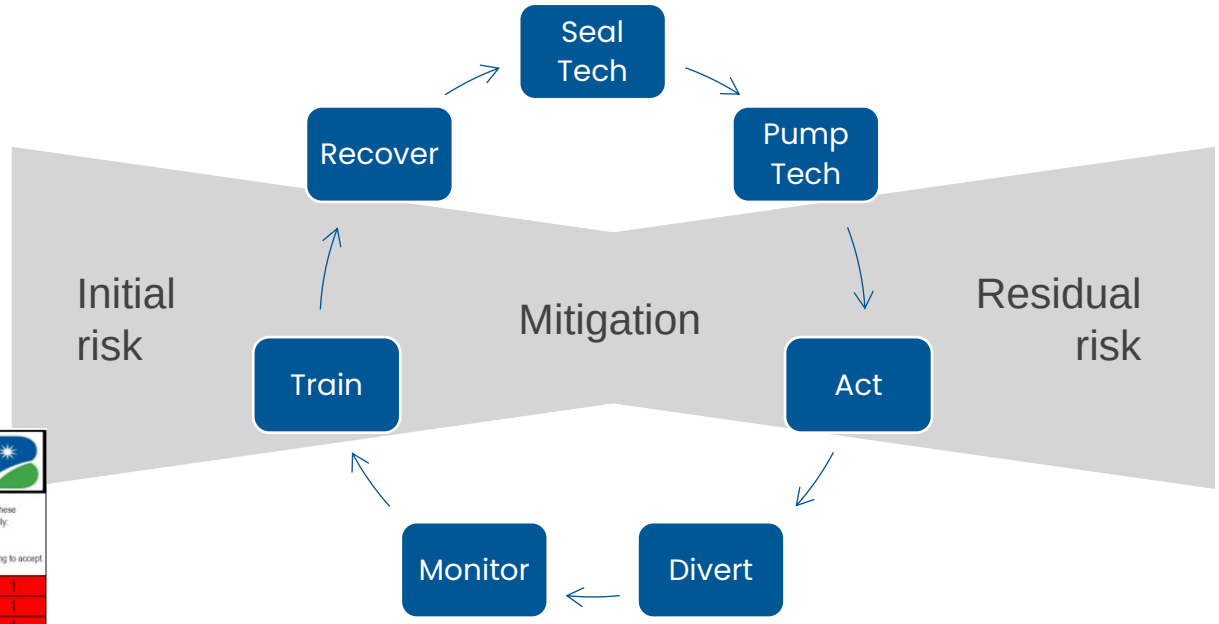

Ray Hinske
Process Safety SME

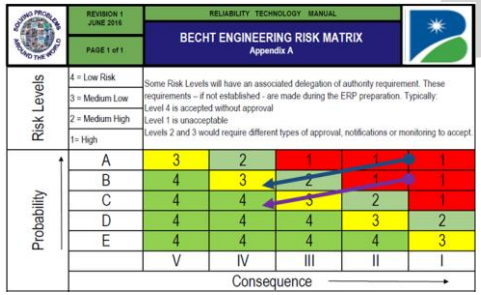

Patrick Williams
Process Safety SME


LaKeshia Taylor
Reliability Lead


Seth Tate
Machinery Lead

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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Risk assessment

Tolerability of pump seals in hazardous service

Pump Seal Risk & Remediation

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

BECHT SOLUTION

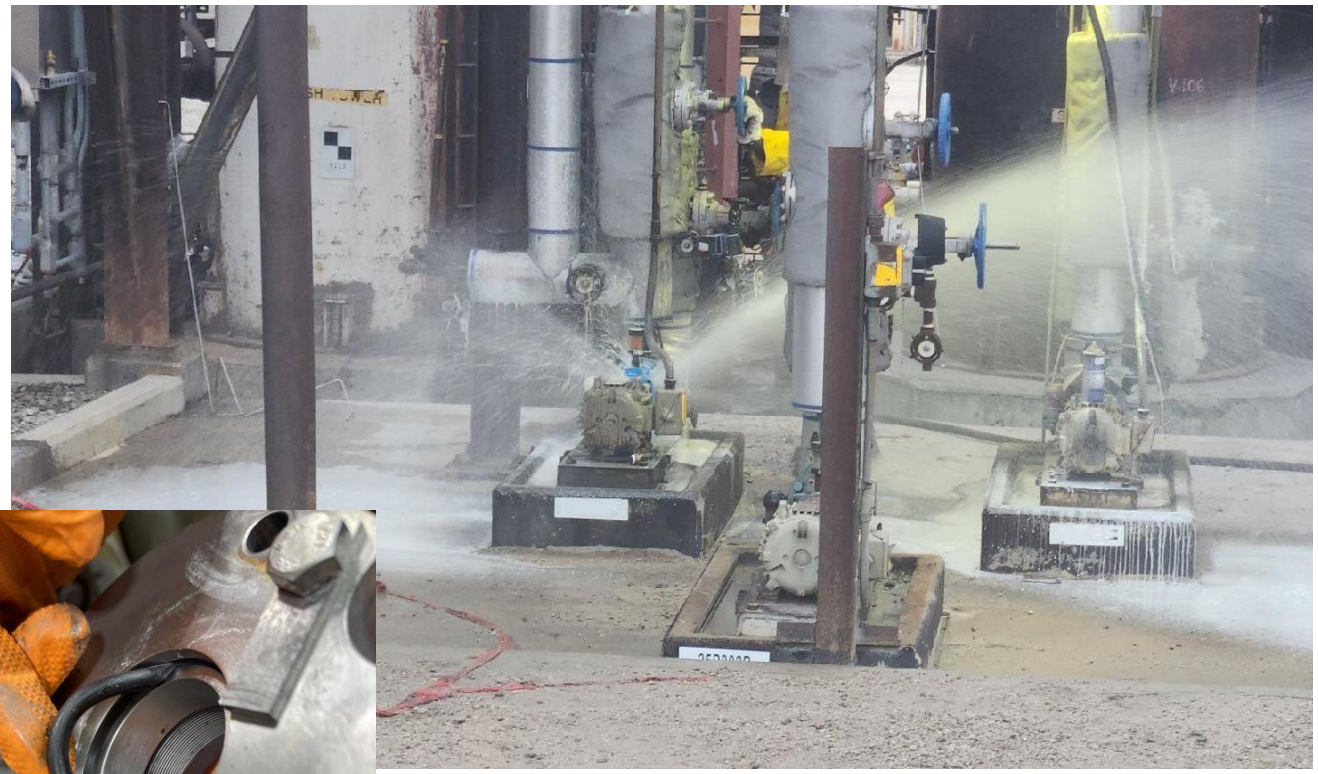
Risk Evaluation, Remediation Recommendations, and Project Optimization

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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