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Becht's Approach to Tank Integrity & Reliability Optimization

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ENGINEERING SOLUTIONS | PLANT SERVICES | SOFTWARE TOOLS | LEARNING & DEVELOPMENT

Outline

- Tank Integrity Optimization Trends
- Actions & Steps Toward Optimization
- Tools for Optimization
  - Similar Services Assessments
  - Risk Based Assessments
  - Robotic Inspections
  - In-Service Retrofits
  - Risk Based Work Selection
- Two High Value Take-Aways

Tank Integrity Optimization Trends

Intervals for Internal Inspection	Large % of owner / users	Industry	Good Actor Optimized Scenario
Initial Max	10 years	10 - 20 years	Unlimited
Initial Average	9 years	12 years	Upward trend
Subsequent Max	20 years	25 years	Unlimited
Subsequent Average	13 years	16 years	Upward trend

Actions Toward Optimization

Internal Inspection Type	Action 1 Consequences Reduction (Projects / Maintenance)	Action 2 Likelihood Reduction (Projects / Maintenance / Integrity)	Action 3 Analysis (Integrity)
Initial	▪ Release Prevention Barrier ▪ Leak Detection	▪ Coating (High Performance / Multipurpose) ▪ Cathodic Protection ▪ Non-Intrusive & Robotic Inspections	▪ RBI Assessment
Subsequent	▪ Release Prevention Barrier ▪ Leak Detection	▪ Corrosion Rate per Similar Service ▪ Non-Intrusive & Robotic Inspections ▪ Cathodic Protection Improvements ▪ Vapor Corrosion Inhibitors ▪ Coating (High Performance / Multipurpose)	▪ Similar Service ▪ RBI Assessment ▪ 10 years RBI Re-assessments

Steps Toward Optimization

A. Good actors dentification

- Low risk attributes analysis
- RBI and Similar Service
- Regulatory framework

B. Robotics technology candidates

- High flash point service tanks.
- Roof configurations
- Tanks with light sediments

C. Risk based repair scope of work

- Repair window / budget vs. next run
- Company risk matrix
- Repairs to mitigate consequences
- Repairs to reduce likelihood

A+B = Optimized Inspection Interval

B+C = Optimized Repair

Tools for Optimization – Similar Service / RBI

Typical instantaneous savings in the first 5 years

- Internal Inspection Interval extended for at least 5% of the tanks planned to take OOS
- Average saving per deferred tank $400K
- Tank RBI assessment investment per deferred tank 1% of OOS Costs

Risk Profile Across Tank Fleet

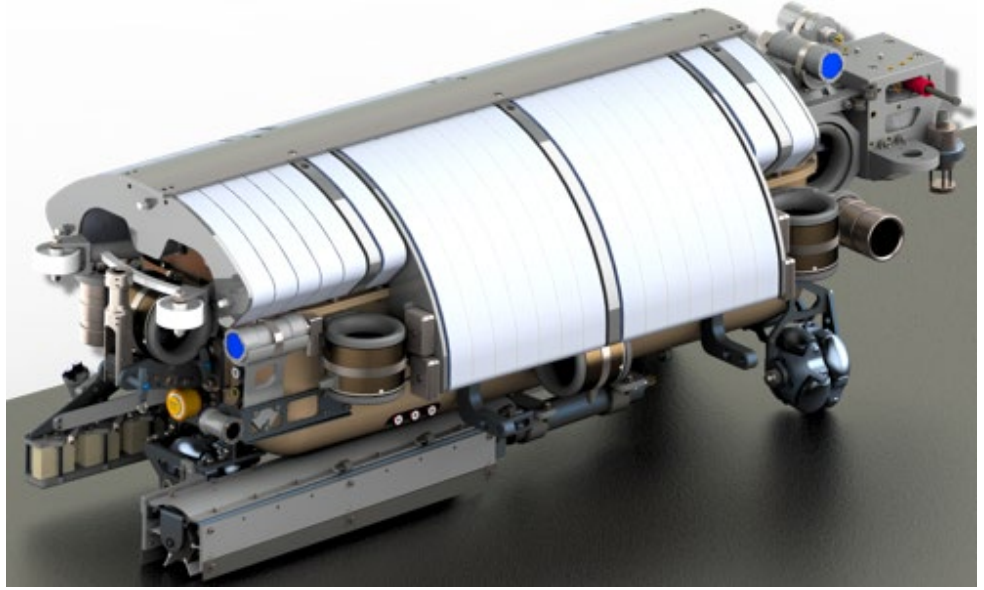
- Relative risk rank for all tanks
- Level Loaded Tank Maintenance
- Operational and Commercial Flexibility

Influence Industry and Regulators

- Building risk management case studies
- Incorporating new technology options
- Leading industry optimization initiatives

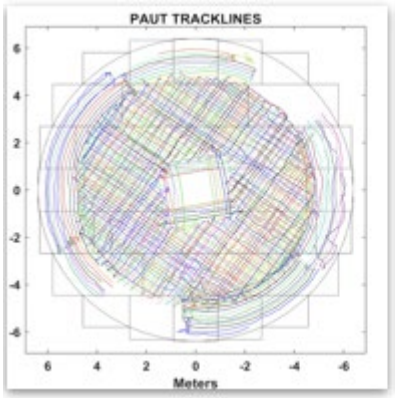
Tools for Optimization – Robotic Inspections

- Autonomous / Hovering vehicle
- C1D2 Certified for High Flash Point Service
- Equipped with Sonar, Video and PAUT
- 90%+ floor coverage
- In-service Settlement Survey



ROOF LAUNCH

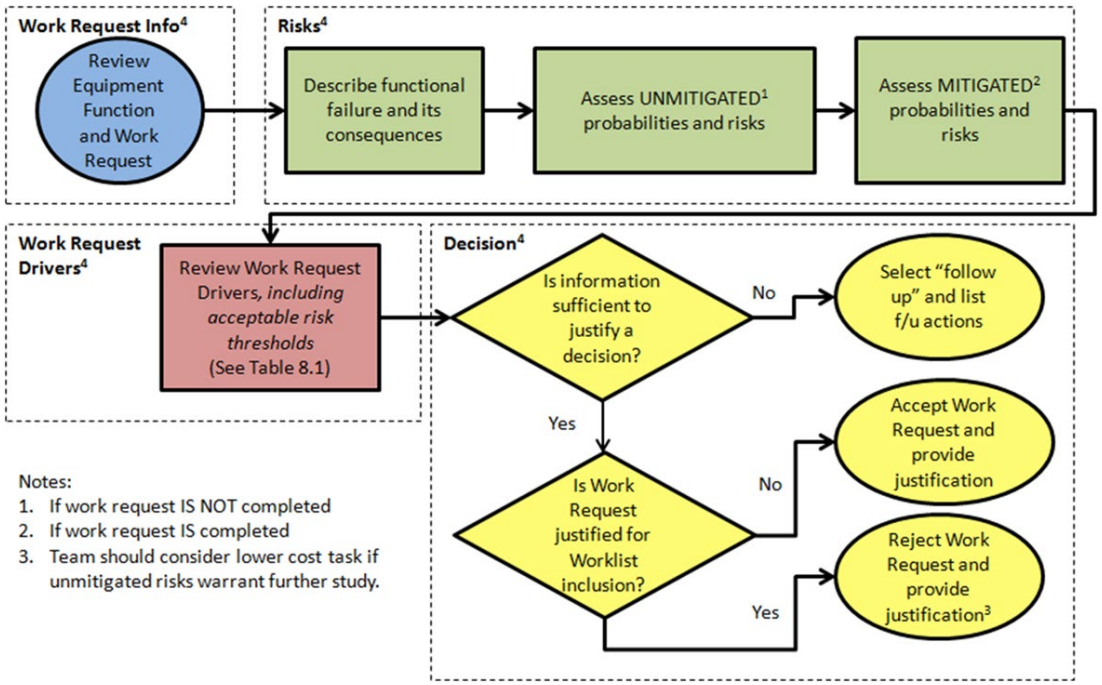
RECOVER



Images from Veritank

Tools for Optimization – RBWS

- API-653 allows a wide-open range of repair options
- Tank repair scopes typically conservative / not fit for purpose
- Risk Based Work Selection (RBWS) systematic approach to screen repair work
- RBWS Process
  - Relies on Risk to justify tasks
  - Consistency of decision making
  - Results in an optimized and risk-justified worklist
  - Combines risk management, reliability, and financial considerations
  - Resources used cost effectively to mitigate Health, Safety, and Environmental and Financial risks
  - Results documented for leadership and future tank OOS projects



Two High Value Take-Aways

- Good Actor Optimized Scenarios are achievable with Proved Processes and Technology
- Bad Actors turning into Good Actors by using freed up resources from the Optimization

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Backup Slides

- Becht's Risk Based Program Implementation Strategy
- Tank Assessments Case Studies
- Risk Based Considerations, Background and Benchmark

Risk Based Program Implementation Strategy

- Develop Tank RBI and Similar Service Policies
- Revise Integrity Management Program and Maintenance Manuals to allow RBI
- Appoint the Tank Risk Management Owner (Organization / Position / Job Description)
- Develop Multiannual Tank RBI Implementation Plan
  - Non-regulated tanks coming OOS in the next 5 – 10 years
  - Pre-identified low-risk tanks
  - Estimate for tank retrofits per actions 1 and 2 toward optimization
- $5K budget estimate per Tank for RBI initial assessment
- Tank RBI Training

Case Studies

- Case Study – Tank Inspection Optimization based on ERP
- Remote Terminal Tank Integrity Program Optimization
- Tank Initial Inspection Interval Limited by Underside Corrosion Susceptibility
- Midstream Risk-Based Inspection (RBI) Program

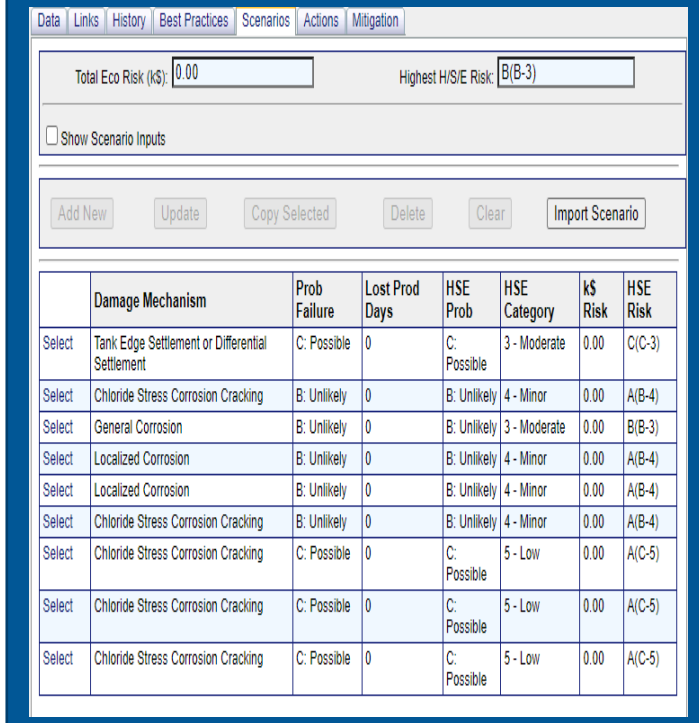
Case Study – Tank Inspection Optimization

Becht performed a risk-based evaluation on over 90 tanks utilizing the Becht ERP tool. Tanks included in the evaluation were from different facilities around the United States and Canada with many similarities and differences damage mechanisms.

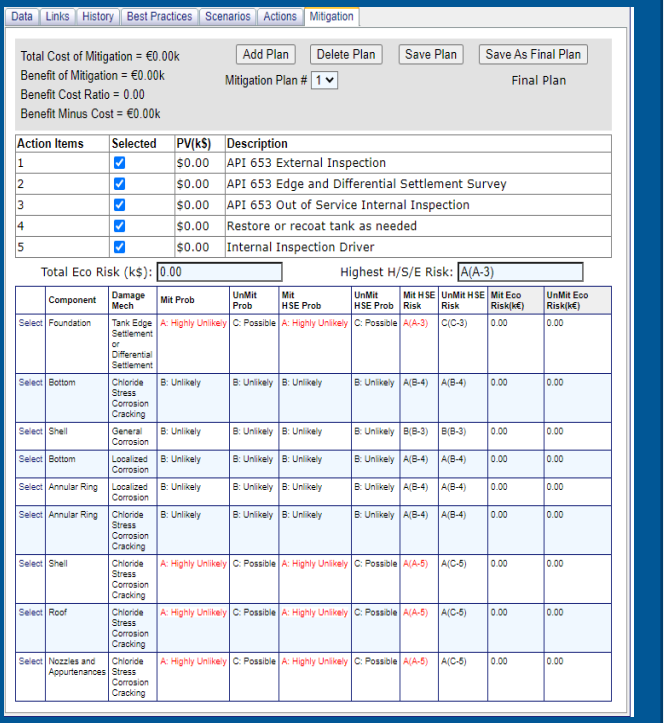
Becht's multi-disciplinary team of Reliability Engineering, Inspection and Mechanical Integrity SMEs customized a library of ERPs to define the regulatory & preventative maintenance tasks for the ASTs.

An aggressive project budget & schedule was met to incorporate findings into budget cycle planning.

Becht was able to extend the inspection interval for 23 ASTs (25% of total ASTs/165 tank years) and identified major repairs or end of life for 29 ASTs.



	Damage Mechanism	Prob Failure	Lost Prod Days	HSE Prob	HSE Category	k$ Risk	HSE Risk
Select	Tank Edge Settlement or Differential Settlement	C: Possible	0	C: Possible	3 - Moderate	0.00	C(C-3)
Select	Chloride Stress Corrosion Cracking	B: Unlikely	0	B: Unlikely	4 - Minor	0.00	A(B-4)
Select	General Corrosion	B: Unlikely	0	B: Unlikely	3 - Moderate	0.00	B(B-3)
Select	Localized Corrosion	B: Unlikely	0	B: Unlikely	4 - Minor	0.00	A(B-4)
Select	Localized Corrosion	B: Unlikely	0	B: Unlikely	4 - Minor	0.00	A(B-4)
Select	Chloride Stress Corrosion Cracking	B: Unlikely	0	B: Unlikely	4 - Minor	0.00	A(B-4)
Select	Chloride Stress Corrosion Cracking	C: Possible	0	C: Possible	5 - Low	0.00	A(C-5)
Select	Chloride Stress Corrosion Cracking	C: Possible	0	C: Possible	5 - Low	0.00	A(C-5)
Select	Chloride Stress Corrosion Cracking	C: Possible	0	C: Possible	5 - Low	0.00	A(C-5)



Action Items	Selected	PV(k$)	Description
1	☑	$0.00	API 653 External Inspection
2	☑	$0.00	API 653 Edge and Differential Settlement Survey
3	☑	$0.00	API 653 Out of Service Internal Inspection
4	☑	$0.00	Restore or recoat tank as needed
5	☑	$0.00	Internal Inspection Driver

Total Eco Risk (k$): 0.00 Highest H/S/E Risk: A(A-3)

	Component	Damage Mech	Mit Prob	UnMit Prob	Mit HSE Prob	UnMit HSE Prob	Mit H SE Risk	UnMit H SE Risk	Mit Eco Risk(k€)	UnMit Eco Risk(k€)
Select	Foundation	Tank Edge Settlement or Differential Settlement	A: Highly Unlikely	C: Possible	A: Highly Unlikely	C: Possible	A(A-3)	C(C-3)	0.00	0.00
Select	Bottom	Chloride Stress Corrosion Cracking	B: Unlikely	B: Unlikely	B: Unlikely	B: Unlikely	A(B-4)	A(B-4)	0.00	0.00
Select	Shell	General Corrosion	B: Unlikely	B: Unlikely	B: Unlikely	B: Unlikely	B(B-3)	B(B-3)	0.00	0.00
Select	Bottom	Localized Corrosion	B: Unlikely	B: Unlikely	B: Unlikely	B: Unlikely	A(B-4)	A(B-4)	0.00	0.00
Select	Annular Ring	Localized Corrosion	B: Unlikely	B: Unlikely	B: Unlikely	B: Unlikely	A(B-4)	A(B-4)	0.00	0.00
Select	Annular Ring	Chloride Stress Corrosion Cracking	B: Unlikely	B: Unlikely	B: Unlikely	B: Unlikely	A(B-4)	A(B-4)	0.00	0.00
Select	Shell	Chloride Stress Corrosion Cracking	A: Highly Unlikely	C: Possible	A: Highly Unlikely	C: Possible	A(A-5)	A(C-5)	0.00	0.00
Select	Roof	Chloride Stress Corrosion Cracking	A: Highly Unlikely	C: Possible	A: Highly Unlikely	C: Possible	A(A-5)	A(C-5)	0.00	0.00
Select	Nozzles and Appurtenances	Chloride Stress Corrosion Cracking	A: Highly Unlikely	C: Possible	A: Highly Unlikely	C: Possible	A(A-5)	A(C-5)	0.00	0.00

Becht has worked on multiple upstream production units (onshore and offshore) for tens of thousands of equipment tags (tanks, pressure vessels, exchangers, rotating equipment, instruments, HIPPS, electrical, compressors, and infrastructure).

Case Study – Remote Terminal Tank Integrity Program Optimization

A terminal company with tanks in several small islands in the Pacific Ocean was managing tank integrity based on heritage companies and previous owner practices with no consistency and lacking a company policy to address regulatory compliance and risk management. Resulting in a significant tank maintenance backlog compromising operations and maintenance resources. Becht was asked to review their tank program against industry benchmark, and develop fit for purpose polices, standards and processes.

Using experience and the owner/user perspective of our SME's, we assessed key elements of their assets, regulatory framework, risk and new technology. Becht developed risk-based policies which were applied to the existing tanks that were coming due for maintenance and inspection.

The maintenance workload was leveled appropriately within the 5-yr plan, providing flexibility for operations and creating the foundation for a risk based multi decades tank inspection strategy and schedule.

For an investment of about $60K, this terminal company was able to avoid commerce disruption and avoid $5MM impact in their maintenance budget in the first year.

The company senior leadership was very impressed on how the Becht team was able to work with all levels of the company, understanding and addressing all perspectives into the policies

Example: Tank Initial Inspection Interval Limited by Underside Corrosion Susceptibility

Evaluate the extension of the initial inspection interval of a new tank schedule to come out of service for inspection after 10 years in service. An extension to 15 years was confirmed by Becht with the recommendation to install a vapor corrosion inhibitor system and corrosion coupons monitoring. System installation in-service.

Evaluation conducted by reviewing the tank foundation design and latest investigations and standards work conducted by AMPP and API committees where Becht has representation. Also, by reviewing industry benchmark data.

Tank foundation design: No cathodic protection, no release prevention barrier, no coating.

Tank service: gasoline

References:
API-653
API-655 (2021 new document describes implementation of vapor corrosion inhibitors)
API-651 (Current ballot evaluating vapor corrosion inhibitors to control underside corrosion)

Industry benchmark data:
- Initial inspection interval typically going up to 20 years, with exceptions where applicable regulations limited to 10 years.
- Several tank owner / users reporting good results on vapor corrosion inhibitors implementation

Midstream Risk-Based Inspection (RBI) Program

A midstream operator, operating over 50 facilities in multiple US regions, needed assistance implementing an RBI program of tanks pressure vessels to optimize existing inspection programs and drive consistency between regions/locations.

The Becht team launched pilot projects in each region, developed a corporate RBI program document and work process, and implemented the RBI program at multiple locations over subsequent years.

Becht implemented the RBI program in each region and at over 30 sites, developed the corporate RBI procedure, and trained inspectors on the RBI program.

Becht's innovative approach reduced inspection costs by an estimated 40% over 10 years, reduced unnecessary internal inspections, and collected required PSM data.

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Risk Based Considerations, Background and Benchmark

- Risk Based vs. Condition Based
- Tank Risk Based Inspection Background
- Tank Integrity Programs Benchmark

Risk Based vs. Condition Based

- **Risk Based**
  - Consequences (analysis beyond the lost of containment event)
  - Likelihood (not only a condition trend, but probability)

- **Condition Based**
  - No consideration for Consequences
  - Inspection event intervals
    - Arbitrarily time based per code / standard / regulation
    - Condition trend based (some degradation mechanisms can’t be effectively modeled)

Tank Risk Based Inspection Background

- **RBI** (Initial Inspection up to 30 years / Subsequent Inspections no limit with 10 years re-assessments)
  - API RP 580, Risk Based Inspection
    - Provides general guidelines in the development of an RBI program
    - A company internal risk assessment process can be developed based on API 580
    - 3rd party proprietary software complies with this document
  - API RP 581, Risk-Based Inspection Technology
    - Specific methodology for risk calculations
    - Detailed software package requires significant data input (need assumptions)
- **API-653 Risk Based Elements**
  - Similar Service - Annex H (Candidate tank low likelihood to fail when reliable reference tanks)
  - Time Credits for Initial Inspection starting with 10 years – Section 6.4.2.1 (+10 RPB, +5 CP, +2 Coatings)
- **Regulatory Implications**
  - PHMSA – Doesn't recognize RBI / Doesn't recognize "initial credits" edition / Recognize Similar Service
  - State Local Regulations – Few states don't recognize RBI (i.e., New Jersey and California*)

Tank Integrity Programs Benchmark

- **Regulatory & Timing Opportunities**
  - Large % of tanks are not federal or locally regulated
  - Industry average interval between internal inspections is 16 years and it is trending up
  - Large % of tank owner / users have average interval between internal inspections under 13 years
  - RBI cost analysis can be assumed as 1% of the Tank Out of Service T/A cost
  - At least 3% of tanks coming out of service for inspection in the next 10 years can be pre-identified as low risk tanks and get deferred

- **Low Consequences Opportunities**
  - High viscosity service i.e., Asphalt Tanks
  - Tanks with Release Prevention Barriers
  - Tanks with Leak Detection

- **Low Likelihood Opportunities**
  - Large % of tanks are in clean products
  - Must of the tanks have bottom coatings
  - Upward trend of tanks with CP (new fabrication, new floors, VCI retrofits)

- **Non-Intrusive Inspection data**
  - Tank Robotics Inspections
  - Critical zone UT evaluation from chime