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Midstream Integrated Services
Terminals – Tanks - Pipelines

November 2022

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

Outline

1. Becht Profile
2. Midstream and Terminal Services
3. Examples of problems we can solve
4. Turning bad actor tanks into good actor tanks
5. Steps toward tank integrity optimization
6. Tank integrity optimization tools
7. Case Studies

A Technical Consulting Group

BROAD AND DEEP TECHNICAL EXPERTISE TO RELENTLESSLY HELP OUR CLIENTS SUCCEED

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Becht Profile

Becht's Focus is Specialty Consulting to "Help our Clients Succeed" With…..

Proven Becht Methodologies & Tools to add Value

Owner / Operator Perspective

Multi-Disciplinary Problem Solving

"Get it right the first time" Family Business Commitment

ENGINEERING SOLUTIONS

- Process Technology
- Reliability
- Mechanical Engineering
- Corrosion & Materials
- Instruments & Electrical
- Rotating Equipment
- Strategic Business Planning

PLANT SERVICES

- Turnaround
- Fired Heaters
- Inspection Planning
- Heavy Lift
- Capital Projects
- Human Performance

Highlights

1500+ SME's from senior positions in owner/operators
200+ Master Service Agreements
Recent Changes:

- Many SME's joined Becht due to changes at SGS, UOP, BP, EM and others
- Strategic Business Planning & Fired Heater Divisions added

Tanks, Storage & Transportation Facilities

The Team

- 20+ Advisors
- 1,500 experts across disciplines
- Rafael Rengifo, Manager Midstream & Tanks
  rrengifo@becht.com

Storage Tanks Integrity Programs

- Tank Integrity Program Optimization
- Tank RBI
- Tank FFS & FEA
- Tank Similar Service Assessments
- Tank Level Management Optimization
- In-Service Tank Cleaning & Retrofits Evaluations
- Non-Intrusive Inspections Evaluations
- RBWS (Risk Based Work Selection) for Tank T/As

Storage & Distribution Facilities

- Facility Integrity Fit for Purpose Programs
- Unpiggable Piping Assessments
- Buried and splash zone piping focused programs
- Upload / Offload Facilities Optimization
- Logistics/Supply Chain Optimization
- Plant Conversions to Terminals

Pipelines

- Pipeline Safety Management System Assessments
- Pipeline Risk Assessments
- Fouling/Corrosion Troubleshooting
- Anomalies FFS
- Hydraulics Modeling
- Rotating Equipment Troubleshooting
- Heavy Lift for Crossings Boring
- Pipe-soil Interactions and Modeling

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Midstream Terminals
Business Objectives Examples

Problems we can solve

- VCU / VRU Bottleneck
- Water Treatment Bottleneck
- Vessel Demurrage
- Storage Availability & Connectivity Bottleneck
- Transmix Management Issues
- Piping Hydraulic Issues
- Rotating Equipment Reliability
- Custody Transfer Issues

Analysis

- Business Model Definition
- Offloading / Uploading rates
- Connectivity sources & flow rates
- Products to move/storage
- Available vs. projected storage
- Pump's capacity

Midstream Terminals Operational Excellence Examples

Problems we can solve

- Piping Leaks
  - Inadequate thermal relief
  - Process Induced Fatigue
  - Valve Lineups Gaps
- Compromised Piping Flexibility
- Pumps Performance
- Tank overfill / underfill

Analysis

- PFDs, P&IDs
- MOC
- DHR
- HAZOP
- Operational Procedures
- Updated Control Logics
- Operators Training
- Tank Level Alarms Updated Calculations

Midstream Terminals
Mechanical Integrity Examples

Problems we can solve

- Unexpected failures in “new” high risk systems
- CUI where insulation is not needed
- New deadlegs created / unaccounted
- Inadequate piping schedule & supports
- New service / changes causing internal corrosion

Analysis

- RBI
- CUI Program
- Piping Circuits
  - Degradation Mechanisms
  - Spec Breaks
  - CCDs
  - IOWs
- Piping Flexibility Analysis
- Tank Integrity Program Evaluation

How to turn bad actor tanks into good actor tanks?

- **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

Bad Actor Tank

- No safeguards
- Bottom high corrosion rates
- History of recordable leaks
- Short internal inspections Intervals
- Significant accumulation of sediments
- Significant discoveries in T/A
- Overbudget and extended T/As

Safeguards
- Design
- Retrofits

On-line / In-service Inspections
- Robotics
- Critical Zone LRUT

Assessments
- Similar Service
- RBI

Good Actor Tank

- All safeguards applied
- Effective underside corrosion control
- High performance internal coating
- Achieving maximum internal inspections intervals
- Tank cleaning effort accurately predicted
- No surprises in T/A
- On budget / On time T/As

Steps Toward Tank Integrity Optimization

A. **Good actor tanks identification**
- 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 Tank Internal Inspection Interval

B+C = Optimized Tank Repair

Tools for Optimization – Similar Service / RBI

Typical instantaneous savings in the first 5 years

- Internal Inspection Interval extended for at least 10% of the tanks planned to take OOS
- Average saving per deferred tank $500K
- Tank RBI assessment investment per deferred tank less than 1% of OOS Costs

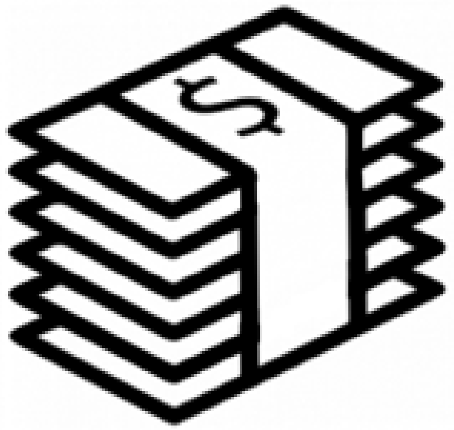
Risk Profile Across Tank Fleet

- 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

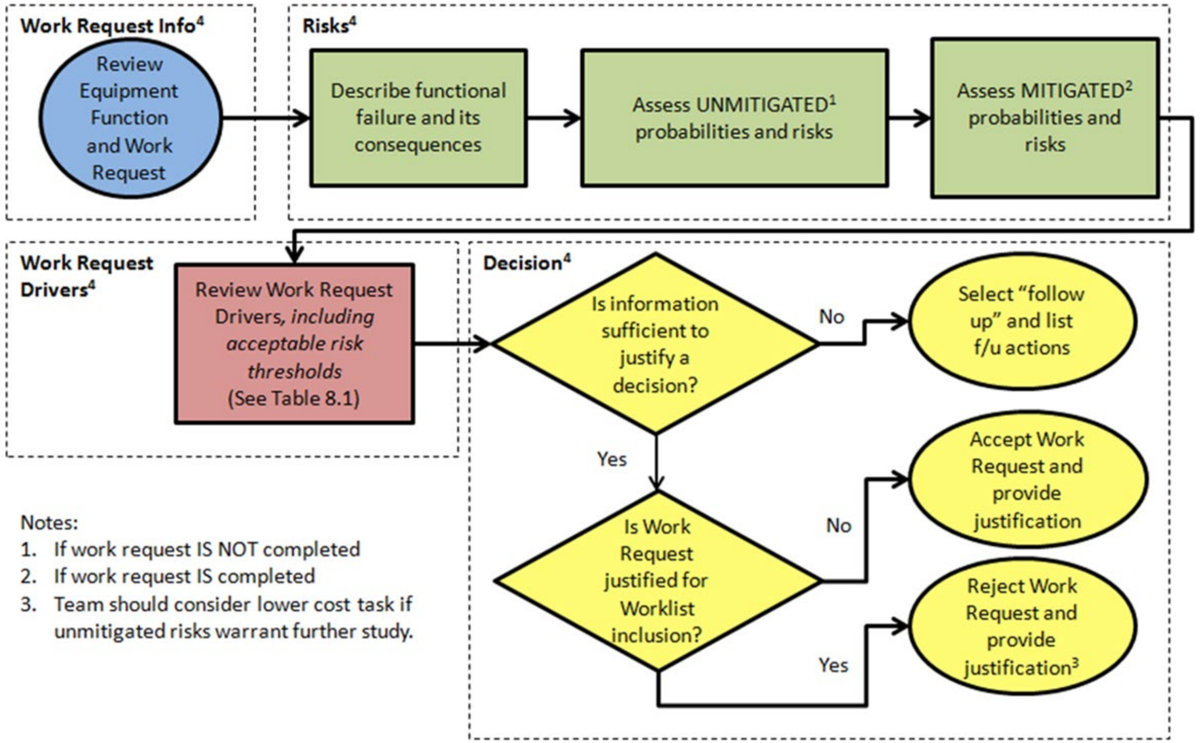
Traditional Out-Of-Service Inspections



- Temporary Storage
- Cleaning
- Blasting
- Traditional Inspection
- Coating
- HSE Risk
- LOST PROFIT

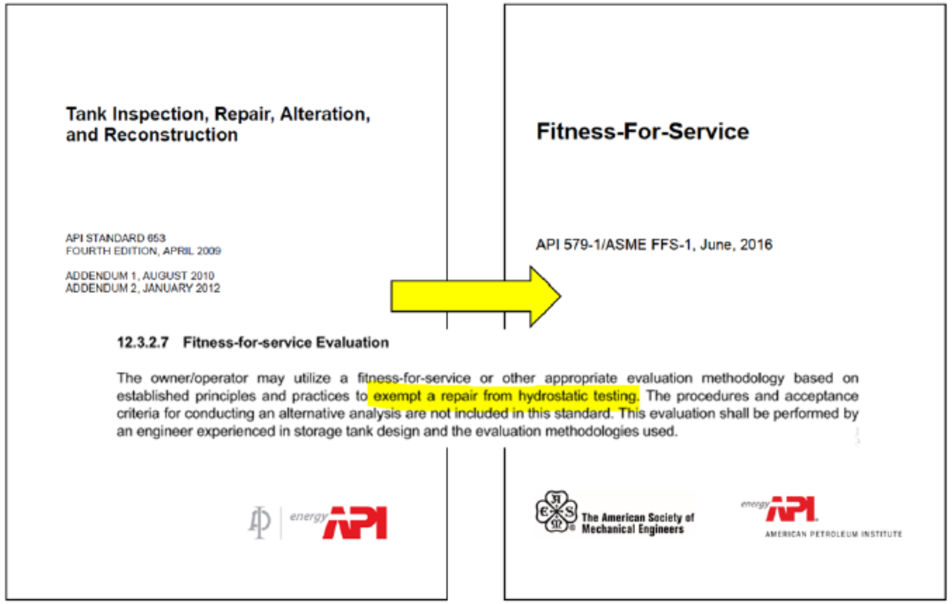
Tools for Tank Repair Optimization – RBWS

- **API-653 allows a wide-open range of repair options**
- **Tank repair scopes typically conservative**
  - No data before the outage
  - Conservative approaches from OOS MFL data
  - Not a fit for purpose approach
- **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

Tools for Tank Repair Optimization
Hydro Exemptions – FFS / FEA


Tank Inspection, Repair, Alteration, and Reconstruction

API STANDARD 653
FOURTH EDITION, APRIL 2009

ADDENDUM 1, AUGUST 2010
ADDENDUM 2, JANUARY 2012

Fitness-For-Service

API 579-1/ASME FFS-1, June, 2016

The American Society of Mechanical Engineers

AMERICAN PETROLEUM INSTITUTE

12.3.2.7 Fitness-for-service Evaluation

The owner/operator may utilize a fitness-for-service or other appropriate evaluation methodology based on established principles and practices to exempt a repair from hydrostatic testing. The procedures and acceptance criteria for conducting an alternative analysis are not included in this standard. This evaluation shall be performed by an engineer experienced in storage tank design and the evaluation methodologies used.

<u>The analysis for hydrotest exemption requires the following steps</u>:

1. Detailed FEA model includes all repairs to the shell which are **greater than 12"**
2. Identify regions of the highest hoop and bending stress – near new welds at wall repair and bottom
3. Conduct fracture mechanics testing on welded plate samples to determine the toughness of the repaired weld
4. Use the stress and the toughness fracture mechanics evaluation
5. Evaluate results to establish the hydrotest exemption.

Midstream Backup Slides

1. Case Study 1: Remote Terminal Tank Integrity Program Optimization
2. Case Study 2: Tank Inspection Optimization
3. Case Study 3: Midstream Risk-Based Inspection (RBI) Program
4. Case Study 4: Rating Calculations for Midstream Tanks and Vessels
5. Case Study 5: Vibration Analysis and Pulsation Study
6. Case Study 6: Tank Hydrotest Exemption after Repairs
7. Case Study 7: Refining Tanks Conversion to Leasing Terminal Tanks
8. Case Study 8: Terminal Emissions Reduction Strategy

Case Study 1 – 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

Case Study 2 – 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.

Data | Links | History | Best Practices | Scenarios | Actions | Mitigation

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

Show Scenario Inputs

Add New | Update | Copy Selected | Delete | Clear | Import Scenario

	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)

Data | Links | History | Best Practices | Scenarios | Actions | Mitigation

Total Cost of Mitigation = €0.00k
Benefit of Mitigation = €0.00k
Benefit Cost Ratio = 0.00
Benefit Minus Cost = €0.00k

Add Plan | Delete Plan | Save Plan | Save As Final Plan

Mitigation Plan # 1 Final Plan

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 HSE Risk	UnMit HSE 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 3 - 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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Case Study 4 – Midstream Vessel and Tank Rating Calculations

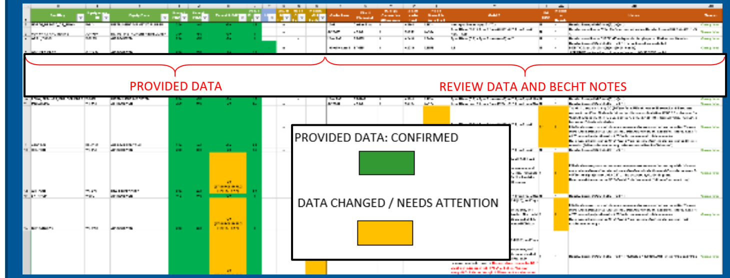
85 tanks and pressure vessels lacked complete design and operating information.

Becht was supplied the tabulated information and a large collection of original design documents (U1-A forms, drawings, etc.).

Becht verified or corrected each item's MAWP, MAWT, MDMT, geometry, CA, etc. and added details and Code Calcs for: t(min) for shell & heads, weld E, nozzle reinforcement, etc.

This deep dive into the client's equipment created a clear dashboard for the tanks and vessels that the client can use for both evaluating future operation and spotting deficiencies they need to reconcile.

Air Tanks
Atmospheric API 12F Tanks
Bullet Tanks
Discharge Bottles
Filters (Pressure Vessels)
Separators
Towers



"This project went off wonderfully. We were under pressure to evaluate our equipment and Becht's team accomplished our goals much faster than expected and with great clarity for our engineers."

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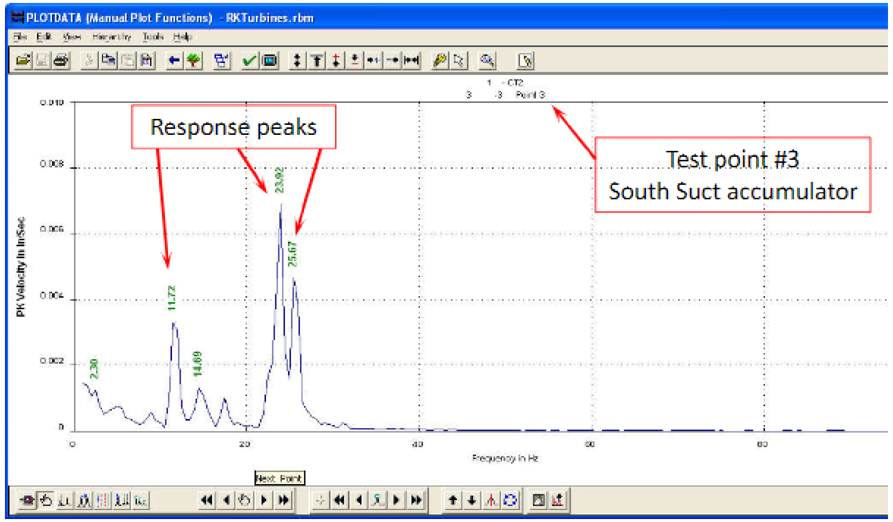
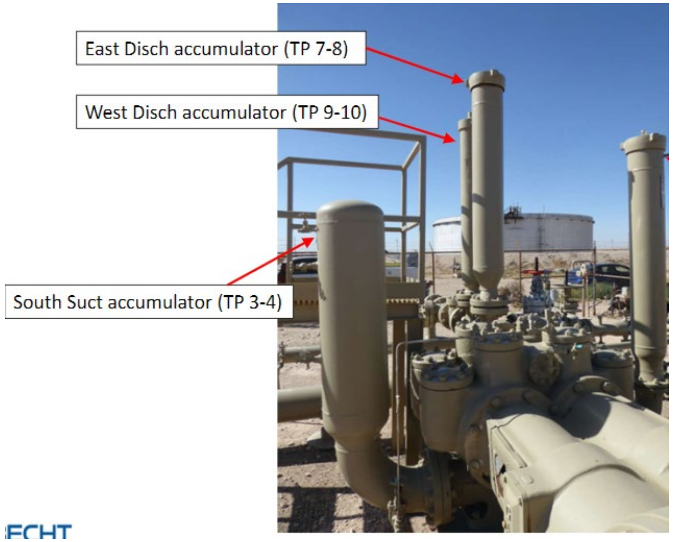
Case Study 5: Vibration Analysis and Pulsation Study

- Becht was hired to provide an evaluation of a pumping system that was experiencing pipe cracking and high vibration at several different locations
- Becht utilized a multidisciplinary approach to perform a pipe stress analysis along with vibration analysis at different points in the system, with the intent to correlate piping vibration frequencies with pump pulsation and running frequencies to determine the root cause.
- The vibration spectrum revealed system natural frequencies closely matched pump natural frequencies and recommendations on pump speed and piping supports were developed to improve frequency responses



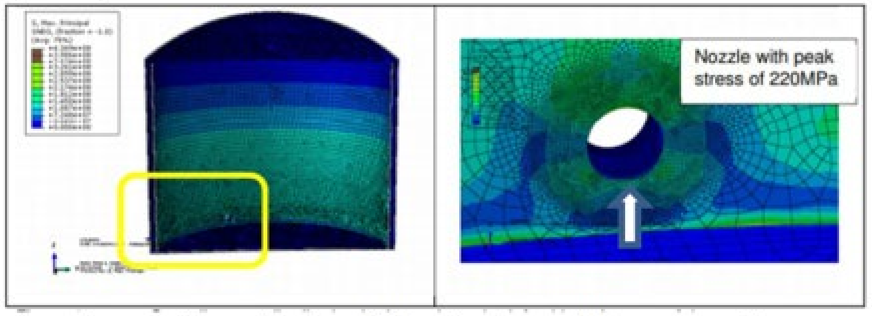


Case Study 6: Tank Hydrotest Exemption after Repairs

An example of the stress analysis for an area that has undergone a significant repair is shown below, a repair was conducted of a large nozzle

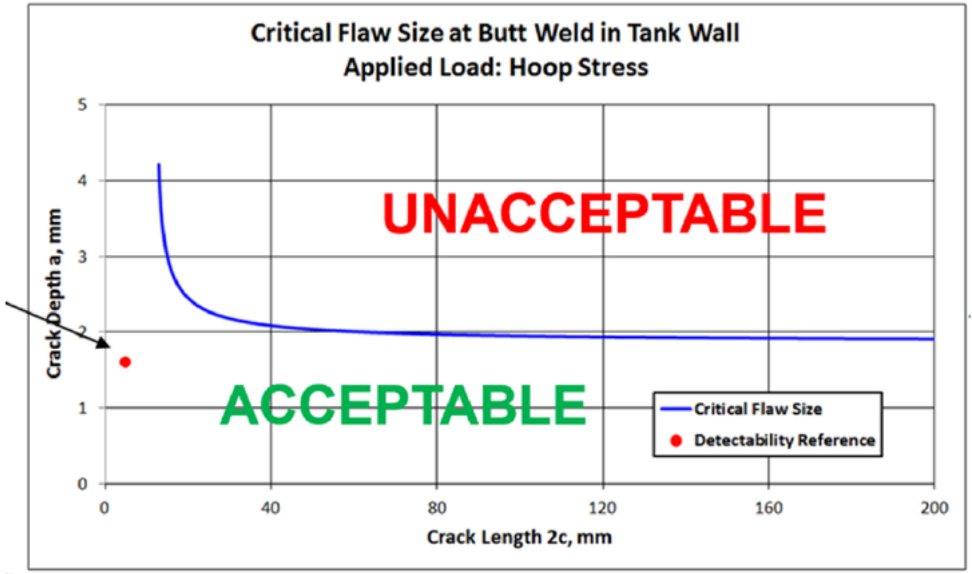
Employing the stress, the estimated welding residual stresses from the repair in combination with the material toughness, the maximum allowable crack sizes can be established.

In this example, the largest flaw that could be missed during the inspection (reference flaw) of 1.5mm in depth and 5 mm in length is compared with the critical crack size curve



Finite element analysis of the tank and focus on the repaired nozzle (white arrow shows the area of interest)

The critical crack size line must be greater than the minimum detectable crack during inspection (1.5 x 5mm)
OUTCOME: PASS



Case Study 7 - Refining Tanks Conversion to Leasing Terminal Tanks

Refining dedicated tanks were idled in need of significant resources to repair them. A fuel market demand in the area created opportunities to evaluate the use of the idled tanks for the leasing business

Considering the leasing agreement terms, a risk-based evaluation of the idled tanks condition and a fit for purpose evaluation of the repair scopes was conducted in the framework of risk-based work selection process (RBWS)

Optimized repair scopes were aligned with the new products and the intervals between leasing contracts. Also, the implications of applicable regulations to the new business model were considered. Implementation of new technology in service of inspection and repairs was a key element

5 idled tanks were reactivated providing 1MM Bbls storage capacity for the leasing business with $750M savings in repair scope from original estimates

The “fit for purpose” mindset shift was the key element that allowed us to capture this business opportunity. Consultant's experience and processes were the pillars of this “mindset shift” for us

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Case Study 8 – Terminal Emissions Reduction Strategy

Environmental regulations on annual limit of emissions were compromising terminal operations and the execution of tank maintenance work

Options on tank maintenance work deferment, using of degassing units and low volatiles coating implementation were evaluated and recommended

Several tank out service inspection and repair projects were deferred based on risk assessments; degassing units were used based on mitigation impact vs. cost and new low volatiles fast cure coating formulas were included in the company specifications

Emissions related to tank maintenance projects were reduced in more than 40% allowing room for terminal operation emissions within the regulation limits

The evaluation of emissions optimization in tank maintenance work not only helped the environmental case, but also increased our awareness of opportunities to optimize tank integrity and maximize tank availability

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