



## CASE STUDY

# Global, Comprehensive Materials, Corrosion & Integrity Support

A client operating domestically and internationally needed expert technical support for materials and corrosion control. Their senior management came to Viking for a proposal to provide a variety of consultancy services to cover the following essential needs: materials selection, failure analysis, corrosion monitoring, technical assurance for procurement, and risk assessment.

The Viking Materials, Corrosion and Integrity (MCI) team delivered all these services and many more as the client identified additional opportunities around the world. We provided subject matter experts to work closely with our client as technical authorities for materials and corrosion, protective coatings, and production chemistry.

### Solution

Using a systems-based and interdisciplinary approach to engineering, we provided comprehensive support through a small core team—one backed by a company with expertise ranging all the way from the reservoir to the refinery. By working simultaneously with operations and projects, we were able to leverage up-to-date awareness of operational challenges to inform project planning and decisions.

### Technical Achievements

- Viking In-house laboratory provided dozens of failure analyses on damaged components.
- Suggested process controls to minimize future corrosion risk.
- Created simple, user-friendly dashboard in Excel for a customized erosion model.
- Provided new strategies and updated specifications for protective coatings.
- Created easy-to-read materials compatibility tables for chemical systems with risks clearly identified.
- Predicted vessel risk of an LOPC, allowing safe continued operation until repairs could be made.
- Developed a comprehensive NDT guideline.



Degraded Butterfly Valve Sent in for Failure Analysis

## Failure Analysis & Materials Selection

When several butterfly valves in the seawater injection system failed, Viking worked with facilities engineers, production chemists, and our own Laboratory Services to conduct a failure analysis that revealed multiple degradation mechanisms.

Along with metallurgical analysis, Viking was able to suggest process controls to minimize future corrosion risk. We also recommended materials for procuring replacement valves that would hold up. Participation at multiple levels from production chemistry to integrity management allowed Viking to address a complex issue from multiple angles.

Viking performs many such failure analyses every year. Each time, we work closely with personnel from a variety of disciplines, supporting RCA workshops and gathering contextual data to offer “big picture” suggestions.

**Viking was able to recommend process controls to minimize the client's future corrosion risks.**

## Flowline Erosion Modeling & Prevention

When erosion became difficult to manage at one asset, Viking modeled an appropriate range of conditions for the relevant equipment geometries using SPSS to produce data sets. We then benchmarked the model against field data to ensure consistency with field experience and good correlation between inputs and predictions.

Next, the data was piped into a simple, user-friendly



Rapid Atmospheric Corrosion on an Offshore GOM Piping Spool

dashboard in Excel, which allowed the client to input current operational parameters and instantly obtain safe operating envelopes—and for future designs, modifications to piping geometry. Erosion controlled!

## Getting Ahead of External Corrosion

How many millions of dollars is your company spending each year on external corrosion in the Gulf of Mexico? There's the painting budget—that's a big-ticket item—and on top of that there's the cost of repairing and replacing structural steel, piping, and even tanks and vessels. It adds up fast, but it doesn't end there. Regulatory compliance issues, environmental risk, risk to reputation, and worst of all, risk to the people who make it all work every day. After all, half of all LOPCs result from external corrosion.

Our client saw all this and enlisted us for assistance tackling the problem. Among other things, we provided:

- Updated New and FM coating specifications.
- Updated tables of approved coating systems.
- A new specification substituting a superior bolting coating for legacy coatings.
- Support in creating a written fabric maintenance strategy.
- Improvements to all aspects of the FM process, from surveys to QA/QC.
- New technologies and alternatives to liquid-applied coatings.

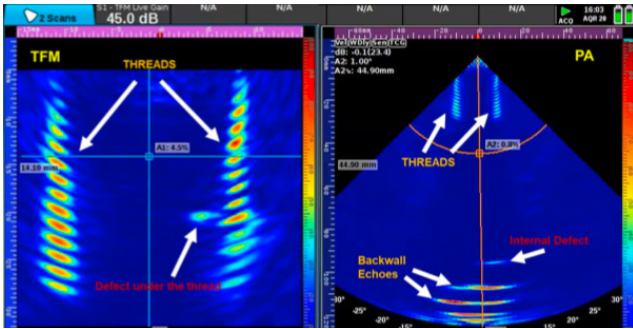
Following success in the Gulf of Mexico, the client asked Viking to help them implement these new strategies and methods in their other business units. For business units operating in vastly different conditions, such as North Dakota, we offered solutions tailored to specific needs.

## NDT Guideline for Integrity Engineers & Operators

Nondestructive testing is an ever-growing set of methods and techniques for finding a variety of defects in a wide range of equipment, materials, and geometries. It can be a challenge for the engineers and operators to know what technique to use for each situation, and what information the results really provide.

Our client requested an extensive written guideline that would help personnel in selecting techniques, evaluating proposals from NDT providers, and knowing the limitations of the results. We brought in our subject matter expert, an NDT level 3 with numerous certifications, and collaborated to create something comprehensive yet comprehensible.

Sometimes a picture is worth a thousand words, and sometimes a thousand words are 900 too many. Together we made sure our guideline would be accessible and useful to integrity engineers and even to people with little to no background in NDT.



Display Images for Total Focusing Method (TFM) and Phased Array Ultrasonic Testing (PAUT)

## Chemical Systems Material Compatibility Matrix

How often does a facility change the chemicals it's using? Generally, more often than it originally planned during design and construction. So, how do the production chemists know if the new chemical will be safe in the new system? Well, there are the data books... but wouldn't it be easier to have some easy-to-read tables, with risks clearly identified?

After a couple of failure analyses, our client asked us to check materials compatibility in their chemical systems. We assessed all the components, metallic and non-metallic, for compatibility with all chemicals used previously and currently as well as those under consideration. When a new chemical is considered, we make a quick update to the compatibility tables we created.

Pumps	PBE-XXXX	Ceramic Bronze		
		CS/LAS	Y	
		NBR	Y	At any concentration to 150°F
		Polyamide		
		FKM	N	
	PEEK	Y	To 212°F	
	PBE-YYYY, ZZZZ	CS	Y	
		316SS	Y	
		Stellite		
		TC		
PTFE		Y		
		GFP	Y	

Compatibility Notes	Swelling		Loss of Tensile Strength	
	Linear (Plastics)	Volumetric	(Plastics)	(Elastomers)
No Compatibility Issues	<10%	≤15%	<15%	≤15%
Limited Compatibility Issues	<15%	≤30%	<30%	≤30%
Use with Caution	<20%	≤50%	<50%	≤60%
Not Recommended	>20%	>50%	>50%	>60%
Not Tested/Need More Info	NA	NA	NA	NA

Tables Made to Efficiently and Effectively Show the Compatibility of Materials

## Analyzing the Risk of an LOPC Incident

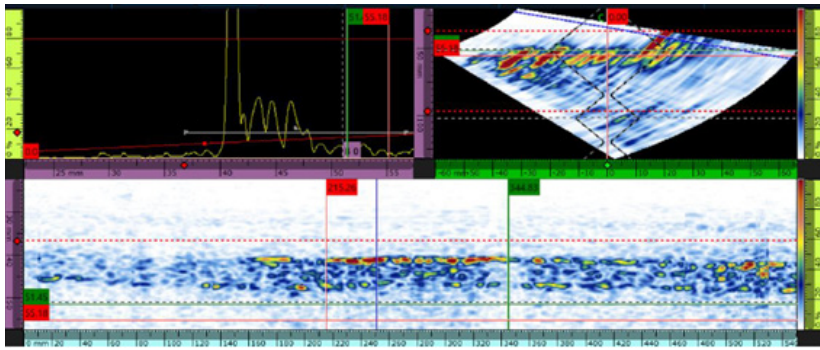
How do you decide if a vessel handling corrosive fluids is in danger of a loss of primary containment? This may be the most critical kind of process safety assessment in any industry—after all, such an LOPC puts people, assets, and reputation all at serious risk.

Here's the background: The client had a vessel fabricated from standard carbon steel clad with a 3 mm thick layer of type 316 stainless steel. The plate of the vessel walls was explosion-clad and the nozzle connections were weld-clad. On a routine internal inspection (visual and dye-penetrant) after a few years of service, the inspectors found several indications that looked like defects or even cracks in the welds.

For both onshore and offshore operations, we provided day-to-day asset support.

We modeled the crack as a V-shaped opening progressing through the material at the tip. We made some basic assumptions about how the fluids could flow through the crack and estimated the corrosion rate using conventional CO<sub>2</sub> corrosion models. Because the gas processed in this vessel was water-saturated and contained CO<sub>2</sub>, the operator was concerned that





**PAUT Scan of Crack Through Vessel Cladding**

CO<sub>2</sub> corrosion could begin if the cracks in the cladding penetrated through to the base metal. We assembled a geometrical simulation of the deepest observed defects and combined that with a structural analysis that demonstrated the conditions under which the crack could progress and expose the base metal to the process fluids.

Working with the asset team, we developed an operation and inspection plan that added heat tracing to keep the process fluids above the dewpoint (prevent corrosive water from condensing) and predicted how long the vessels could be in service before the risk of an LOPC increased to an unacceptable level. The client was able to continue to safely operate the vessel and avoid downtime until repairs could be completed.

## Other Services Delivered

Over the course of three years, we delivered quite a few other services to this client as well. Here are some examples:

- Mill audits for oil country tubular goods (OCTG)
- Reservoir stimulation & stim-fluid flowback risk assessments
- Onshore rig operation site audits
- Corrosion monitoring program management
- Procurement support & supply chain management
- Welding support (WPS & PQR code review, fabrication troubleshooting)
- Production chemistry (embedded SME/TA)
- Bacterial monitoring & control strategy
- Custom coding of dashboards for data management & visibility

## Conclusion

The Viking MCI team takes a highly cooperative approach to solving your problems. Science and engineering knowledge are only half of the equation—the other half is practical, collaborative application and responsiveness. In other words, we know that fast and effective communication between field operations and engineering is what gets the work done right. We always pay attention to what “good” looks like to the client, and our solutions to your problems are all about your needs. We will be the team that makes it work right the first time.

## Viking MCI Services

- Failure Analysis & Materials Testing
- Corrosion Control
- Materials Selection & Qualification
- Risk Assessment & RBI Support
- Protective Coatings & Fabric Maintenance
- Production Chemistry
- QA/QC Oversight & Procurement Support
- NDT Field Inspection & Level 3 Consulting
- Corrosion Monitoring Programs
- Asset Integrity Management
- Life Extension

Contact us today for assistance with field testing or failure support at 281.870.4016 or [www.vikingeng.energy](http://www.vikingeng.energy)

## Office Locations

Houston, TX  
New Orleans, LA  
Mexico City

## Lab Locations

Houston, TX