# In-Line Automated Inspections Now Achievable on Reactor Coils & Common Headers

Figure 1. Reactor

## Overview: The Challenge

Reactors are critical vessels that play a vital role in petroleum and chemical processing. High value products such as diesel, naphtha, LPG and vinyl chloride monomer (VCM) are produced from chemical reactions that take place within the reactor with feedstocks in the presence of a catalyst.

Maintaining these assets to achieve continuous and uninterrupted operations can be a challenge. One such owner-operator was experiencing ongoing issues with leaks in the 180-degree return bends of piping coils located in two large reactors, resulting in very costly disruptions in production.

Given the design, as with most reactors, very limited space was available inside the reactor to safely conduct non-destructive testing to determine the overall extent of damage in the coils. With few alternates at hand, manual ultrasonic (UT) testing was performed on the exterior of the coils once the units were taken offline line and scaffolding was erected.

With many coils inaccessible for testing due to space issues, less than 1% UT inspection coverage was obtained, leaving more questions than answers. A much more effective inspection technique was required to ensure asset integrity and prevent future failures.

## Project Services: The Solution

Quest Integrity was contacted by the plant to apply its Furnace Tube Inspection System (FTIS™) and Header Delivery System (HDS) technologies for a comprehensive inspection of all coils and circular common headers located in both reactors (see Figure 2). Combined, both reactors contained over 300 piping coils (with around 7000 straight pipes and return bends) welded to circular and straight headers.

Quest's fitness-for-service screening assessment, following the API 579-1 standard, was also requested to ensure that the reactors could be safely returned to service and operated until the next planned shutdown.

FTIS was selected for this application because of its high-resolution ultrasonic in-line inspection capability, comprehensive coverage and data collection speed.

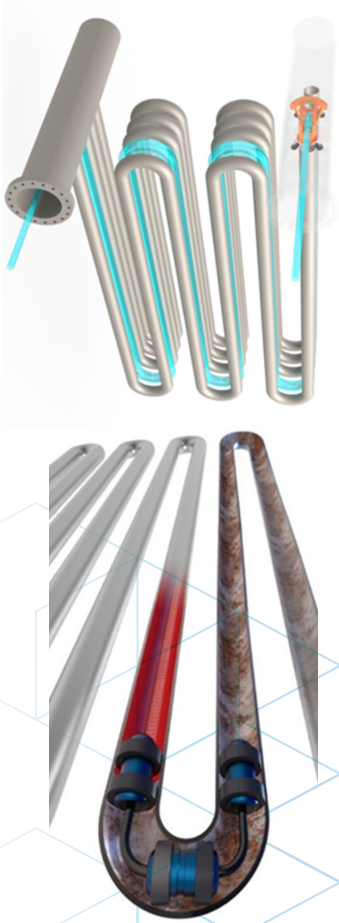

Figure 2. HDS and FTIS Technologies

The FTIS technology detects and measures damage such as localized and general internal and external corrosion (see Figure 3), erosion, pitting and fretting as well as deformations such as bulging, swelling, denting and ovality in numerous coil configurations.

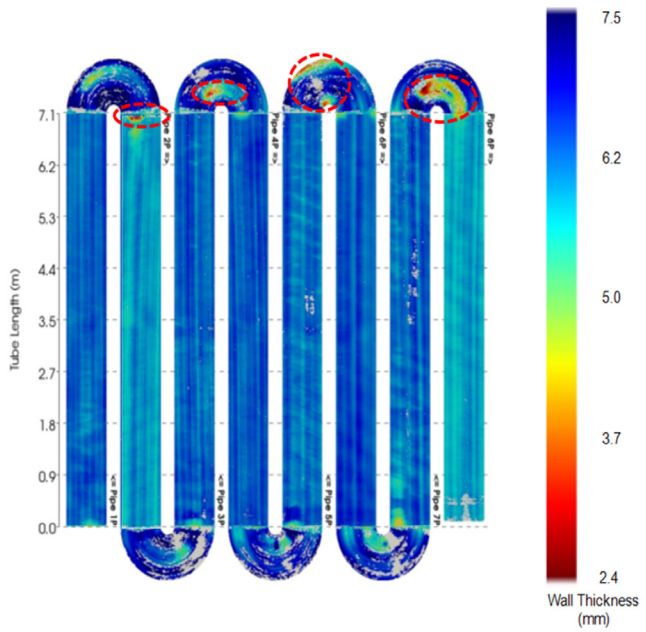


**Figure 3. Localized Metal Loss Damage**

The inspection is accomplished by flooding the coils with water (typical medium) and propelling the FTIS tool through the coils using a self-contained pumping unit. This technique eliminates the need for scaffolding and confined space entry and provides owner-operators with a complete and quantitative mapping of a coil's wall thickness and geometry.

Quest Integrity utilized its HDS technology to provide a means for easy entry into the coils to perform the FTIS inspection without having to remove the common headers (see Figure 4). This method eliminated the need for costly modifications and additional inspection time.

The coils had never been cleaned before and light internal fouling was suspected. As such, Quest Integrity was also requested to clean the coils using its Advanced Mechanical Cleaning technology.

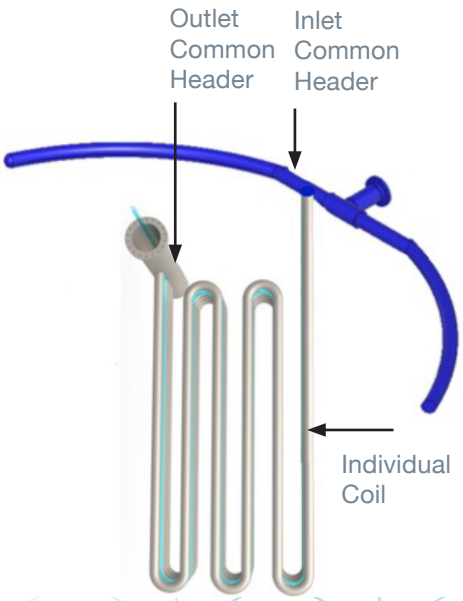


**Figure 4. Individual Reactor Coil and Common Headers**

## Execution

Crews and equipment were mobilized to the plant and the project was safely and successfully performed around the clock over an 18-day period. Approximately 16 coils totaling over 300 pipes and bends were inspected daily including data analysis and initial reporting of the findings. Well over 400 million ultrasonic readings were obtained in the 300+ piping coils inspected between the two

reactors, compared to 1000 readings with manual UT testing prior to the project (see Figure 5).

Six large circular common headers were also requested for inspection while on site and completed within the same 18-day period. Like the coils, very little inspection data was available, therefore the overall condition of the header walls was largely unknown. A tool configuration and run plan were quickly established for this portion of the project using the self-contained pumping unit and a hand pull retrieval system to successfully inspect each of the six headers (see Figure 6).

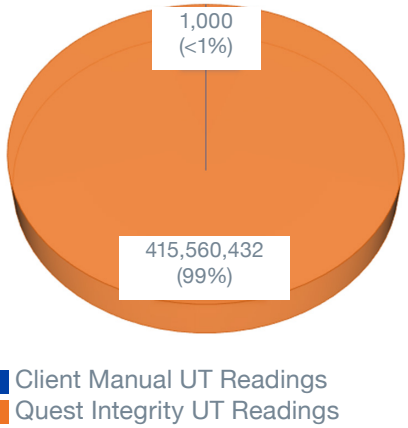


**Figure 5. UT Data Comparison**

## Inspection and Assessment Results

The FTIS inspection revealed significant metal (wall) loss upwards of 70% percent in the 180-degree return bends and straight pipes (see Figures 7 & 8). Almost 90 return bends and 40 straight pipes contained over 50% metal loss. Unexpected damage was also found in a majority of the common headers with a maximum metal loss of approximately 50%.

A screening assessment for metal loss and creep damage was also performed for each straight pipe and 180-degree return bend in the reactor following the guidelines of API 579-1/ASME FFS-1 and API 530 Annex A methodology. Integrating a detailed metal loss analysis, the assessment evaluated the significant localized metal loss damage from flow accelerated corrosion and external erosion from catalyst circulation. Two tubes and numerous bends failed the assessment, requiring further action. Quest then provided mitigation strategies including the requirements of additional inspections, root cause failure investigation, and an API 579-1 Level 2 assessment to manage the operating risk and plan for future replacements.

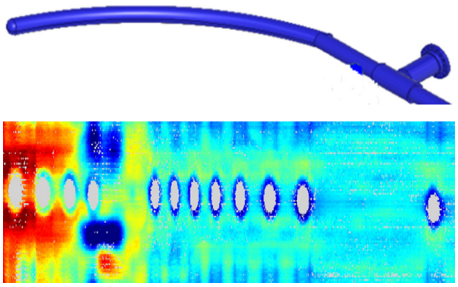

**Figure 6. Circular Common Header Inspection Data (Red areas indicate significant wall loss)**

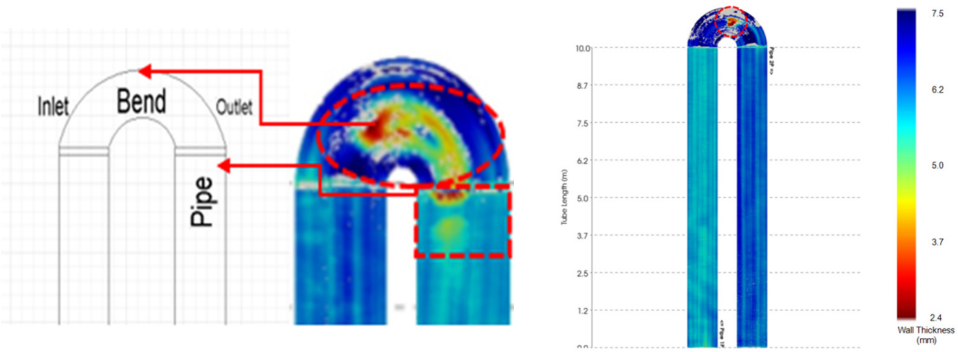


**Figure 7. External Metal Loss in Return Bend**

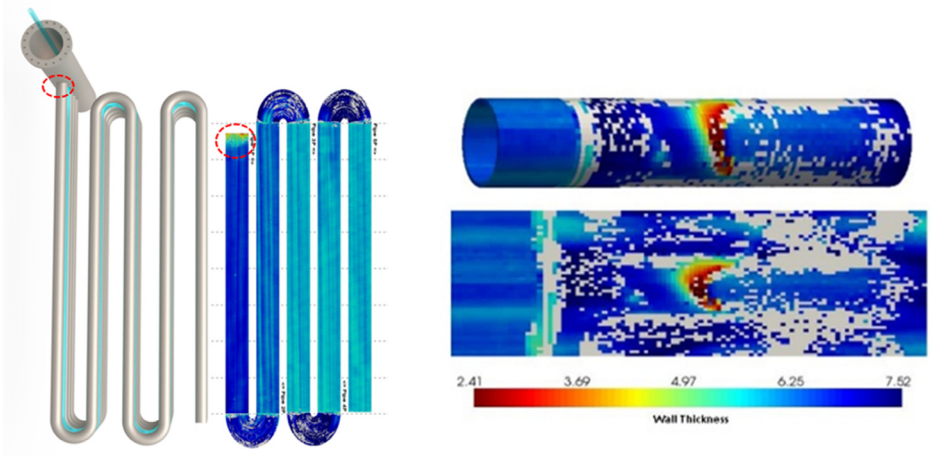


**Figure 8. Internal Metal Loss in Straight Pipe**

## Conclusion

FTIS In-line inspection technology, in conjunction with the custom-built header delivery system, HDS, provided invaluable insights into the overall condition of the reactor coils and circular headers that were previously unobtainable by any other inspection means. The information acquired from both the inspection and screening assessment provided the plant with the necessary information to safely and confidently operate the reactors until the next scheduled shutdown.

Straight pipes and numerous return bends were replaced based on the inspection results and recommendations provided from the assessment findings, preventing in-service failures and unexpected shutdowns.

Seeing the tremendous value providing from the first FTIS inspection, the plant is already planning a second inspection during the next shutdown to establish accurate corrosion rates and determine if any other coils are nearing retirement.

The time and money saved by implementing a comprehensive and proactive coil integrity program was significant. Relying on random manual UT testing at accessible coil locations did not alleviate long-term concerns with vessel reliability, proving to be a very costly and ineffective method.

By offering a fully integrated service, Quest enabled the plant to optimize the performance and reliability of the reactor coils and common headers, minimizing downtime and maximizing production and asset profitability.

Quest Integrity, is a global leader in the development and delivery of asset integrity and reliability management services. The company's integrated solutions consist of technology-enabled, advanced inspection and engineering assessment services and products that help organizations improve operational planning, increase profitability, and reduce operational and safety risks. Quest Integrity is built on a foundation of leading edge science and technology that has innovated and influenced industry best practices since 1971.