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DECEMBER 2005

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# Laser scanning solutions secure accurate dimensional data

**This engineering and construction planning tool can reduce schedules, overall costs and exposure to potentially hazardous onsite environments**

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In October 2001, the Houston office of a large engineering, procurement, construction and maintenance service organization began a series of projects for a major Gulf Coast refinery. The goal was to reduce emissions of nitrogen oxide (NO<sub>x</sub>) and highly reactive volatile organic compounds to comply with the Texas Commission for Environmental Quality clean air regulations. The projects ultimately improved the control and monitoring of emissions across the entire plantsite.

A significant portion of the work included modifying 17 tightly spaced process heaters, 3 carbon monoxide boilers and 1 FCC scrubber column. The heaters and boilers required replacing older burners with new ultra-low NO<sub>x</sub> burners as well as adding new fuel gas piping. The scrubber column also had to accommodate new internals.

The owner of the refinery knew from previous experience that the engineering, procurement and construction (EPC) contractor had an excellent track record of finishing projects on or ahead of schedule. This reputation for quality is especially important for these projects, where each process unit required an outage or a turnaround to accomplish the required modifications.

## CHALLENGES

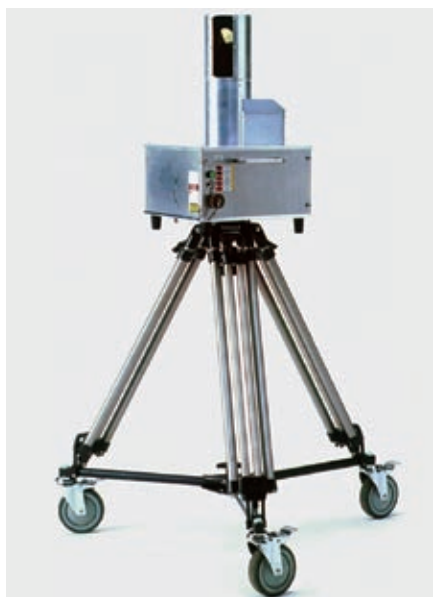
The environmental compliance program was grouped into multiple projects that were completed within a three-and-a-half-year timeframe. The construction phase of each project required retrofit activities during an outage for each process unit being modified. Therefore, thorough shutdown and turnaround planning had to go into each phase

of engineering, procurement and construction to minimize the revenue losses for the refinery since these process units generally operate 24 hours/day and 7 days/week.

The engineering and procurement phases of the projects were of short duration, and the projects overlapped each other. This required fast acquisition of accurate as-built information of the existing facilities on which to base the design of the new modifications; the entire program consisted of modifying and retrofitting new components into the existing process units.

The compressed and overlapping nature of the projects' engineering and procurement schedules resulted in the decision to place the engineering and design team at the plantsite, thus minimizing the time needed to access the facilities being modified. More than 80 people were assigned to work onsite. During the course of the NO<sub>x</sub> reduction projects, the team worked on as many as four projects simultaneously and faced major challenges.

**Space constraints.** For example, the space under each heater and around each boiler was extremely tight and congested. There were support columns, platforms, inlet air ducting, fuel gas piping, instruments and utilities. This setup made it very difficult to access the areas to be modified. In addition, much of the equipment was older—with many upgrades and modifications applied over the years. Therefore, existing drawings of the process units had to be verified or new drawings created to show the as-built status of the equipment and surrounding facilities.



**FIG. 1** A laser scanner's small size and light weight make it suitable for working in cramped process facilities.



**FIG. 2** Actual laser documentation (not a picture) for refinery equipment. Each point is a highly precise measurement.

Conventional physical surveying and measurement would consume many hours, days and weeks. Personnel would have to work under the furnaces and around the boilers while the plant was operating. This would be a hot, noisy and potentially dangerous undertaking. However, the design team needed to identify distances to all obstructions and the required operating clearances so modifications could be made for installing and operating the new burners. The new burners would also require changes to the heater floors and boiler walls, as well as the connecting gas and air lines. Workers had limited room around the furnaces and boilers in which to operate. The site was crowded with fuel gas headers, air ducts, structural members, instruments and utilities.

Additionally, the large 25-ft diameter scrubber column required new internal components, such as chimney trays, spargers and packing. An accurate way of measuring the “roundness” of the vessel while the scrubber was operating was required. Large-diameter vessels are never completely round, and the “out of roundness” varies from one cross-section of the shell to another. The design team needed to know the exact out-of-roundness dimensions in the section of the column where new internals were being installed, which was approximately 30 ft to 40 ft aboveground.

Traditional methods of measuring the scrubber dimensions are labor intensive, often requiring project teams to cut out cardboard or plywood pieces to generate a pattern of the scrubber vessel diameters for the full 360° at the various heights of interest. This would be time-consuming and involve the risks associated with working at higher elevations.

For these reasons, the EPC contractor’s team determined that traditional field surveying techniques were not the best approach.



**FIG. 3** Zooming into the laser documentation shows fine details that are captured, including threading on bolts.

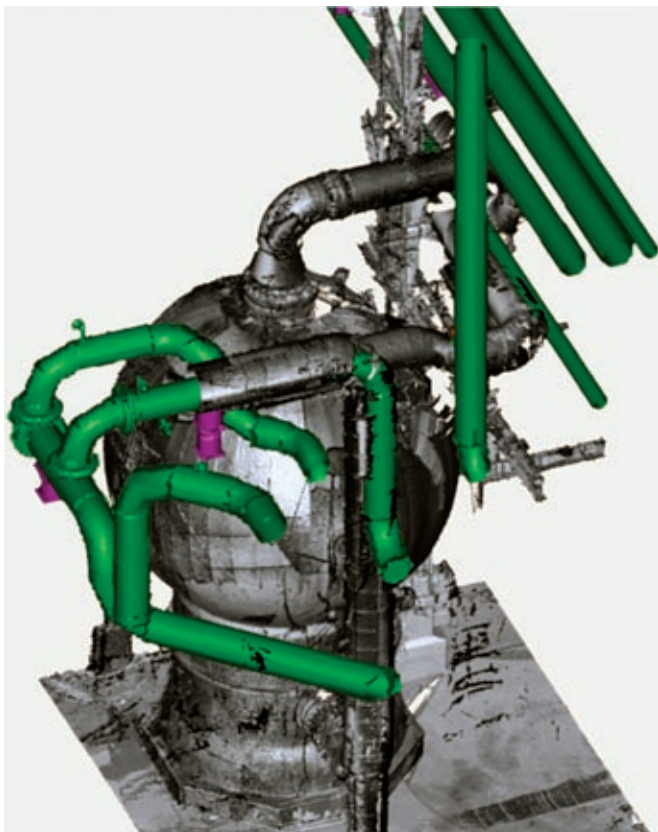
A solution was needed to minimize the delays and safety exposure that would be caused by sending teams of two to four designers into the operating units for several days at a time to collect as-built data and then repeating the effort for constructability checks on the design prior to issuing drawings. The EPC contractor also wanted to obtain the most comprehensive and accurate set of data that reflected the area being modified.

### SOLUTION

Due to the congestion and proximity of the heaters to one another, it was decided to use laser documentation. The service provider of as-built laser documentation has completed more than 700 projects for refineries, offshore platforms, pulp and paper facilities and power plants. “We started looking at how close the quarters were on these heaters and how hot and noisy it would be to send people under the operating furnaces, and that’s when we selected the provider to perform laser documentation because of the vendor’s significant refining experience,” according to the EPC contractor’s project manager.

The EPC contractor and the service provider began working on this refinery assignment in January 2003. The laser scanning provider rapidly captured high-resolution dimensional data in the difficult-to-reach areas around the perimeter of and beneath each process heater and boiler, providing complete and accurate as-built laser documentation. The high-density laser equipment was capable of scanning a 50-ft radius and yielding an accuracy of no worse than 0.125 in. Laser scanners function by line-of-sight; if they can “see” it, the laser scanners will capture the scan data (Fig. 1). The scanning radius made it possible to collect most of the required data without going under the operating heaters, thus avoiding the more inhospitable and hazardous working conditions.

The provider made four separate trips to the site for laser documentation of the equipment and areas associated with different project scopes. On each trip, a team of three field specialists operated the equipment. A designer from the EPC contractor accompanied and assisted the laser-scanner team. Each trip typically took two to four days, depending on the number of different areas that had to be documented. Generally, the teams were able to capture the area around two or three heaters in a nine-hour day. This effort required a site safety



**FIG. 4** 3D laser models can be clashed against 3D CAD models to identify potential interferences or busts.

training and orientation session, hot work permit and safe work plan for each area. The vendor's team captured five to six locations around each piece of equipment and integrated the data to provide a 360° view of the equipment and its process unit infrastructure (Fig. 2).

It took approximately seven days to set up, gather, process and deliver the laser scanning data to the EPC contractor. This was much faster, safer and more accurate than conventional methods would have been. Special software was used to import data into a common plant design software. This background of as-built laser documentation was used to overlay the new modifications and check for clearances and clashes.

The combination of background scan data and engineering design input provided a 3D representation of the modified equipment to the refinery operations personnel. Thus, operations and construction had the opportunity to participate in a "virtual walk-through" review of the proposed modifications prior to issuing the design drawings. This enhanced the constructability, operability and maintainability of the final design once the review comments were implemented.

**Benefits to schedule, cost.** Through the use of as-built laser documentation, the project was completed with virtually zero field rework and with scheduling enhancements derived from fewer man-hours being required in engineering as well as reduced outage time during construction. The construction work on each of the heaters was completed about three days earlier than scheduled because the new equipment, steel and piping fit properly (Fig. 3). The scrubber column internals also fit without

any time-consuming modifications during the turnaround. The advantages were apparent in the accuracy of fit-up, improved design review capabilities, less physical survey time and improved safety by reducing the design personnel's exposure to the operating environment. All of these contributed to a lower project cost.

This approach also provided less disruption to refinery operations, and it maximized the time designers spent in the design office drawing layouts, which shortened the design duration. The EPC contractor saved 75% to 80% of the time it normally would have spent inside the operating units by using as-built laser documentation instead of relying on traditional data collection methods. Design and construction goals were met in record time. The following summarizes the benefits:

**Project completion.** Project scope where laser documentation was used came in ahead of schedule and under budget with an excellent safety record. The total NO<sub>x</sub>-reduction-program exposure hours for the EPC contractor were 1.5 million hours with a TRIR of 0.13. Use of laser documentation helped reduce shutdown durations by 5% to 20%.

**Reduced cost.** The number of construction man-hours decreased. The project was completed in a reduced timeframe with essentially no rework. The provider's laser scanning data enabled the EPC contractor to use its 3D plant design tool economically on a retrofit project in process units where no 3D model existed. The cost reductions stemming from the use of laser documentation and 3D design approach were many times greater than the cost of the solution provider's service and supporting software.

**Optimized schedule.** The time required for creating, validating and marking up existing drawings was significantly reduced because drawings issued for construction matched what was actually in the field. Using a 3D design model allowed the EPC contractor to electronically transfer the design to multiple engineering offices for around-the-clock design. This enabled the owner/operator to benefit from a compressed engineering schedule.

**Increased quality.** The newly purchased ultra-low NO<sub>x</sub> burner designs were placed into the 3D model and modification comments were sent to the burner vendors. This provided the optimum fit into the existing facilities. Re-work from cutting and refitting was significantly reduced. This helped ensure a clash-free design (Fig. 4). The 3D layout made it easier for construction personnel to review the proposed design for improved planning of shutdown activities and constructability input into the design. Plant operations personnel were able to participate in virtual 3D reviews of the new facilities for operability and maintainability before the drawings were issued to construction. This resulted in "fewer surprises," shorter punch lists and improved customer satisfaction.

**Improved safety.** Overall, the laser documentation provided the design team free access to a digitized 3D version of the equipment to be modified on the designers' desktops, without requiring personal protective equipment or permits each time a dimension was needed. This saved about 75% to 80% of the time design personnel would have had to spend in the operating units compared to using traditional data collection methods.

**Recommendations.** When dependable drawings are not available and there is limited access to the equipment being modified, as-built documentation using laser scanning saves time and money and becomes integral for doing the job right. It is most appropriate when the project scope involves modifications to existing facilities in a localized and congested area. **HP**



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**James McGill** is the vice president of marketing for Quantapoint, Pittsburgh, Pennsylvania. He is responsible for increasing market awareness for the value of as-built laser documentation solutions. He earned an MSc degree in chemical engineering from the University of Louisville and an executive master of business administration degree from the Universities of Calgary and Alberta.