Cianbro surveyors use high definition scanner to create measurable 3D digital images that are then used to verify component positional accuracy.

REFINED DIMENSIONS

high-definition scanning helps redefine oil refinery fabrication

Today's modern oil refinery is a huge, efficient industrial facility that takes crude petroleum pumped from deep within the earth and turns it into useful products such as gasoline, aviation fuel, lubricating oil, home heating oil, and more.

Motiva Enterprises LLC, a joint-venture owned by affiliates of Shell and Saudi Aramco, is building an epic expansion at its refinery in Port Arthur, Texas. This project is vital to providing additional transportation fuels for the American consumer.

When completed in 2010, the Motiva Port Arthur Refinery Expansion Project will create a 325,000 barrel-per-day (b/d) capac-

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ity expansion at the Port Arthur refinery, increasing its crude oil throughput capacity to 600,000 b/d. The expansion will make the refinery the largest in the U.S., and among the top 10 in the world. The project is equivalent to building a major new refinery. The last new refinery in the U.S. was built more than 30 years ago.

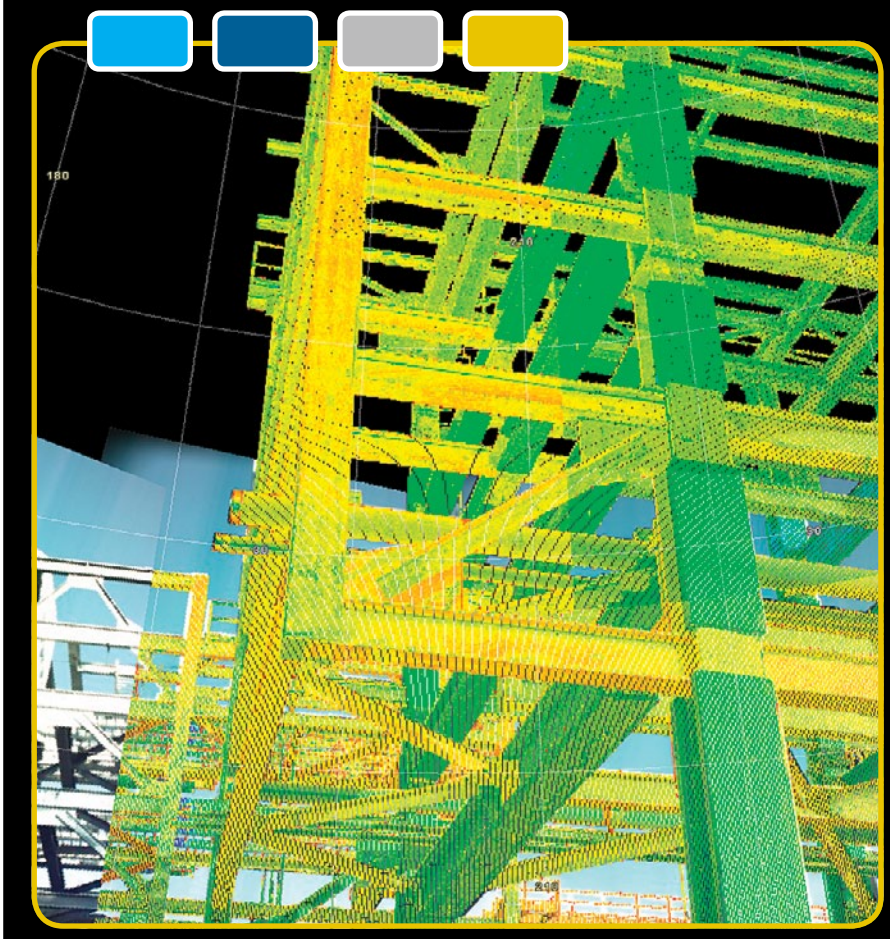
To accommodate a project of this magnitude, the construction plans include offsite fabrication of modular units. The modules that are being fabricated are pipe racks and large sections of the process units.

These modular sections of the plant are built to a tight tolerance, and are designed to fit one another while matching up correctly with the remaining sections of the unit that are built onsite. All the modules will arrive at the Port Arthur dock on barges, to be off-loaded onto a large multiple-wheel transport vehicle which takes the modules directly to their final positions within each unit.

Four fabrication contractors–located in Maine, South Carolina, Texas, and Mexico–were selected from more than 120 companies worldwide.

Located in Brewer, Maine, Cianbro Constructors, LLC is fabricating 53 of these geometrically complex modules. Each module weighs up to 650 tons, with an average size of 40 ft x 50 ft x 120 ft, and every module must be constructed to within one-eighth of an inch tolerance at pipe connections.

It's a complex surveying task that normally is accomplished by using conventional total stations, tapes and automatic levels. Today, Cianbro surveyors and engineers look to the latest high-definition surveying and reflectorless total station technology for improved speed, accuracy and reliability.



Millions of points are gathered during a scan session and then mapped into a single 3D model that is compared to theoretical designs.

From Paper to Oil

Modern refineries are made up of heat exchangers, reactors, separators, compressors and other oil processing equipment. These components are linked by an intricate network of pipes designed to convert crude oil into a useful petroleum product, efficiently and with environmental care. A critical phase of this conversion is called hydrotreating and/or hydrocracking, the process that removes sulfur and other contaminants from refinery products.

Cianbro's job is to fabricate Motiva's advanced hydrotreater and hydrocracker units, along with other modules for the expansion project. This task creates approximately 500 local, quality jobs and contributes significantly to Maine's economy.

As a start, Cianbro converted its 39-acre Eastern Manufacturing Facility located along the Penobscot River in Brewer from an idle paper mill into a state-of-the-art modular fabrication yard. The jobsite includes a sprawling crushed rock yard, sidewalk-grade concrete slabs and giant hydraulic cranes designed to lift the steel beams and columns that eventually frame each modular section.

A 500-square-foot module fabrication pad is able to accommodate up to 20 modules simultaneously. The administration building encloses 12,000 square feet, and a heavy haul road leads to the barge bulkhead.

Tight Tolerances

Each refinery module is a prefabricated, self-standing steel structure approximately four stories tall. It is constructed of steel beams that create the frame upon which pipes, valves, pumps and wiring are pieced together to form a catalytic-cracker-feed hydrotreater, and hydrocracker units.

Before the fabrication begins, a team of work package engineers at Cianbro's Eastern Manufacturing Facility dissects detailed 3D diagrams of the refinery units, drawings that are provided by the owner. The team builds work packages for each module, using 3-D Construct Sim software. The work packages consist of isometric drawings that detail weld types, pipe specifications, and 3D spatial data. Once a module's work package is complete, fabrication begins.

At each module staging pad, construction crews position transport beams and vertical column base plates that form the foundation of a unique module. The horizontal transport beams are positioned four to five feet above the ground so that the hauling trailers can slide under the module, lift it and carry it to the shipping dock upon completion.

Cianbro's field engineers use two Leica TCRA 705 reflectorless total stations tied to the Maine state plane coordinate system to monitor every module fabrication pad continuously. Once the beams and columns are in place, engineers are able to

At every position, field crews scan about one-quarter of a module depending on the module's size in about 15-30 minutes, gathering some 1.5 million points per set-up.

verify that the structural steel tolerances of 3/8" on location, 5/8" per 50 vertical feet plumb and 1/8" on elevation are met.

The two Leica TCRA 705 total stations continue to monitor for settlement and/or column movement throughout the module construction, since such movements might cause the structural steel to be out of tolerance. Engineers check the tolerances every morning, and prescribe the proper adjustments so as not to hold up production.

Scanned Alternatives

Once a module's beam and plate foundation is in place, structural crews begin to piece the components together at the module's lowest level, based upon the specifications contained in the work package. Every work package includes pre-defined pipes and other components.

When a module level is complete, Cianbro surveyors verify the positional location and accuracy of each component per the owner's specifications.

In previous situations that required field verifications such as these, Cianbro relied on conventional tapes, automatic levels and total stations to gather the necessary spatial data. It's typically a long and tedious process which would prove detrimental to the tight timelines defined by the client for construction of the refinery's modules.

Instead, Cianbro turned to high definition scanning, a relatively new technology that allows surveyors to create highly accurate, measurable 3D digital images of a structure or scene, quickly and easily. Studies conducted by Cianbro indicated that scanning a module would cut the position verification process from days to just hours, while providing improved accuracy and data consistency. In early 2008, the manufacturer purchased its first Leica ScanStation 2 scanner able to provide full 360° x 270° field of view from a single scan and long range accuracy to six millimeters, with 300-meter maximum range. The Leica ScanStation 2 fires at 50,000 points per second.

Collecting Clouds

As structural crews complete a module level, Cianbro surveyors set up the HDS ScanStation 2 on a tripod and begin scanning.

A scan typically covers about one-quarter of a module depending on the module's size. That process takes about 15–30 minutes to complete and will record some 1.5 million points. The field engineering crew then moves to the next position to scan another portion of the module. The full verification scan takes about two hours as the scanner is moved four to six times to ensure complete coverage of the module. The crew uses a traverse method to collect, constrain, and register a 3D point cloud of the entire module. The data is then tied directly to the site's local coordinate system.

Once the 3D scan data is collected, the ScanStation 2 technicians map the information into a single file. They verify that the collected data is precise and highly accurate by using Cyclone 6.0 and Cloudworx 4.0 software. The database created within the team's laptop in the field is then transferred to the Dell XPS desktop, which is also equipped with the proper Cyclone software for the final

As construction crews use cranes to moved refinery components into place, Cianbro scanning crews complete scans at a safe distance from the activity, minimizing risks on the busy fabrication site.

rendering and geospatial referencing of the structural steel and pipe end locations.

This information is then compared to the design values acquired from the owner's pre-determined theoretical design. If the engineers find a variance out of tolerance, they note the pipe end or structural steel values and relay the information to the Quality Assurance/Quality Control (QA/QC) team. The appropriate crew then receives the required re-alignment procedures from QA/QC.

The laser scan verification is repeated at each module's construction hold point, typically at the completion of a defined level. Follow-up scans at the second, third and fourth levels of a module provide further verification that variances found during previous scans have been corrected. The final report is then placed within the deliverables to the client.

Less Risk, Speedy Support

Typically, the structural crews can erect an average-size module in a little over a week. The combination of high definition scanning and reflectorless total stations has allowed Cianbro to minimize its field engineering crew to four team members, who support more than 450 craftspeople in the construction of all 53 modules.

The scanning technology has also helped minimize the risk to field engineers on the busy fabrication site by eliminating the need to climb modules to gather position data. With the high definition laser scanner, they can collect all necessary data from the ground.

Not only is the risk eliminated, but the time to collect the data is only a fraction of the traditional collection methods that are carried out by much larger field crews. By reducing the time needed to collect data, the field engineering crew is less apt to impact the production yield of the associated crafts who erect the modules.

Author Notes:
As of mid-October 2008, 12 modules are under various stages of assembly. By the end of 2009, all 53 modules will be completed and shipped to Port Arthur.

All HDS and survey equipment for this project was purchased from Maine Technical Source of Yarmouth, ME, a local Leica Geosystems Distributor.

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