

## Experience meets innovation: World-class coke drum replacement project

Six large coke drums at Chevron's El Segundo refinery, which supplies 20% of Southern California's vehicle fuel, were showing signs of aging after 46 years in service. Nearly five decades of high-pressure/high-heat cycles that thermally crack crude oil into petroleum products were also cracking the coke drum shells. This cracking posed a significant challenge to their safe removal and replacement in a \$55 MM turnaround completed in June. Everyone involved in the project credits extensive planning by experienced contractors, continuous top-to-bottom communication, and innovative problem solving for making the project one that Chevron calls "world class."

"Our approach was to hire the best we could get, because the job was going to be highly complex. Clearly, we wanted nobody to get hurt because any potential incident on a structure like this could be significant," said Rick Miller, Chevron Coke Drum reliability project manager. "So we decided to sole source to Nooter, which arguably, along with its sister company Wyatt, are the premier coke drum replacement contractors."

The El Segundo coke drums had come full circle for Nooter Construction, the St. Louis, Missouri company that installed them in 1968. Nooter has a long history of coke drum turnarounds, specializing in removing the cutting deck and derricks from the top of the coker unit to allow one-piece drum removal and replacement.

"Using this method to remove and replace a completed coke drum, on average, takes about a day to perform, which compares to a period of approximately one month per drum if the vessels were removed and replaced in sections," said Ed Collins, Nooter Construction senior rigging engineer. "If the benefit of expediting a project vs. the cost to expedite results is a ratio greater than one, it solidifies our position to perform the complex one-piece structure lift operation. We have typically found owners agreeable to this approach."

**The project.** The Chevron project involved 15 major lifts totaling 8.3 million (MM) aggregate pounds in just 15 days. A 1,600-metric-ton PTC-35 DS ring crane equipped with 400 ft of twin boom provided by Mammoet lifted the cutting deck and six coke drum derricks in one piece and set the approximate 1.4 MM-lb lift at grade. Six old coke drums weighing 400,000-lb each were pulled and replaced by six improved 600,000 lb drums. Then, the cutting deck and derrick structure were lifted back into place. Finally, the team removed a 125-ft abandoned column near the coker unit. The entire

turnaround took 42 days; it was completed on schedule, under budget and incident free.

"We (Nooter) considered it a world-class performance," Miller said.

Jerry Rother, Nooter Construction onsite project manager, said, "Some people would look at this and say, 'There is no way you can do that in 42 days.' From my standpoint, we went in and said 'We can do this.' That passes confidence along to everyone else."

**Plan your work; work your plan.** Nooter, along with engineering contractor Fluor, assembled a highly integrated plan in 2011 that called for 13 months of pre-turnaround construction preparation including structural upgrades for compliance with current seismic codes. The cutting deck and derrick required



**FIG. 1.** Side view of El Segundo coker unit.

extensive reinforcement, cut line preparation and installation of splice joint steel.

**Collaboration, communication, and creativity were essential in the safe and efficient replacement of six coke drums at Chevron's El Segundo refinery.**

"The craftsmen had a lot of experience with rigging and moving members; it was great seeing them work," said Seth Hall, Nooter project engineer. "Over the years, the drums themselves had minor deformities. In certain places, insulation had sagged. We trimmed all the existing members that were close to the drum to permit enough clearance to get them out. That was a definite time saver."

The preparation work was conducted while refinery operations continued. So, the team needed alternative plans to keep the project moving forward when coke cutting cycles changed on short notice.

"Our goal was to put an experienced team together," said Mike Tourville, Nooter Project Manager. "Since we have four in-house rigging engineers, we have excellent input at the planning stage about constructability. The key to success is to plan your work and work your plan."

Coke drum removal generally works best with two, four or even eight coke drum units because the rigging required to re-

move the derrick structure is symmetrical. That is not the case with a six-drum unit.

"It's difficult to balance the lift with the rigging," Collins said. "Mammoet had four 72-ft, 400-mton, multi-holed lifting beams. Into each beam, the sling load from six tower legs could be attached. Two upper slings from the top of each beam were placed in the ends of a 90-ft spreader bar at the next level. A single sling from each end was placed in a 600-mton shackle hanging from the top rigging beam which crossed over the top of the structure."

The crane required two months just to set up, but it was capable of moving the six-derrick structure and cutting deck in one piece without twisting or distorting the shape.

"When we made the lift of the cutting deck, people were actually cheering," Miller said. "That doesn't happen very often."

"We had good rigging plans. The crane vendor did an excellent job. The machinery was reliable," Rother said. "The key to the whole thing is you have to prepare to do the job. You don't need anything extra hanging over your head. No surprises. No holdups."

"The design of the bracing worked exactly as the design team intended. The structure was placed back into position as easily as it was removed, as has always been the experience of Nooter," Collins said.

**Innovation and experience—Controlling the risk.** The planning paid off during a key decision involving the method to remove the old coke drums. Normally, lifting lugs are weld-



FIG. 2. Cranes and rigging in place for the main lift.



FIG. 3. The El Segundo project was an unique six-drum lift.

ed onto opposite sides of each drum so slings can be attached to lift the drums out. However, concerns emerged that the required welding would extend the turnaround time and that the stress on the lifting lugs could cause unnoticed cracks on the 46-year-old vessels to open.

Rigging engineer, Ed Collins proposed an innovative solution to place a 30-in.-diameter pipe horizontally through the drum 2 ft beneath the top tangent line. Then, a wire rope sling was basket-hitched around each end of the pipe.

“During the lift, the upper half of the pipe would bear against the upper half of the hole cut-out in the shell,” Collins said. “Any undetectable cracks would not be detrimental to the integrity of the metal since they would be in a state of compression; they would be forced closed instead of opening.”

In addition, a welded plate was placed directly beneath the shell opening to stiffen the 30-in. pipe to eliminate any out-of-roundness deformation. Miller said there was disagreement about whether the through-pipe method would work. Chevron evaluated finite element analysis (FEA) data and decided it would support using the innovative approach. When the coker unit was shut down, the team used a high-pressure water-cutting process to cut two 30-in. holes in each drum well in advance of removing the overhead structure. When the rigging was loaded on the first drum, no excessive deformation was noted on the coke drum shell at the cut-out location. When the through pipe was removed from one drum, it slid easily into and out of the next drum.

“From the standpoint of constructability and usability, every component of the design worked exactly as intended,” Collins said.

“This saved a huge amount of time, and was a very technically savvy way to do it,” Miller said. “It looked a little bit old school compared to welding on big fancy lifting lugs, but it worked perfectly.”

**Communications: Early, detailed and candid.** From the beginning, Chevron instituted an active communication structure. An executive committee ensured that all major entities stayed in regular contact to discuss the project’s actual progress.

“It was the way things should be done,” said John Walling, Nooter Construction vice president. “People were very honest with one another. If there was a problem onsite, we talked about it. Because Chevron’s site manager was involved with the executive committee, he was bringing current issues. Each contractor felt we were involved and that our input was not only required but was welcome.”

“The real big thing was the attitude from Chevron management all the way through the team,” Rother said. “When you have a positive attitude, it’s like a chain reaction. There’s a real good chance that events and outcomes will come out good instead of bad.”

The philosophy extended to the craftsmen. Chevron shared project details using CAD designs, 3D animations, videos, a project website, weekly tailgate meetings, and daily information briefings from supervisors. Chevron’s Miller believes that a publicly declared project vision helped empower employees.

“The coolest thing was that, during the height of the turnaround, there were 580 people working,” Miller said. “And we probably had hundreds of leaders in that group—people stepping up at the right time doing the right thing.”

“It comes down to communication and good relationships with the client, our subcontractors and the craftsmen provided by the unions. You have to say what you mean and mean what you say. This approach was a united effort and everyone really bought into it,” Tourville said.

**Time is money; but safety is paramount.** Extremely high expectations about safety prompted an enhanced focus on training, implementation of an intensive safety management plan, and strong preventive programs. A “Stop the Drop” program called for every object to be tethered to prevent falling objects of any kind.

“That made a huge difference,” Hall said. “Even the small tools I use to lay things out were tethered. It made a huge difference. The safety culture was top notch.”

Craftspeople at all levels on the jobsite were empowered to “Stop the Work” in its tracks if they sensed a looming problem.

“The job came off very well safety wise, especially for all the critical lifts we did over a short period of time,” Walling said. “The team deserves way more than an ‘Atta boy’. It was a great, safe job.”

“Craftsmanship has improved,” Rother said. “We do everything we can to train them and teach them. They are more productive. And, from the safety standpoint, if people don’t get hurt, they are more productive. We want to make sure they know what they are doing so they don’t get hurt. That in and of itself improves productivity.”

“I’ve done a lot of projects. This one is way up at the top of that list, if not at the top. I will always look back on it with pride and be glad I worked with these guys,” Miller said. **HP**

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