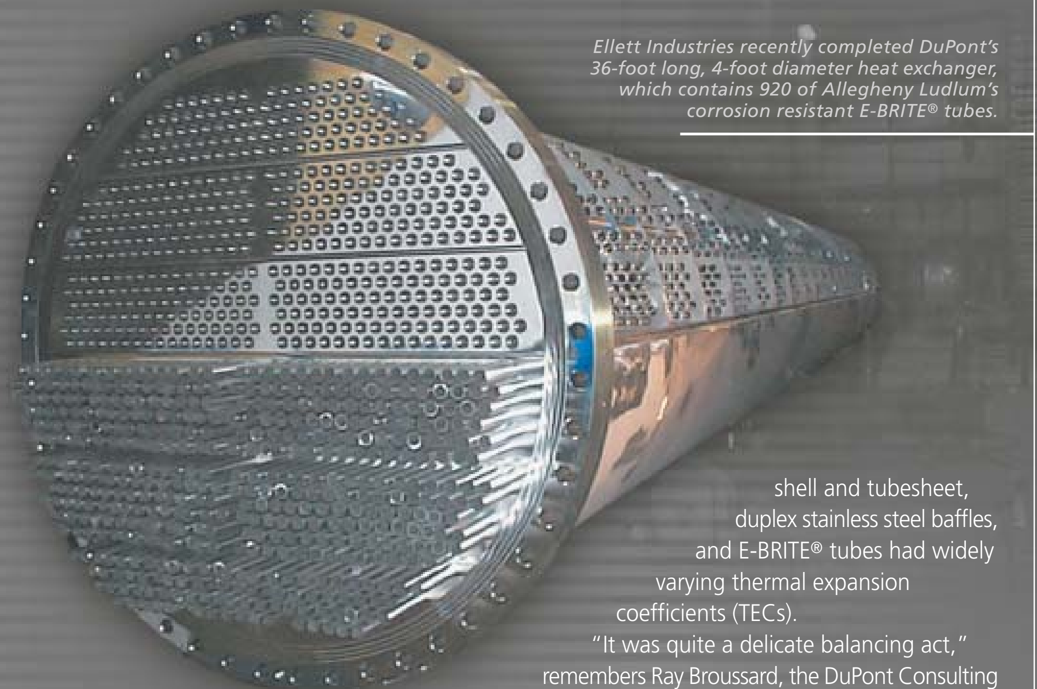
DuPont Heat Exchanger Design a Real Balancing Act

BY: KIRK RICHARDSON — *WAH CHANG*



Ellett Industries recently completed DuPont's 36-foot long, 4-foot diameter heat exchanger, which contains 920 of Allegheny Ludlum's corrosion resistant E-BRITE® tubes.

The word balance is derived from the Latin word bilanx, which means, "having two scale pans". The success of recent heat exchanger designed by DuPont and fabricated by Ellett Industries hung in this state, pivoting around a four-foot diameter tube of material and design challenges.

Selection of the corrosion resistant alloys to build this complex piece of replacement equipment (destined for stripper column service at one of the chemical giant's Gulf Coast plants) fell to Mike James, DuPont Materials Engineering Consultant. In making this decision, James had to find equilibrium between corrosion resistance and life cycle costs.

"We've been doing field corrosion coupon testing in this process over the years, starting back in the early 80s," according to James. "The service is a complex process that changes during the operating run," he explains. Among varying elements, the media includes large doses of phosphoric acid, ammonium carbamates, and other ammonia compounds. "It operates in the 150-160°C range," he adds. "For this process, E-BRITE® has always been the best choice (for tubes) from a life cycle cost standpoint."

So what exactly is E-BRITE®? It's an alloy in the truest sense, a specialty ferritic stainless steel that contains a cocktail of elements, including chromium, molybdenum, nickel, copper, manganese, phosphorus, sulfur, silicon, carbon, nitrogen, and even a little niobium. According to manufacturer Allegheny Ludlum, an Allegheny Technologies Company, the alloy's chromium (26%) and molybdenum (1%) "confer general corrosion resistance and resistance to pitting and crevice corrosion."

In addition, the ferritic structure of E-BRITE®, combined with controlled low levels of nickel and copper, provide resistance to stress corrosion cracking. Ultra-low carbon and nitrogen content, plus a controlled addition of niobium provide resistance to intergranular corrosion and give the alloy superior ductility when compared to conventional ferritic stainless steels.

Though DuPont's previous heat exchanger for this application also contained E-BRITE® tubes, the new unit posed new challenges, including a more stringent ASME stress code. Finding materials tough enough to withstand the severe processing environment and meet the stiffer stress code was an impediment to solving the puzzle.

As it turned out, the ideal materials of construction created less than ideal teammates when welded or mechanically joined. The biggest hurdle? The soon to be united 316 stainless steel shell and tubesheet, duplex stainless steel baffles, and E-BRITE® tubes had widely varying thermal expansion coefficients (TECs).

"It was quite a delicate balancing act," remembers Ray Broussard, the DuPont Consulting Engineer tasked with finding a way around the design obstacles. He explains that the materials' different TECs and the range of operating metal temperatures, combined with stricter ASME code requirements from the old unit's original design basis, made it "much more difficult to get a flanged and flued expansion joint to work." Broussard points out that "the problem was solved with a higher strength expansion joint material (FERRALIUM® 255), which had higher allowables, that could handle the stress induced by the differential expansion of the tubes."

No small effort later, Broussard prevailed, developing a workable design, which he handed off to equipment fabricator Ellett Industries.

David Clift, Manager of Production

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Fabrication complete, the heat exchanger heads south for stripper column service at one of DuPont's Gulf Coast plants.

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Engineering for Vancouver, BC-based Ellett, was responsible for transforming DuPont's engineering design specification into a 36-foot long, 920-tube heat exchanger. The usually affable engineer gets serious when describing the effort involved in building the equipment. "Working with E-BRITE® alloy required great care," he says, noting that the alloy galled when slid over 316L stainless steel surfaces.

Clift says that one of the most difficult elements in the job was building the exchanger's complex baffle system. "Everything had to be perfect," he says. "This was not a conventional design." The drawings called for 76 baffle segments, comprising a relatively complex cross-baffling system... no small feat of engineering. The 24-foot longitudinal baffle running down the length of the exchanger "had to be flat", as Clift puts it, to ensure that the top and bottom cross baffles aligned precisely. "Alignment of the cross baffles was critical," he says.

Ellett's David Clift (right) says that "everything had to be perfect" in fabricating the atypical heat exchanger. The tube holes [pointed out by Jim Hunt (left)] were drilled to tight tolerances.

Clift claims that his team not only met TEMA tolerances, but also exceeded them in some cases. He points out that the E-BRITE® tubes have higher strengths than the supporting 316L stainless steel tubesheets. "This presents a challenge when attempting to produce a mechanically expanded tube to tubesheet joint," he says. "Tube holes were drilled to tighter than TEMA special close fit tolerances (1.010 +/- 0.002), and a pre-production mock-up of the proposed joint was subjected to shear load testing."

In March 2003, Ellett Industries shipped the unit to the Gulf Coast for installation. Project team members are off working on other challenges, but can be proud of their recent efforts. All things considered, DuPont's and Ellett's successful balancing act adds weight to the word balance well beyond "two scale pans."

For more information on Allegheny Ludlum's E-BRITE® alloy and other corrosion resistant metals, please call 800.258.3586 or visit www.alleghenytechnologies.com. For further details about Ellett Industries capabilities, call 604.941.8211 or visit their web site at www.ellettindustries.com. ■

The Effect of Oxidizers on the Corrosion Resistance of Reactive Metals

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use. Pickling process equipment prior to service can be an effective preventative measure to remove oxidizing contaminants; it also minimizes the effect of oxidizing impurities present in solution by eliminating the preferred sites on the metal surface where the oxidizers are most likely to attack.

The differing effects of oxidizers on the corrosion resistance of reactive metals can be quite dramatic, as illustrated in the previous example of zirconium and titanium in hydrochloric acid solutions. This is just one specific case; each process solution is unique, and the corrosion behavior of each of the reactive metals in that solution is unique.

Laboratory and corrosion coupon testing can be helpful in determining how a reactive metal will perform in a particular chemical environment; with this information, intelligent decisions can then be made to minimize or take advantage of any corrosive effects caused by the presence of oxidizers.

For more information or to discuss a potential testing program, visit corrosionsolutions.com or contact the Corrosion Lab at 541.926.4211 x6521. Mr. Abraham can be reached by e-mail at mike.abraham@wahchang.com. ■

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