

PLANT DESIGN AND ENGINEERING

SPECIAL REPORT

Lessons learned during revamp of 34 year-old reformer

Retrofit of heater required unique engineering, design and construction methods

K. EDMUNDS, North Atlantic Refining Ltd., Come by Chance, Newfoundland, Canada, **S. UZELAC** and **R. NEWNHAM**, Born Heaters Canada ULC, Calgary, Alberta, Canada

The North Atlantic Refining Ltd. (North Atlantic) refinery was built as an export refinery in 1973 in Come by Chance, Newfoundland, Canada. The refinery has a continuous catalytic reformer (CCR) with a catalytic reformer heater. This heater consists of two separate radiant sections with a common convection section that generates saturated and superheated steam (Fig. 1). The furnace has a total duty of 236×10^6 Btu/hr and generates 627,000 lb/hr of saturated steam and 66,000 lb/hr of superheated steam.

Exposure to harsh environments and 34 years of service have caused mechanical and structural deterioration to unit equipment, even to high-alloy cast tube supports. The failed tube supports were repaired to prevent further damage. However, the temporary solution was a sign that further work was necessary to maintain future operating effectiveness. In addition, refractory spalling created hot spots on the walls, which required rectification. The structural integrity of the convection box was also reviewed. Replacement of the convection box was considered necessary. The challenge for this revamp was to accomplish such a retrofit during a tight refinery turnaround and under inclement weather with very limited access.

Background. The primary causes for this deterioration were erosion and corrosion. The external erosion was generated due to the close location to the Atlantic Ocean under some of the most extreme weather conditions in any part of the world. Internal corrosion resulted from the fuel-oil composition containing high sulfur and vanadium. This corrosive environment caused failure of the internal tube sheets due to high-temperature corrosion from the vanadium pentoxide and residue sulfur in the flue gases. Although the tube sheets were constructed with 25Cr–20Ni materials in accordance with the design specifications and temperatures at the time of installation, current specifications would require 50Cr–50Ni–Cb construction materials.



FIG. 1 The radiant sections and convection section of the Come by Chance refinery were deteriorating due to severe North Atlantic climate.

The original construction used bolted panels and had no seal welding. In an environment that features heavy rain, snow and fog, moisture was constantly being drawn into the structural seams by negative pressure inside the convection box, combined with capillary action. The contacting and condensing of flue gases created sulfuric acid. This acid became the corrosion source of the inner shell and refractory anchorage.

Solutions. The mentioned problems were presented to an engineering team in Calgary. Working with the owner, five solutions were developed and recommended to North Atlantic. Each solution presented unique benefits, but all shared significant improvement from current design and operating conditions. The options were:

1. Install a new catalytic reformer heater
2. Install a new grade-mounted convection section
3. Replace the convection section per original geometry, using upgraded materials
4. Replace the convection section with studded tubes
5. Replace the convection section with studded tubes and higher absorption.

After careful technical and commercial analysis, it was determined that replacement in kind (Option 3) with upgraded materials and design was the most feasible option due to limited downtime and delivery schedules.

Scope of work. The convection section essentially maintained its geometry but underwent several modifications. Mechanical and structural improvements were to be conducted

while carefully ensuring that the final weight of the new unit did not exceed the weight of the original convection section (Fig. 2). The new design consisted of 18 rows of steam-generating carbon steel tubes and another three rows of Cr-Mo, P22 tubes that would service as the steam superheater coils. This maintained the original steam superheater configuration while removing six rows of steam-generation tubes.

Soon after fabrication commenced, the team conducted a study of installing four additional rows of tubes to the steam-generating rows, thereby increasing steam generation and efficiency. The structure was adequate for the new design loads and higher production output. The additional four rows would be beneficial as long as they did not drastically affect the final delivery schedule.

Beside the delivery schedule and production output, a careful erection evaluation had to be conducted to establish whether adequate clearances were still in place with the new coils. The design team established that, if the additional rows were added, the erection clearance would remain acceptable.

With this completed, the full scope was defined. Engineering design began in a sustained effort that cross-checked the field as-built with the new design concept. The fast-paced project consisted of approximately 40 detailed engineering drawings and over 300 vendor shop drawings. The new convection section had a total length of 80 ft 8 in. (24,587 mm), a width of 6 ft 4 in. (1,930 mm) and a height of 36 ft 4 in. (11,074 mm). Total erect weight of approximately 260 tons was too high for the available cranes in Newfoundland. The design team addressed this problem as fabrication commenced.

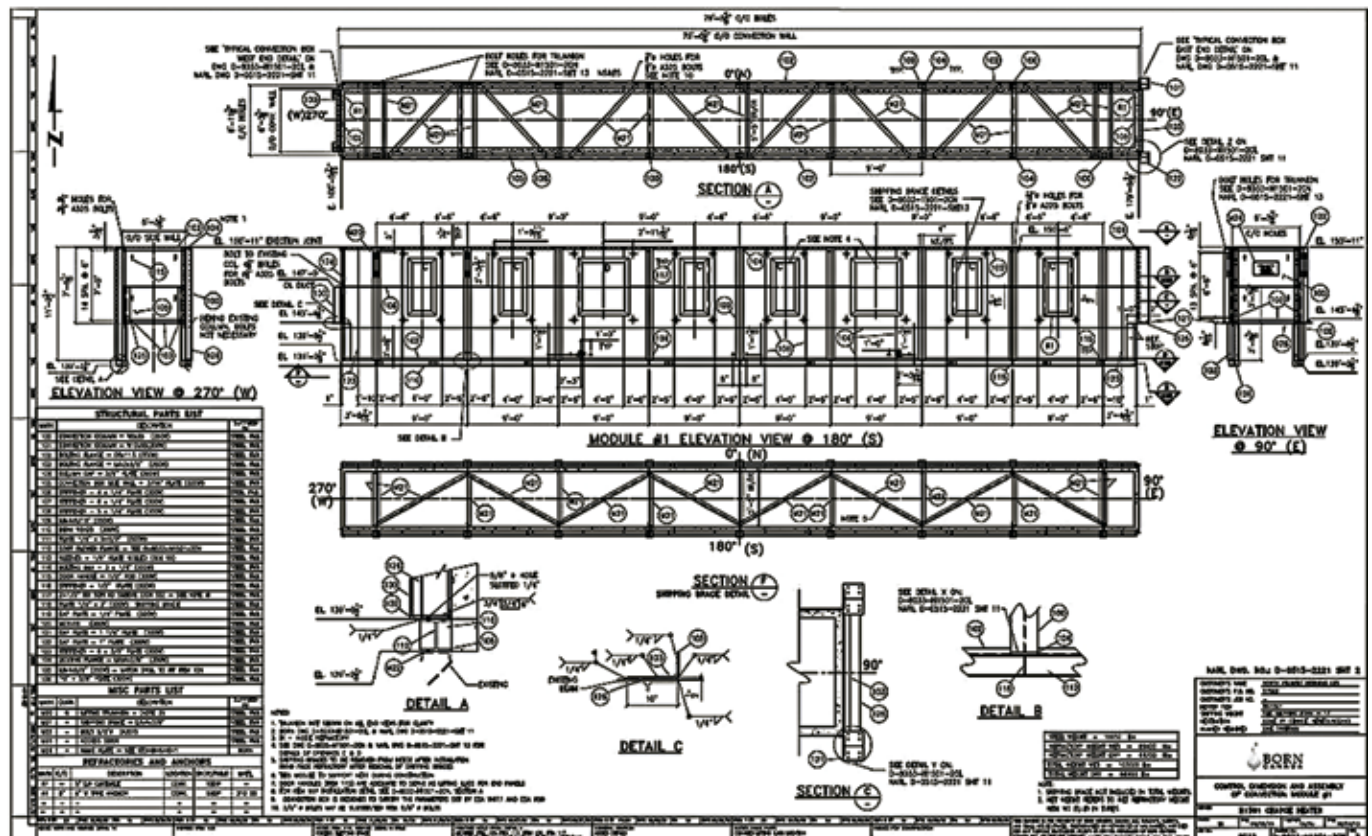


FIG. 2 Detail drawing of a typical convection section.

Design for construction. The furnace was originally installed in 1971–1973 as part of a grassroots construction phase. This original furnace was built by erecting the furnace skeleton made up of heavy structural members and proceeding by part assembly. This would not be possible for the revamp due to the lack of heavy-lift equipment and limited access.

In the original concept, the skeleton was completed, followed by tube supports and tubes. Most of the tubes were welded in a “hockey stick” manner with a long tube along and a return bend that was welded offsite. Despite eliminating one half of the coil field welds by creating “hockey sticks,” the remaining welds amounted to substantial onsite work. As these welds were completed, prefabricated panels were then bolted to the skeleton. Each panel spanned between two columns and was approximately 9 ft in height. For this convection box, that amounted to approximately 120 panels. With the size of the heater, replacing the convection section in the same manner was not feasible if work was to be completed under a very tight schedule.

From the start, the design team and the client’s intention was to fabricate this convection box in completed modules—all the steelwork, tube supports, tubes and castable refractory installed (Fig. 3). The goal was to minimize the number of modules and to improve field-erection efficiency while not exceeding the capacity of the available cranes. The size of each module was based on the initial weight and crane estimate.

The first requirement was a complete survey of the existing heater. This survey was to be conducted while the heater was in operation, and this provided the “hot” dimensions. A second survey would be required during the scheduled refinery slow-down to determine the cold dimensions of the furnace.

Fabrication. The new modules had to fit the existing 34-year-old structure. A module even ½-in. out when it is elevated 100 ft in the air was unacceptable. The design team and the refiner worked together on establishing and obtaining the critical survey dimensions of the furnace. The critical items were all the mating surfaces of the convection section, all structural members and external piping that tied to new manifolds.

First components to be fabricated were the 50Cr–50Ni–Cb tube sheets, as these were long-lead items. Therefore, the casting process had to start well ahead of the furnace fabrication. During the design of the tube sheets, several meetings were held with foundry engineers to optimize the tube-sheet design before creating patterns to minimize the number of potential defects. This attention focused on the pilot castings, and production proceeded to schedule.

The convection box was fabricated locally, in close proximity to the refinery. This allowed for efficient transportation, and first-hand inspection by the refiner. The local fabricator had a facility that allowed them to manufacture the modules of such proportions and to subsequently store them for the turnaround.

The fabrication went mostly as planned, with a dedicated team of surveyors closely verifying the geometry of each module. With a project of this magnitude, some dimensional inconsistencies were encountered, with the majority being repaired in the shop before field erection.

The first two completed modules had significant storage time. With the ever-changing Newfoundland weather, prolonged storage poses a problem for castable refractory. As each module was completed, it was stored outside and was protected with plastic tarps from weather storms. During the day, the heat generated

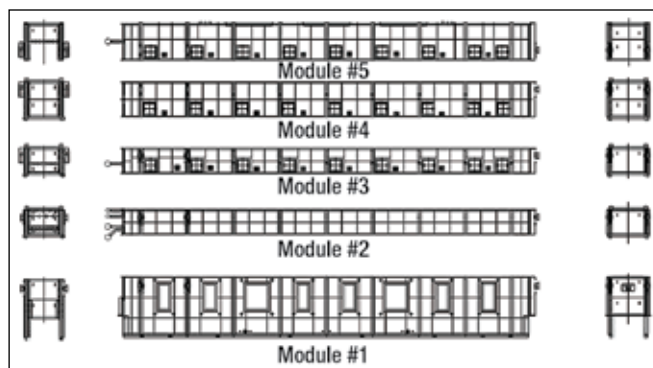


FIG. 3 Modularized convection box of the reformer heater.



FIG. 4 The convection box after demolition; the skeleton is available for new construction to begin.

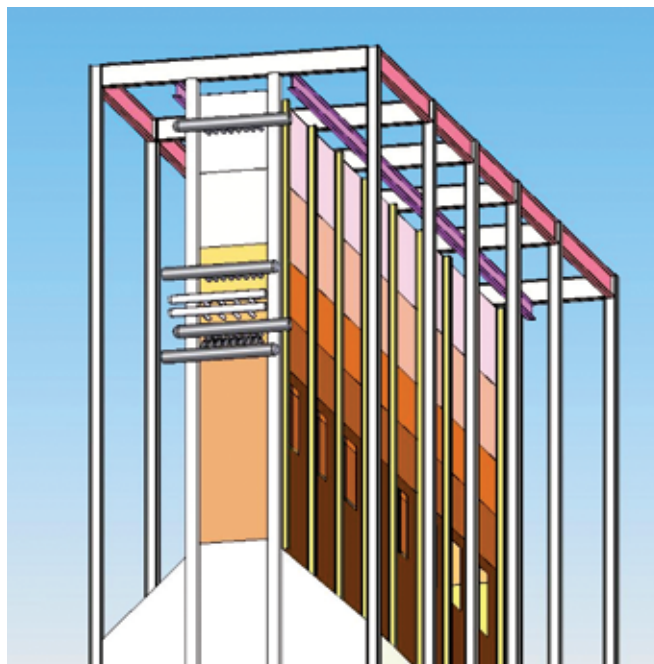


FIG. 5 New convection box in the existing skeleton; the erection beams are shown as purple.

from the sun triggered evaporation of moisture from the refractory. As the module was covered, the moisture would condense on the refractory surface. To prevent hydrolysis, the shop built tent-like structures that would encourage air flow and yet protected each module from additional moisture.

Erection. The first part of the revamp was to strip the structure of existing tubing and already lined steel panels. As the coils and steel panels were removed, the heater was prepared for reassembly



FIG. 7 Lifting of Module 5 during the revamp of the reformer heater.



FIG. 6 Module 1 is erected and Module 2 is being lifted. Both cranes use trolleys in the background.

of the new modules (Fig. 4). All lift preparations were conducted during the daytime hours, while the lifts were conducted during the night when gentler Newfoundland winds prevail.

Limitations on heavy-lift cranes that can reach over the existing equipment eliminated the possibility of lifting the module in the conventional manner. The existing stack was kept in place to minimize the scope of demolition and subsequent construction.

A concept was developed to reuse the beams that were in place at the top of the structure (underside of stack structure) and were used for the construction of the original convection box. Due to their unique position on the existing structure, the five modules created a solution by using “trolleys” that would slide along these erection beams (Fig. 5).

The erection sequence was to bring each module on the special hydraulic ride trailer and position it under the trolley beam. From that point, each module was to be lifted vertically with two conventional cranes (one at each end). As the module made its way up, the crane closest to the furnace would secure and gradually transfer its load to two trolleys. The trolleys would progressively move toward the opposite end of the heater moving the module along with them. The crane on the further end would extend its boom to accommodate the movement of the modules toward the furnace (Figs. 6 and 7).

As the module reached its position inside the skeleton, it was carefully lowered to meet its supports. To minimize erection time for each module, the design engineers determined the minimal number of connections that had to be in place before proceeding with the next module.

Project review. The task of revamping the 34-year-old reformer heater was met by solving the engineering challenges in a timely manner in a limited refinery turnaround schedule. The refinery was able to commission and start up as planned, with all thermal and process requirements met and, in several cases, improved upon. **HP**

NOMENCLATURE

Cr	Chromium
Ni	Nickel
Mo	Molybdenum
Cb	Columbium



Kirt Edmunds is a lead project engineer with North Atlantic Refining Ltd. He has 10 years experience in the oil and gas industry, including five years with North Atlantic. Mr. Edmunds has a BS degree in mechanical engineering from Memorial University of Newfoundland and is a professional engineer.



Roger Newnham is president of Born Canada and has over 30 years of experience in direct-fired heater design, engineering and installation. He has also developed specific expertise in burner-management systems, and has provided clients with design, engineering and other services related to refractory installation, burner revamps and the installation and maintenance of direct-fired heaters. He is a member of M.I.Mech.E. in Great Britain.



Slavko Uzelac is a project manager for Born Heaters Canada ULC in Calgary, Alberta. He has been employed by Born Heaters for the last six years during which his role varied from design work, sales engineering, project engineering to project management. Mr. Uzelac has a technical diploma from Southern Alberta Institute of Technology (2001) in Calgary, and is scheduled to graduate with a BSc degree in manufacturing engineering from the University of Calgary in April 2008.