



CASE STUDY: Recovery Reactor Feed Cooler Heat Exchanger

Precision Thermal Design for a Critical Process Stream in a Chemically Aggressive Environment

Project Snapshot

Industry: Petrochemical / Process Equipment

Equipment Type: Shell and Tube Heat Exchanger

Service: Recovery Reactor Feed Cooler

Design Code: ASME Section VIII Division 1, 2019 Edition

Standards: TEMA 10th Edition, 2019 + API 660 9th Edition

TEMA Type: BFU

Material: Stainless Steel TP316L

Challenge: Design and deliver a reliable, code-compliant feed cooler capable of conditioning a chemically sensitive reactor feed stream while resisting corrosion in a demanding process environment.

Result: A fully engineered, ASME-compliant heat exchanger meeting TEMA BFU and API 660 requirements, fabricated in SS TP316L for long-term corrosion resistance and process integrity.

1. Opening Hook – The Challenge

In petrochemical processing, the condition of a reactor feed stream is critical. Feed temperature directly influences **reaction selectivity, yield, and catalyst life**. Delivering feed at the wrong temperature—even temporarily—can cause runaway reactions, catalyst degradation, or unsafe operating conditions.

This project required the engineering and fabrication of a **Recovery Reactor Feed Cooler**, a heat exchanger tasked with precisely conditioning the process stream before it enters the reactor. The challenge was not just thermal performance—it was delivering that performance **reliably, safely, and durably** in a chemically aggressive environment where material selection, code compliance, and mechanical integrity were non-negotiable.

2. Problem Definition



The design brief presented several interconnected engineering requirements:

1. **Thermal duty:** The exchanger needed to cool the reactor feed stream to a precise target temperature within tight process tolerances.
 2. **Material compatibility:** The process fluid's corrosive nature demanded a material that could resist degradation over the full design life—ruling out carbon steel and requiring **SS TP316L**, known for its superior resistance to chloride-bearing and acidic environments.
 3. **Code and standard compliance:** The exchanger had to satisfy three distinct and overlapping frameworks simultaneously:
 - **ASME VIII Div.1** for pressure vessel integrity.
 - **TEMA 10th Edition** for mechanical design and construction standards.
 - **API 660** for shell-and-tube heat exchangers in petroleum and gas industries—the most demanding industry benchmark for this equipment class.
 4. **TEMA Type BFU configuration:** The BFU designation (Bonnet front head, Fixed tubesheets, U-tube bundle) required careful attention to thermal expansion management and bundle pull requirements within the fixed tubesheet arrangement.
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3. Our Approach

Thermal and Hydraulic Design

The design process began with a detailed **thermal and hydraulic analysis**:

- Heat duty calculations to size the exchanger for the required cooling load.
- Tube-side and shell-side pressure drop optimization to stay within allowable limits.
- LMTD (Log Mean Temperature Difference) and correction factor analysis for the BFU multi-pass configuration.
- Fouling factor allocation per TEMA standards to ensure long-term performance between cleaning cycles.

Mechanical Design and Code Compliance

Mechanical design addressed every pressure-retaining component per **ASME VIII Div.1**:

- Shell, channel covers, tubesheets, and nozzles sized and rated for design pressure and temperature.
- Weld joint efficiency and NDE requirements established per code.
- **API 660** compliance layer applied for nozzle loads, bundle extraction clearances, and material traceability requirements.



Material Selection and Corrosion Strategy

SS TP316L was selected for both shell and tube wetted surfaces:

- The low-carbon "L" grade minimizes sensitization during welding, preventing intergranular corrosion.
- Superior pitting and crevice corrosion resistance compared to 304/304L grades.
- Long-term compatibility with the process fluid chemistry, reducing unplanned maintenance and replacement risk.

Fabrication and Inspection

Fabrication followed a rigorous **quality plan** aligned with TEMA and API 660:

- Qualified welding procedures (WPS/PQR) for stainless steel to prevent heat-affected zone degradation.
- Full dimensional inspection of tube bundle, baffle spacing, and tubesheet drilling.
- Hydrostatic testing and NDE of all welds per ASME and API 660 requirements.
- Material traceability maintained from mill certificates through final documentation package.

4. Results and Impact

Parameter	Details
Equipment	Recovery Reactor Feed Cooler
TEMA Type	BFU
Design Code	ASME VIII Div.1, 2019 Edition
Standards	TEMA 10th Ed. + API 660 9th Ed.
Material	SS TP316L (Shell and Tubes)
Key Compliance	ASME stamp applicable, API 660 full compliance

- **Process protection:** Reactor feed stream delivered at target conditions, protecting catalyst life and reaction yield.
- **Corrosion resistance:** SS TP316L selection ensures long equipment life in chemically aggressive service.
- **Regulatory compliance:** Full ASME, TEMA, and API 660 compliance provides client confidence and regulatory assurance.



- **Reliability:** Proper thermal margin, fouling allowances, and material selection combine to minimize unplanned shutdowns.
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5. Takeaway & Forward Value

This project demonstrates how **multi-standard compliance, material science, and thermal engineering** come together in mission-critical process equipment. A reactor feed cooler is not simply a heat transfer device—it is a **process-critical safeguard** that protects the reactor, the catalyst, and the entire downstream production train.

By engineering to the intersection of **ASME, TEMA, and API 660**, and by selecting materials with long-term corrosion resistance as a design priority, this exchanger was built to deliver **reliable, accurate, and safe performance** for the full design life of the plant.

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