

# Fuel Oxidizer Rocket Engine Heat Exchanger

Exergy engineered a custom tube-in-tube heat exchanger enabling precise propellant conditioning of highly reactive MMH and NTO oxidizers for a rocket testing facility combining extreme pressure structural integrity with precision thermal control in a compact, aerospace-grade package.

## The Engineering Challenge

The customer required a system capable of both heating and cooling fuel oxidizers (MMH and NTO) under stringent process conditions with no margin for error. The application demanded dual-mode thermal operation across a wide temperature range, from a lower bound of 10 °F up to 140 °F during heating cycles, and from 150 °F down to 20 °F during cooling cycles. Flow rate requirements of 5 GPM necessitated that a 50-gallon batch reach thermal equilibrium within a 2-hour window placing strict demands on heat transfer efficiency.

The system nominal operating pressure was 400 psi; however, the design was required to withstand burst conditions up to 2,200 psi, reflecting the extreme safety factors standard in aerospace propellant handling. All wetted materials required full compatibility with the hypergolic propellants MMH (Monomethylhydrazine) and NTO (Nitrogen Tetroxide), which are highly toxic and spontaneously ignite upon contact with each other.

## Design Specifications — Model #01194-01

### 1 Construction

316L stainless steel, all-wetted surfaces — chosen for superior corrosion resistance against hypergolic propellants and compliance with aerospace material standards.

### 2 Heat Transfer Area

3.7 ft<sup>2</sup> of effective heat transfer surface, sized to achieve batch equilibrium within the 2-hour requirement at 5 GPM flow rate.

### 3 Surface Finish

Electropolished to 20 μin (0.5 μm) Ra max minimizing propellant entrapment and ensuring cleanability to aerospace cleanliness standards.

### 4 Connections

Inner tube stubs for secure, leak-tight propellant-side connections; outer NPT fittings for reliable utility-side integration into the test stand infrastructure.

# 400

**psi Operating**

Nominal system operating pressure during propellant conditioning cycles

# 2200

**psi Design Rating**

Pressure rating providing a 5.5× safety margin above operating conditions

# 3.7

**ft<sup>2</sup> Heat Area**

Effective heat transfer surface area in a compact tube-in-tube geometry

# 2 hr

**Batch Equilibrium**

Time to achieve thermal equilibrium across a 50 gallon propellant batch at 5 GPM

## Thermal Operating Envelope

The heat exchanger was validated across a demanding dual-mode thermal envelope. In heating mode, the unit conditions propellant from a cryogenic-adjacent 10 °F up to 140 °F — a 130 °F span ensuring propellant viscosity and reactivity characteristics meet pre-test conditioning specifications. In cooling mode, the unit drives propellant temperature from 150 °F down to 20 °F, a 130 °F reduction, providing symmetric thermal authority on both sides of the conditioning target. This symmetric capability is critical for facilities conducting back-to-back test sequences where propellant temperature must be reset rapidly between runs.

The tube-in-tube configuration isolates the propellant stream in the inner tube while the utility fluid whether a heating medium or coolant circulates in the annular space. This geometry maximizes counter-flow heat exchange efficiency while keeping the overall assembly footprint minimal, a decisive advantage in congested test cell environments where space allocation is at a premium.

## Results & Operational Benefits

### Precise Temperature Control

Safe and repeatable propellant conditioning achieved across the full ±130 °F operating range.

### Structural Integrity

Reliable performance at 400 psi operating pressure with verified 2,200 psi design margin.

### Compact Footprint

Durable, space-efficient solution optimized for dense aerospace test cell environments.

### Operator Confidence

Electropolished 316L construction and ISO 9001:2015 quality assurance deliver traceable, certifiable performance.

✔ **ISO 9001:2015 Certified Quality Management System** — All design, fabrication, and testing processes governing Model #01194-01 were executed under a certified QMS, ensuring full traceability and compliance with aerospace procurement standards.