CASE STUDY: Specifying, Procuring, and Installing a Dual-Mode Liquid-Fuel Pumping System

Building Reliability by Engineering for Performance and Emergency Readiness

Project Snapshot

Industry: Aerospace / Combustion Systems Integration
Challenge: Deliver a high-pressure liquid-fuel pumping system capable of both dry-fuel and fuel-water emulsion operation.
Result: Fully integrated three-stage skid designed, procured, and commissioned with advanced control, redundancy, and purge safety—meeting precise duty targets while ensuring safe emergency response.

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1. Opening Hook – The Mission

This project didn't begin with a failure to fix—it began with a **capability to enable**. The client required a new **liquid-fuel pumping system** that could operate in both **dry** and **emulsified fuel modes** to expand their combustion-test flexibility.

The target duty parameters were challenging—pressures exceeding **3,000 psi**, at a flow rate of **1500 lb/hr**, feeding six independently staged fuel circuits, and the ability to run cleanly in standard liquid-fuel mode or mix fuel with water to form a controlled emulsion for emissions control testing.

Equally important, the system needed to perform **safely and predictably under emergency conditions**, where loss of control could mean damage worth hundreds of thousands of dollars.

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2. Defining the Right Requirements

We began by co-developing the system requirements with the client—focusing not only on nominal performance, but on the **failure envelopes**:

- What happens in an emergency shutdown?
- How can we safeguard the operator and the test article?
- How can the system automatically depressurize or purge when the unexpected occurs?

hort, success meant **specifying the right details up front**—not merely reaching target and pressure numbers, but engineering for stability and safety across all operating states.

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3. Our Approach – Three-Stage System Architecture

Stage 1 – High-Pressure Pumping Skid

We engineered the complete pumping skid as the foundation of the system, integrating:

- **Pump and motor assembly** rated beyond 3,000 psi.
- **Dual-stage filtration:** a low-pressure inlet filter for incoming fuel and a high-pressure outlet filter to capture potential debris released by pump wear—protecting critical downstream instrumentation.
- **Redundant safety pressure-relief network:**
  - Burst disk
  - Mechanical pressure-relief valve
  - E-stop-linked solenoid valve to automatically vent pressure on emergency stop

Together, these precautions ensured the system could **safely depressurize instantly**, preventing over-pressurization or uncontrolled fuel delivery.

The skid also incorporated a **Variable Frequency Drive (VFD)** on the motor and a **coarse/fine valve pair** for precise pressure and flow modulation.
This combination enabled **exceptional turndown control**, smoothly ranging from 0 to 1,500 lb/hr fuel flow—critical for staged combustion testing.

Stage 2 – Water and Emulsion Control

To enable **water–fuel emulsification**, we added a dedicated water-pumping loop with its own **control valve** and **flow meter**, delivering accurate water-to-fuel ratios.
After an optimized mixing configuration to allow proper emulsification, the main manifold distributed flow to **six independent fuel circuits**, each fitted with:

- Individual **flow meters**, and
- Automated flow **control valves**
  This allowed the facility to **stage fuel delivery** precisely across the six combustion zones.

low components—valves, meters, and fittings—were specified for the full **3,000 psi ng**, a crucial safeguard since mis-specification could easily cause catastrophic failure in high-pressure rigs.
Attention to these specification details is where **ProReady Engineering's systems expertise** most clearly differentiates our work: we engineer for reliability before problems can occur.

Stage 3 – Integrated Purge and Emergency System

The final stage addressed one of the most critical aspects of safe operation: **emergency purge and shutdown performance**.

During rapid test termination at full load, **residual fuel trapped in hot lines** can carbonize ("fuel coking") and destroy fuel-premixer hardware within minutes.
Our design incorporated a **nitrogen-based purge system** that:

- Injects purge gas **as close as physically possible** to the engine inlet to minimize unintentional-fuel pockets.
- Includes a **pressure-referenced regulator** that automatically tracks the operating pressure of the combustion system rather than using a fixed setpoint.

This means that whether shutdown occurs at idle or maximum power, **nitrogen pressure remains correctly set relative to system operational pressure**—avoiding damaging flame spikes or incomplete purges.

The purge subsystem was fully integrated with the emergency-stop logic and tested through multiple simulated shutdown events.

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4. Results and Validation

- **Operational flexibility:** Seamless transition between dry-fuel and water-emulsion modes.
- **Precise control:** Full-range turndown (0–1,500 lb/hr) with synchronized pressure and flow accuracy.
- **Safety performance:** Verified instant depressurization and successful purge response during emergency tests.
- **Specification accuracy:** All high-pressure components validated for 3,000 + psi continuous duty without fatigue or flow-measurement drift.

system was designed, procured, and commissioned end-to-end—meeting all technical rics while incorporating best-practice design safeguards normally overlooked in conventional fueling skids.

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5. Takeaway & Forward Value

This project demonstrates the **ProReady Engineering philosophy**: we don't just meet design targets—we **engineer capabilities** to ensure long-term, reliable, and safe operation.

By thinking through *how the system behaves in every state—nominal, off-nominal, and emergency*—our team delivered a pumping system that is:

- **Technically precise**,
- **Operationally flexible**, and
- **Intrinsically safe** under the toughest conditions.

This capability expanded the client's testing envelope while establishing a new internal standard for **specification discipline and emergency resiliency** in high-pressure fuel delivery systems.
