

Gall-O-Matic: High-Pressure Friction & Galling Test System

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PROJECT MOTIVATION

Lack of high-pressure friction data for aerospace cold-working

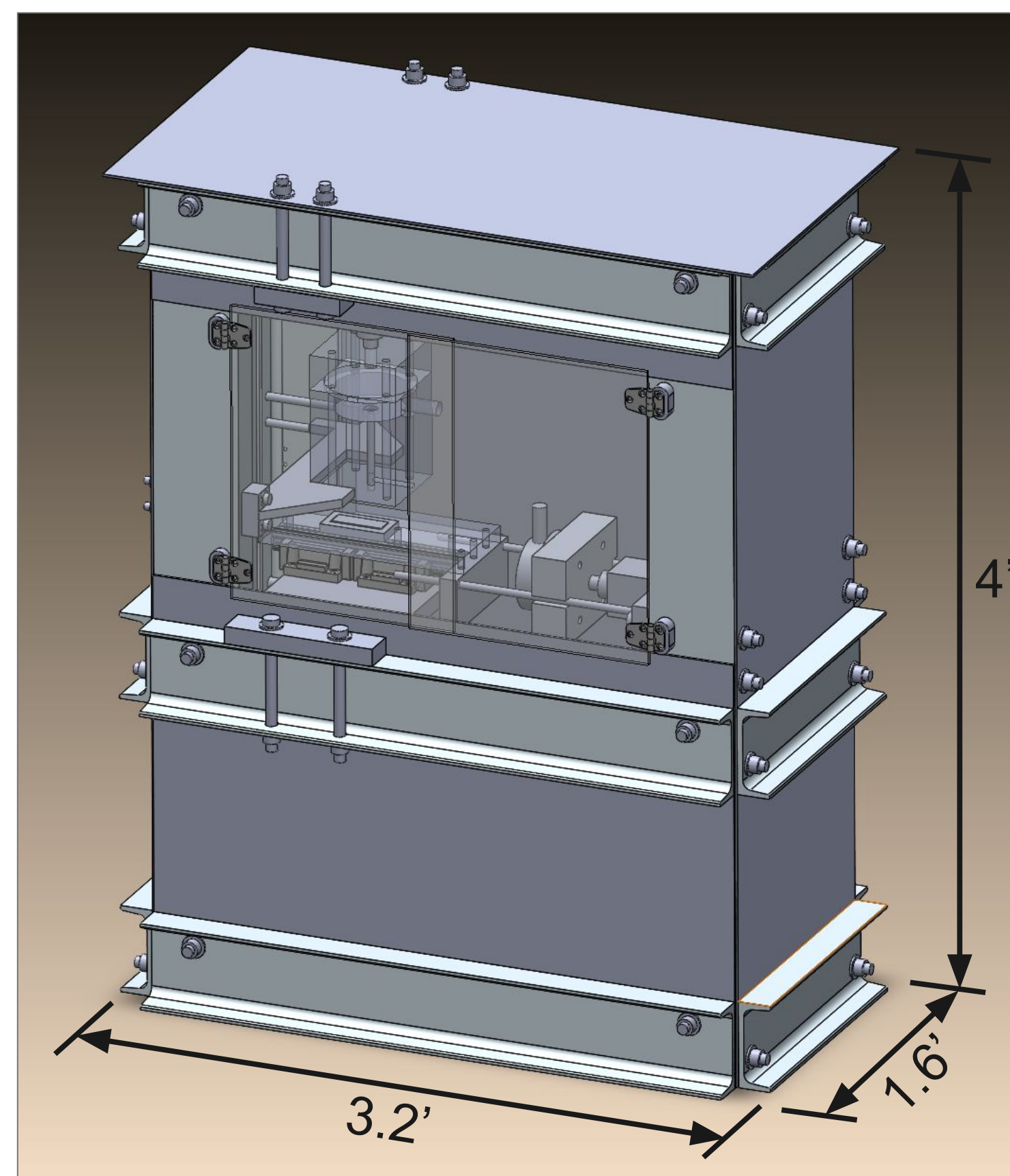
- Pressures reach 550,000 psi
- No reliable COF data for metals w/wo lubricants
- Current method requires full mandrel fabrication
- ★ Slow, expensive, and limits material development

SOLUTION

Custom high-pressure friction test system

- Simultaneously measures normal force, tangential force, and displacement
- Computes COF in real time
- Uses small, interchangeable test coupons
- ★ Rapid, repeatable, low-cost testing

SYSTEM OVERVIEW



ELECTRICAL SYSTEM DESIGN

Power System

- Dual 120V circuits for independent pump operation
- Isolated AC-DC supplies + DC-DC conversion
- 24V and 5V regulated power rails
- Stable 5V excitation voltage for load cells and ADC
- Star grounding and decoupling for noise reduction

Sensors

- Two 10,000 lb compression shear-web load cells
- LVIT displacement sensor (non-contact)
- Measurement range matched to test conditions
- Low-wear sensors for repeated high-load operation

Data Acquisition

- 24-bit ADS1256 precision ADC and reference
- SPI-based data acquisition via Raspberry Pi 5
- Differential load cell inputs; single-ended LVIT input
- Analog RC filtering for noise reduction

Firmware & User Interface

- Raspberry Pi 5 control system with touchscreen
- Real-time display of COF, force, and displacement
- Integrated data logging for post-test analysis
- Hardware Troubleshooting and Test Hub

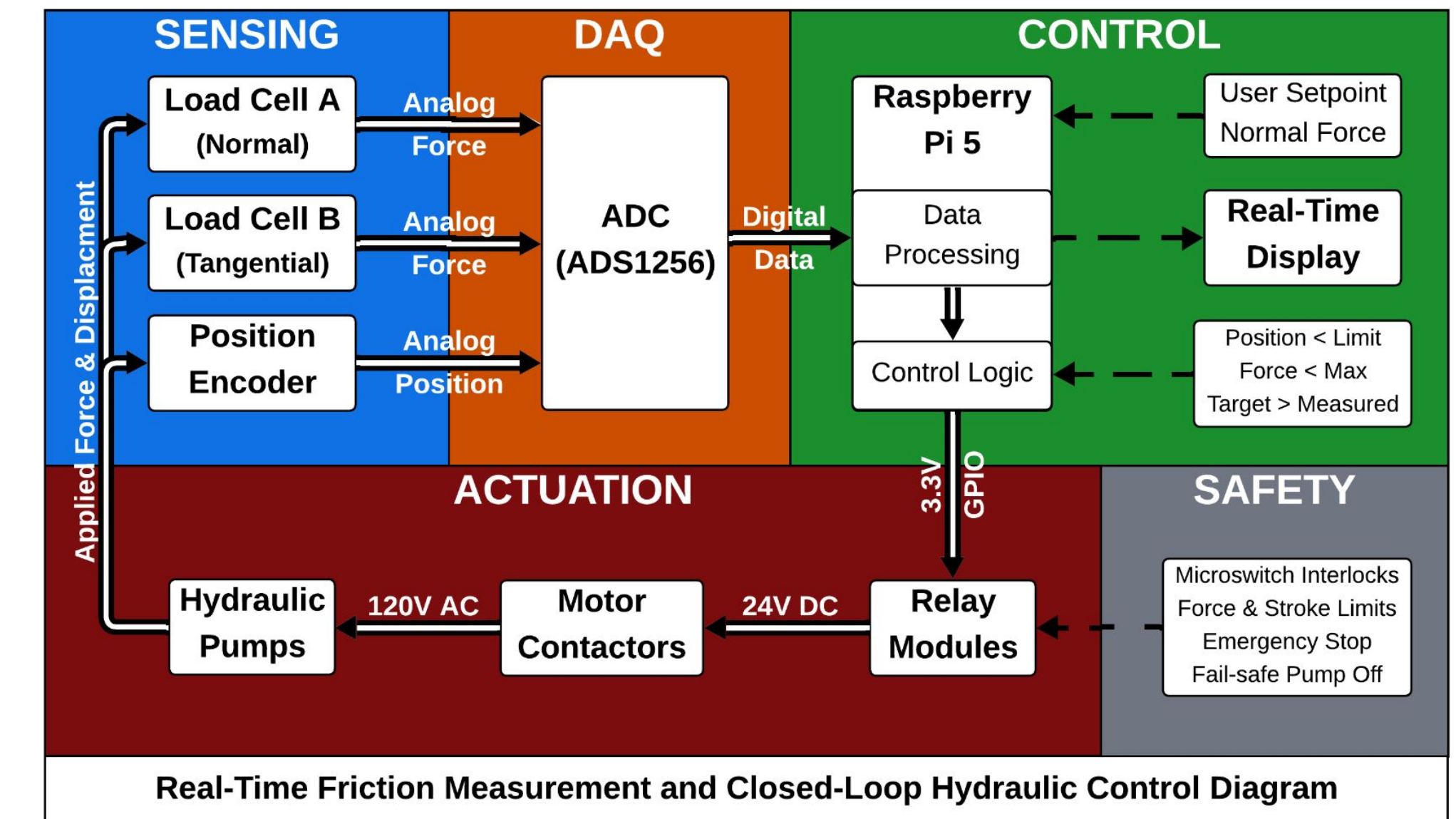
Hydraulic Control

- 3.3V logic controls 24V safety bus via relays
- 24V safety bus controls 120V pumps via contactors
- Control of normal and tangential force pumps
- Reliable electromechanical actuation of solenoids

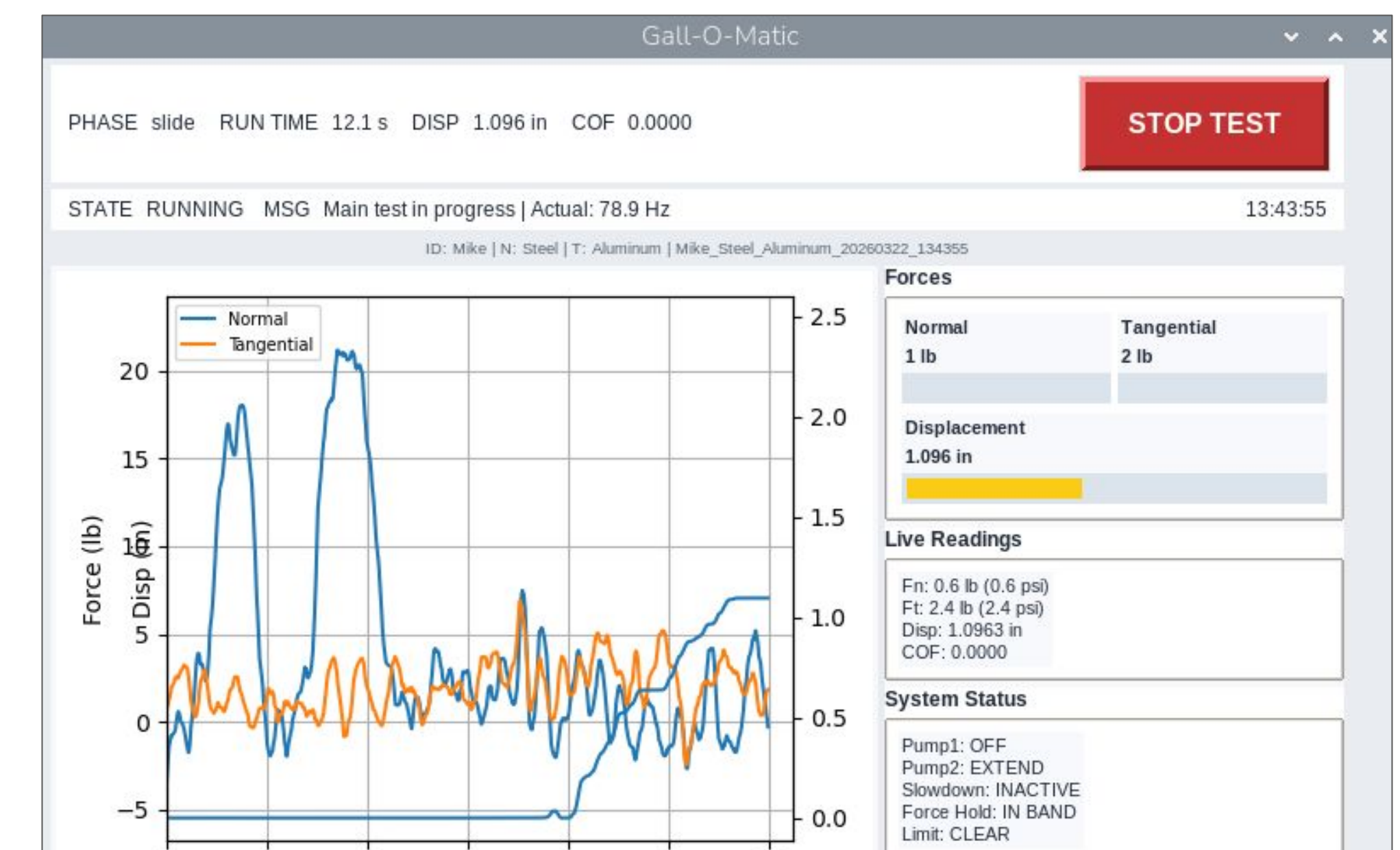
Safety Systems

- Microswitch interlocks (fail-safe design)
- Software limits on force and displacement
- Emergency stop with immediate pump shutdown
- Automatic shutdown on over-travel, overload, or unsafe access
- Fail-safe: pumps de-energize on system fault

SYSTEM ARCHITECTURE



DEMONSTRATION & RESULTS



IMPACT

- Replaces \$3,000 mandrel-based testing with \$50-\$100 metal coupon evaluations
- Reduces testing time from weeks → minutes
- Enables rapid material and lubricant evaluation
- Improves cold-working process reliability