Turnkey Design SERVICES LLC

Micro Pump/Variable Speed Dive Technology &
Advanced Engineering Services

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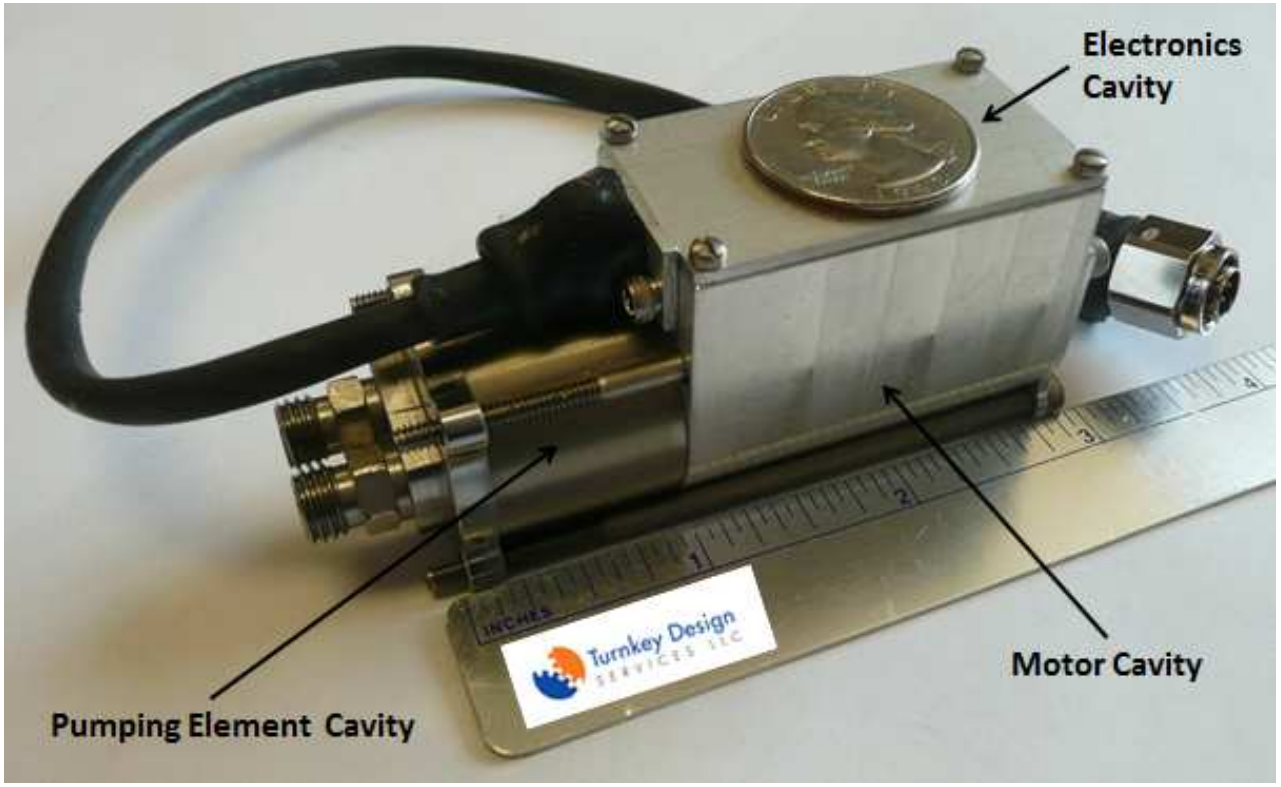
Micro Pump Technology

Overview of Design



Turnkey Design Services MFP30-1 Pump
Weight: 7.8 OZ

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Overview of Design

- Pumping Element
  - Fixed displacement radial piston technology
- Motor
  - 3-Phase Brushless DC with wet rotor/dry stator
- Electronics
  - Transmit and receive data
  - Sensor-less with closed loop on velocity
- Baseline and Smart Configurations
  - Input voltage range: 12-32 Vdc
  - Flow set by 4 to 20 mA or 0-5 V command input
  - Fluid inlet temperature: -40℉ to 187℉
  - Viscosities up to 5500 cSt

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Overview of Design

- Patent Technology
  - Patent Claims
    - Capable of achieving approx. 2X higher rotary speed by drastically reducing sliding velocities between components
    - Microprocessor Technology
      - Capable of setting pump to required flow rates
      - Capable of satisfying the requirement of many engine sizes using common hardware
      - Capable of maintaining a constant flow rate independent of temperature
      - Capable of compensating for internal wear (flow sensor required)
    - Health Monitoring
      - Capable of monitoring and transmitting remaining pump life

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Pump Performance

- MFP30 Performance
  - Pressure up to 8 Bar
  - Flow 50 to 640 ml/min
- MFP350 Performance
  - Pressure up to 28 Bar
  - Flow 280 to 2300 ml/min

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Durability

- Have completed over 4000 hours of room, hot & cold temperature performance and endurance testing using multiple fluids
- Pump life using JP-8 at 60 PSI is over 1500 hours without any flow degradation nor impending failures
- Have completed over 200 hours of engine testing for various engine manufactures

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Advantages over Competitors

- Smaller and Lighter
  - Fully integrated pump, motor and controller
    - All components are designed in-house
  - Capability to operate at higher motor speeds
    - Patent pending technology
  - Higher hydraulic efficiency and suction performance
    - Less leak paths and easier to control mfg. tolerances
- Better Performance
  - Metering accuracy
  - Transient response
  - Lower power consumption

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Advantages over Competitors

- V/L Capability
  - Better filling capabilities
    - Lower required charging pressure
    - Less prone to cavitation
  - Break up bubbles
    - When vapor enters pump it is broken up to smaller manageable pieces
  - Accumulator
    - Pump inlet is feed thru a filled accumulator so that inlet remains charged
- Higher Resistance to Contamination
  - Torturous path before entering pump inlet (bubble masher)
    - Metal particles are attracted to the motor permanent magnets
    - Heavier dirt particles are slung to the outside and flow to inlet is inside

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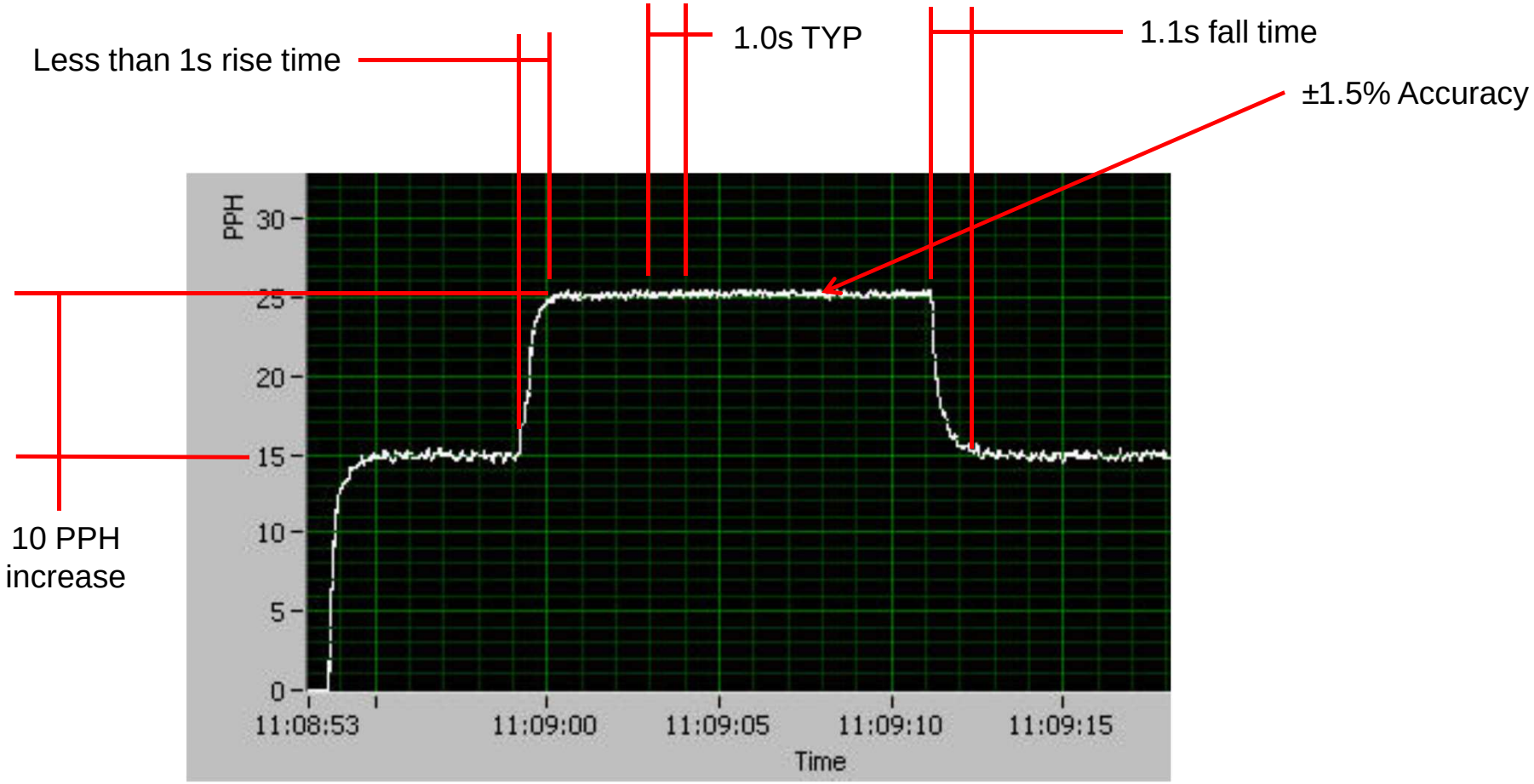
Advantages over Competitors

- Lower Cost
  - Many flow/pressure variations using common generic hardware
    - Microprocessor, cam eccentricity and rotor
  - High cost materials/coatings not required to meet life requirement
  - Easier to machine hardware (simple shapes)
  - No hall effect sensors, bonding and wiring
- Reduce overall System Cost
  - For automotive fuel injection type systems able to eliminate injector pressure regulator ($400 cost savings)
  - Have twice the time between overhaul of competitor

Transient Response



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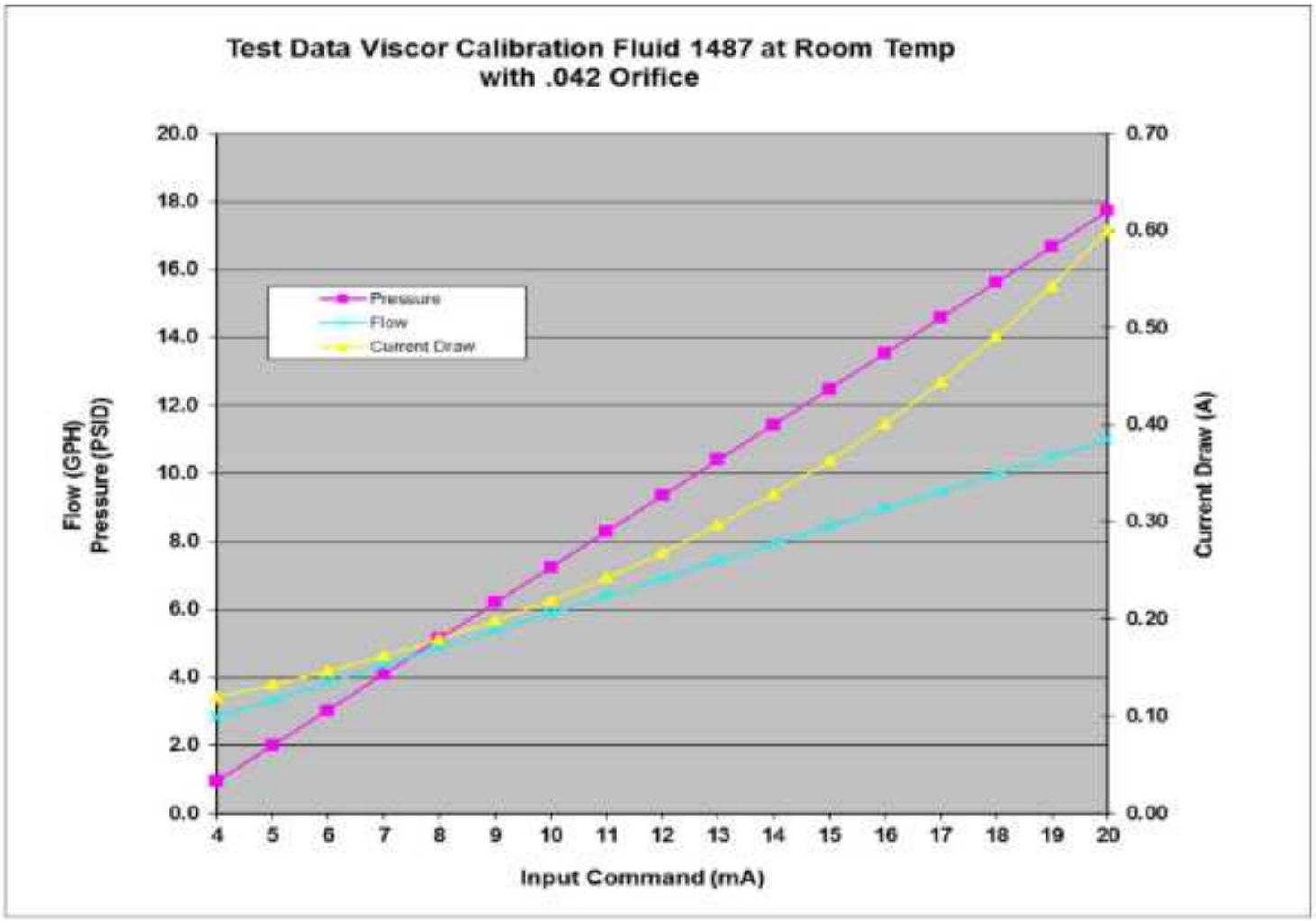
MFP30 Flow Data



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MFP30 Flow Data