**Electronic Propellant Feed System Centrifugal Pump Performance Test**

This description of procedure defines the conditions for the hydraulic testing of the electric feed system centrifugal pump.

# **Overview**

The objectives of testing the electric feed systems centrifugal pump are to:

* Document system pump performance.
* Establish the system curve for the pumping system.
* Determine the operating point of the pump; i.e. the point where the pump’s impeller curve crosses the system curve with the discharge valve throttled and with the discharge valve fully open.
* Assess the match between “full flow”—flow delivered by the EFS pump with the discharge valve fully open—and the actual design flow requirement.
* Assess the implications of modifying pump performance via trimming the impeller, adding a cutwater, and using impellers of differing solidity.
* Detect and diagnose other control or performance problems.

**Test Equipment**

Pump suction and discharge pressures will be measured and recorded under each test condition. Pump pressures are measured using analog gauges and pre-calibrated pressure transducers on the pump inlet (suction side) and pump outlet (discharge side). A third transducer is tapped into the impeller housing. Fluid temperature at the pump inlet is recorded using a K-type thermocouple. Other useful equipment includes a load cell for measuring pump torque a tachometer and an amp/wattage probe.

## **EFS Pump Performance Testing**

1.1 **Verify all EFS pre-functional checklists are complete.** Prior to performing any functional tests, the commissioning pre-start, start-up verification should be completed, Pre-functional checklist items include, but are not limited to, the following:

1.1.1 Control system point-to-point checkout is completed to ensure all EFS input/output points are wired correctly, and all actuators and relays or motor starters respond to control signals.

1.1.2 Power is provided to pump assembly at proper voltage and phase rotation. As an alternative to verifying phase rotation, pump rotation should be verified.

1.1.3 The electric feed system has been proportionally balanced with all control valves fully open.

1.1.4 All necessary sensors are calibrated.

1.1.5 Locations of EFS pump, valves, and other system components are clearly and correctly located on as-built drawings.

# **EFS Standard Operating Procedure**

## *Preliminaries*

1. With discharge valve closed, suction valve of the pump is opened which causes fluid flow to the impeller and fills the volute.
2. Open the vent (drain) valve which is on the discharge line before the discharge valve of the pump which will cause all air to move out of the casing and flow loop.
3. When some quantity of the fluid exits from the vent valve close it.
4. The pump discharge and suction valves are adjusted to the fully open position and the motor speed set to zero.
5. The electrical supply and motor drive switch are turned on. The motor control knob is adjusted slowly to [insert]. The system is ensured to have no leaking. All the gauges etc. are checked to reduce the motor speed back to zero.

## *Test Process*

1. Suction valve and discharge valve is fully open. The maximum speed N (rpm) is selected by adjusting speed control to [insert] %.
2. Discharge valve is fully opened and water is allowed to circulate. The volume of flow indicator is noted and decides suitable increments in flow to give adequate sample points.
3. Allow the pump to attain its capacity read from the discharge line pressure gauge. When the readings are stable, record all test measurements.
4. The discharge valve is then slowly adjusted (decreasing flow) to the next desired capacity point.
5. Step 4 is repeated until all flow increments have been recorded.
6. All the gauges etc. are checked to reduce the motor speed back to zero and power down the EFS system.

**Test Precautions**

* Exercise care when changing operating RPM if the equipment served by the pump is in operation.
* Avoid sudden flow changes to minimize the potential for water hammer, especially when throttling the discharge valve for a shut-off test.
* Verify that all components between the discharge of the pump and the discharge throttling valve (including the pump casing) are rated for the peak pressure with the impeller installed plus the static pressure on the inlet side of the pump prior to performing a shutoff test.
* Exercise proper caution when working around live wiring and terminals and taking voltage or amp readings.
* Exercise proper caution while working around the rotating parts of the pump.
* **DO NOT** let EFS centrifugal pump operate for long periods of time at zero flow.
* **DO NOT** operate pump in reverse direction, this could cause severe damage to the impeller shaft.
* **DO NOT** run EFS pump dry.

## **Analysis and Opportunities**

2.1 Analyze data. After conducting the tests, the recorded data will be used to assess the pump’s performance. The operation of the system will always occur at the point where the pump curve (which is concretely defined for the EFS pump by the impeller and the pump rotational speed) intersects the system curve (which will change depending on the operating mode). If the pump is producing flow greater than necessary, changing either the pump impeller size or the pump speed can deliver design flow at reduced power.

2.1.1 Determine the actual impeller size by plotting no-flow pressure on the set of pump curves produced through testing. Keep in mind that measurement errors will influence the calculated differential pressure across the pump.

2.1.2 Plot the wide-open operating point by following the pump curve for each impeller to the pressure reading from the worst-case wide-open test. Note the flow rate at this point. This point defines the system curve for the system with the discharge valve wide open.

2.1.3 Use the worst-case wide-open point on the pump curve to manually draw in the system curve on the set of pump curves. Use the following equation to determine approximate points for a range of intermediary flow rates on the system curve:

*Hintermediary = Hmin + [Hwide-open × (Qintermediary / Qwide-open)2]*

Where, H, is head, Q, is flow, and Hmin refers to the minimum pressure requirement for the system. The system curve will cross the “head” axis at the minimum pressure value when flow is 0 GPM.

2.1.4 Identify on the system curve the operating point achievable with an impeller trim or speed change: the point on the system curve that corresponds to the design flow rate.

2.1.5 Locations of EFS pump, valves, and other system components are clearly and correctly located on as-built drawings.

2.2 **Estimate energy use.**

System brake horsepower can be estimated from the pump curves or calculated using the following equation:

*bhp = [flow × head] / [3960 × pump efficiency]*

Where flow is in gallons per minute, head is in feet, and pump efficiency is read off the pump curve.

Motor input power is calculated by**:**

*kW = [bhp × 0.746 kW/hp] / motor efficiency*

Where motor efficiency can be estimated based on motor rated efficiency and part load operating point.

Troubleshooting

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

For team to look out for. *(Remove after tests are performed)*

1. The shut-off head, this is the maximum head that the pump can achieve and occurs at zero flow. The pump will be noisy and vibrate excessively at this point. The pump will consume the least amount of power at this point.
2. The best efficiency point B.E.P. At this point, the impeller is subjected to minimum radial force promoting a smooth operation with low vibration and noise. The pump will consume the power corresponding to its B.E.P. rating at this point.
3. The maximum flow point, the pump may not operate past this point. The pump will be noisy and vibrate excessively at this point. The pump will consume the maximum amount of power at this point.