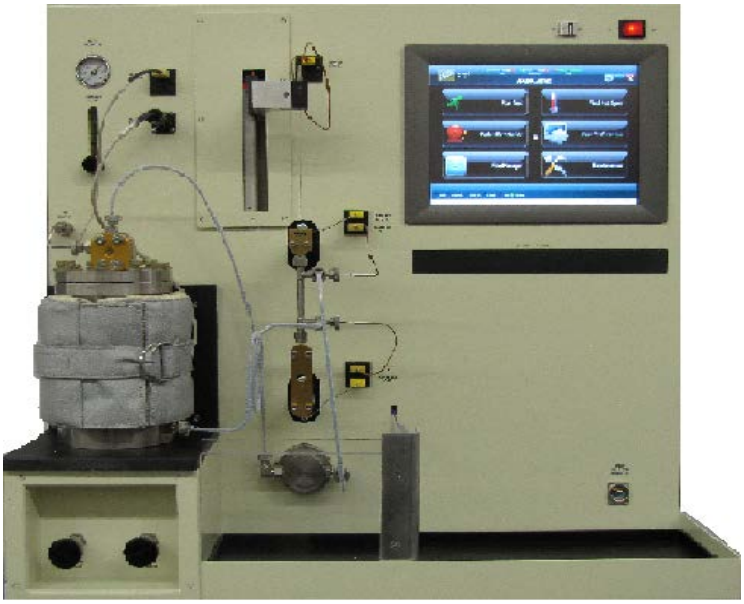
FALEX 450

Falex Thermal Fowling Tester (FT2)

** SAE Unit **



OPERATION & MAINTENANCE MANUAL

Version 1.1

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FT2 (F450) SAE Instruction Manual

Table of Contents

Forward - How to Use This Manual, Safety, Safety Label Descriptions, Hazardous Areas of Test Machine

This manual provides information and procedures to safely install, operate, and maintain the Falex 450 Thermal Fowling Test machine (FT2). For your own safety and protection from injury, carefully read, understand and observe the safety instructions described in this manual.

Keep this manual with the machine. If you lose this manual or need an additional copy, please contact Falex Corporation.

The information contained in this manual was based on machines in production at the time of publication. Falex Corporation reserves the right to change any portion of this information without notice.

This operation manual is divided into sections and addenda as listed in the "Table of Contents".

Safety Introduction

The following safety precautions are published for your information. This manual does not purport to detail all of the safety concerns, if any, associated with the equipment's use. It is the responsibility of the operator of this equipment to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

This machine is built with operator safety in mind; however, it can present hazards if improperly operated and serviced. Follow operating instructions carefully! If you have questions about operating or servicing this equipment, please contact Falex Corporation.

Note: This equipment should only be operated by personnel trained by Falex or a Falex approved distributor.

This manual may contain DANGER, WARNING, CAUTION, and NOTE callouts, which must be followed to reduce the possibility of personal injury, damage to the equipment, or improper service. This machine must be electrically grounded. Do not change the grounding requirements of the instrument.

DANGER indicates a hazardous situation, which if not avoided, will result in death or serious injury.

WARNING indicates a hazardous situation, which if not avoided, could result in death or serious injury.

CAUTION indicates a hazardous situation, which if not avoided, could result in minor or moderate injury.

Symbol calls attention to a '***NOTE***', which provides important information.

Safety Labels

The following are safety labels placed in areas on the test machine that may be hazardous to the operator. Please take caution and understand what these labels indicate before operating the test equipment.

This label indicates hot surface areas on the test machine. Use caution when working in these areas where components could be hot.

This label indicates hazardous voltage is present when opening the electrical cabinet. This unit is to be serviced by trained personnel only.

Hazardous Areas of Test Machine:

There are specific areas on the Falex 450 (FT2) machine that could be potential operational hazards. These areas are listed here:

1. Warning! ELECTRIC SHOCK HAZARD. Do not remove any cabinet covers without removing power connection. Covers should not be removed without proper training by Falex or a Falex approved distributor. These are areas containing hazardous voltages which can cause electrocution. This equipment to be serviced by trained personnel only.

2. Warning! SPRAY HAZARD. Do not loosen reservoir lid or lines when unit is in test mode. Reservoir and lines are pressurized and have the potential of spraying test fluid. Always make sure pressure has been completely depressurized prior to removing reservoir lid or disconnecting any pressurized lines.

3. Warning! Test lubricants and solvents are flammable and may cause irritation to the eyes or skin. Wear protective goggles, gloves, and an apron; avoid contact with skin, eyes, and clothing. Use in well ventilated areas and keep **away** from heat or flame. Follow all Material Safety Data Sheet (MSDS), Hazardous Materials Identification System (HMIS), ISO 9000-2, Lab Safety Operating Procedures (SOP), and related instructions. Failure to comply may result in personnel injury or death.

4. Caution! BURN HAZARD. The heater tube holder assembly can reach high temperatures of 450 °C during a test based upon test configuration. Always place test area safety cover over the heater tube test area when running a test to prevent contact with the test section. When the cover is removed, always assume the heater tube holder assembly is hot and use caution when operating around this area.

5. Caution! PINCH POINT. Keep hands and fingers clear.

1. General Information

The Falex 450 Thermal Fouling Test Machine (FT2) is designed to evaluate the coking propensity of synthetic ester-based aviation lubricants under single phase flow conditions found in certain parts of gas turbine engines. It meets SAE ARP5996.

This machine uses Falex heater tube specimens (refer to section 8). Falex certifies these tubes meet all of the SAE ARP5996 requirements for dimensions, surface finish and material.

Note: Falex Corporation does not guarantee any specific test results or desired functionality of this equipment outside of its intended usage.

Figure 1 shows the location of various components and connections.

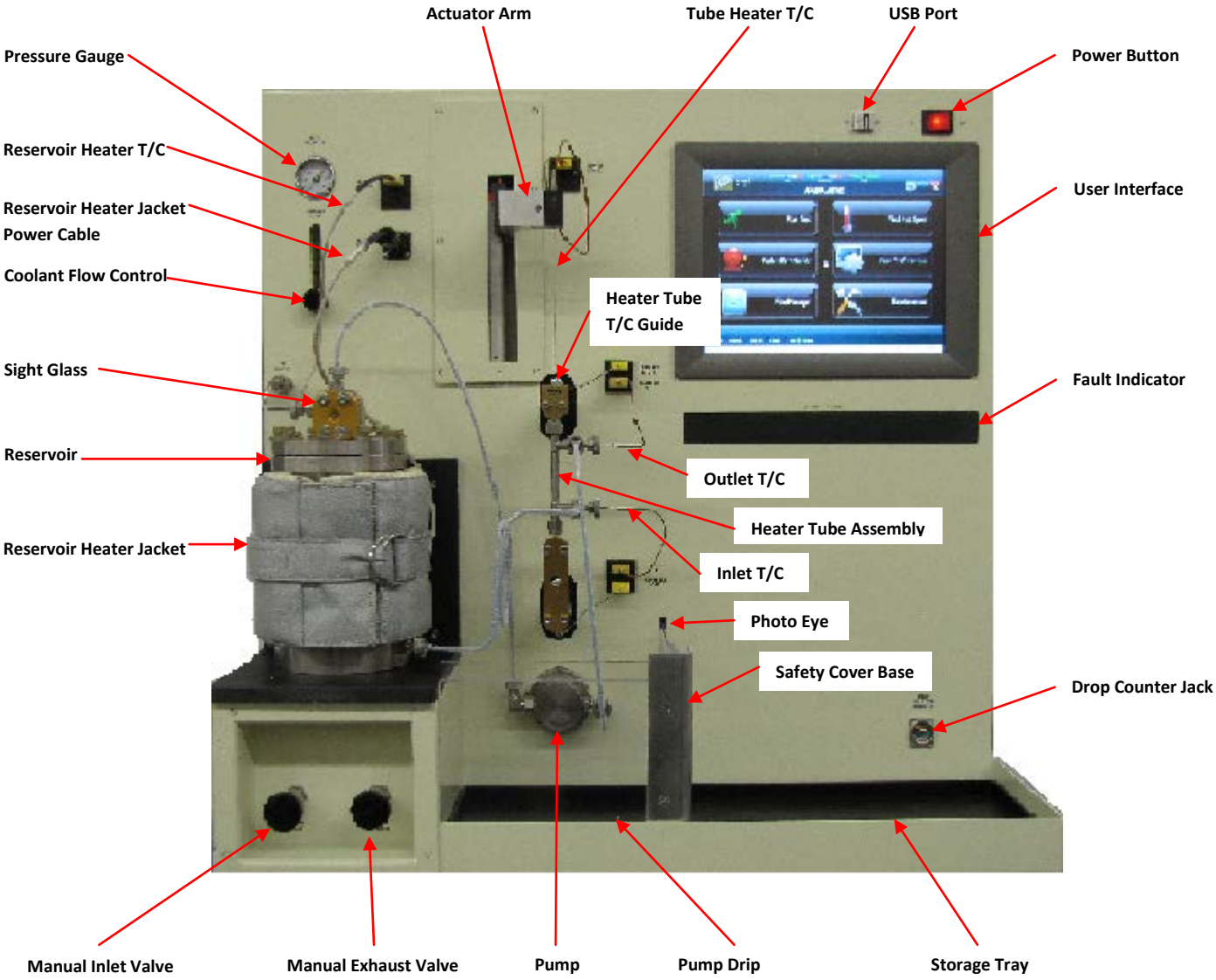


Figure 1 – Falex 450 (FT2) Test Machine

2. Setup

2.1 Space & Leveling

The Falex 450 (FT2) requires bench space of approximately 36”W x 30”D to comfortably operate the test machine. The table should be reasonably level (1/32 in. per foot) and should be able to support the test equipment, while being free of external vibrations. The machine weighs approximately 180 lbs (82 kg). Access to the rear of the machine can facilitate changing the air line when needed and allow the operator access to the USB ports, network connections and breakers. It must be located in close proximity to a properly secured air cylinder. It is recommended that the machine be placed in an area free from drafts, air currents and within a stable temperature environment (preferably away from windows and air vents). This machine uses various test lubricants and cleaning solutions, so adequate ventilation is required.

If a printer is to be connected to the machine, it can be positioned on either side of the machine or on top of the machine, as long as it will fit between the ventilation fans.

Note: Blocking the ventilation fans will cause damage to internal components.

2.2 Installation

Note: Refer to figure 1 for device locations

1. Carefully remove packing materials protecting the machine and the heater tube thermocouple.
2. The machine comes equipped with a startup kit, which includes all the necessary items required to run the machine. Unpack the startup kit and verify its contents (see listing at the end of this section).
3. Install storage tray in its proper location (next to pump drip tray).
4. Install the reservoir using the locator pins.
5. Install the reservoir heater jacket around the reservoir.
6. Connect the heater jacket power cable to the power connector on the front of the machine.
7. Connect the heater jacket thermocouple to its associated connector on the front of the machine.
8. The heater tube thermocouple was installed at the factory. Verify that the thermocouple is straight and is secure in the actuator arm (front and side set screws use a 0.050” Allen wrench). If the heater tube thermocouple is bent, carefully straighten while still installed in the actuator.
9. Plug inlet/outlet thermocouples into their respective connectors. These are identical thermocouples. Initially, it does not matter which one is

used for inlet and which one is used for outlet. However, for consistent temperature readings, they should be plugged into the same connector from this point on.

10. Place new O-rings (#620-006-004) on all tubing ends and inlet/outlet thermocouples.
11. Connect all tubing lines to their respective locations. Make sure all connections are hand tight.
12. Plug drop count switch into jack located in lower right on the front of the machine.
13. Connect a cylinder of clean dry air that meets the requirements of ARP5996 to the air inlet port on the rear of the machine (figure 2). The supplied air should be regulated not to exceed 200 psi.

Figure 2 – Air Connection

Note: For safety reasons, it is recommended that a pressure gauge be installed on the outlet of the tank. Always make sure system is completely depressurized prior to removing reservoir lid or tubing lines.

Note: It is recommended that a filter be installed on the air inlet port to prevent any debris from the air tank from entering the system.

Note: It is recommended to cover the vent port on the rear of the machine to catch any oil that may be vented when pressure is released.

14. If ordered, connect the remote Emergency E-Stop Switch assembly into the power connector located on the back of the machine. The power cord is then to be connected to the remote Emergency E-Stop Switch assembly.
15. If the remote Emergency E-Stop Switch assembly was not ordered, the power cord is to be connected into the power connector located on the back of the machine.

16. Plug the power cord into an outlet appropriate for the plug (120V, 60Hz for North America, 220V 50Hz for Europe).
17. Power up machine by toggling the power button (located on the front of the machine) to the 'on' position.

Prior to running a test for the first time, the following should be done:

- Clean the reservoir and tubing lines to flush any dust or debris that may have accumulated during shipment. Refer to section 3.3 for proper cleaning techniques.
- Verify the heater tube thermocouple position offset. Refer to section 4.4.7.6 for details.
- Setup for a test per section 3.4 (heater tube preparation) and 3.5 (machine setup).

Note: Do not run pump dry. Doing so will damage the pump.

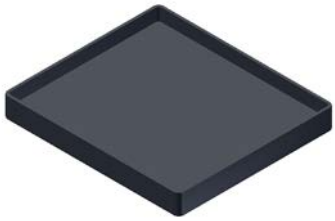
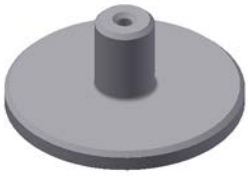
Note: It is recommended that a hot spot determination test be conducted prior to running a timed test for the first time.

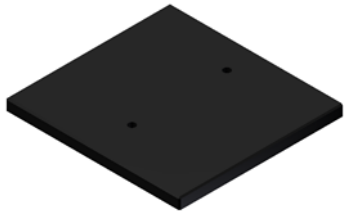
If the machine was shipped with a printer, the user interface is already configured for the printer. If the machine was not shipped with a printer and a printer is to be configured, refer to section 4.4.5.2 for printer configuration details. The printer can be connected to any of the available USB ports on the back of the machine (figure 3). However, it is recommended that the printer be connected to the lowest available USB port. This will keep all remaining available USB ports open above it for easy access when connecting other USB devices.

If the machine is to be connected to a local network, plug the network cable into the upper network connection (network) on the rear of the machine (figure 3). The lower network connection is for factory use only. Refer to section 4.4.5.3 for network configuration details.

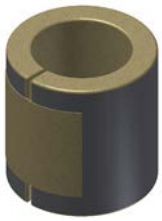
Figure 3 – Convenience Port

2.3 Startup Kit Contents

QTY	PART #	DESCRIPTION	PICTURE
1 pack	400-018-003	Insulation bushing (2 pairs/pack)	
1	400-108-004	Lead calibration holder with melted lead	
1 box	400-560-003	Heater tubes (316SS) (12 tubes/box)	
1	450-021-005	Pump drip tray (mounted on unit when shipped)	
1	450-041-002	Tube Holder (for oven and balance)	
1	450-041-003	Heater tube alignment tool	

QTY	PART #	DESCRIPTION	PICTURE
1	450-099-001	Heater tube holder assembly	
1	450-103-004	Reservoir insulation top plate (mounted on unit when shipped)	
1	450-103-008	Thermocouple - heater tube (with ball tip) (mounted on unit when shipped)	
1	450-105-005	Storage tray assembly	
1	450-105-006	Tube assembly (inlet air to reservoir)	
1	450-105-007	Tube assembly (pump out to reservoir)	

QTY	PART #	DESCRIPTION	PICTURE
1	450-105-009	Tube assembly (reservoir to tube holder inlet)	
1	450-105-010	Bypass cleaning line assembly	
1	450-105-014	Reservoir (1000ml) with sight glass assembly	
1	450-105-015	Tube assembly (tube holder outlet to pump inlet)	
1	450-105-017	Safety cover top (mounted on unit when shipped)	
1	450-105-018	Safety cover bottom (mounted on unit when shipped)	

QTY	PART #	DESCRIPTION	PICTURE
1	450-106-001	Reservoir heater jacket	
2	450-109-004	Thermocouple assembly- inlet/outlet	
1	450-112-001	Manual-CD	
1 bag	620-006-004	O-Rings tubing (package of (100)	
1 bag	620-008-006	O-Rings heater tube (package of 25)	
1	648-400-007	Hex Socket wrench	

QTY	PART #	DESCRIPTION	PICTURE
1	648-400-009	Ceramic insulator removal tool	
1	648-450-001	Heater tube cleaning brush	
1	648-450-002	Beaker, 400 ml, tripour	
1	650-030-150 650-030-161	Power Cord 220V (650-030-150) or Power Cord 120V (650-030-161)	
1	650-051-109	Handheld pushbutton switch	
1	650-204-048	Keyboard/Mouse	

QTY	PART #	DESCRIPTION	PICTURE
1	650-204-065	Touch screen stylus	
1	659-050-002	7/16" x 1/2" open end wrench	

3. Typical Test Procedure

3.1 Overview

The test procedure for the Falex 450 (FT2) follows the SAE ARP5996 standard. The following is a general description of a typical test (hot spot determination test and timed test) process. The components are to be cleaned (refer to section 3.3) and a new heater tube prepared (refer to section 3.4) prior to starting a test. 100mm of test fluid is placed into the reservoir and the reservoir is to be sealed. Using the user interface, a startup process is to be completed. The startup process purges the system, heats the reservoir to 150°C, heat soaks the reservoir for 30 minutes to allow the temperature to equalize, pressurizes the reservoir to 200 psi (1380 kPa) with air and allows the operator to set the pump flow rate (1 ml/min). The pump pulls the test fluid from the reservoir, through the heater tube holder assembly containing the heater tube, through the pump and back to the reservoir. When the startup process has been completed, the test (hot spot determination or timed test) is initiated from the user interface by the operator.

<u>Hot Spot Determination Test</u>

The heater tube thermocouple initializes to the top of the heater tube and moves to the 10mm position. The tube temperature is ramped to 375°C over a 10 minute period. When at temperature, the test duration time is initiated and a 30 minute heat soak period ensues, allowing the heater tube temperature to equalize. A temperature profile of the heater tube is initiated and the hottest spot within the heater tube is determined (i.e. hot spot). Once the test profile is complete, the heater tube temperature ramps down, the pump is stopped and the pressure is released. The outlet temperature is cooled (< 40°C) and the heater tube thermocouple is returned to its home position. The machine is now safe to be broken down and cleaned in preparation for a timed test.

<u>Timed Test</u>

The heater tube thermocouple initializes to the top of the heater tube, moves to the 10mm position and then moves to the current 'A' position (hot spot of the tube). The hot spot is previously determined from a hot spot determination test. The tube temperature is ramped to 375°C (for a standard SAE ARP5996 test) over a 10 minute period. When at temperature, the test duration time is initiated and a 30 minute heat soak period ensues, allowing the heater tube temperature to equalize. A temperature profile of the heater tube is taken during the 1st hour. The average of the three (3) temperatures captured at the 'A+40' position is determined. This average is used as the control temperature setpoint for the test duration with the heater tube thermocouple positioned at the 'A+40' position. As the heated test fluid flows over the hot heater tube, deposits are formed on the heater

tube. A 2nd temperature profile of the heater tube is taken during the last hour of the test. Once the test duration has completed, the heater tube temperature ramps down, the pump is stopped and the pressure is released. The outlet temperature is cooled (< 40°C) and the heater tube thermocouple is returned to its home position. The machine is now safe to be broken down and the heater tube can be weighed to determine the deposit.

Note: New oil, new heater tube, new heater tube O-rings, new inlet/outlet thermocouple O-rings and new tubing line O-rings are required for every hot spot test or timed test.

3.2 Equipment and Materials

The following is a listing of equipment and materials that are required to successfully run a test and to accurately determine the resulting deposit.

- Falex 450 (FT2) machine
- Laboratory oven capable of maintaining a temperature of 100°C (±5°C), for drying of test tubes
- Desiccator filled with suitable desiccant for storing of test heater tubes
- Laboratory balance capable of weighing heater tubes to 0.01 mg (5 decimal places)
- 100 ml or 250 ml graduated cylinder for measuring of test fluids
- 10 ml graduated cylinder (boiling tube) for heater tube soaking
- Compressed air supply, clean, dry and oil free, capable of pressurizing the reservoir to 200 psi (1380 kPa)
- Reference heater tube for test verification of cleaning process (to be of same material of heater tube used for test)
- 316 stainless steel heater tube for SAE ARP5996 tests
- O-rings (Heater tube, inlet thermocouple, outlet thermocouple, tubing lines, reservoir, sight glass, pump inlet/outlet, reservoir outlet fitting)
- Ceramic insulator bushings
- Solvents (Acetone and Petroleum Ether) for cleaning of oil soaked parts and preparation of heater tube
- Gloves for safely handling of the heater tubes and for safely cleaning the apparatus
- Hex wrench for heater tube holder assembly installation/removal
- ½” wrench for reservoir top installation/removal
- Test fluid

3.3 Component Cleaning

Note: Prior to cleaning, always verify that the system has been completely depressurized before removing reservoir lid or any tubing lines.

Inlet/Outlet Thermocouples

1. Clean inlet/outlet thermocouples and the reservoir with acetone.
2. Blow-dry with a clean oil free air supply.
3. Replace O-rings.

Reservoir

1. After reservoir has cooled, disconnect inlet tubing line (top of sight glass), disconnect outlet tubing line from the heater tube assembly and unbolt the reservoir top. Remove the reservoir top.

Note: Do not disconnect outlet tubing line from reservoir base with oil in the reservoir. Otherwise, oil will run out.

2. Remove the reservoir from the machine and pour out remaining used test fluid and rinse the interior of reservoir with acetone. Pour out accumulated acetone. Wipe dry with a paper towel, making sure no pieces of paper towel remain.

Note: Properly dispose of test fluid and acetone per safety procedures designated by local facility

3. Place the reservoir back on its base using the locating pins.
4. Flush the system by pouring a minimum of 350 ml of acetone into the reservoir. Do not attach the reservoir lid. Install the bypass cleaning line (figure 4) in place of the heater tube holder assembly.

Figure 4 – Bypass cleaning line installation

5. Place a 250 ml plastic beaker inside the reservoir to catch the fluid being flushed (lip of beaker will rest on reservoir edge) (figure 5). Manually start the pump at a high flow rate (20 – 30 %) using the Maintenance portion of the user interface. Flush until no more fluid is being pumped into the catch beaker. The acetone should run clear. Manually stop the pump.

Figure 5 – Catch beaker placement

6. Properly dispose of the fluid accumulated in the catch beaker.
7. Remove the reservoir from the machine and empty the reservoir of the remaining acetone. Wipe dry with a paper towel, making sure no pieces of paper towel remain. Blow dry with compressed air.
8. Place the reservoir back on its base using the locating pins.
9. Flush the system again, this time with test fluid. Pour a minimum of 150 ml of the fluid to be tested into the reservoir. Do not attach the reservoir lid. Make sure the bypass line is still installed in place of the heater tube holder assembly. Place a 250 ml plastic beaker inside the reservoir to catch the fluid being flushed (lip of beaker will rest on reservoir edge). Manually start the pump at a higher flow rate (20 – 30 %) using the Maintenance portion of the user interface. Flush until no more fluid is being pumped into the catch beaker. Manually stop the pump.
10. Remove the reservoir from the machine and clean the interior with acetone. Squirt acetone through the supply line. Pour out accumulated acetone. Wipe dry with a paper towel, making sure no pieces of paper towel remain. Place the reservoir upside down on a paper towel and blow clean compressed air through the supply line to dry.
11. Remove the large O-ring from the reservoir lid and check for signs of wear. Replace if necessary.
12. Clean the underside of the reservoir top with acetone and blow dry with air. Do not let the O-ring come in contact with the acetone.

<u>Heater Tube Holder</u>

1. Flush the inside of the heater tube holder with acetone.
2. Push the heater tube cleaning brush through the heater tube holder to dislodge any debris.
3. Rinse the inside and outside of the heater tube holder with acetone.
4. Rinse ceramic insulator bushings and tube holder end nuts with acetone.
5. Blow dry heater tube holder, ceramic insulator bushings and end nuts with a clean oil free air supply.
6. Inspect ceramic insulator bushings for damage. Replace if cracked or chipped.

3.4 Heater Tube Preparation

Note: Reference tube required to undergo same preparation for 20 hour, 40 hour, custom, 20+20 hour tests only. Reference tube to be reused, but must be properly prepared for each test.

Note: For hot spot determination or hot spot validation tests, only follow steps 1 – 6 (disregard any instruction regarding reference tube).

1. Remove a new heater tube from its container. Wear gloves and handle the heater tube by the ends only. Do not touch the center section of the heater tube.
2. Inspect new heater tube for scratches, corrosion or other visible defects and discard should any be found.
3. Clean the new heater tube with acetone. Rinse the outside of the heater tube with acetone, wipe with an acetone soaked lint free paper towel. Re-rinse with acetone. Flush the inside of the heater tube with acetone.

Note: Do not wipe the heater tube in a twisting motion, only wipe along the axis of the heater tube.

4. Clean the reference tube with acetone using the same procedure defined in step 3.
5. Dry both heater tubes in a preheated laboratory oven set at 100°C (±5°C) for 30 minutes. Set heater tubes in a holder vertically.
6. Remove heater tubes from oven and cool in the desiccator for at least 30 minutes.
7. Remove the heater tube that will be used for the test from the desiccator. Using the laboratory balance, weigh the new heater tube to 0.01 mg a minimum of three (3) times. Record the average of three (3) successive weights within 0.02 mg of each other on a test sheet.
8. Remove the reference tube from the desiccator. Using the laboratory balance, weigh the reference tube to 0.01 mg a minimum of three (3) times. Record the average of three (3) successive weights within 0.02 mg of each other on a test sheet.

Note: If the reference tube varies by more than 0.12 mg from its previous reading, the acetone used in the cleaning process may be contaminated. Both the new heater tube and the reference tube should be re-cleaned with fresh acetone.

9. When reference tube is not needed, it is to be stored in the desiccator.

3.5 Machine Setup

1. Attach inlet line to fitting near bottom of reservoir using a new O-ring and place the reservoir on its base using the locating pins.
2. Fill clean graduated cylinder with approximately 102 ml of new test fluid (there will be fluid loss when pouring into the reservoir). Test requires that reservoir is to be filled with 100 ml of test fluid.
3. Pour new test fluid from graduated cylinder into clean reservoir (reservoir to be cleaned per section 3.3).
4. Bolt the reservoir top into place, making sure all bolts are tight. Tighten bolts in a star pattern to allow even compression of the sealing O-ring.
5. Connect all tubing lines to the reservoir using new O-rings.

6. Install the reservoir heater jacket on the reservoir making sure that the reservoir thermocouple and power plug are connected to the machine.
7. Assemble the heater tube holder assembly (figure 6) with clean components and new O-rings.

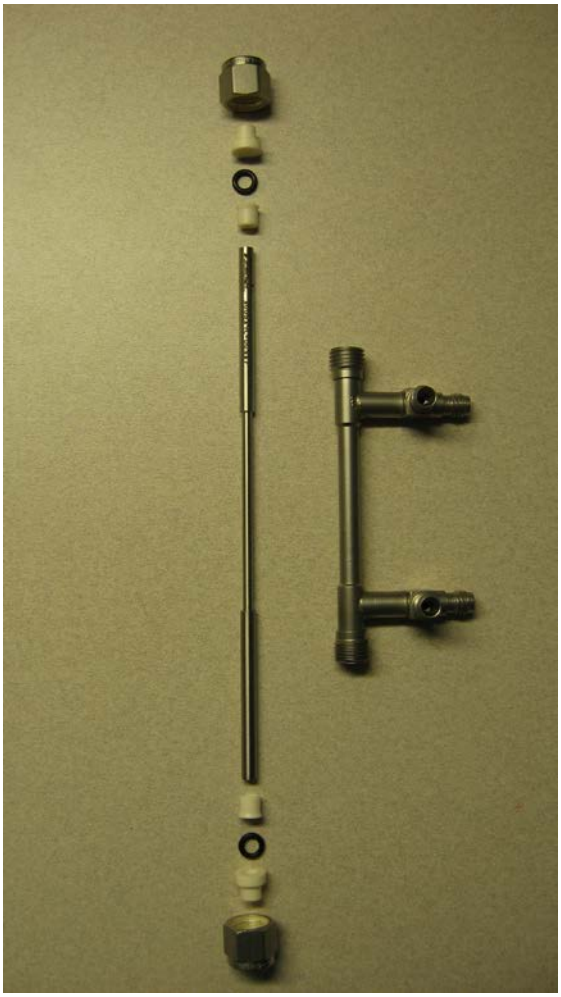


Figure 6 – Heater tube holder assembly

Place heater tube into the heater tube holder with serial number at the top. The heater tube is properly positioned within the heater tube holder when the tube shoulders are visible within the upper and lower thermocouple ports. This can be accomplished by various methods. Using the heater tube alignment tool (figure 7 & figure 8), position the new heater tube within the heater tube holder (heater tube shoulder distance outside of the heater tube holder should be the same on both ends). A scale or caliper can be used for proper positioning of the heater tube as an alternate to using the alignment tool.

Figure 7 – Heater tube holder positioning with alignment tool

Figure 8 – Heater tube holder with alignment tool

Heater tube holder end nuts are only to be hand tightened. Over tightening could crack the ceramic insulator bushings.

Note: It is recommended that the heater tube be positioned in the heater tube holder the same way for each test for consistent results.

8. Remove the bypass cleaning line.
9. Install the heater tube holder assembly on the Falex 450 (FT2) machine into the bus bars using the hex screws. The heater tube holder assembly should be positioned so that the top of the tube is even with the top of the bus bar (figure 9). Make sure that the end of the heater tube thermocouple is inserted into the heater tube thermocouple guide (figure 10) before tightening down the upper bus bar cap.

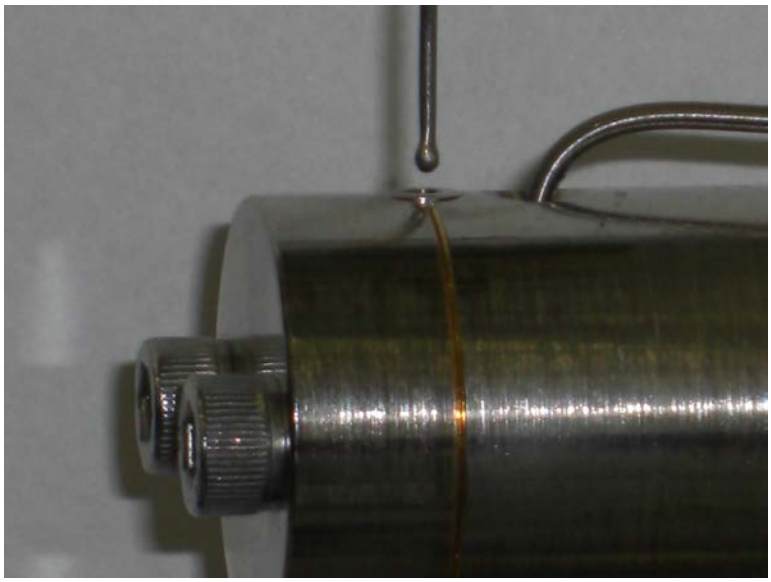


Figure 9 – Heater tube holder assembly positioning

Figure 10 – Heater tube thermocouple inserted into heater tube thermocouple guide

Note: The bus bar caps are a matched to the bus bar. If the bus bar caps get mixed up, they can be matched to the associated bus bar by the numbers stamped inside the bus bar cap and on the end of the bus bar.

Note: Make sure bus bar hex screws are tight. Failure to tighten the bus bar hex screws will cause the heater tube to not properly heat to the required setpoint.

10. Attach all tubing lines and thermocouples to the test section using new O-rings. Inlet thermocouple is attached to the bottom of the heater tube holder assembly and the outlet thermocouple is attached to the top of

the heater tube holder assembly. All tubing lines are to be hand tightened only.

11. It is recommended to initiate a leak test, which will start the pump and pressurize the system to determine if any of the connections are leaking. Refer to section 4.4.7.6 for more details. This is an optional procedure and is not a requirement.

3.6 Starting A Test

1. On the user interface, select the Run Test button or the Find Hot Spot button.
2. Fill in the associated test information on the Test Configuration display and select the type of test to be run. Select the Continue to Test button.
3. A startup process is to be completed to initialize the machine for the test. Follow the on screen instructions to complete. Make sure that the cooling water flow is set to the 10 GPH position (flow gage ball is in the center of the green area). The startup process (for standard test) will take approximately 1.25 hours to complete. Refer to section 4.4.2 for details.
4. Once the startup process has been completed, select the Continue to Test button on the Continue display. Select the Start button on the Run Test display to initiate the test. Everything is automatic from here.
5. A series of actuator moves will occur to correctly position the heater tube thermocouple into the heater tube. The actuator moves will differ based upon the type of test that is to be executed. The actuator will move as follows:
   - Heater tube thermocouple is initialized, where it is moved the distance from the home position to the top of the heater tube.
   - Heater tube thermocouple is moved to the 10mm position

   If the test that is to be executed is a hot spot validation, 20 hour, 40 hour, custom or the 1st 20 hour segment of a 20+20 test, the heater tube thermocouple is moved to its current 'A' position.

   If the test that is to be executed is the 2nd 20 hour segment of a 20+20 test, the heater tube thermocouple is moved to the 'A+40' position.

6. The heater tube temperature will ramp to temperature setpoint (approximately 10 minutes).
7. The test time will be initiated and the heater tube temperature will equalize for 30 minutes.
8. If the test to be executed is a 20 hour, 40 hour, 20+20 hour or custom, follow steps 9 – 12. If the test to be executed is a hot spot determination or hot spot validation, the temperature profile will be captured (skip to step 13).

9. Temperature profile #1 will be captured (if 20+20 hour test, profile #1 captured only during 1st 20 hour segment).
10. The test will continue controlling at the mean control temperature calculated from profile #1 (average of the three (3) A+40 temperature captures).
11. Temperature profile #2 will be captured in the last hour of the test.
12. The test will continue until time duration has completed controlling at the mean control temperature at the A+40 position.
13. Heater tube temperature will ramp down.
14. Pump will stop, reservoir heating will stop and pressure will be released.
15. When outlet temperature is <40°C, the cooling is stopped and the heater tube thermocouple will go to the home position.
16. Test is complete.

3.7 Disassembly/Deposit Determination

Note: Deposit determination not required for a hot spot determination or hot spot validation test.

Note: During a 20+20 hour test, the reservoir remains heating after the 1st 20 hour segment is completed. Disregard references to the reservoir when disassembling after the 1st 20 hour segment.

1. Verify test is complete, system is depressurized (0 psi / 0 kPa), tube temperatures are at a safe value and heater tube thermocouple is in the home position.
2. Loosen heater jacket from reservoir to allow cooling.
3. Disconnect inlet/outlet thermocouples from the heater tube holder assembly.
4. Disconnect tubing lines from heater tube holder assembly.
5. Carefully remove the heater tube holder assembly from the bus bars.
6. Unbolt the reservoir top and disconnect all reservoir tubing lines. Remove the reservoir top and allow air to circulate inside the reservoir to allow cooling.
7. Carefully removed heater tube from heater tube holder so that the formed deposit is not disturbed. This should be done over a beaker to catch any of the deposit, should it break off. Wear gloves when handling the heater tube.
8. Place heater tube into a clean graduated cylinder (boiling tube). Fill graduated cylinder with petroleum ether so that fill line is at least 10mm above the top of the center section of the heater tube. Refer to SAE ARP5596 method for loose debris handling.
9. Let the heater tube soak for at least 10 minutes and then gently agitate the heater tube in the solution.
10. Remove heater tube from graduated cylinder. While holding the heater tube over the beaker, gently rinse the outside of heater tube with petroleum

ether and rinse through the center with petroleum ether. Do not wipe heater tube. Collect any loose debris per SAE ARP5996 method.

11. Rinse reference tube with petroleum ether in the same manner.
12. Dry both heater tubes in a preheated laboratory oven set at 100°C (±5°C) for 30 minutes. Set heater tubes in a holder vertically.
13. Remove heater tubes from oven and cool in the desiccator for at least 30 minutes.
14. Remove the heater tube that was used for the test from the desiccator. Using the laboratory balance, weigh the new heater tube (plus any deposit collected from the wash) to 0.01 mg a minimum of three (3) times. Record the average of three (3) successive weights within 0.02 mg of each other on a test sheet.
15. Remove the reference tube from the desiccator. Using the laboratory balance, weigh the reference tube to 0.01 mg a minimum of three (3) times. Record the average of three (3) successive weights within 0.02 mg of each other on a test sheet.
16. Calculate the difference in mass using the weight from before and after the test for each tube. Record to 0.01 mg on a test sheet.
17. If heater tube being weighed is from the 1st 20 hour segment of a 20+20 hour test, reassemble the heater tube holder assembly and re-install into the bus bars to complete the 2nd 20 hour segment. Refer to section 3.5 (machine setup) and follow steps 7 – 9. Select the resume button on the display to initiate the startup process (minus the reservoir heating) and follow section 3.6 (Starting a Test) steps 4 – 16. At the end of the 2nd 20 hour segment, follow steps 1 – 18 in this section.
18. Store the used heater tube in its plastic case for future reference. Return the reference tube to the desiccator.

4. Description of Equipment

4.1 Principal of Operation

The Falex 450 (FT2) test machine is a very versatile and flexible bench test machine. It incorporates an internal cooling system to help regulate heater tube temperatures. It also incorporates an automatic actuator that moves the heater tube thermocouple to its required positions with precision, thus increasing data repeatability. From the heater tube thermocouple positions, temperature profiles are created. These temperature profiles are captured heater tube temperatures at the various heater tube thermocouple positions. All heater tube temperature thermocouple moves are based from the 'A' position, which is the determined hottest point on the heater tube. The hottest point on the tube is determined by running a 'Hot Spot Determination' test. Refer to section 4.4.3 for detail on the hot spot test functionality. Heater tube temperature profiles contain captured temperatures at the following heater tube thermocouple positions:

- A – 4
- A
- A + 4
- A + 10
- A + 14
- A + 20
- A + 30
- A + 40
- A + 50

For example, if the determined hot spot position is 14mm on the heater tube, the 'A' position would be 14mm, the 'A – 4' position would be 10mm, the 'A + 10' position would be 24mm, etc.

Once the machine has been setup, configured, and the startup process has been completed by the operator, the test will run to completion without any additional operator intervention. Two (2) controllers are used within the machine. One is used as the main controller for all control functionality and one is used as a safety backup. The safety controller will abort the test and stop all devices to protect the machine should the main controller fail.

This machine is capable of running many types of tests that meet many commercial and military specifications and can simulate a broad range of field applications. It can run the following types of tests:

- Hot Spot Determination (per SAE ARP5996)
- Hot Spot Validation (per SAE ARP5996)
- 20 hour test (per SAE ARP5996)
- 40 hour test (per SAE ARP5996)
- 20 hour + 20 hour test (per SAE ARP5996)

- Custom test

The Custom test allows the operator to change the heater tube temperature, reservoir temperature, system pressure, fluid flow rate and test duration from what is designated in the standard SAE ARP5996 tests.

Refer to section 4.3 for a detailed description of the user interface functionality and section 4.4 for detailed functionality of the individual displays.

4.2 Electrical Features, Controls, Inputs & Outputs

Several connectors are located on the front of the machine. These include: reservoir heater jacket connector, reservoir heater jacket thermocouple, heater tube thermocouple, upper/lower bus bar thermocouples and inlet/outlet thermocouples. All thermocouple connectors are 'K' type connectors.

Reservoir Heater Jacket Connector

This connector provides power to the heater jacket. The output of the heater is controlled in software. The heater jacket is controlled at 150°C for all SAE ARP5996 standard tests. Custom tests will allow a temperature range from 100°C to 210°C. The heater jacket is controlled through feedback from the heater reservoir thermocouple.

Reservoir Heater Jacket Thermocouple

This thermocouple is used to control the heater jacket temperature and for alarm monitoring. The thermocouple connector is located above the reservoir. This thermocouple output is split internally. One output is wired to the main controller for temperature control and one output is wired to the safety controller for backup protection. The thermocouple is sewn into the inside of the heater jacket. The main controller temperature reading is monitored for alarm purposes, shown on the display and recorded in the data file. The safety controller temperature reading is monitored for alarm purposes and shown on the display. The two (2) readings should read the same (+/- 2°C). If they aren't, verify calibration data (refer to section 4.4.7.5).

Heater Tube Thermocouple

This thermocouple is used to control the heater tube temperature and record the temperature at various heater tube thermocouple positions. The thermocouple connector is located above the actuator arm. The thermocouple is to be mounted into the actuator arm assembly. This thermocouple output is split internally. One output is wired to the main controller for temperature control and one output is wired to the safety controller for backup protection. The main controller temperature reading is monitored for alarm purposes, shown on the display and recorded in the

data file. The safety controller temperature reading is monitored for alarm purposes and shown on the display.

Upper Bus Bar Thermocouple

This thermocouple is used to monitor the upper bus bar temperature. The thermocouple connector is located to the right of the upper bus bar. The thermocouple is to be inserted into the thermocouple hole located on the top of the upper bus bar. The temperature reading is not shown on any display, but is monitored for alarm purposes and recorded in the data file.

Lower Bus Bar Thermocouple

This thermocouple is used to monitor the lower bus bar temperature. The thermocouple connector is located to the right of the lower bus bar. The thermocouple is to be inserted into the thermocouple hole located on the underside of the lower bus bar. The temperature reading is not shown on any display, but is monitored for alarm purposes and recorded in the data file.

Inlet Thermocouple

This thermocouple is used to monitor the fluid inlet temperature to the heater tube holder assembly. The thermocouple connector is located to the right of the lower bus bar (above the lower bus bar thermocouple connector). The thermocouple is to be inserted into the lower thermocouple port on the heater tube holder assembly. The temperature reading is monitored for alarm purposes, shown on the display and recorded in the data file.

Outlet Thermocouple

This thermocouple is used to monitor the fluid outlet temperature from the heater tube holder assembly. The thermocouple connector is located to the right of the upper bus bar (below the upper bus bar thermocouple connector). The thermocouple is to be inserted into the upper thermocouple port on the heater tube holder assembly. The temperature reading is monitored for alarm purposes, shown on the display and recorded in the data file.

Power Button

The red illuminated power button on the front of the machine enables power to the entire machine.

User Interface

The user interface is a PC and uses touchscreen functionality. No keyboard or mouse are required (a USB mouse/keyboard can be connected if desired). Refer to section 4.3 for more details.

Fault Indicator

A fault indicator strip is located on the front of the machine below the user interface. It will illuminate various system faults, should one exist. The possible system faults that can be illuminated are:

- 24 VDC
- Encoder
- 5 VDC
- T/C Actu
- Filter DP
- System Press
- ESD 24 VDC
- Tube Htr SCR
- Cooler 12 VDC
- Vent Vlv
- N2 Vlv
- Bypass Vlv
- Pos DP Vlv
- Neg DP Vlv
- Fans
- Pump Speed
- Switch

Circuit Breaker

The circuit breaker is located on the back of the machine next to the power plug. It is a 10 amp device for protection of the machine. It can be reset by pushing the button.

Device Breaker Reset

Various devices have individual power protection associated with them. Individual breaker reset buttons for the pump, tube heater, reservoir heater and 24V power are located on the back of the machine. They can be reset individually by pushing the associated button.

Coolant Flow Control

Coolant flow can be controlled using the flow control knob on flow meter. The flow meter is located on the front of the machine above the reservoir. The standard flow setting is 10 GPH (39 L/Hr). Each tic mark on the flow meter is 2 GPH. Adjust flow so that the ball float is within the recommended range shown on the flow meter.

Drop Counter

Fluid drop count timing can be started/stopped by using the drop count switch. It is to be connected to the jack located on the lower right on the front of the machine.

4.3 User Interface

4.3.1 Overview

The F450 (FT2) user interface makes testing easy to setup, repeat and control. It is operated entirely under a Windows® operating system environment and is completely menu driven. It utilizes touchscreen

functionality that allows items to be selected by simply touching the item to be selected with ones finger, stylus, or selecting it with a mouse (if a mouse is connected). Live signal values are displayed, even when a test is not running. During testing, test data is displayed both numerically and graphically.

Software functionality monitors various inputs (i.e. heater tube temperature, heater power, inlet temperature, outlet temperature, reservoir temperature, system pressure, heater tube thermocouple position) and their values are saved into a data file at a selectable interval. The data file created is saved in a format that can be opened with a standard spreadsheet or document application, once transferred to an external PC.

Besides running the various types of tests, the user interface is capable of the following functionality:

- Data transfer
- Data retrieval
- Report creation
- Printing
- Alarming/Alarm log update
- Manual device control
- Device calibration
- Runtime statistics logging
- Safety backup monitoring
- Demo testing for training
- User preference customization
- Network capability
- Date/Time setting

The user interface software application is automatically started when the machine is powered up. Should the display go to sleep, it can be reawakened by touching somewhere on the touchscreen surface.

4.3.2 Display Architecture

The displays are made up of four (4) areas (figure 11), with each area having special functionality. The various display areas are:

- Header
- Main display area
- Status/navigation bar
- Message bar

Figure 11 – display component areas

Header

The header area contains safety controller temperature information, the display title and various icons that when pressed, initiate additional functionality.

The three (3) temperatures readings shown at the top of the header area (figure 12) that are monitored by the safety controller as backup protection are: tube temperature (high alarm/abort), reservoir temperature (high alarm/abort) and outlet temperature (low alarm/abort).

Figure 12 – Monitored Safety Temperatures

The current value is displayed within the temperature bar. The temperature bar is color oriented with the green area representing the safe level, the yellow area represents approaching alarm limits and the red area represents approaching abort limits. A vertical white line represents where the current reading is on the color temperature bar.

The display title is shown in the center of the header area.

The right side of the header area has various icons that have functionality associated with them when selected. Icon availability can differ between displays. They can call up a help screen for the particular display (figure 13), return to the Main Menu (figure 14), exit from current display or exit out of the Falex 450 (FT2) user interface application (figure 15), or initiate printing (figure 16).

Figure 13 – Current display 'Help' information icon

Figure 14 – Return to Main Menu 'Home' icon

Figure 15 - 'Exit' from display application icon

Figure 16 - 'Print' current page icon

Main Display Area

The main display area contains graphs, numeric data, buttons, and enterable fields to allow the operator to configure, run and manage tests.

Status/Navigation Bar

The status/navigation bar contains information regarding the operation status of important devices and can also contain display navigation arrows (figure 17). It will also show the type of test that has been selected to run or is running. Various key values will also be shown here during specific startup sequences.

Current device operational status information is shown for: fluid pump, reservoir heater, tube heater, cooling pump, inlet valve and exhaust valve. A green status light to the left of each device indicates that it is 'on' or 'open' (in the case of the inlet/exhaust valves). If the device status is not green, then it is 'off' or 'closed'.

Navigation arrows will open up additional displays associated with the button category selected on the Main Menu. They navigate forward (→) or backward (←) through the additional displays. They are not available on all displays.

Figure 17 – Status bar contents

Message Bar

The message bar is divided into three (3) tabular areas that keep the operator informed on what the machine is doing (figure 18).

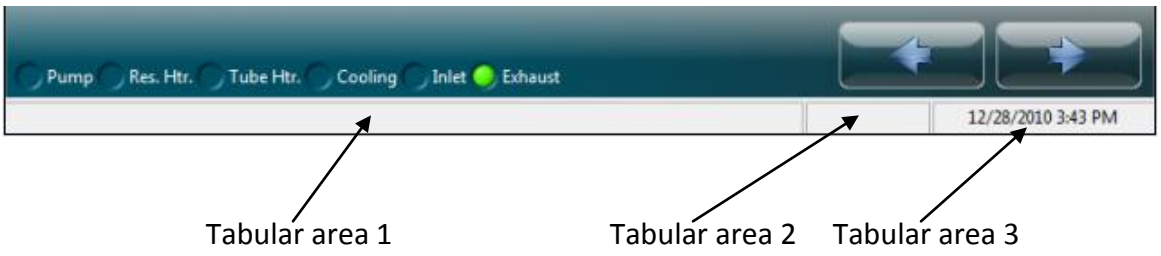


Figure 18 – Message bar tabular areas

Tabular area 1 shows current messages on what operation the machine is trying to perform or will display an active alarm message. Tabular area 2 lets the operator know if the machine is in 'Demo' mode (if this area is blank, it is in normal operational mode). Tabular area 3 shows the current date and time utilized by the 'user interface'.

4.3.3 Functionality

As described earlier, buttons, icons and enterable fields can be selected by simply touching the item to be selected with ones finger, stylus, or selecting it with a mouse (if a mouse is connected).

Buttons and enterable fields that are grayed out, are not enabled (figure 19). If a grayed out button is selected, nothing will happen. Various conditions must be met within the control software before particular buttons or enterable fields are enabled.

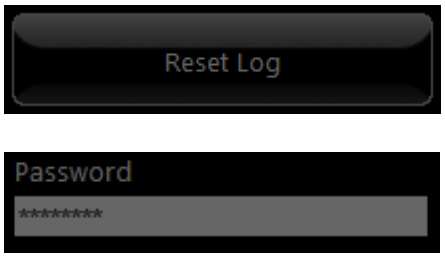


Figure 19 – Disabled functionality

Enterable fields are shown as white rectangular areas. These fields allow the operator to enter alpha-numeric information or to enter numeric information. If an alpha-numeric field is selected, a full keyboard will appear on the screen so that the information can be entered (figure 20). If a numeric field is selected, a keypad will appear so that the numeric value can be entered (figure 21). If a keyboard is connected to the machine, information can be entered from the keyboard for the selected enterable field.

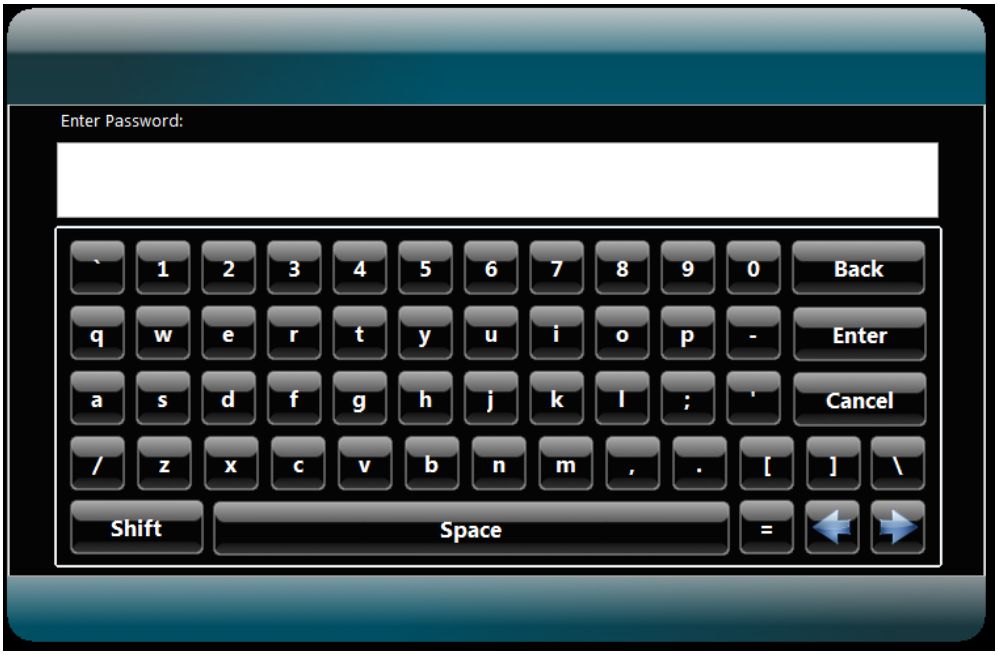


Figure 20 – Alpha-numeric keyboard

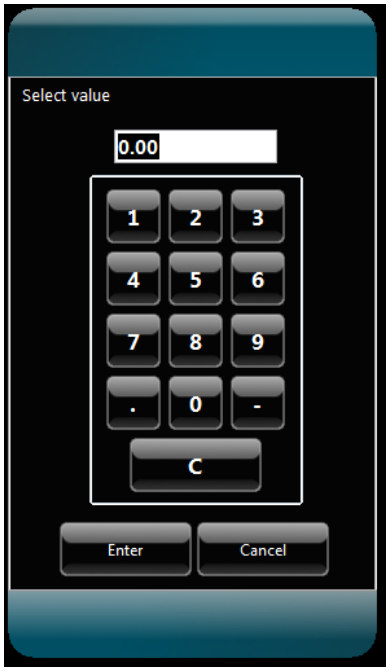


Figure 21 – Numeric keypad

Actions taken by the operator require a secondary operator verification before the action is executed (figure 22). This will prevent accidental selection of critical functionality. Such actions requiring secondary verification are saving changes, file deletion, aborting a test and exiting the user interface application.

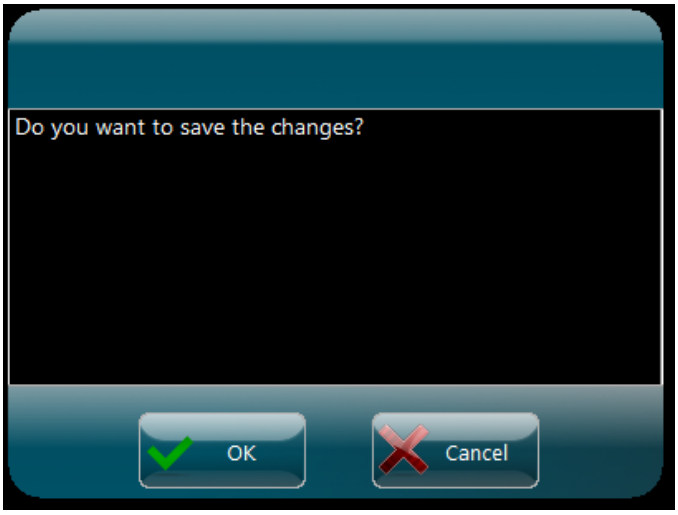


Figure 22 – Operator verification pop-up

4.3.4 Password Levels

The user interface incorporates two (2) levels of passwords, each enabling additional functionality.

Level 1 is for supervisor access. It enables the following additional functionality:

- Enable demo mode for training purposes
- Access to Windows® Explorer interface
- Ability to change network settings
- Enable calibration functionality

The machine is delivered with the default level 1 password of '123456'. It can be changed in the 'User Preferences' area and periodically should be changed for security purposes (the department supervisor is the intended facilitator of this functionality). Should the level 1 password be forgotten, it can be determined by contacting your local Falex representative. When/where the level 1 password is required will be detailed as it applies to a particular display.

The level 2 password is for factory and authorized service personnel use only.

4.4 Display Functionality

The following sections will describe the functionality of each display.

4.4.1 Main Menu

The Main Menu display is the 'home' position for the user interface application and is the active display that appears upon a system power-up. From the Main Menu, the operator can run a timed duration test, run a hot spot test, set the redundant safety alarm/abort limits, configure user preferences, conduct file management and initiate maintenance functionality (figure 23). In addition, 'Demo Mode' can also be activated from this display and one can safely shutdown the user interface application prior to a machine power down. Select what operation is desired by touching the button with your finger, a stylus, or clicking on it with a mouse (if a mouse is connected).

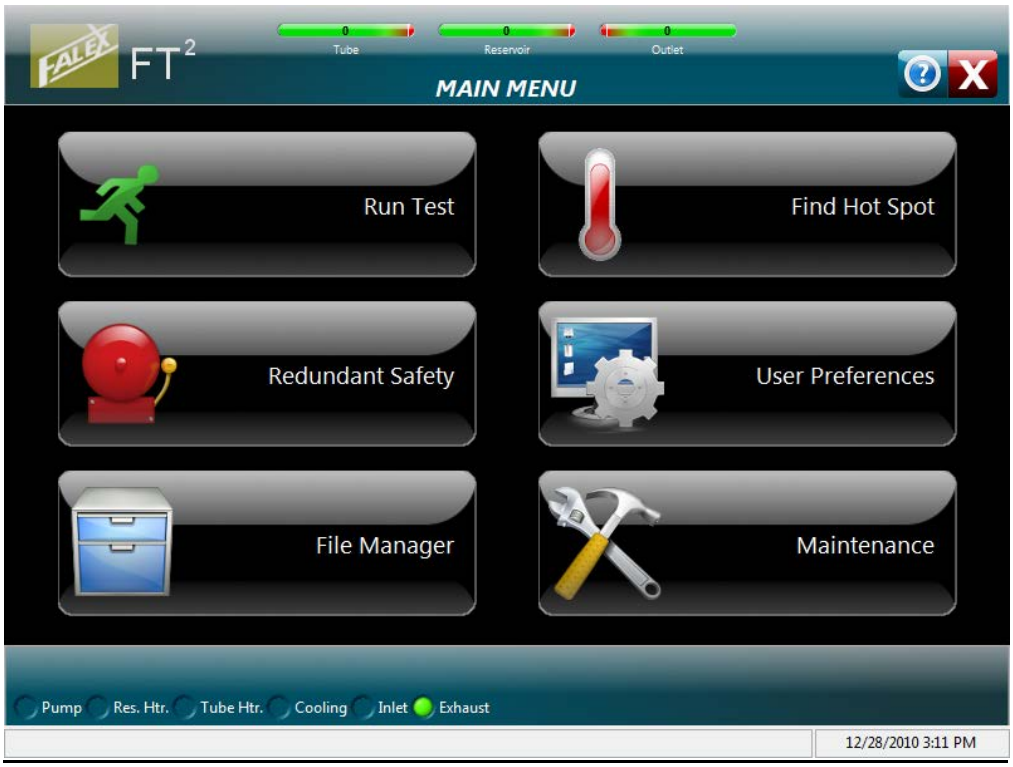


Figure 23 – Main Menu

Run Test

This selection allows the operator to enter test information and select the desired test type to initiate: 20 hour, 40 hour, 20+20 hour, or a custom test. Refer to section 4.4.2 for more detail.

Find Hot Spot

This selection allows the operator to enter hot spot test information and select the desired hot spot type to initiate: hot spot determination or a hot spot validation. Refer to section 4.4.3 for more detail.

Redundant Safety

This selection allows the operator to enter 'operator' abort levels for the three (3) temperatures monitored by the safety controller: outlet temperature, tube temperature and reservoir temperature. Please note that there are hardcoded temperature limits set in the software outside the enterable limit. Refer to section 4.4.4 for more detail.

User Preferences

This selection allows the operator to customize various parameters to meet their preferences and/or requirements. Parameters such as trend colors, graph scales limits and data collection options can be configured. Additional functions such as user table configuration (operators, test fluids, tube IDs), printer setup, network setup and the level 1 password can also be configured. Refer to section 4.4.5 for more detail.

File Manager

This selection allows the operator to copy reports, data files and test profiles to an external device. It also allows report printing (if a printer is configured and connected), allows the operator a way to get into Windows® Explorer (with level 1 password) and displays user interface disk usage. Refer to section 4.4.6 for more detail.

Maintenance

This selection allows the operator to manually initiate machine functionality and view data manually when the machine is not running a test. The many functions that can be done here are:

- View raw values
- View/print alarm log
- View test statistics
- View last hot spot data
- View machine serial #
- Set time/date in controller
- Enable system calibration*
- View calibration data
- Calibrate touchscreen
- Manually control devices
- Set heater tube thermocouple position offset

Note: system calibration can be enabled with the level 1 password.

Refer to section 4.4.7 for more detail.

Miscellaneous Functionality

There is miscellaneous functionality associated with the Main Menu. From the Main Menu, the operator also can:

- Enable/disable 'Demo' mode
- View software versions
- Exit user interface application

Demo Mode

'Demo' mode is a function that will demonstrate the functionality of the machine without running the pump, applying heat to the reservoir, heat to the heater tube, or pressurizing the system. Demo mode executes all the steps of a 20 hour test or a hot spot determination in a short time duration (18.5 minutes for 20 hour test and 9.5 minutes for hot spot determination). This can be a useful tool for troubleshooting, training new employees, or demonstrating to customers. Refer to Addendum B to review test timing associated with Demo tests.

To enable demo mode, select the Falex icon in the upper left hand corner (figure 24) and enter the level 1 password using the pop-up keyboard. Select 'OK' at the 'Enable Demo Mode?' pop-up display (figure 25).

Figure 24 – Icon to enter password

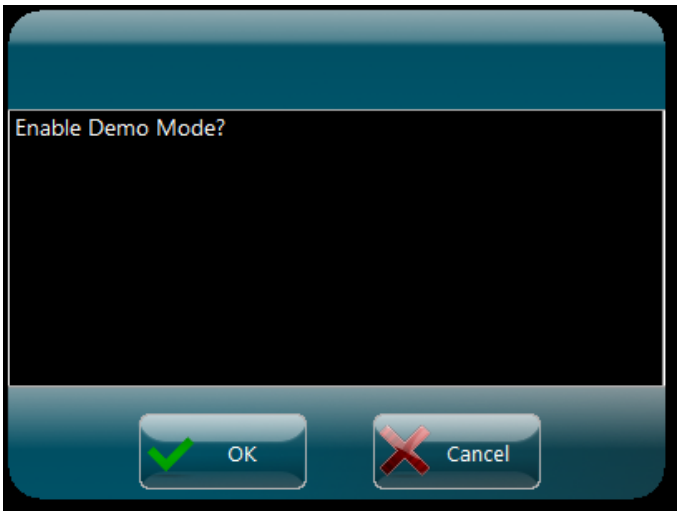


Figure 25 – Demo mode enable pop-up

When demo mode is enabled, 'Demo Mode' will be displayed in various colors on the right side of the status bar area on the Main Menu (figure 26). All other displays will show 'DEMO MODE' in tabular area 2 of the message bar (figure 27). Since no heating is initiated during demo mode, all temperature readings displayed are ambient temperature.

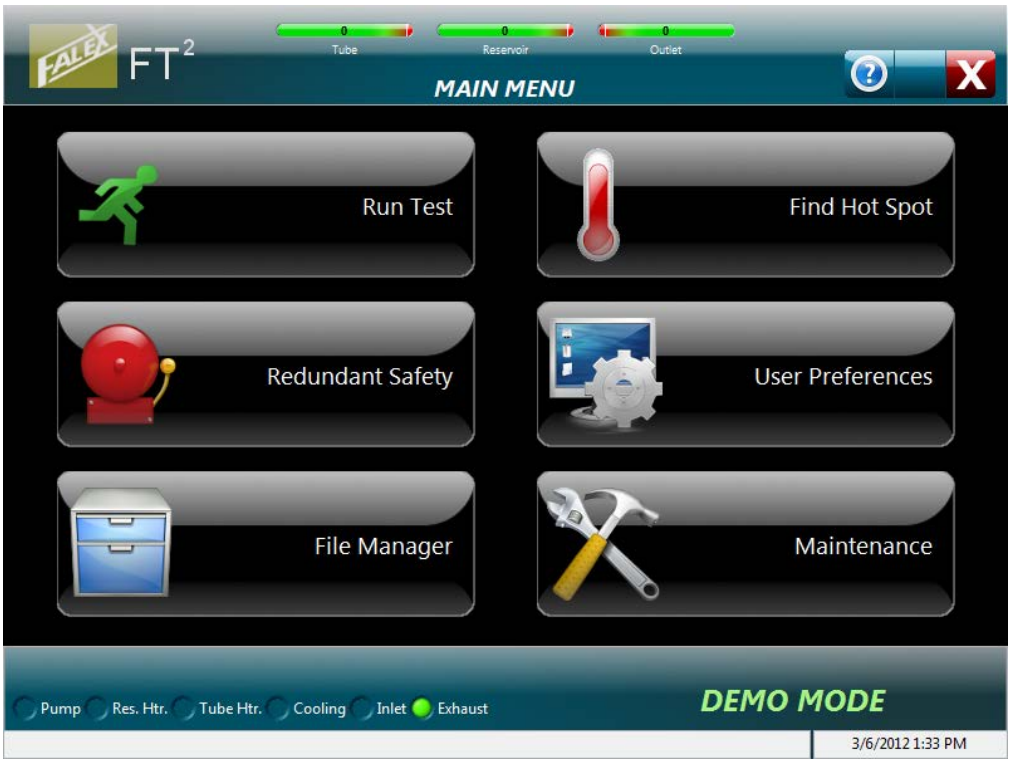


Figure 26 – Main Menu demo mode designation

Figure 27 – Message bar demo mode designation

Once 'Demo Mode' is enabled, the test configuration and startup will be the same as a standard 20 hour test or hot spot determination test (refer to section 4.4.2 for test details or section 4.4.3 for hot spot test details). When in demo mode and the 'Run Test' button is selected, any of the tests selected in the 'Test Selection' area will initiate a demo 20 hour test. When in demo mode and the 'Find Hot Spot' button is selected, any of the tests selected in the 'Test Selection' area will initiate a demo hot spot determination test.

Once 'Demo Mode' is no longer required, it must be disabled by the operator. To disable demo mode, select the Falex icon in the upper left hand corner (figure 24) and enter the level 1 password using the pop-up keyboard. Select 'OK' at the 'Disable Demo Mode?' pop-up display (figure 28). The 'Demo Mode' reference on the displays will disappear.

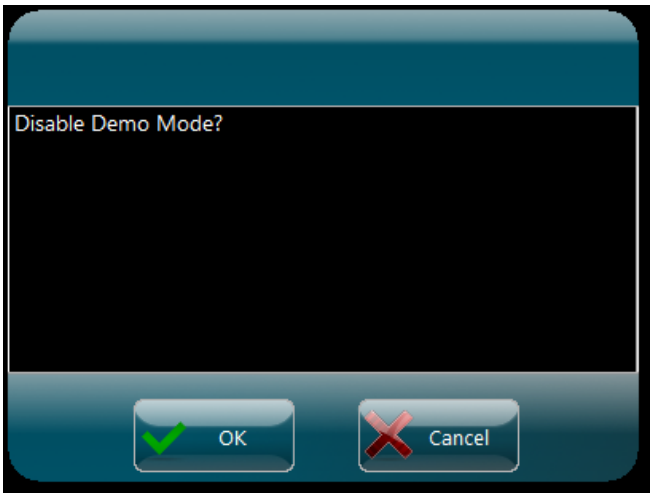


Figure 28 – Demo mode disable pop-up

Software Versions

Selecting the help button on the Main Menu will call up a pop-up window showing the software version numbers (figure 29). Separate software version numbers exist for the user interface (HMI) application, main controller software application and the safety controller software application.

Figure 29 – Software version pop-up

Exit User Interface Application

Selecting the from the header portion of the display will safely exit the user interface application before the machine is powered down. This will properly save and close any open files and/or tables before power is removed.

Note: It is recommended that the user interface application be properly shutdown prior to removing the machine from power. Powering down the machine without doing so could cause data loss and should only be done in an emergency.

4.4.2 Run Test

The ‘Run Test’ selection initiates the process of configuring, initializing and starting a timed test. There are many steps that must be completed before the actual test is started. Once the test configuration parameters have been entered, a ‘startup’ process is initiated. This ‘startup’ process initializes the machine and its various devices to required pretest conditions. When the various ‘startup’ conditions have been met, the actual test can then be started. The ‘startup’ process takes approximately 1.25 hours (for a standard test) to complete before the ‘start’ button can be pressed.

The ‘startup’ process consists of a series of displays that require the operator to initiate specific functionality so that required pretest conditions can be achieved.

Note: The test cannot start unless <u>all</u> conditions are met.

The following conditions must be met before a test can be initiated (figure 30):

Figure 30 – Test startup conditions that must be met

The condition is satisfied when the indicator next to the condition is green.

Not all the conditions have a separate process associated with them requiring operator/user interface interaction. ‘Cooling Enabled’ and ‘Redundant Safety OK’ conditions are achieved internally, once the ‘Continue to Test’ button has been selected from the Test Configuration display (a test

type must be selected). The cooling system will automatically turn on (ball should be floating within coolant flow meter) and the safety controller is checked to see if it functioning properly. The 'Safety Cover in Position' condition will be satisfied once the safety cover has been correctly placed over the heater tube holder assembly and has been detected (photo eye is located to the right of the lower bus bar). The safety cover can be placed at any time during the startup process.

An audible 'beep' will sound when the time consuming startup conditions have been met (purge, reservoir heating, reservoir heat soak, pressurization). This is to alert the operator that the step has been completed and allows the operator to perform other duties while the particular startup sequence completes.

Once the 'startup' process has been completed, the main test display will appear, where test can be started and variables can be monitored. Navigation buttons exist that allow the operator to access additional displays while a test is active.

Note: If a thermocouple is not plugged in or one fails during the startup process, an alarm message will pop-up alerting the operator (figure 31).

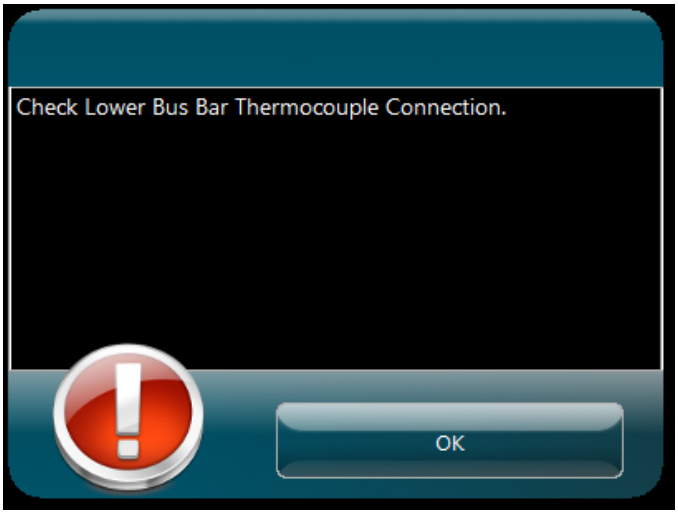


Figure 31 – Thermocouple Fail pop-up

All of the displays associated with the 'Run Test' button are discussed in the sub sections below.

4.4.2.1 Test Configuration

When the 'Run Test' button is selected from the Main Menu, the 'Test Configuration' display appears (figure 32). This display allows the operator to enter test information for the test and also select the type

of test that is to be initiated. It is not mandatory that test information be entered. However, it is recommended that this information be entered to help in distinguishing test parameters and associated data for future reference. This information is stored in the data file and will appear on the generated report.

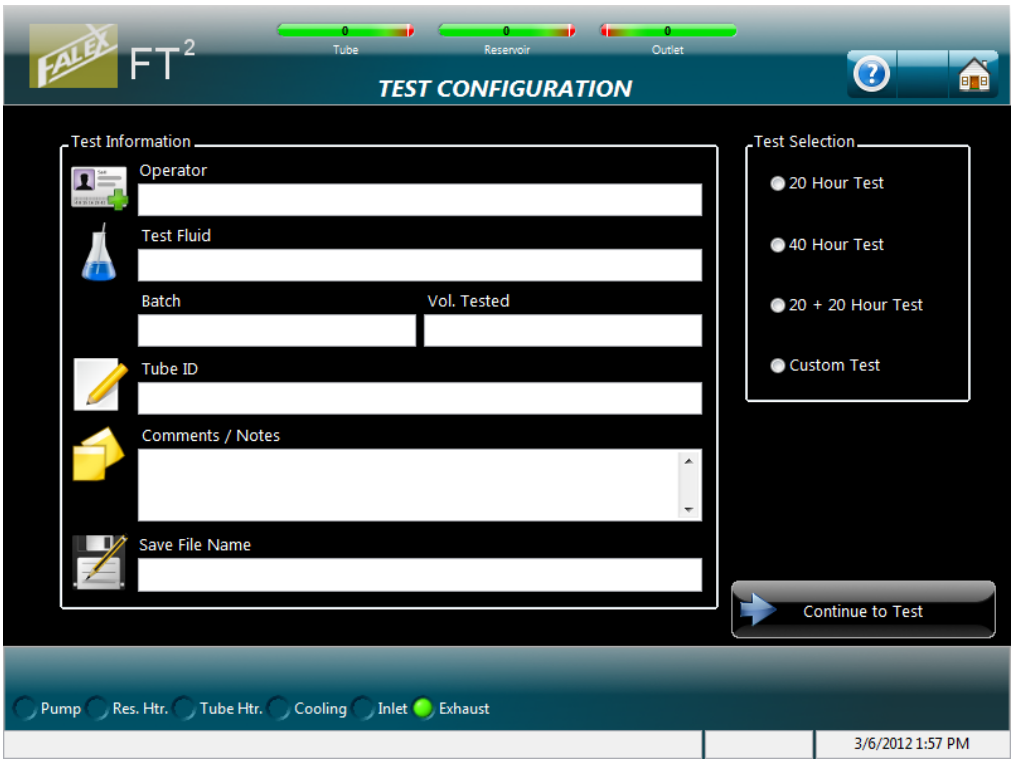


Figure 32 – Test configuration display

Test information that can be entered is:

- Operator Name
- Test Fluid
- Fluid Batch ID
- Volume Tested
- Heater Tube ID
- Test Comments
- Data File Name

Entered information is stored in the Name, Test Fluid and Tube ID fields for quick retrieval for future tests. Previous Tube ID numbers can be called up and quickly modified using the back space key and replacing the required numbers. Select the white field to call up the available names already entered and select the desired name. If the name is not entered, select 'Add…' and enter the required name via the alpha-numeric keyboard. Always hit the 'Enter' key on the keyboard to enter the data into the proper field.

Information entered in the data file name field (if anything) will be contained in the data file name structure. Data file names are

defaulted with the current date & time stamp along with a test type designation.

The data file name structure is as follows:

YYYYMMDD_TTTT_X_Z.csv, where
Y = year
M = month
D = day
T = time (24 hour clock format)
X = operator entered information
Z = test type designation. The various test type designations are:

20HrData	*(20 hour test data file)*
20HrProfiles	*(20 hour test temperature profile)*
40HrData	(*40 hour test data file)*
40HrProfiles	*(40 hour test temperature profile)*
2020HrData	*(20+20 hour test data file)*
2020HrProfiles	*(20+20 hour test temperature profile)*
CustData	*(custom test data file)*
CustProfiles	*(custom test temperature profile)*

Report file names have the same format as the data files, except they are .pdf files.

Example of 20 hour test data file without operator entered information:

20101228_1413__20HrData.csv

Example of 20 hour test data file with operator entered information:

20101228_1413_Tuesday_20HrData.csv

The type of test that is to be run is to be selected. Test types that can be selected are:

- 20 hour test
- 40 hour test
- 20+20 hour test
- Custom test

(Individual test details are discussed further down in this section).

The operator cannot advance to the next display unless a test type has been selected. Should the 'Continue to Test' button be selected without a test type being selected, a notification pop-up display will appear alerting the operator (figure 33).

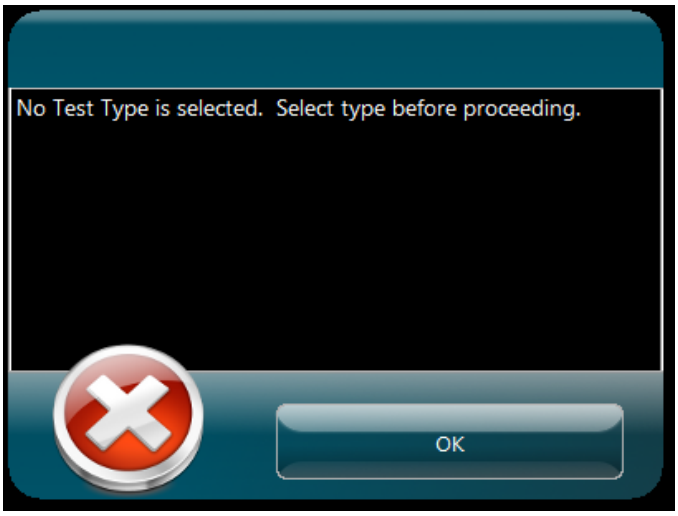


Figure 33 – Test selection notification

20 hour test

This is a standard SAE ARP5996 test. Test parameters cannot be modified. It requires the startup procedure to be completed before test duration is started. The test parameters are:

- Test duration (20 hours)
- Heater tube temperature (375°C)
- Reservoir temperature (150°C)
- System pressure (200 psi / 1380 kPa)
- Pump speed (1ml/min or 20 drops in 30 seconds)
- Two (2) temperature profiles created (1st profile captured in hour 1 and 2nd profile captured in hour 19)

Refer to Addendum B to review timing associated with this test type.

Once the test is complete, the heater tube temperature is cooled, the system pressure is released, the pump is stopped and reservoir heating is stopped. The heater tube temperature thermocouple will go to the home position when the outlet temperature is <40°C. Once the heater tube thermocouple is in the home position, a test complete pop-up display will appear notifying the operator that the test is complete. The machine can now be broken down for cleaning and weighing of the heater tube.

40 hour test

This is a standard SAE ARP5996 test. Test parameters cannot be modified. It requires the startup procedure to be completed before test duration is started. The test parameters are:

- Test duration (40 hours)
- Heater tube temperature (375°C)
- Reservoir temperature (150°C)
- System pressure (200 psi / 1380 kPa)

- Pump speed (1ml/min or 20 drops in 30 seconds)
- Two (2) temperature profiles created (1st profile captured in hour 1 and 2nd profile captured in hour 39)

Refer to Addendum B to review timing associated with this test type.

Once the test is complete, the heater tube temperature is cooled, the system pressure is released, the pump is stopped and reservoir heating is stopped. The heater tube temperature thermocouple will go to the home position when the outlet temperature is <40°C. Once the heater tube thermocouple is in the home position, a test complete pop-up display will appear notifying the operator that the test is complete. The machine can now be broken down for cleaning and weighing of the heater tube.

<u>20+20 hour test</u>

This is a standard SAE ARP5996 test. Test parameters cannot be modified. It requires the startup procedure to be completed before test duration is started. This test runs for 40 hours, but is broken down into two (2) continuous 20 hour segments (segment #1: hour 1 – 20 and segment #2: hour 21 – 40). The test is paused after segment #1, the sample pump is stopped, system pressure is released, the heater tube is cooled and the reservoir <u>remains</u> heating so that the heater tube holder assembly can be broken down and the heater tube observed & weighed for deposit formation. Once the heater tube holder assembly is reassembled, the test can be resumed. The test startup procedure must be completed again (except for reservoir heating/soak). The test parameters are:

- Total test duration (40 hours) broken down into two (2) continuous 20 hour segments
- Test segment #1 duration (20 hours)
- Test segment #2 duration (20 hours)
- Heater tube temperature (375°C)
- Reservoir temperature (150°C)
- System pressure (200 psi / 1380 kPa)
- Pump speed (1ml/min or 20 drops in 30 seconds)
- Three (3) temperature profiles created (1st profile captured in hour 1 of test segment #1, 2nd profile captured in hour 19 of test segment #1 and 3rd profile captured hour 39 of test segment #2)

Refer to Addendum B to review timing associated with this test type.

Once the test is complete, the heater tube temperature is cooled, the system pressure is released, the pump is stopped and reservoir

heating is stopped. The heater tube temperature thermocouple will go to the home position when the outlet temperature is <40°C. Once heater tube thermocouple is in the home position, a test complete pop-up display will appear notifying the operator that the test is complete. The machine can now be broken down for cleaning and weighing of the heater tube.

Custom test

This is not a standard SAE ARP5996 test. Test parameters can be modified. It requires the startup procedure to be completed before test duration is started. The startup procedure differs from the startup procedures done for standard SAE ARP5996 tests. If the required flow rate is changed from the standard 1 ml/min rate, the drip count in 30 seconds for the custom flow rate is not known. The flow verification is not required, since in is a non-standard test and the flow requirements are not specified.

Test parameters can be modified as follows (figure 34):

- Test duration (2.5 - 500 hours)
- Heater tube temperature (300 - 450°C)
- Reservoir temperature (100 - 210°C)
- System pressure (0 - 200 psi / 0 – 1380 kPa)
- Pump speed (0.5 – 10 ml/min)
- Up to two (2) temperature profiles can be created , the 2nd temperature profile is optional (1st profile captured in hour 1 and optional 2nd profile captured in last hour).

Note: Prior to running a custom test, verify the graph scales and redundant safety abort limits are set correctly for the desired test parameters. Graph scales can be modified by selecting the 'User Preferences' button on the Main Menu. See section 4.4.5 for more details. Redundant safety abort limits can be modified by selecting the 'Redundant Safety' button on the Main Menu. See section 4.4.4 for more details.

Figure 34 – Custom Test Configuration display

Refer to Addendum B to review timing associated with this test type.

Once the test is complete, the heater tube temperature is cooled, the system pressure is released, the pump is stopped and reservoir heating is stopped. The heater tube temperature thermocouple will go to the home position when the outlet temperature is <40°C. Once the heater tube thermocouple is in the home position, a test complete pop-up display will appear notifying the operator that the test is complete. The machine can now be broken down for cleaning and weighing of the heater tube.

Once all test information has been entered and a test type has been selected, selecting the 'Continue to Test' button will advance to the 'Test Startup' series of displays.

4.4.2.2 Purge System

The first display in the startup process is the Purge System display (figure 35). The purpose of this process is to pump test fluid through the system to displace any air being held within the tubing lines and to achieve a constant stream of drops visible in the sight glass window.

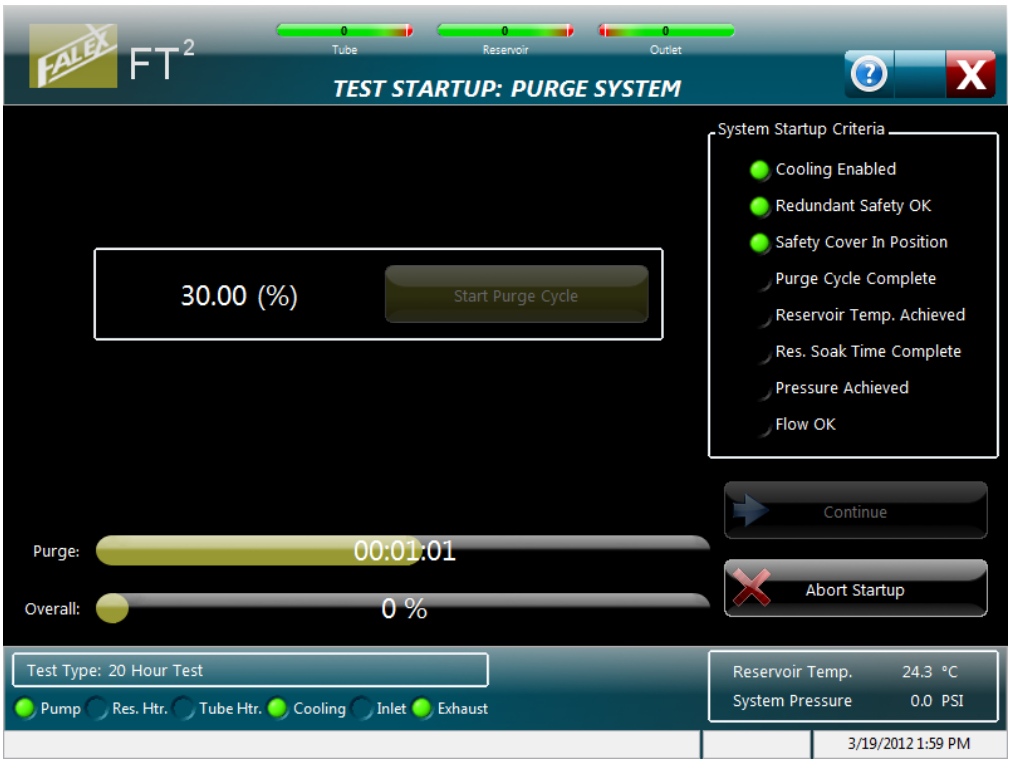


Figure 35 – Purge System display

This process is initiated by selecting the 'Start Purge Cycle' button. The sample pump will start at a higher than normal speed and will run at this speed for 2 minutes (the duration of this sequence). The pump speed is shown as a percentage and cannot be changed.

When the sequence is complete, the following will occur:

- Pump speed is automatically changed to the value defined for the test. For a standard test, the default setting is used that yields a flow rate of approximately 1 ml/min. For a custom test, the speed set by the operator is used.
- An audible 'beep' is sounded notifying the operator that the sequence is complete
- In the 'System Verification' section of the display, the indicator next to the 'Purge Cycle Complete' will turn green
- The 'Continue' button will become enabled

Two (2) progress bars are displayed to keep the operator informed on the startup process status. They are:

- *Purge* - purge sequence progress (entire progress bar represents 2 minutes)
- *Overall* - overall startup process progress

Selecting the 'Abort Startup' button will abort the startup process and stop any devices that may be running.

The ‘Continue’ button is not enabled until the condition has been satisfied. Once enabled, selecting the ‘Continue’ button will advance the startup process to the next step, heating the reservoir.

4.4.2.3 Heat Reservoir

The next display in the startup process is the Heat Reservoir display (figure 36). The purpose of this process two fold, heating the reservoir to a desired temperature and allowing the reservoir to heat soak for 30 minutes to allow the temperature to equalize.

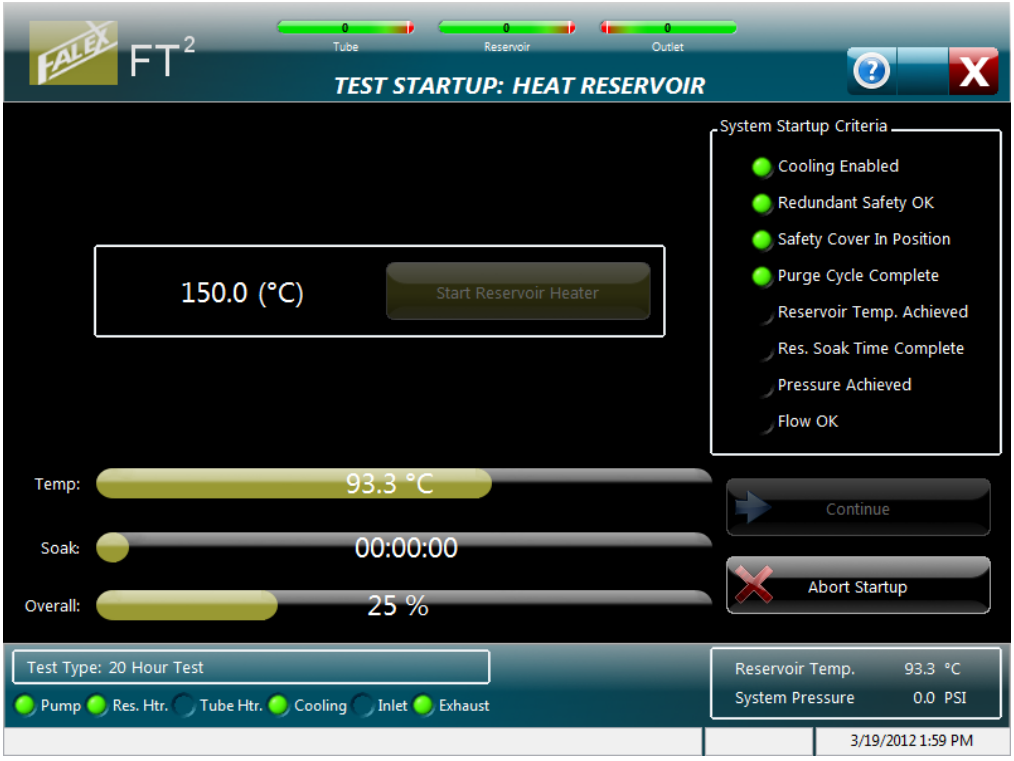


Figure 36 – Heat Reservoir display

This process is initiated by selecting the ‘Start Reservoir Heater’ button. It will take approximately 15 – 30 minutes to attain the default temperature of 150°C. The reservoir temperature setpoint is shown and cannot be changed.

Note: Reservoir temperature must be 5% below the temperature setpoint (142.5°C for a standard test) before the reservoir will start heating. This is important should an abort occur during the startup process and the process is restarted.

When the heating to temperature sequence is complete, the following will occur:

- An audible ‘beep’ is sounded notifying the operator that the reservoir temperature is within 3% of the setpoint and the 30 minute temperature soak sequence has started
- In the ‘System Verification’ section of the display, the indicator next to the ‘Reservoir Temp. Achieved’ will turn green
- The heat soak sequence will start

When the heat soak sequence is complete, the following will occur:

- An audible ‘beep’ is sounded notifying the operator that the sequence is complete
- In the ‘System Verification’ section of the display, the indicator next to the ‘Res. Soak Time Complete’ will turn green
- The ‘Continue’ button will become enabled

Three (3) progress bars are displayed to keep the operator informed on the startup process status. They are:

- *Temp* – current reservoir jacket temperature (entire progress bar represents reservoir jacket temperature setpoint)
- *Soak* - elapsed soak time (entire progress bar represents 30 minutes)
- *Overall* - overall startup process progress

Selecting the ‘Abort Startup’ button will abort the startup process and stop any devices that may be running.

The ‘Continue’ button is not enabled until the reservoir temperature soak condition has been satisfied. Once enabled, selecting the ‘Continue’ button will advance the startup process to the next step, pressurizing the system.

4.4.2.4 Pressurize System

The next display in the startup process is the Pressurize System display (figure 37). The purpose of this process is to slowly pressurize the system with clean oil free air (default 200 psi / 1380 kPa). Once pressurized, check for leaks (tighten connection if a leak is found).

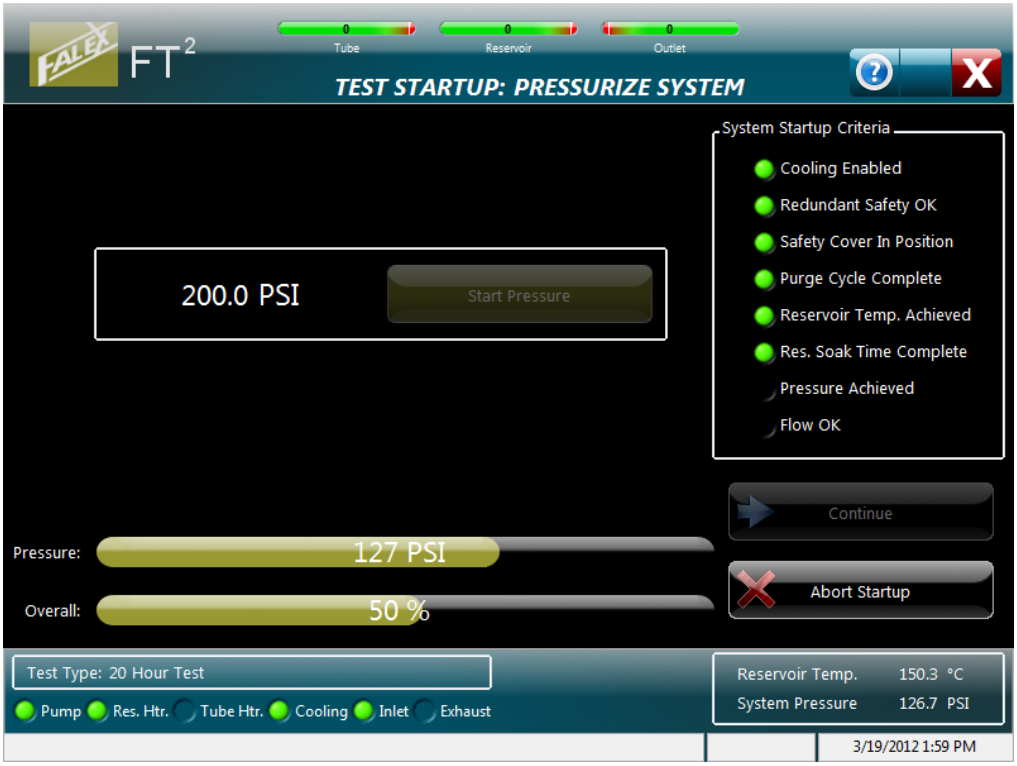


Figure 37 – Pressurize System display

This process is initiated by selecting the 'Start Pressure' button. The vent valve will close, the inlet valve will open and a pop-up display will appear reminding the operator to set the air tank regulator to the desired pressure (figure 38). Once the air tank valve is opened, the system will begin to pressurize. The pressure setpoint is shown and cannot be changed.

Note: Make sure that the manual inlet valve is opened and the manual vent valve is closed. These are located on the front of the machine, under the reservoir.

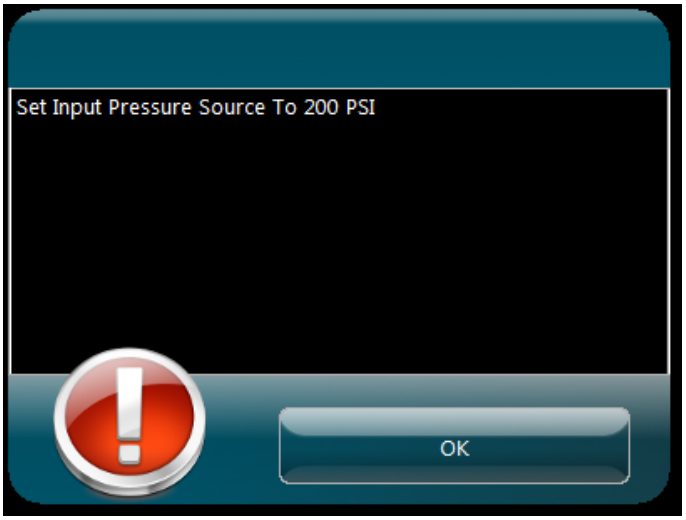


Figure 38 – Pressurization pop-up

When the sequence is complete, the following will occur:

- An audible ‘beep’ is sounded notifying the operator that pressure is within 3% of the setpoint and the sequence is complete
- In the ‘System Verification’ section of the display, the indicator next to the ‘Pressure Achieved’ will turn green
- The ‘Continue’ button will become enabled

Two (2) progress bars are displayed to keep the operator informed on the startup process status. They are:

- Pressure value as system Is pressurizing (entire progress bar represents system pressure setpoint)
- Overall startup process progress

Oil drops will become inconsistent until newly introduced air is displaced from tubing lines.

Selecting the ‘Abort Startup’ button will abort the startup process and stop any devices that may be running.

The ‘Continue’ button is not enabled until the condition has been satisfied. Once enabled, selecting the ‘Continue’ button will advance the startup process to the next step, verifying the fluid flow rate.

4.4.2.5 Flow Rate

The next display in the startup process is the Flow Rate display (figure 39). The purpose of this process is to verify that the fluid flow rate is running at 1 ml/min (standard test only). The fluid flow rate can be adjusted here, if necessary.

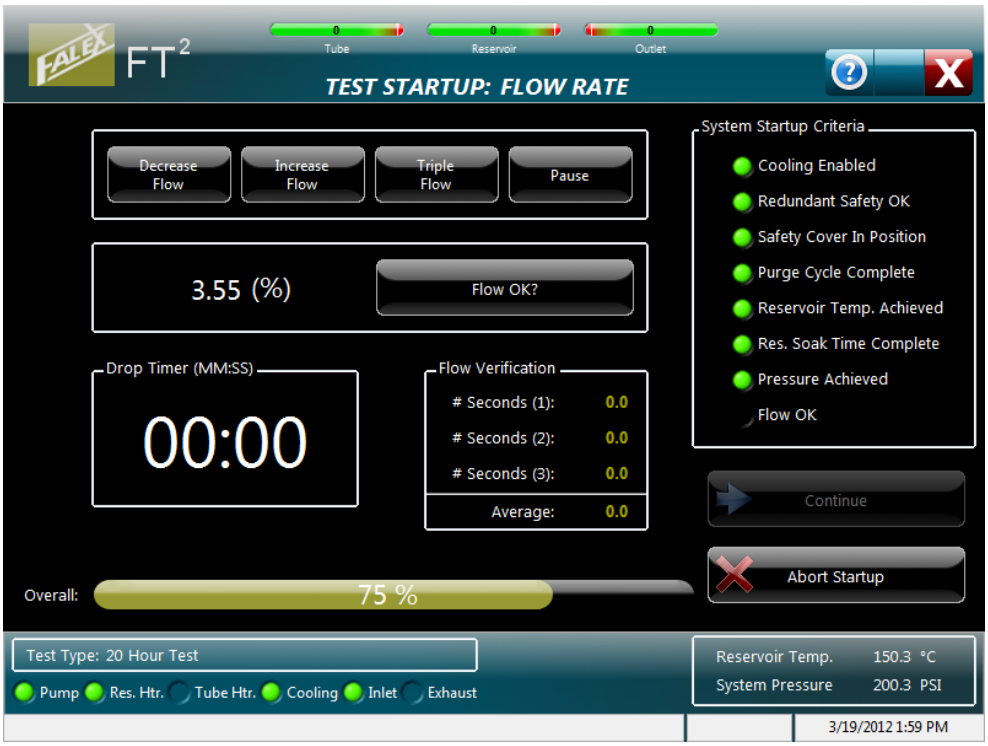


Figure 39 – Flow Rate display

Before starting this process, make sure consistent fluid flow is visible through the sight glass. Should it take several minutes to achieve a consistent fluid flow rate, selecting the 'Triple Flow' button will increase the flow rate 3 times the default flow to shorten the time it takes to obtain a consistent fluid flow. When selected, the following will occur:

- Pump speed increased to 3 times the default flow
- Button text changes to say 'Standard Flow'
- Button color changes to gold
- Other buttons become disabled

Once a consistent fluid flow exists, pressing the 'Standard Flow' button will set the pump speed back to its default speed which is consistent with 1 ml/min. When selected, the following will occur:

- Pump speed set back to default
- Button text changes to say 'Triple Flow'
- Button color changes to black
- Other buttons become enabled

Should a condition exist that can be easily corrected (i.e. fluid leak), pressing the 'Pause' button will pause the startup sequence so that the leak can be corrected without having to restart the entire startup sequence. The pump will stop and system pressure will be released, but the reservoir will remain heating. When selected, the following will occur:

- Pop-up display confirmation will appear
- Pressure will be released (upon selecting 'OK' on pop-up)
- Button text changes to say 'Resume'
- Button color changes to gold

Note: Make sure pressure has been completely vented prior to trying to correct the leak.

Once the condition has been corrected, selecting the 'Resume' button will continue the startup process. The startup process will transfer back to the Pressurize System display (refer to section 4.4.2.4) to re-pressurize the system. Continue the startup process from there to satisfy the remaining startup conditions.

Once a consistent fluid flow exists, the flow rate is to be verified by counting the drops. If the flow is running at the triple flow rate, it must be set back to its default rate (select 'Standard Flow' button – button color will change to black) before continuing. For a standard test, a flow rate of 1ml/min is required and is consistent with 20 drops (starting with count 0) in 30 seconds (± 2 seconds). Should the drop count be outside of the acceptable time, the pump speed can be adjusted accordingly (pump speed is shown as a percentage) by selecting the 'Decrease Flow' or 'Increase Flow' buttons. Once the pump speed has been changed, wait one (1) minute to allow for the flow to equalize before counting the drops. Three (3) successful drop count timings for the particular pump speed are required.

Note: If a custom flow rate is entered, it is not known what the equivalent drip count should be. Select 'Flow OK' button to skip the flow verification process and complete the startup process.

There are two (2) methods of timing the drops: using the drop count switch that is plugged into the front of the machine or using a portable timer. If using the drop count switch, pressing the button will initiate the timer. A short 'audible' beep will notify the operator that the button push was accepted. Pressing it a second time will stop the timer. Again, a short 'audible' beep will notify the operator that the button push was accepted. Pressing in the 'Drop Timer' area on the display will allow the value to be automatically entered into the display. A pop-up will appear asking the operator if the time is to be accepted (figure 38). If 'Accept' is selected, the time will be entered on the display. If 'Reject' is selected, the time will be discarded. If using a portable timer, the time to achieve 20 drops (starting with count 0) is to be manually entered on the display. Pressing in the 'Flow Verification' area on the display will pop-up a

keypad, where the value can be manually entered. A pop-up will appear asking the operator if the entered time is to be accepted (figure 40). If 'Accept' is selected, the time will be entered on the display. If 'Reject' is selected, the time will be discarded. Using either method, after three (3) timings are entered, the average will be determined. The average drop count time will be included within the test data file and on the generated report.

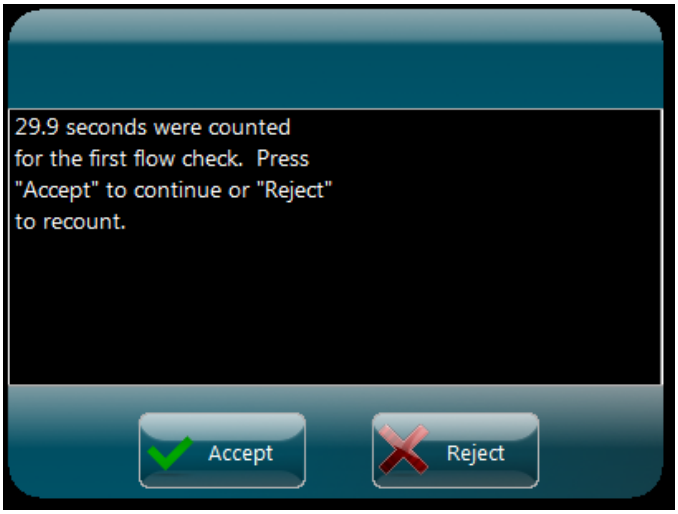


Figure 40 – Time Acceptance Verification

The sequence is complete when the 'Flow OK ?' button is selected. Once selected, the following will occur:

- In the 'System Verification' section of the display, the indicator next to the 'Flow OK' will turn green
- The 'Continue' button will become enabled

Note: The ability to adjust the pump flow exists during the temperature ramp and during the 30 minute heat soak equalization period. Refer to section 4.4.2.6 for further details.

Selecting the 'Abort Startup' button will abort the startup process and stop any devices that may be running.

The 'Continue' button is not enabled until the condition has been satisfied. Once the condition has been satisfied (it should be the last startup condition to be satisfied), a 'Startup Completed Successfully' pop-up display will appear (figure 41).

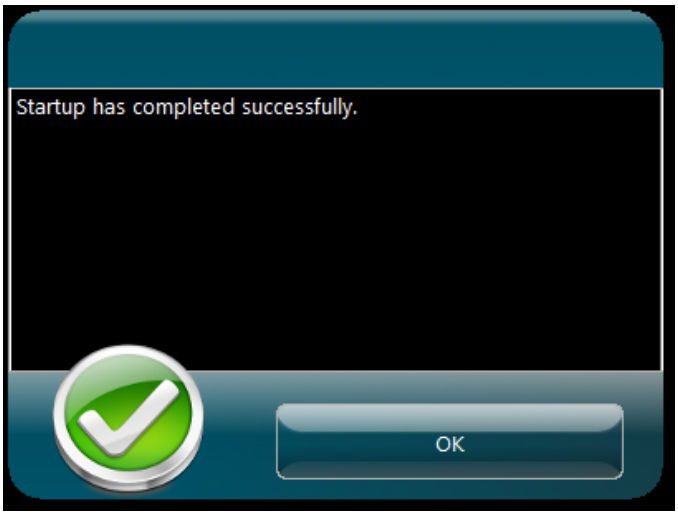


Figure 41 – Startup Completed Successfully pop-up

Selecting the 'OK' button will cause a 'Continue' display to appear (figure 42).

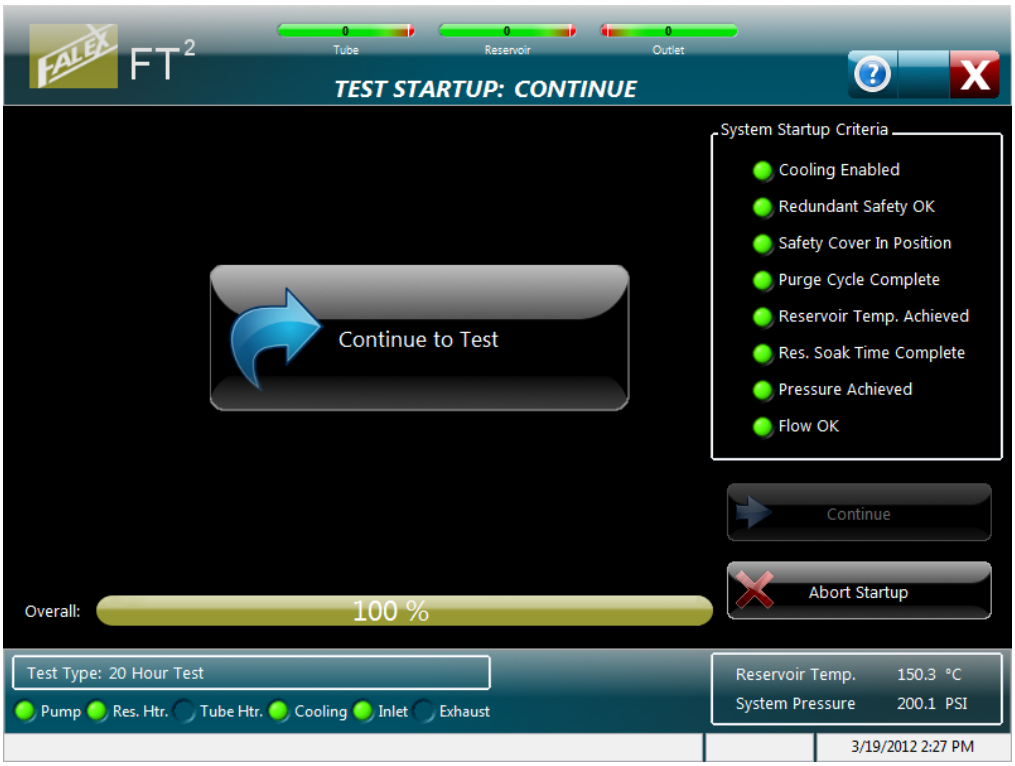


Figure 42 – Continue to Test display

Selecting the 'Continue to Test' button will advance the operator to the Run Test display, where the test can be started.

4.4.2.6 Run Test

The Run Test display is the display that will be active for the duration of the timed test (figure 43) and has the following functionality:

- Test can be started by selecting the 'Start' button
- Pump flow can be adjusted (only during temperature ramp and heat soak equalization periods)
- Test data can be viewed both graphically and numerically
- Trend pens can be enabled/disabled
- Trend can be manipulated using trend tools
- Test can be aborted by selecting the 'Abort' button
- Access other displays associated with test

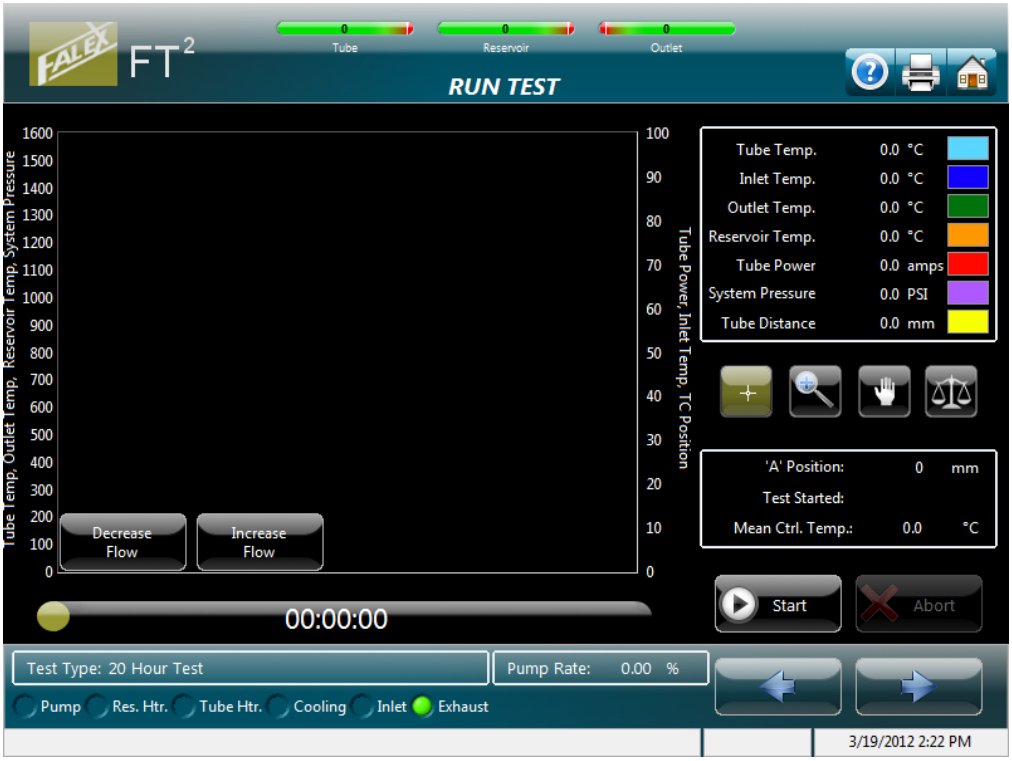


Figure 43 – Run Test display

Because the fluid viscosity will change as the heater tube heats up, the flow rate may no longer be equivalent to the 1 ml/min rate initially set during the startup sequence. Therefore, increase/decrease buttons can be utilized to adjust the flow rate to the required 1 ml/min flow rate (20 drops in 30 seconds) during the heating sequence. Selecting the increase/decrease button will change the pump flow rate percentage by 0.01%. These buttons are only available during the 10 minute temperature ramp and the 30 minute heat soak equalization period.

Trend pens can be enabled/disabled by selecting the color box next to the particular parameter.

The graph window represents approximately 30 minutes of data.

The following trend tools are available to manipulate the graph:

Selecting this button is the 'No tool selected' button. This is the default trend tool. When this tool is selected, selecting anywhere on the graph will not do anything.

Selecting this button will open up a collection of 'zoom' tools to allow one to zoom in on the trend.

This is the 'Grab' tool. It allows the operator to grab the trend and move it around.

Selecting this button will return the trend to its original appearance.

The progress bar displays elapsed test duration time and represents the total test duration.

The following additional information is also displayed:

- Current hot spot position ('A' position)
- Time/date stamp when test was started
- Mean control temperature (temperature the test is running at during main portion of test)

Note: Mean control temperature is the average of the three (3) A+40 temperatures from profile 1.

Navigation buttons at the bottom of the display allow access to other displays while the test is active. The available displays are:

- Test information
- Instrument Status

- Graph View Selector
- Alarm Log

4.4.2.7 Test Information

The Test Information display shows the current test information associated for the running test (figure 44). This information is for reference only (nothing can be changed). Alarm limits can also be viewed from this display. Selecting the 'View Alarm Limits' button will show the alarm/abort limits for the particular test (figure 45). Whatever has been selected to be displayed (test information, alarm limits) will be retained.

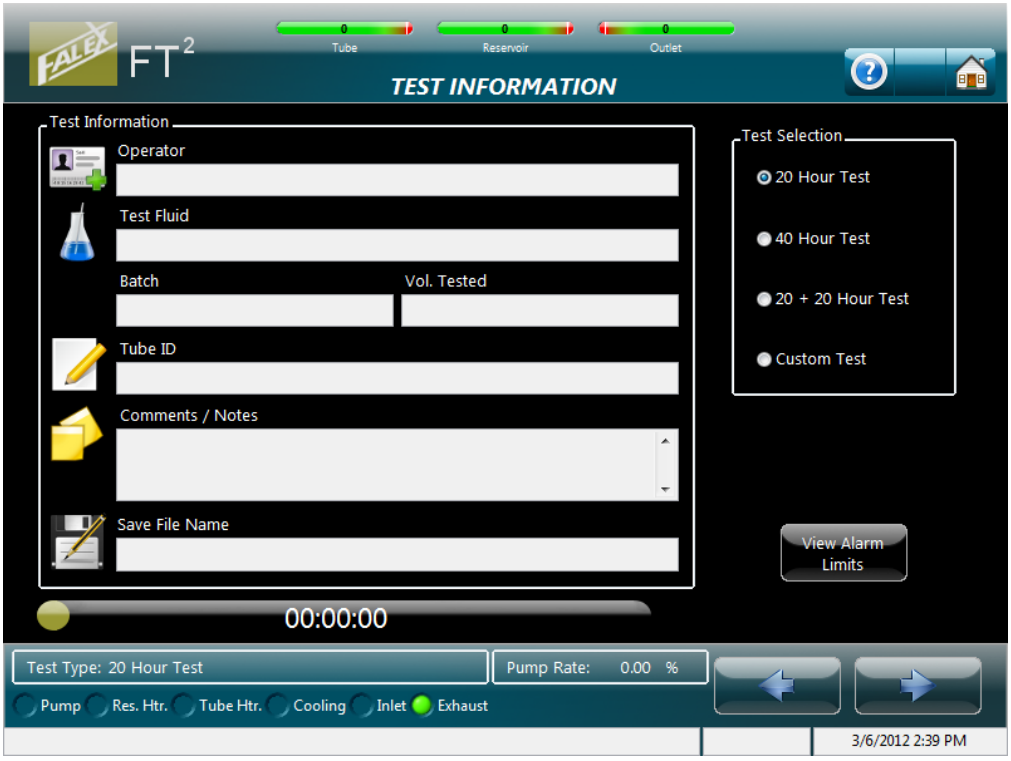


Figure 44 – Test Information display

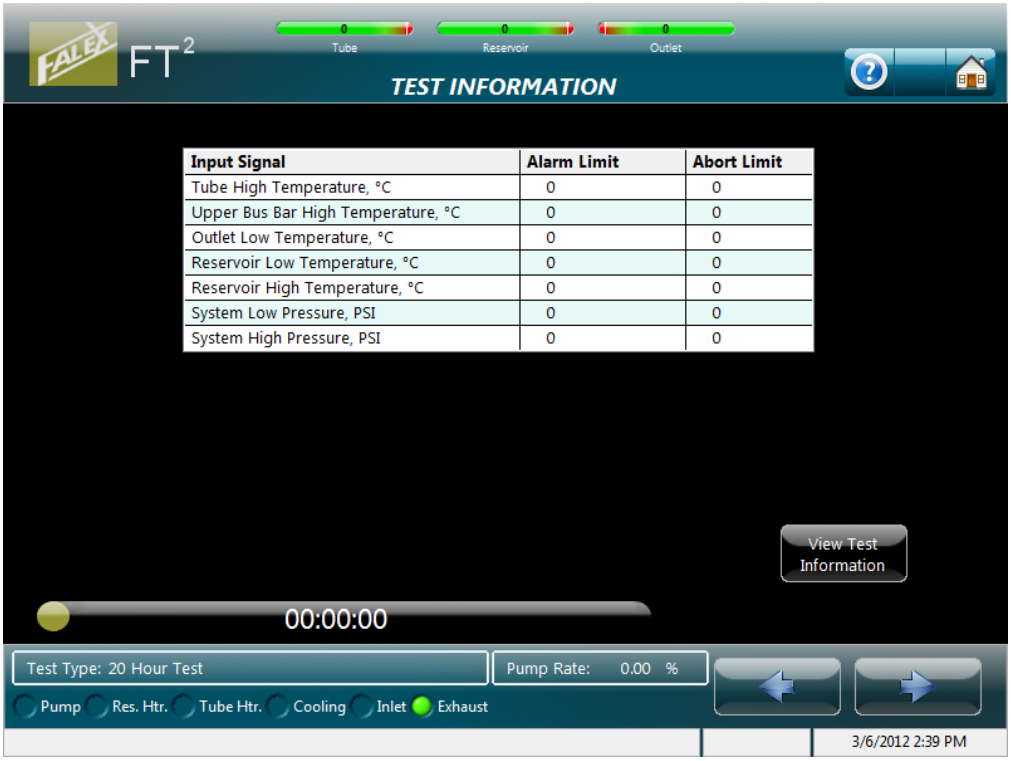


Figure 45 – Alarm/Abort Limits

Note: Alarm/abort limits for heater tube temperature, reservoir temperature and system pressure are determined from their respective setpoints selected for the particular test.

The test information and custom test parameters can be toggled between by selecting their respective button (View Test Information or View Custom Parameters).

The test information and alarm/abort parameters can be toggled between by selecting their respective button (View Test Information or View Alarm Limits).

The progress bar displays elapsed test duration time and represents the total test duration.

Use the navigation buttons to view additional displays or return to the Run Test display.

4.4.2.8 Instrument Status

The Instrument Status display is an overview of current key values and their location on the machine (figure 46).

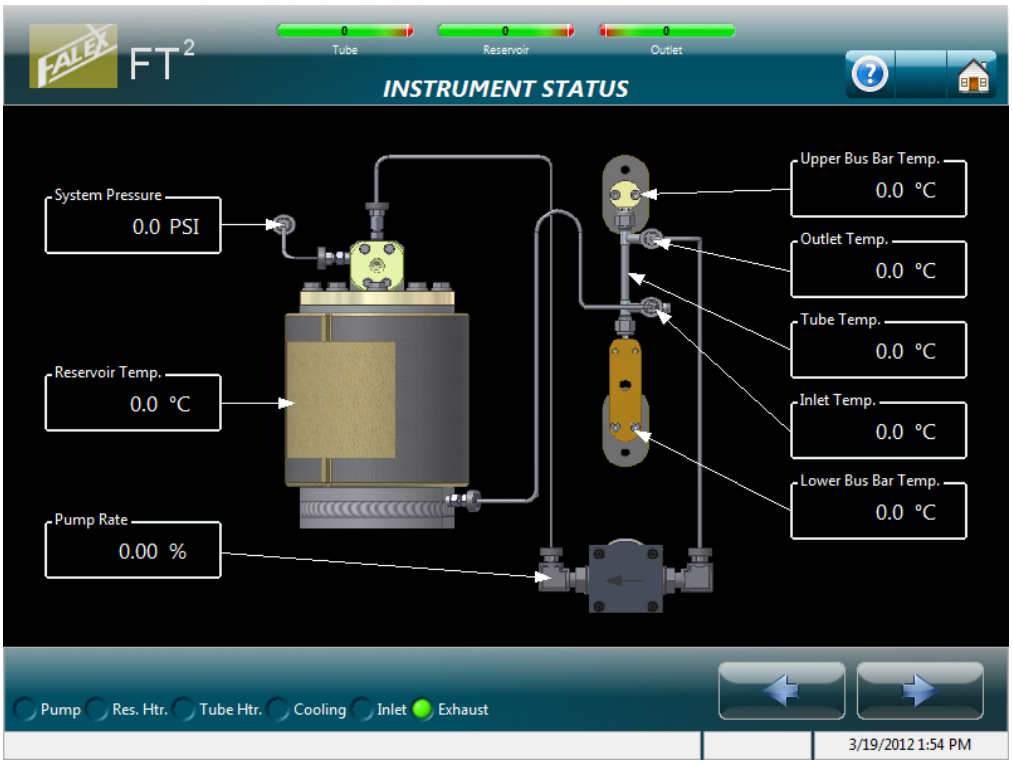


Figure 46 – Instrument Status display

The progress bar displays elapsed test duration time and represents the total test duration.

Use the navigation buttons to view additional displays or return to the Run Test display.

4.4.2.9 Graph View Selector

The Graph View Selector display allows reference to the various profile graphs, if they exist (figure 47).

Figure 47 – Graph View Selector display

Graphs that can be selected are:

- Show Hot Spot Profile
- Show Test Profile 1
- Show Test Profile 2
- Show Test Profile 3
- Overlay Graphs

Select enabled button to view the graph type. The 'Overlay Graphs' button will overlay only the available test profile graphs (hot spot profile is not included). This function allows one to observe the temperature differences due to deposits on the heater tube.

When the 'Show Hot Spot Profile' is selected, an additional zoom tool button (figure 48) is shown. Selecting this icon (button will turn gold) will zoom in on the portion of the graph where the temperature curve and the hot spot location intersect. Deselecting this button (button will turn black) will return the graph to its original configuration.

Figure 48 – Hot Spot Profile zoom button

The progress bar displays elapsed test duration time and represents the total test duration.

Use the navigation buttons to view additional displays or return to the Run Test display.

4.4.2.10 System Alarm Log

The System Alarm Log display shows the last fifty (50) alarms/aborts that have occurred (figure 49). They are shown with the most recent alarm/abort at the top and the oldest at the bottom. A date and time stamp of when the alarm/abort happened and a short description are shown. Refer to Addendum A to see all available alarm/abort conditions and their associated messages.

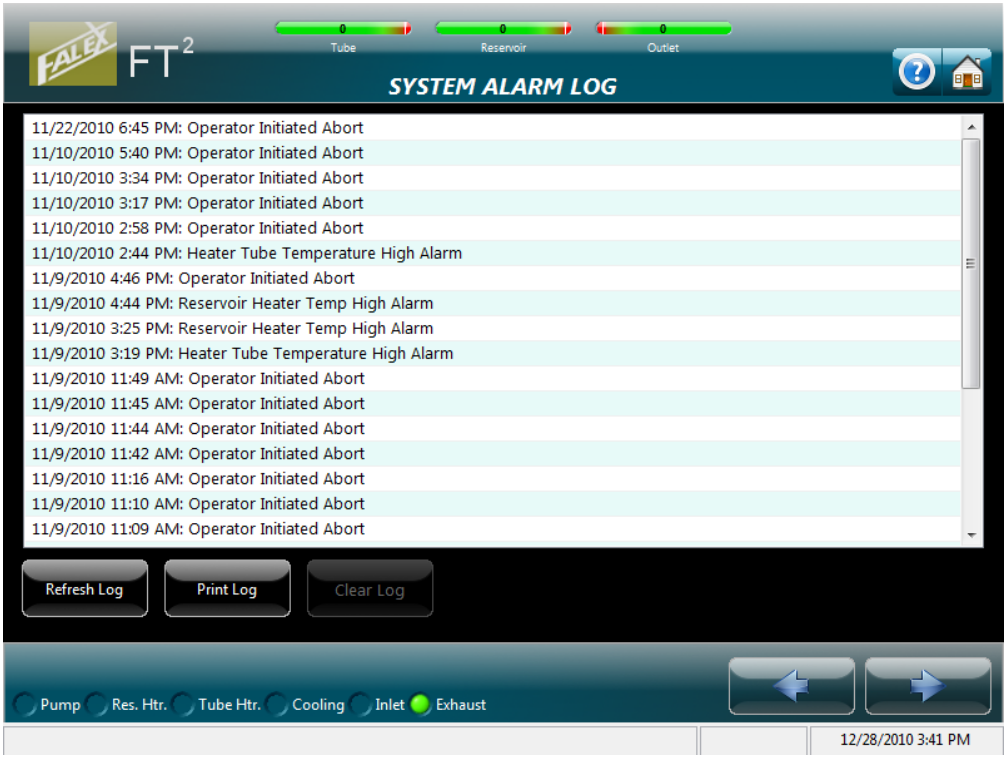


Figure 49 – System Alarm Log display

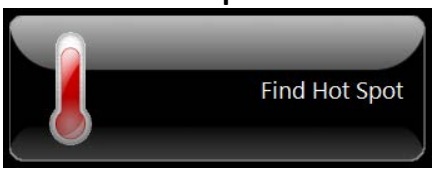
When more alarms/aborts exist than are shown on the display, selecting the slider bar on the right of the display and sliding it down will show the older alarms/aborts.

Note: Only the last fifty (50) alarms are viewable.

The progress bar displays elapsed test duration time and represents the total test duration.

Use the navigation buttons to view additional displays or return to the Run Test display.

4.4.3 Find Hot Spot



Note: Hot spot test fluid requirements are detailed in section 6.

The 'Hot Spot' is the location within the heater tube where the hottest temperature is found. It is the key factor utilized in capturing the test profiles, as it is the base value from where all of the thermocouple moves start from. The hot spot is typically referred to as the 'A' position.

The 'Find Hot Spot' selection initiates the process of configuring, initializing and starting a hot spot test. Refer to section 6 for test fluid requirements for accurately determining the hot spot. Just like running a timed test, there are many steps that must be completed before the actual hot spot test is started. Once the test configuration parameters have been entered, a 'startup' process is initiated. This 'startup' process initializes the machine and its various devices to required pretest conditions. When the various 'startup' conditions have been met, the actual test can then be started. The 'startup' process takes approximately 1.25 hours (for a standard test) to complete before the 'start' button can be pressed.

The 'startup' process consists of a series of displays that require the operator to initiate specific functionality so that required pretest conditions can be achieved.

Note: The test cannot start unless all conditions are met.

The following conditions must be met before a hot spot test can be initiated (figure 50):

Figure 50 – Hot Spot test startup conditions that must be met

The condition is satisfied when the indicator next to the condition is green.

Not all the conditions have a separate process associated with them requiring operator/user interface interaction. 'Cooling Enabled' and 'Redundant Safety OK' conditions are achieved internally, once the 'Continue to Test' button has been selected from the Test Configuration display (a test type must be selected). The cooling system will automatically turn on (ball should be floating within coolant flow meter) and the safety controller is checked to see if it functioning properly. The 'Safety Cover in Position' condition will be satisfied once the safety cover has been correctly placed over the heater tube holder assembly and has been detected (photo eye is located to the right of the pump, above the safety cover collar. The safety cover can be placed at any time during the startup process.

An audible 'beep' will sound when the time consuming startup conditions have been met (purge, reservoir heating, reservoir heat soak, pressurization). This is to alert the operator that the step has been completed and allows the operator to perform other duties while the particular startup sequence completes.

Once the 'startup' process has been completed, the hot spot test display will appear where test variables can be monitored. Navigation buttons exist that allow the operator to access additional displays while a test is active.

All of the displays associated with the 'Find Hot Spot Test' button are discussed in the sub sections below.

4.4.3.1 Test Configuration

When the 'Find Hot Spot' button is selected from the Main Menu, the 'Test Configuration' display appears (figure 51). This display allows the operator to enter test information for the test and also select the type of hot spot test that is to be initiated. It is not mandatory that test information be entered. However, it is recommended that this information be entered to help in distinguishing test parameters and associated data for future reference. This information is stored in the data file.

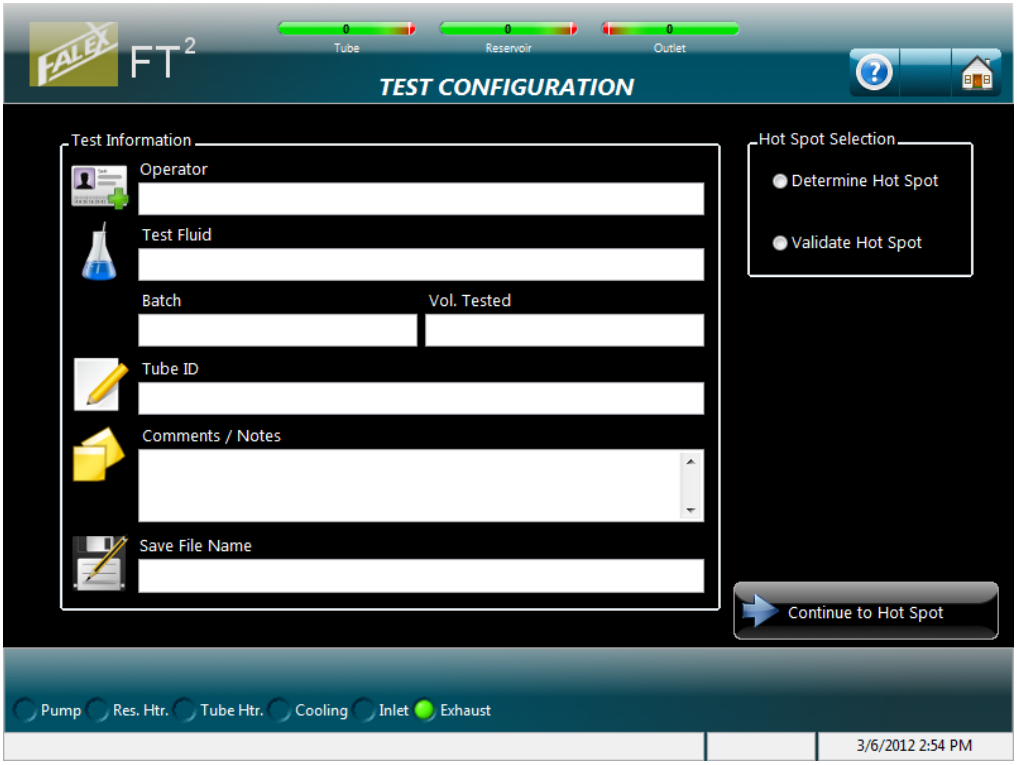


Figure 51 – Test Configuration display

Test information that can be entered is:

- Operator Name
- Test Fluid
- Fluid Batch ID
- Volume Tested
- Heater Tube ID
- Test Comments
- Data File Name

Entered information is stored in the Name, Test Fluid and Tube ID fields for quick retrieval for future tests. Previous Tube ID numbers can be called up and quickly modified using the back space key and replacing the required numbers. Select the white field to call up the available names already entered and select the desired name. If the name is not entered, select 'Add…' and enter the required name via the alpha-numeric keyboard. Always hit the 'Enter' key on the keyboard to enter the data into the proper field.

Information entered in the data file name field (if anything) will be contained in the data file name structure. Data file names are defaulted with the current date & time stamp along with a test type designation.

The data file name structure is as follows:

YYYYMMDD_TTTT_X_Z.csv, where
Y = year
M = month

D = day
T = time (24 hour clock format)
X = operator entered information
Z = test type designation. The various test type designations are:

HSDData	*(hot spot determination data file)*
HSDProfile	*(hot spot determination temperature profile)*
HSVData	*(hot spot validation data file)*
HSVProfile	*(hot spot validation temperature profile)*

Example of a Hot Spot Determination test data file without operator entered information:

20101228_1413__HSDData.csv

Example of a Hot Spot Determination test data file with operator entered information:

20101228_1413_Tuesday_HSDData.csv

The type of hot spot test that is to be run is to be selected. Hot Spot test types that can be selected are:

- Hot Spot Determination
- Hot Spot Validation

(Individual test details are discussed further down in this section).

The operator cannot advance to the next display unless a hot spot test type is selected. Should the 'Continue to Test' button be selected without a hot spot test type being selected, a notification pop-up display will appear alerting the operator (figure 52).

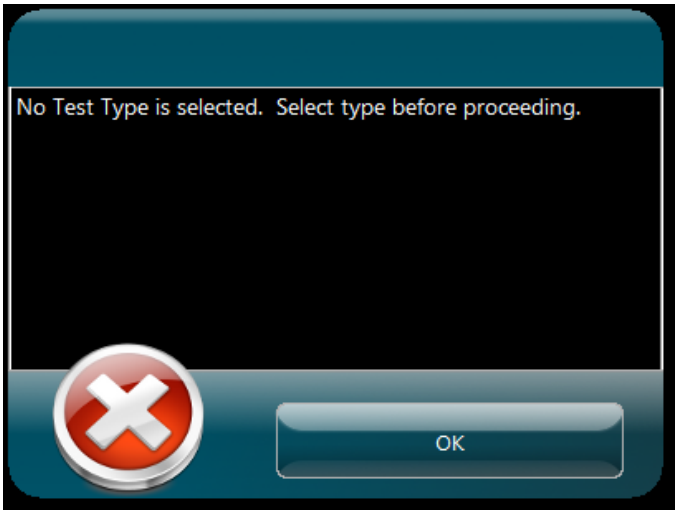


Figure 52 – Test selection notification

Hot Spot Determination

This test determines where the hottest position (A) in the heater tube is located. The test starts using the 10mm position as its base position to determine the hot spot temperature profile. It is from the determined hot spot that all timed test profiles are derived. This is a standard SAE ARP5996 test. Test parameters cannot be modified. It requires the startup procedure to be completed before the test is started. The test parameters are:

- Test duration (55 minutes)
- Heater tube temperature (375°C)
- Reservoir temperature (150°C)
- System pressure (200 psi / 1380 kPa)
- Pump speed (1ml/min or 20 drops in 30 seconds)
- One (1) temperature profile created
- Heater tube thermocouple positions used to determine hot spot: A-4, A, A+4, A+10, A+14, A+20, A+30, A+40, A+50

Refer to Addendum B to review timing associated with this test type.

Note: A hot spot determination should be done any time the heater tube thermocouple has been replaced, the heater tube holder has been replaced or whenever a heater tube of a different material is used. There will be a different hot spot for each material type.

Once the temperature profile has been completed, the temperature profile will be displayed showing what the determined hot spot is. The range for a valid hot spot is 10 – 18mm. Should the determined hot spot be > 18mm, the hot spot determination test is to be run again.

Note: Running a timed test with a hot spot > 18mm could damage the actuator.

Once the test is complete, the heater tube temperature is cooled, the system pressure is released, the pump is stopped and reservoir heating is stopped. The heater tube temperature thermocouple will go to the home position when the outlet temperature is <40°C. Once the heater tube thermocouple is in the home position, a hot spot complete pop-up display will appear notifying the operator that the test is complete. The machine can now be broken down for cleaning.

Hot Spot Validation

This test validates where the hottest position (A) in the heater tube was found. The hot spot position was previously found running a hot spot determination test. The test starts using the current hot spot position as its base position to determine the hot spot temperature

profile. This is a standard SAE ARP5996 test. Test parameters cannot be modified. It requires the startup procedure to be completed before the test is started. The test parameters are:

- Test duration (55 minutes)
- Heater tube temperature (375°C)
- Reservoir temperature (150°C)
- System pressure (200 psi / 1380 kPa)
- Pump speed (1ml/min or 20 drops in 30 seconds)
- One (1) temperature profile created
- Heater tube thermocouple positions used to determine hot spot: A-4, A, A+4, A+10, A+14, A+20, A+30, A+40, A+50

Refer to Addendum B to review timing associated with this test type.

Note: A hot spot validation should be done after a hot spot determination has been completed or any time when the hot spot location is suspect.

When the test is complete, it will compare the hot spot found during the hot spot validation test with the hot spot found during the hot spot determination test. If the hot spot found during the validation is within 2mm of the hot spot found during the determination, a hot spot 'validated' pop-up display will appear notifying the operator of validation (figure 53). Otherwise, a hot spot 'not validated' pop-up display will appear (figure 54). If the hot spot is not validated, it is recommended that the hot spot determination test and hot spot validation test be run again.

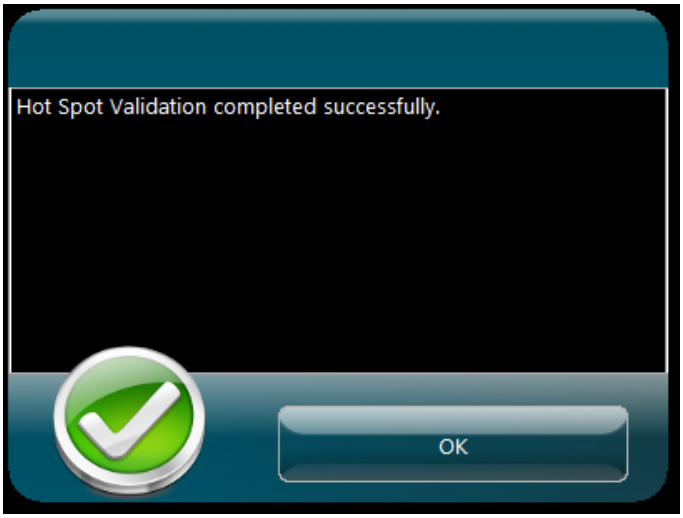


Figure 53 – Hot spot validated pop-up display

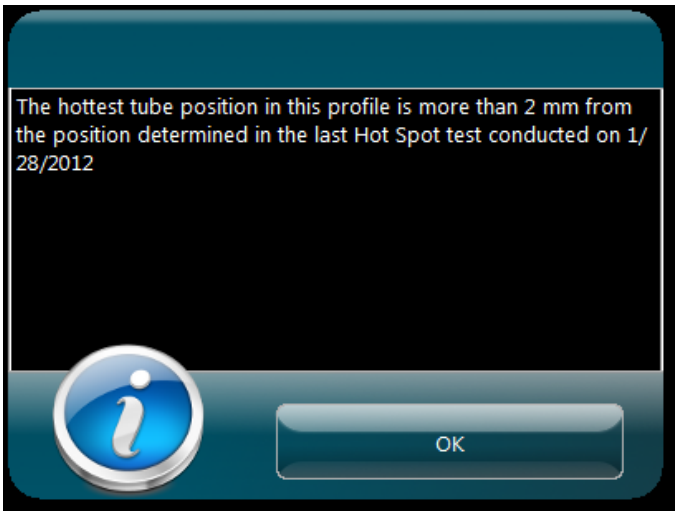


Figure 54 – Hot spot not validated pop-up display

Once the test is complete, the heater tube temperature is cooled, the system pressure is released, the pump is stopped and reservoir heating is stopped. The heater tube temperature thermocouple will go to the home position when the outlet temperature is <40°C. Once the heater tube thermocouple is in the home position, a hot spot complete pop-up display will appear notifying the operator that the test is complete. The machine can now be broken down for cleaning.

4.4.3.2 Purge System

Same display and associated functionality that is utilized for a timed test (20 hour, 40 hour, 20+20 hour, custom test). Refer to section 4.4.2.2 for full details.

4.4.3.3 Heat Reservoir

Same display and associated functionality that is utilized for a timed test (20 hour, 40 hour, 20+20 hour, custom test). Refer to section 4.4.2.3 for full details.

4.4.3.4 Pressurize System

Same display and associated functionality that is utilized for a timed test (20 hour, 40 hour, 20+20 hour, custom test). Refer to section 4.4.2.4 for full details.

4.4.3.5 Flow Rate

Except as noted, same display and associated functionality that is utilized for a timed test (20 hour, 40 hour, 20+20 hour, custom test). Refer to section 4.4.2.5 for full details.

Flow Rate display differences from what is described in the timed test flow rate section:

- Once the 'Startup Completed Successfully' pop-up display appears, selecting the 'OK' button will cause a 'Continue to Hot Spot' display to appear (figure 55).

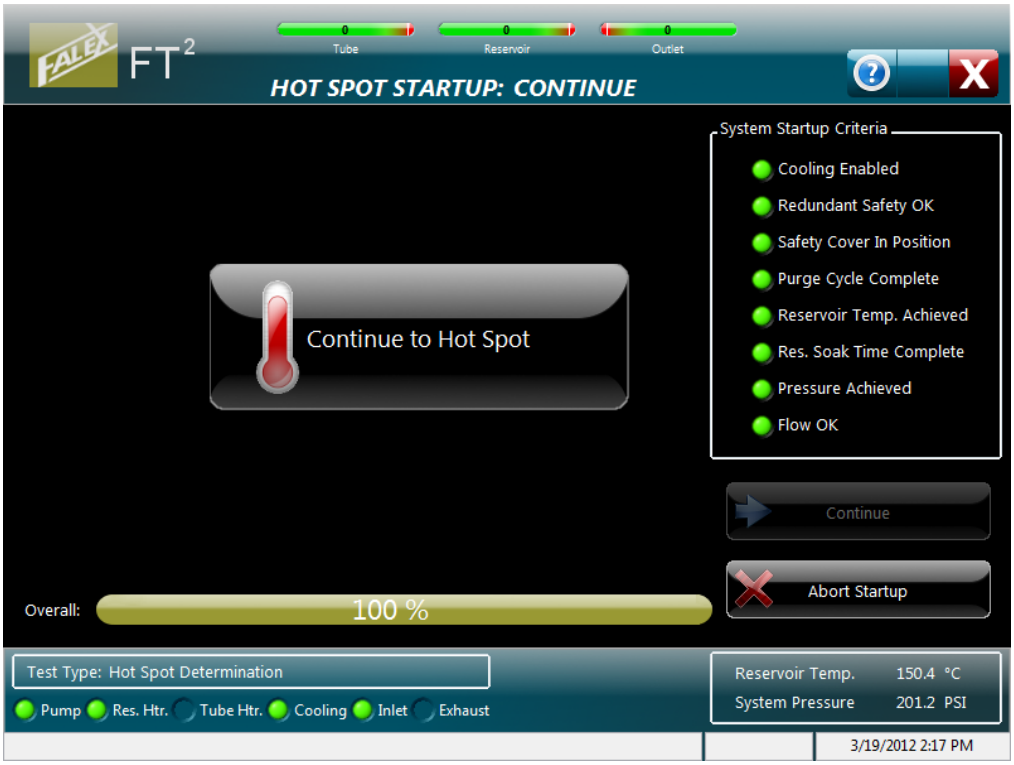


Figure 55 – Continue to Hot Spot display

- Selecting the 'Continue to Hot Spot' button will advance the operator to the Hot Spot Test display, where the test can be started.

4.4.3.6 Hot Spot Test

The Hot Spot Test display is the display that will be active for the duration of the hot spot test (figure 56) and has the following functionality:

- Test can be started by selecting the 'Start' button

- Pump flow can be adjusted (only during temperature ramp and heat soak equalization periods)
- Test data can be viewed both graphically and numerically
- Trend pens can be enabled/disabled
- Trend can be manipulated using trend tools
- Test can be aborted by selecting the 'Abort' button
- Access other displays associated with test

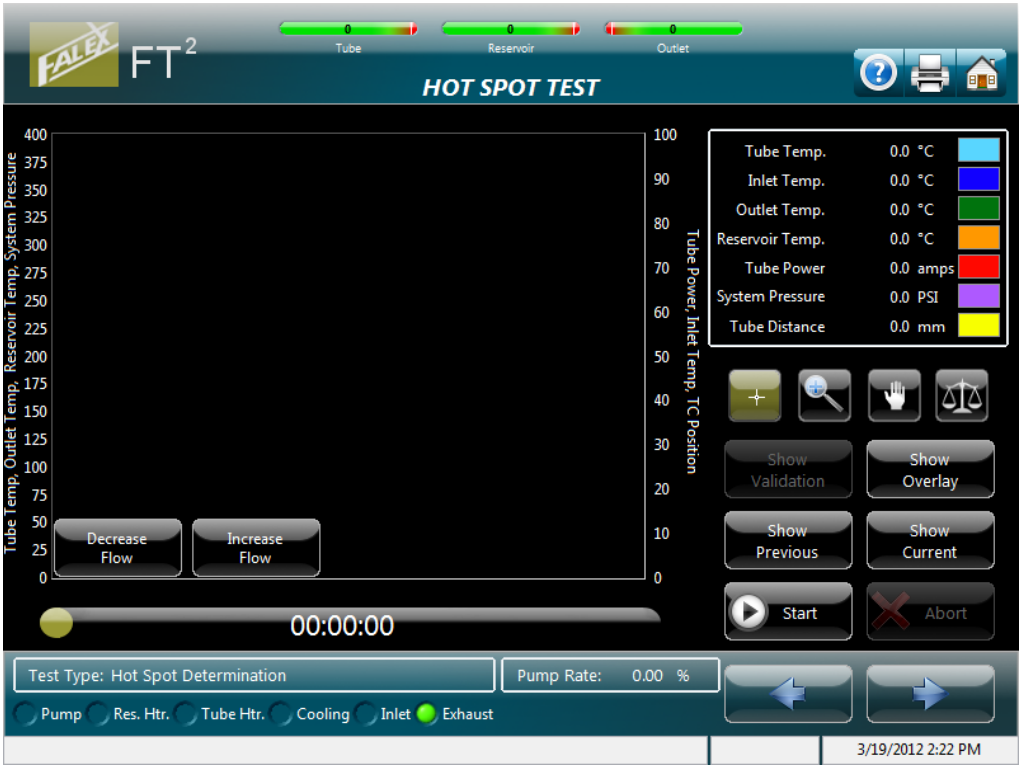


Figure 56 – Hot Spot Test display

Because the fluid viscosity will change as the heater tube heats up, the flow rate may no longer be equivalent to the 1 ml/min rate initially set during the startup sequence. Therefore, increase/decrease buttons can be utilized to adjust the flow rate to the required 1 ml/min flow rate (20 drops in 30 seconds) during the heating sequence. Selecting the increase/decrease button will change the pump flow rate percentage by 0.01%. These buttons are only available during the 10 minute temperature ramp and the 30 minute heat soak equalization period.

Trend pens can be enabled/disabled by selecting the color box next to the particular parameter.

The graph window represents approximately 30 minutes of data.

The following trend tools are available to manipulate the graph:

Selecting this button is the ‘No tool selected’ button. This is the default trend tool. When this tool is selected, selecting anywhere on the graph will not do anything.

Selecting this button will open up a collection of ‘zoom’ tools to allow one to zoom in on the trend.

This is the ‘Grab’ tool. It allows the operator to grab the trend and move it around.

Selecting this button will return the trend to its original appearance.

Selecting the ‘Show Validation’ button will show the current hot spot validation profile graph. This button is only enabled at the completion of a hot spot validation test.

Selecting the ‘Show Overlay’ button will show the current hot spot determination profile graph overlaid with the previous hot spot determination profile graph.

Selecting the ‘Show Previous’ or ‘Show Current’ button will show the respective hot spot determination profile graph.

The progress bar displays elapsed hot spot test duration time and represents the total hot spot test duration.

Navigation buttons at the bottom of the display allow access to other displays while the test is active. The available displays are:

- Test information
- Instrument Status
- Alarm Log
- Test Data

4.4.3.7 Test Information

The Test Information display shows the current test information associated for the running hot spot test (figure 57). This information is for reference only (nothing can be changed).

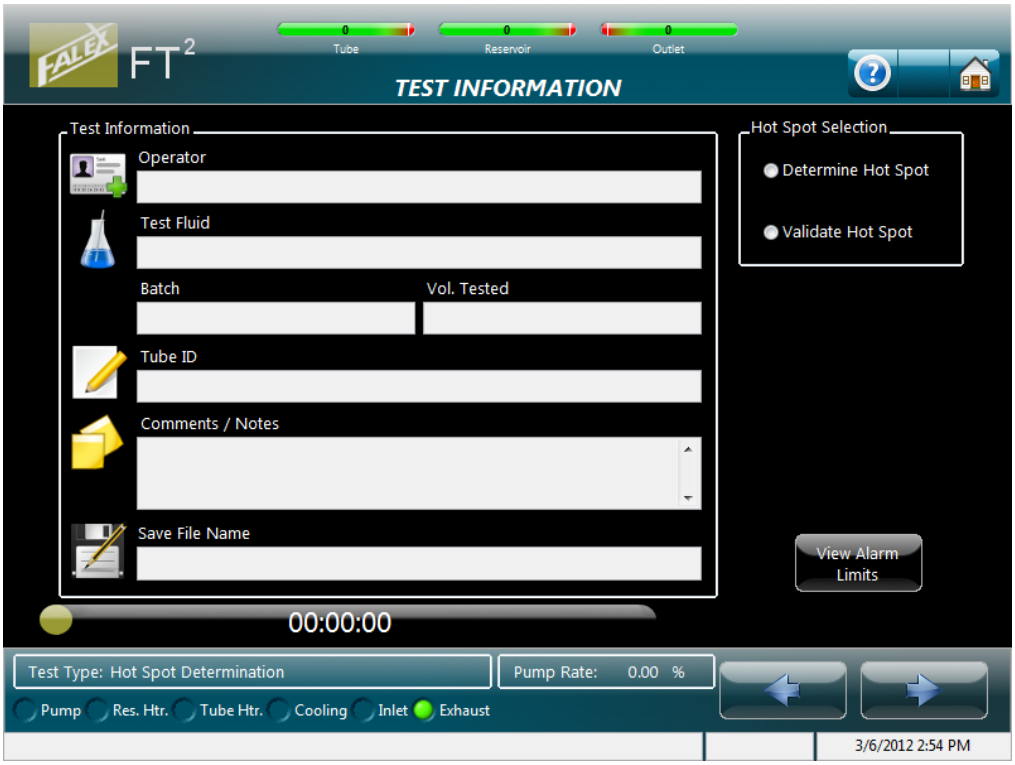


Figure 57 – Hot Spot test Information display

The progress bar displays elapsed hot spot test duration time and represents the total hot spot test duration.
Use the navigation buttons to view additional displays or return to the Run Test display.

4.4.3.8 Instrument Status

Same display and associated functionality that is utilized for a timed test (20 hour, 40 hour, 20+20 hour, custom test). Refer to section 4.4.2.8 for full details.

4.4.3.9 Alarm Log

Same display and associated functionality that is utilized for a timed test (20 hour, 40 hour, 20+20 hour, custom test). Refer to section 4.4.2.10 for full details.

4.4.3.10 Test Data

The Test Data display shows the current test data profile in tabular form associated with the most current hot spot test (figure 58). The type of hot spot test is displayed within the data (hot spot determination data profile or hot spot validation data profile).

Figure 58 – Hot Spot test data display

The progress bar displays elapsed hot spot test duration time and represents the total hot spot test duration.

Use the navigation buttons to view additional displays or return to the Run Test display.

4.4.4 Redundant Safety

The ‘Redundant Safety’ selection shows parameters associated with the safety controller and allows abort limits to be changed (figure 59).

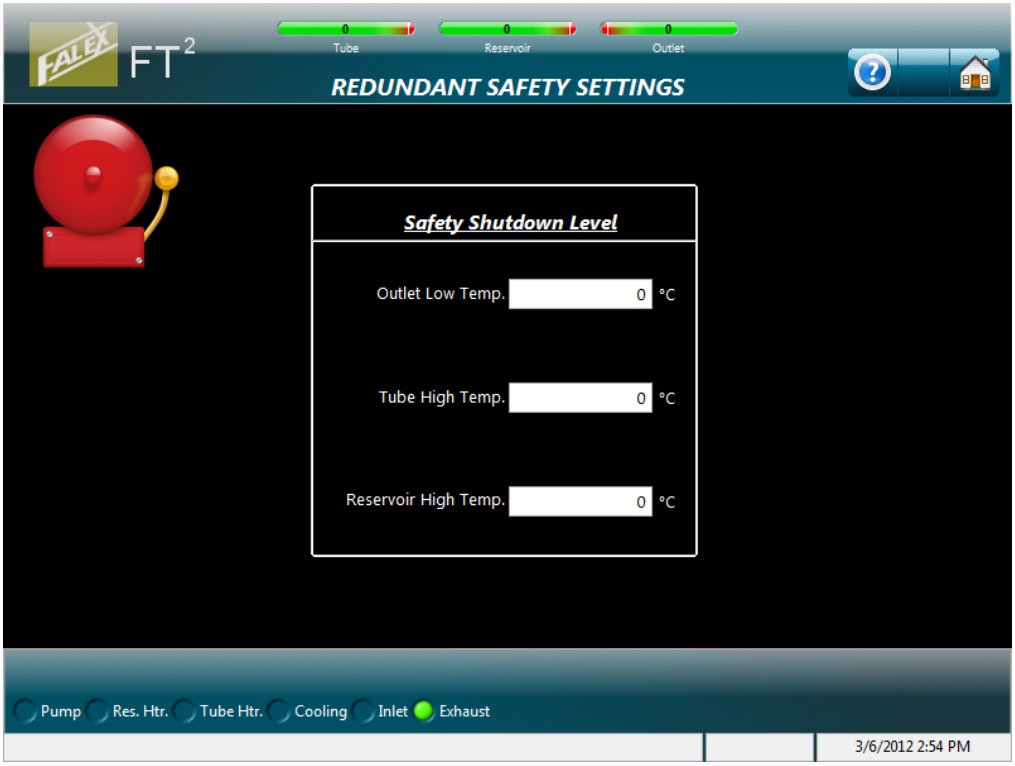


Figure 59 – Redundant Safety display

The safety controller is used as a safety backup. It will abort the test and stop all devices at certain temperature limits to protect the machine should the main controller fail.

There are three (3) temperature values that are monitored by the safety controller. They are:

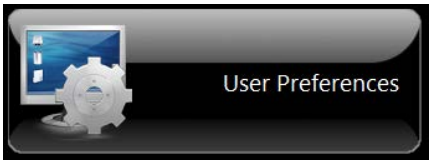
- Outlet temperature (low temperature conditions)
- Heater tube temperature (high temperature conditions)
- Reservoir temperature (high temperature conditions).

Each temperature has a hardcoded abort limit and an adjustable abort limit associated with them. The hardcoded limit is just that, a limit that cannot be changed and is the final limit that the particular temperature cannot exceed. The adjustable limit shown on the display is an operator selectable limit that can be set inside the hardcoded limit (if so desired). Initially, the adjustable limits are set to their default limits, which are equal to the hardcoded limits. Once the adjustable limits are changed, the values are retained. The operator adjustable limits can be changed by selecting the white box for the particular temperature to be changed.

Note: The adjustable limit cannot be set outside of the hardcoded limit. If the entered value exceeds the hardcoded limit, the value will default to the hardcoded limit.

Refer to Addendum A to review all alarm/abort conditions associated with the safety controller.

4.4.5 User Preferences



The ‘User Preferences’ selection allows the operator to change various items to better meet their specific requirements (figure 60).

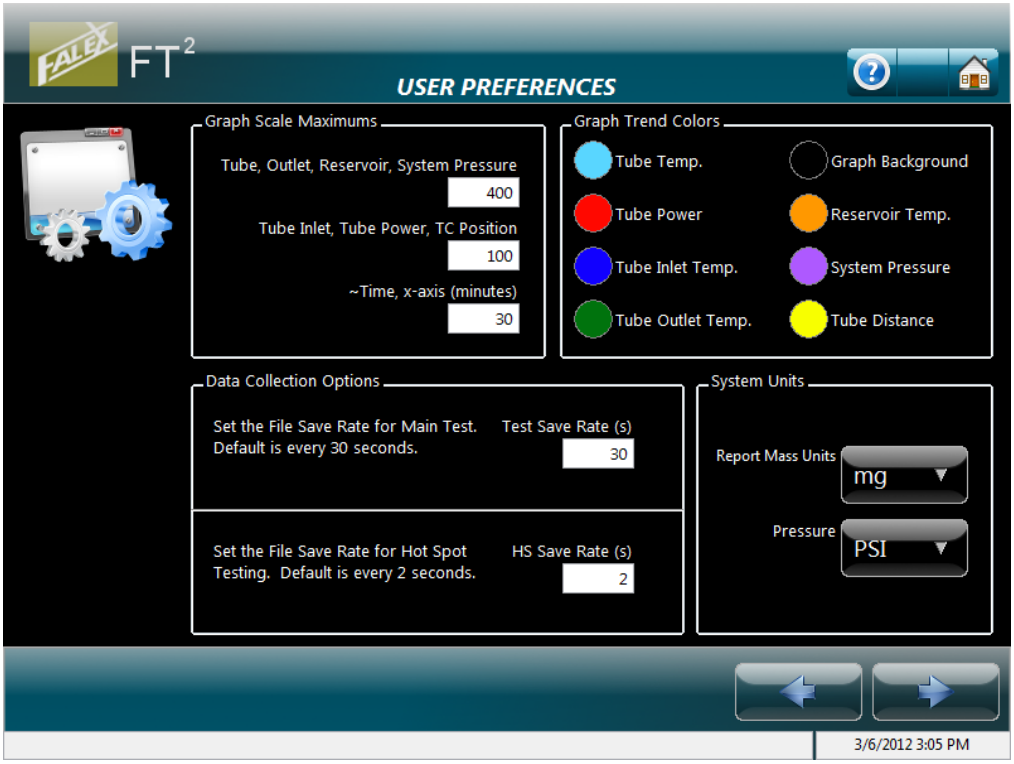


Figure 60 – User Preferences display

In the ‘Graph Scales Maximums’ section, graph scales can be changed from their default values. A graph scale is representative of multiple parameters on the graph. The new values will be retained. These graph scales are located on the Run Test, Hot Spot Test and Maintenance Graph displays. They can be changed by selecting the white box for the particular scale to be changed.

Trend pen colors for a particular parameter can be changed in the ‘Graph Trend Colors’ Section of the display. Selecting the color circle next the particular parameter will call up a color pallet, where a new color can be selected. The new value will be saved by selecting ‘OK’ on the confirmation pop-up display that appears upon exiting the ‘User Preferences’ display. The new color will be retained.

In the ‘Data Collection Options’ section, the data file save rate can be changed for each type of test. The data save rate range for a timed test is 30

– 120 seconds (default 30 seconds). The data save rate range for a hot spot test is 2 – 10 seconds (default 2 seconds). They can be changed by selecting the white box for the particular save rate to be changed. The new value will be saved by selecting 'OK' on the confirmation pop-up display that appears upon exiting the 'User Preferences' display. The change will be retained. Data is always saved for a 'timed' test and for a 'hot spot' test.

In the 'System Units' section, the units for the heater tube weight (mass) and system pressure can be changed. For mass, the available selections are 'mg' or 'g'. The default is 'mg'. For pressure, the available selections are 'PSI' or 'kPa'. The default is 'PSI'. To change the units, select the box of the units that are to be changed and select the desired units. The changes will be saved by selecting 'OK' on the confirmation pop-up display that appears upon exiting the 'User Preferences' display. The change will be retained.

Navigation buttons at the bottom of the display allow access to other displays. The available displays are:

- User Tables
- Printer Setup
- Network Setup
- Change Password

Note: Due to the amount of data that must be accessed when the User Preferences button is selected, there will be a slight delay if immediately try to access other displays using the navigation buttons.

4.4.5.1 User Tables

When test information is entered for the particular test on the 'Test Configuration' display, frequently used information is stored in user tables so that it can be easily recalled. The operator, fluid type and tube ID are stored in user tables. The User Tables display allows items to be added or deleted from the particular user table (figure 61).

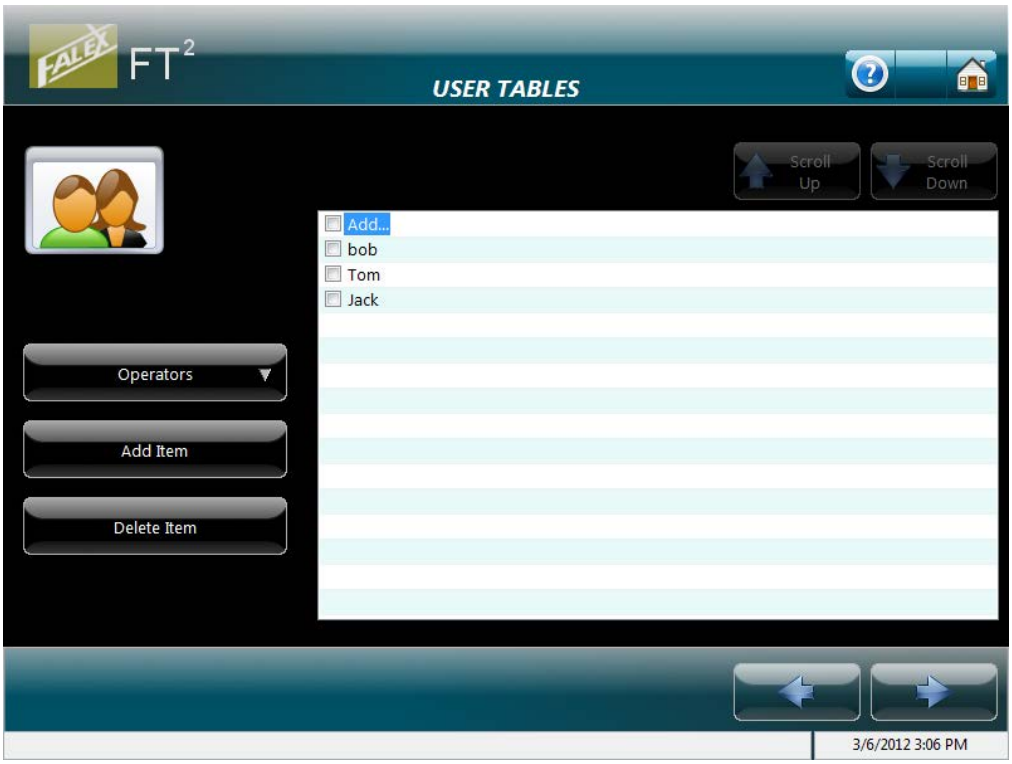


Figure 61 – User Tables display

Selecting the 'Operators ↓' button will allow the operator to select the particular user table to be modified (operators, test fluids, tube IDs). Once the particular user table is opened, the various stored entries are shown. Selecting the 'Add Item' button will pop-up the keyboard and allow a new item to be added to the particular user table. Selecting the particular item within the user table and then the 'Delete Item' button will delete the item from the particular user table. Once a deletion is made to the particular user table, the operator will be prompted if the changes are to be saved when exiting the User Tables display.

If a directory has more items that can be displayed, the 'Scroll Up' and 'Scroll Down' buttons will allow the additional items to be displayed.

Use the navigation buttons to view additional displays or return to the User Preferences display.

4.4.5.2 Printer Setup

The Printer Setup display shows any installed printers and allows a new printer to be configured (figure 62).

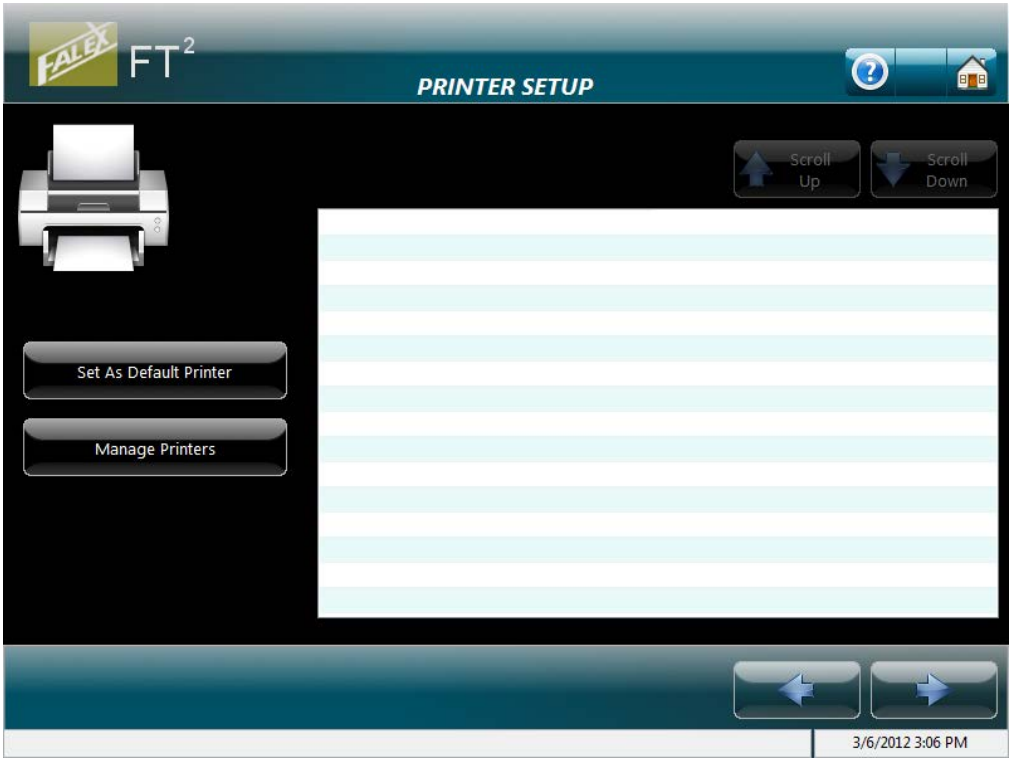


Figure 62 – Printer Setup display

Selecting the 'Manage Printers' button will open the Windows® Printers and Faxes window, where a printer can be added.

Selecting the 'Set As Default Printer' button will set the selected printer as the default printer.

Use the navigation buttons to view additional displays or return to the User Preferences display.

4.4.5.3 Network Setup

The Network Setup display allows the operator to configure the unit to connect to the local network (figure 63). It is recommended that an IT person be consulted prior to making configuration settings.

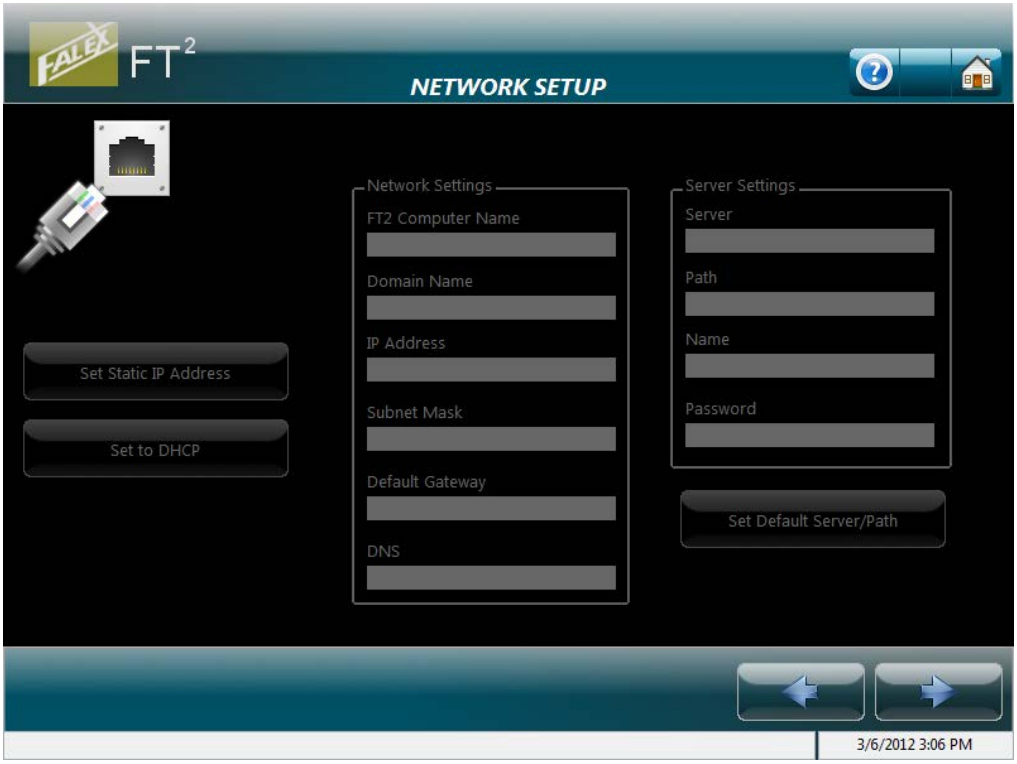


Figure 63 – Network Setup display

The external RJ-45 network connection port is located on the back of the unit, upper port (the lower RJ-45 port is for factory use only). This configuration requires a level 1 password. Select the Falex icon in the upper left hand corner, enter the level 1 password using the pop-up keyboard and select the 'Enter' key. Once the correct password has been entered, the various configuration fields will become enabled.

Selecting the 'Set Static IP Address' button will set the local area connection of the user interface to the configuration parameters entered in the 'Network Settings' area of the display.

Selecting the 'Set to DHCP' button will reset the local area connection of the user interface to dynamic properties.

Selecting the 'Set Default Server/Path' button will set the server path of the user interface to the configuration parameters entered in the 'Server Settings' area of the display. This is where selected data files are copied/moved to when using File Manager functionality (section 4.4.6).

Under the 'Network Settings' section of the display, enter the configuration settings by selecting the white box for the particular parameter to be modified.

Under the ‘Server Settings’ section of the display, enter the configuration settings by selecting the white box for the particular parameter to be modified.

Use the navigation buttons to view additional displays or return to the User Preferences display.

4.4.5.4 Change Password

The Change Password display allows the operator to change the level 1 password (figure 64). The machine is delivered with the default level 1 password of ‘123456’. Periodically, it should be changed for security purposes (the department supervisor is the intended facilitator of this functionality).

Note: Should the level 1 password be forgotten, it can be determined by contacting your local Falex representative.

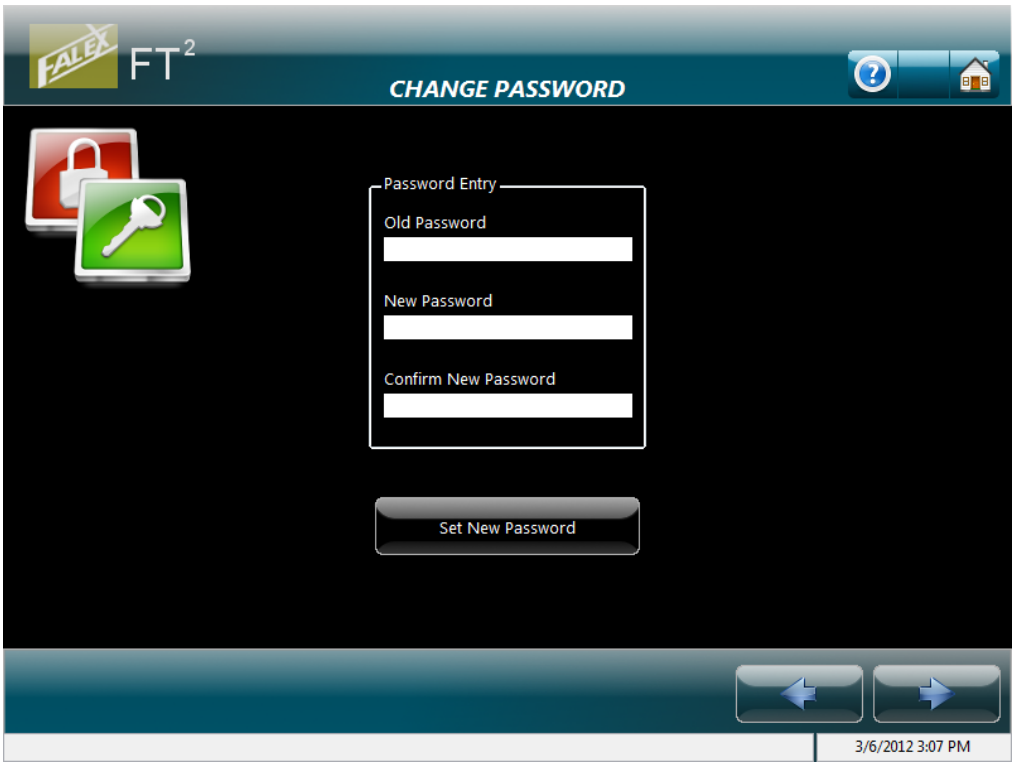


Figure 64 – Change Password display

In the ‘Password Entry’ section, the level 1 password can be changed. It can be changed by doing the following:

- Select the white box under ‘Old Password’ and enter the existing password that is to be changed.
- Select the white box under ‘New Password’ and enter the new password.

- Select the white box under ‘Confirm New Password’ and enter the new password again.
- Select the ‘Set New Password’ button to finalize the password change.

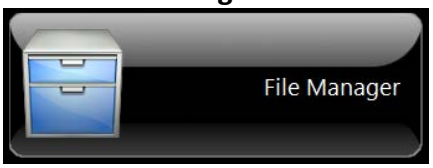
Pop-up displays will notify the operator should a parameter be entered incorrectly.

A pop-up display will confirm that the password was successfully changed.

Note: There are no restrictions on the length of the password or the format of the password.

Use the navigation buttons to view additional displays or return to the User Preferences display.

4.4.6 File Manager



The ‘File Manager’ selection allows the operator to copy various data files to an external device or delete them from the system (figure 65).

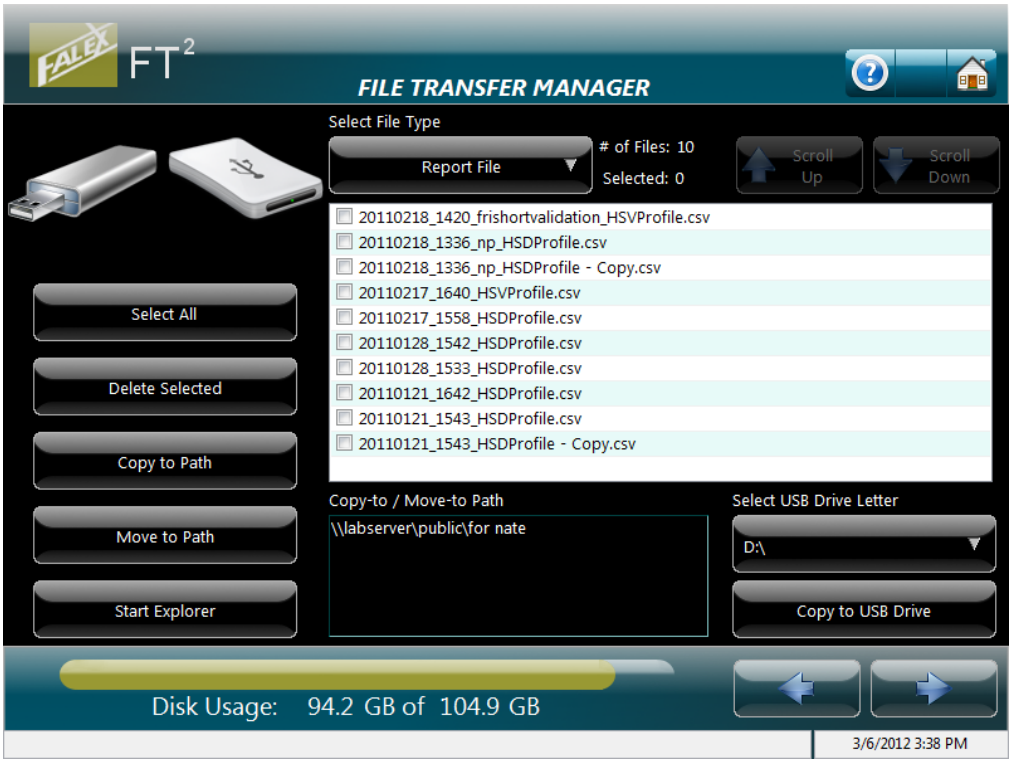


Figure 65 – File Transfer Manager display

There are five (5) types of data files that can be selected: Report file, Test Data file, Test Profile, Hot Spot Data file and Hot Spot Profile. Select the 'Report File ↓' button and select the type of file that is to be transferred or deleted. Within the file type directory, select the file(s) to transfer or delete. A check mark will indicate that the file has been selected. If a file has been selected by mistake, selecting it again will deselect it.

Once the desired file(s) have been selected, there are a number of options available. They are:

- 'Select All' button will automatically select all files contained within the specific file type directory
- 'Delete Selected' button will delete the selected file from the system freeing up disk space
- 'Copy to Path' button will copy the selected file(s) to the path designated in the 'Copy to / Move to Path' location, which was configured in Network Settings of the User Preferences display
- 'Move to Path' button will move the selected file(s) to the path designated in the 'Copy to / Move to Path' location which was configured in Network Settings of the User Preferences display
- 'Copy to USB Drive' button will copy the selected file(s) to the USB drive designated in the 'Select USB Drive Letter' button. The USB drive can be a flash drive, external hard drive or portable cd burner (if properly configured). A specific directory will be created on the external USB device for the particular file type and that is where the data file will be located (FT2 Reports, FT2 Test Data Files, FT2 Test Profiles, FT2 Hot Spot Data Files, FT2 Hot Spot Profiles).

Note: The correct USB drive letter must be selected before the copy button is selected for the copy function to be successful.

The 'Start Explorer' button will open up a Windows® Explorer window. A level 1 password is required. Upon selecting the 'Start Explorer' button, the pop-up keyboard will appear where the level 1 password can be entered. This is to allow the operator to get into Windows® (with supervisor permission), should it be required.

If a directory has more files that can be displayed, the 'Scroll Up' and 'Scroll Down' buttons will allow the additional files to be displayed.

A 'Disk Usage' bar is displayed at the bottom of the display showing how much of the hard disk space is used.

Navigation buttons at the bottom of the display allow access to another display. The available display is:

- Historical Reports

4.4.6.1 Historical Reports

The Historical Reports display allows the operator to print archived report files, view/print archived test profiles or view/print archived hot spot profiles (figure 66).

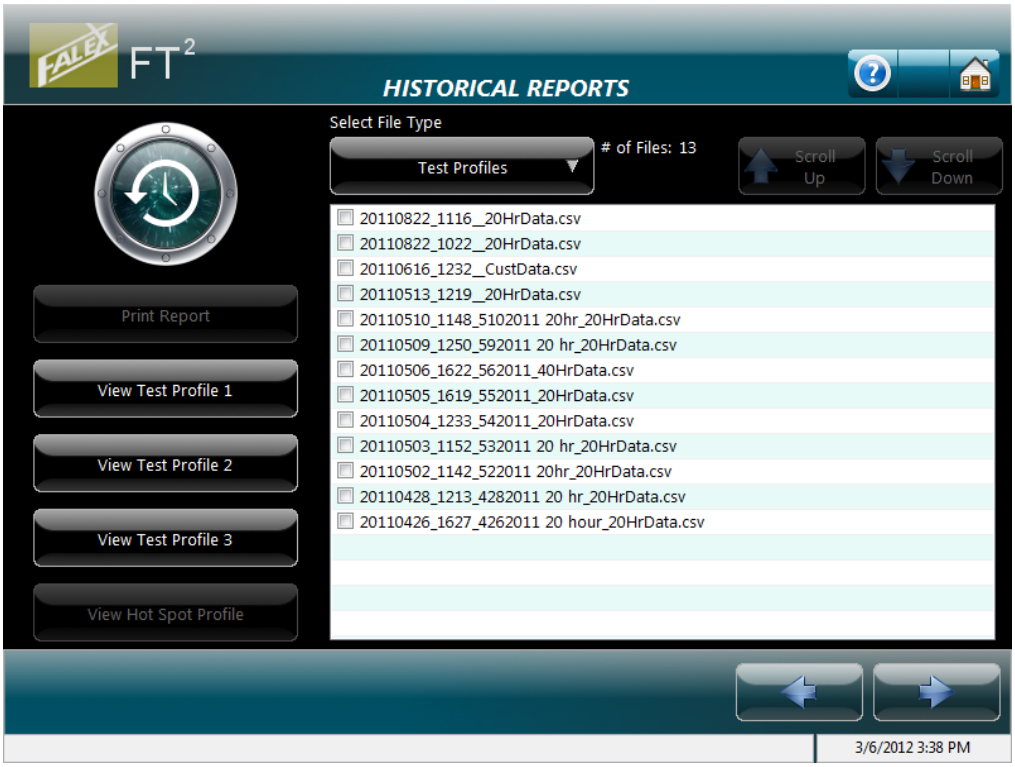


Figure 66 – Historical Reports display

To print an archived report, a printer must be connected and properly configured. Select the 'Report File ↓' button and verify 'Report File' is the file type that is checked. Within the file type directory, select the file to print. A check mark will indicate that the file has been selected. If a file has been selected by mistake, selecting it again will deselect it. Selecting the 'Print Report' button will initiate printing of the selected file.

To view/print an archived test profile, a printer must be connected and properly configured. Select the 'Report File ↓' button and select 'Test Profiles' as the file type. Within the file type directory, select the file to view/print. A check mark will indicate that the file has been selected. If a file has been selected by mistake, selecting it again will deselect it. Select the desired profile 'View' button. The selected profile graph will be displayed. Selecting the print icon from the header portion of the display will initiate printing of the selected file.

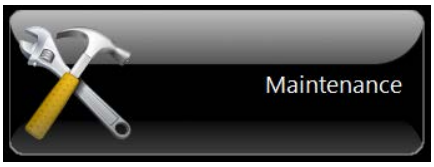
To view/print an archived hot spot test profile, a printer must be connected and properly configured. Select the 'Report File ↓' button

and select ‘Hot Spot Profiles’ as the file type. Within the file type directory, select the file to view/print. A check mark will indicate that the file has been selected. If a file has been selected by mistake, selecting it again will deselect it. Select the ‘View Hot Spot Profile’ button. The selected profile graph will be displayed. Selecting the print icon from the header portion of the display will initiate printing of the selected file.

If a directory has more files that can be displayed, the ‘Scroll Up’ and ‘Scroll Down’ buttons will allow the additional files to be displayed.

Use the navigation buttons to return to the File Manager display.

4.4.7 Maintenance



The ‘Maintenance’ selection allows the operator to view various displays, manually operate certain devices and execute functionality that is not routinely done. The initial display that is shown is the Maintenance Graph display (figure 67).

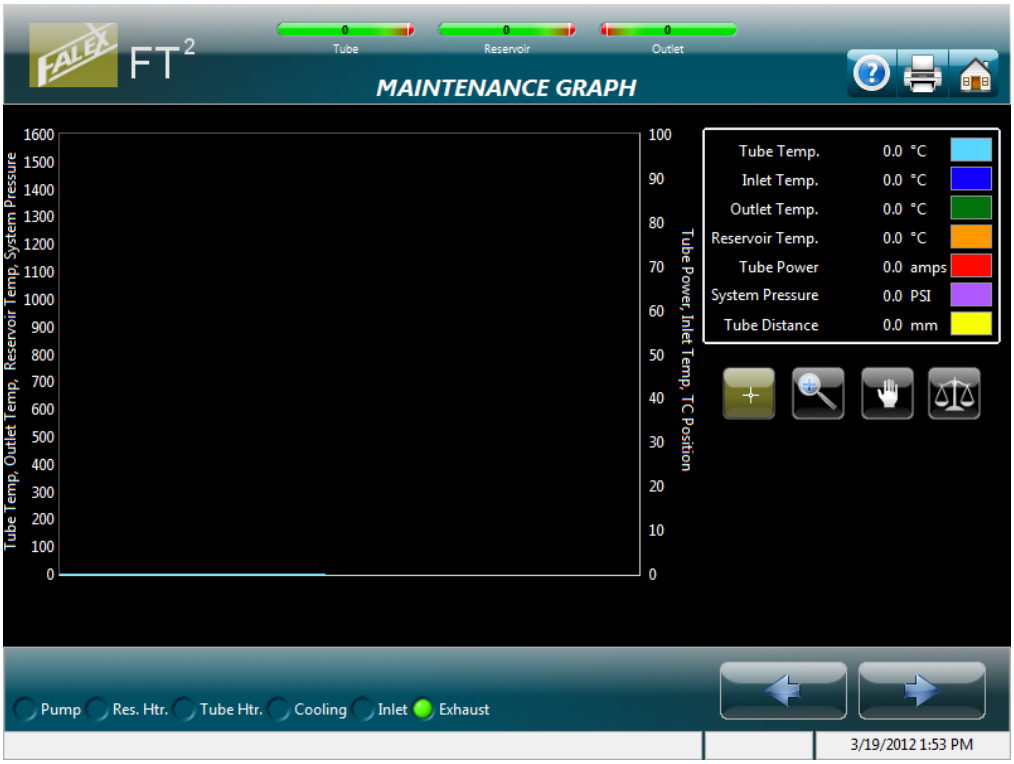


Figure 67 – Maintenance Graph display

The Maintenance Graph display can be used for troubleshooting purposes and has the following functionality:

- Current data can be viewed both graphically and numerically
- Trend pens can be enabled/disabled
- Trend can be manipulated using trend tools
- Access miscellaneous displays

Trend pens can be enabled/disabled by selecting the color box next to the particular parameter.

The graph window represents approximately 30 minutes of data.

The following trend tools are available to manipulate the graph:

Selecting this button is the 'No tool selected' button. This is the default trend tool. When this tool is selected, selecting anywhere on the graph will not do anything.

Selecting this button will open up a collection of 'zoom' tools to allow one to zoom in on the trend.

This is the 'Grab' tool. It allows the operator to grab the trend and move it around.

Selecting this button will return the trend to its original appearance.

Note: Because manual control of the heater tube thermocouple actuator is available within the Maintenance set of displays, the actuator will always be returned to its home position when the operator exits out of the Maintenance set of displays.

Navigation buttons at the bottom of the display allow access to other displays. The available displays are:

- Instrument Status
- System Alarm Log
- System Info

- Time Settings
- System Calibration
- Manual Controls

4.4.7.1 Instrument Status

Same display and associated functionality that is utilized for a timed test (20 hour, 40 hour, 20+20 hour, custom test). Refer to section 4.4.2.8 for full details.

4.4.7.2 System Alarm Log

The System Alarm Log display shows the last fifty (50) alarms/aborts that have occurred (figure 68). They are shown with the most recent alarm/abort at the top and the oldest at the bottom. A date and time stamp of when the alarm/abort happened and a short description are shown. Refer to Addendum A to see all available alarm/abort conditions and associated messages.

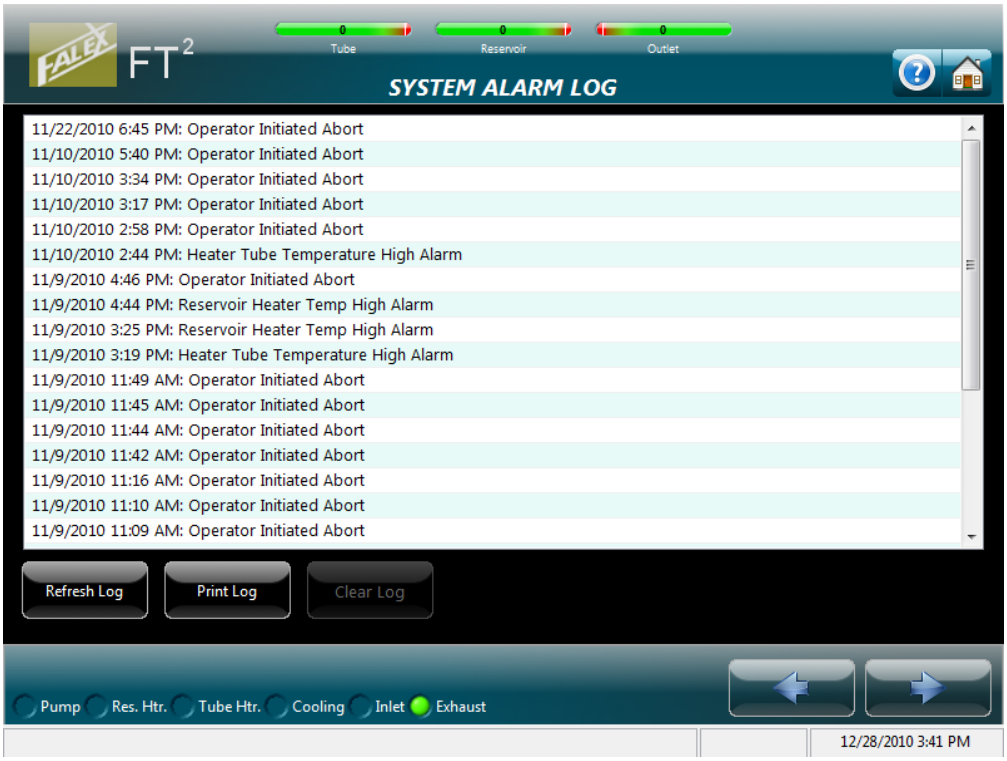


Figure 68 – System Alarm Log display

When more alarms/aborts exist than are shown on the display, selecting the slider bar on the right of the display and sliding it down will show the older alarms/aborts.

Note: Only the last fifty (50) alarms are viewable.

When the alarm log is called up, it will automatically refresh with current alarm/abort information prior to being displayed.

The log can be printed if a printer is configured, connected and the 'Print Log' button is selected.

The 'Clear Log' button requires a level 2 password to become enabled (this is a factory function). Selecting this button will permanently clear all alarms/aborts from the log.

Use the navigation buttons to view additional displays or return to the Maintenance Graph display.

4.4.7.3 System Info

The System Info display shows current test statistics for the unit since last reset and various information regarding the particular unit (figure 69).

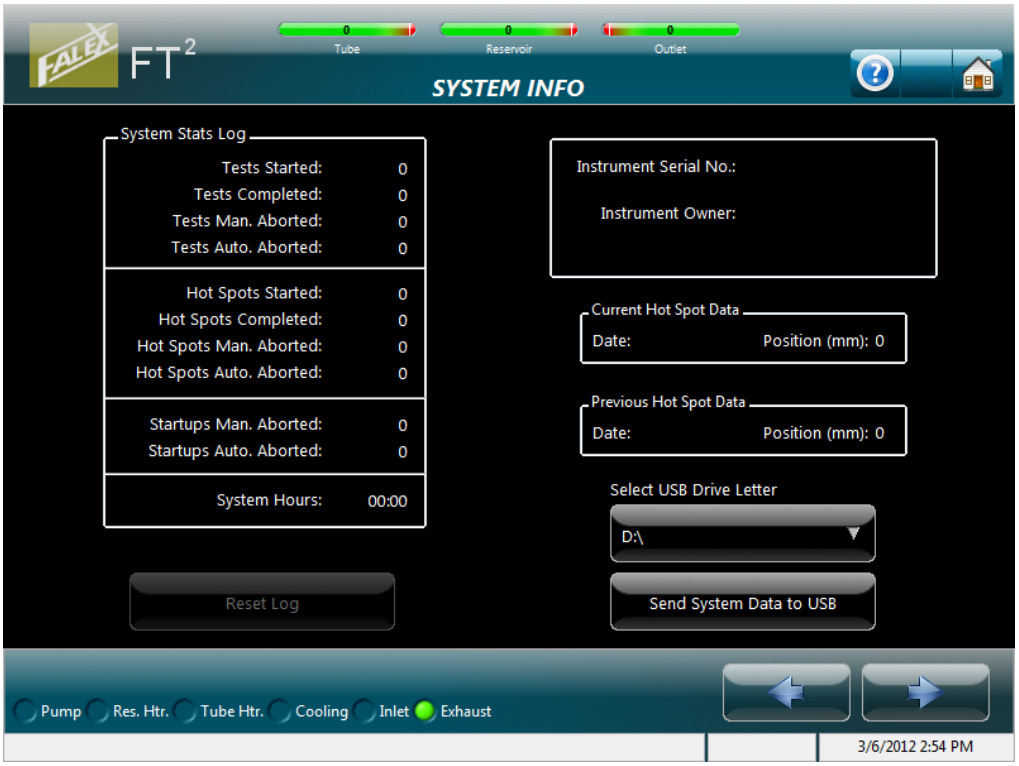


Figure 69 – System Info display

Statistics shown in the 'System Stats Log' section are:

- Tests started
- Tests completed
- Tests manually aborted
- Tests automatically aborted
- Hot Spots started
- Hot Spots completed

- Hot Spots manually aborted
- Hot Spots automatically aborted
- Startups manually aborted
- Startups automatically aborted
- System hours

'Tests' refer to any of the timed tests (20 hour, 20+20 hour, 40 hour, Custom test).

'Startups' refers to the startup process prior to starting a timed test or hot spot test.

'Manually aborted' refers to a test or hot spot that was aborted by the operator.

'Automatically aborted' refers to a test or hot spot that was aborted due to a condition relative to the machine (refer to Addendum A for abort conditions)

'System Hours' is the amount of runtime the machine has accumulated since last reset. The time is accumulated only during the timed duration part of the test or hot spot (time not accumulated during startup process).

The 'Reset Log' button requires a level 2 password to become enabled (this is a factory function).

The 'Instrument Serial No.' and 'Instrument Owner' information is entered at the factory prior to shipment.

'Current Hot Spot Data' shows the date the last hot spot determination test was run and what the current hot spot position is.

'Previous Hot Spot Data' shows the date the previous hot spot determination test was run and what the previous hot spot position was.

'Select USB Drive Letter' allows selection of an available USB drive to copy the system information file to.

'Send System Data to USB' button copies system information to an external device (i.e. flash drive). It will be stored in a .zip file called FT2SystemData. This will be useful should an issue occur and system information be requested by the Falex customer service representative.

Use the navigation buttons to view additional displays or return to the Maintenance Graph display.

4.4.7.4 Time Settings

The Time Settings display allows the operator to change the user interface date/time and also manually synchronize the controller with the same date/time (figure 70).

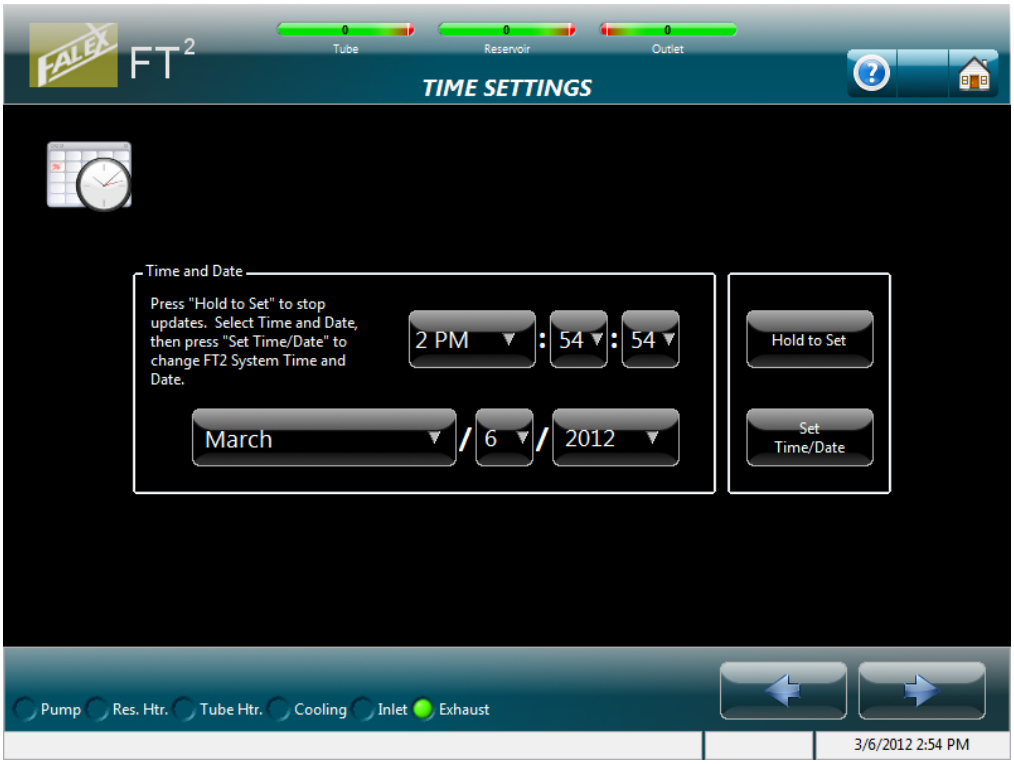


Figure 70 – Time Settings display

Note: The main controller will be automatically synchronized with the current user interface date/time stamp whenever a test (timed duration or hot spot) is initiated.

Select the 'Hold to Set' button to stop the time from incrementing so that the operator can change the time hours/minutes/seconds. The button will turn gold and display 'Time Held'. Selecting the hour, minute, or seconds area on the display will open up a drop down screen where the desired time element can be selected. The month, date, or year can be selected at any time. Selecting the month, date, or year area on the display will open up a drop down screen where the desired date element can be selected.

Once the desired time and/or date has been configured, selecting the 'Set Time/Date' button will change the user interface time and/or date and will also synchronize the main controller time/date with the user interface time/date. The 'Time Held' designation on the hold to set button will return to its default state (Hold to Set and black).

Note: If setting the time and/or date back, the machine must be power cycled.

Use the navigation buttons to view additional displays or return to the Maintenance Graph display.

4.4.7.5 System Calibration

The System Calibration display allows the operator to calibrate the particular device, view calibration data and to calibrate the user interface touchscreen (figure 71).

Figure 71 – System Calibration display

A level 1 password is required to access the various device calibration buttons shown in the 'Input Selection' area of the display. Selecting the Falex logo in the upper left corner will allow the ability to type in the password.

The following devices can be calibrated:

- Tube thermocouple
- Reservoir thermocouple
- Inlet thermocouple
- Outlet thermocouple
- Upper bus bar thermocouple
- Lower bus bar thermocouple
- System pressure

Each thermocouple can be calibrated electronically. The heater tube thermocouple also has the ability to be calibrated by capturing its

lead eutectic point. The system pressure can be calibrated electronically. Refer to Section 5 for calibration details.

Selecting the 'Adjust TC Offsets' button will pop-up the 'System Calibration - Offset Factors' display (figure 72) allowing a thermocouple offset factor to be entered for the particular thermocouple. The allowable range is ± 10 with two (2) decimal places. They can be entered by selecting the white box for the particular thermocouple factor to be entered. The new value will be saved by selecting 'OK' on the confirmation pop-up display that appears after selecting the 'Done' button. The value will be retained.

Note: The thermocouple offset factor is to be determined by a certified calibration service.

Note: If thermocouple offset factors are used, the value must be changed whenever a thermocouple is replaced.

Note: Since only one (1) thermocouple exists for the reservoir temperature and only one (1) thermocouple exists for the heater tube temperature and each are wired to the main controller and the safety controller, the calibration factor must be entered twice (once for each controller).

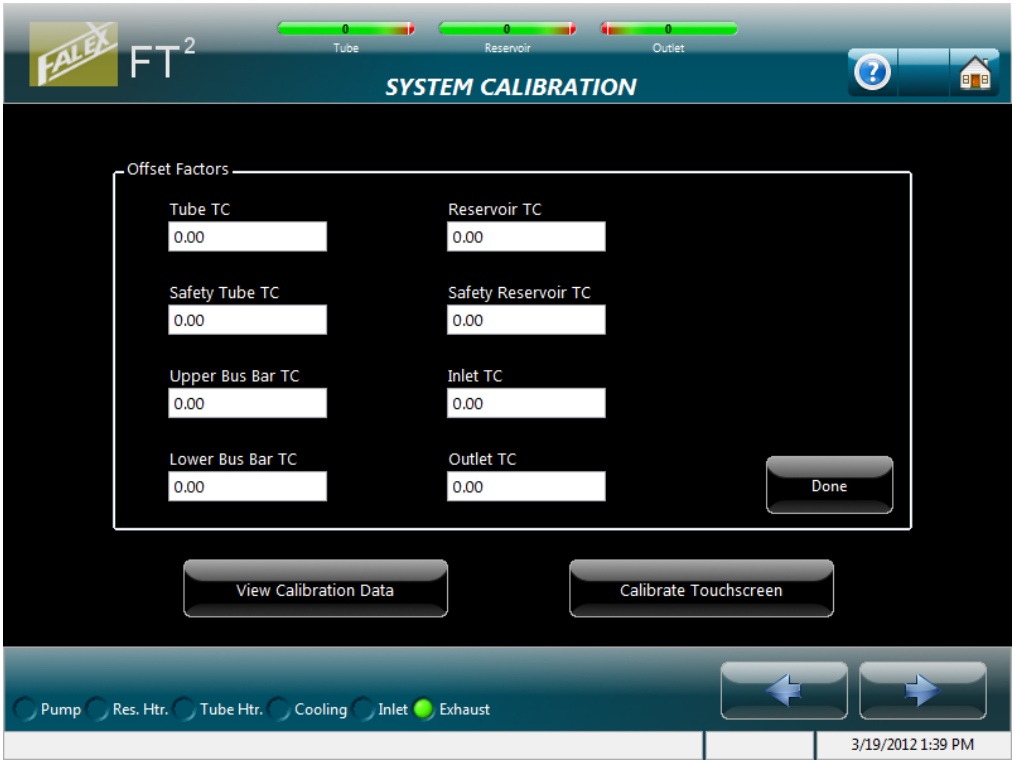


Figure 72 – Thermocouple Offset Factor display

Selecting the 'View Calibration Data' button will pop-up the 'Calibration Information' display (figure 73) showing the current

calibration values and calibration date for the various devices. Selecting the 'Print Info' button will print the calibration information page, if a printer is connected and configured.

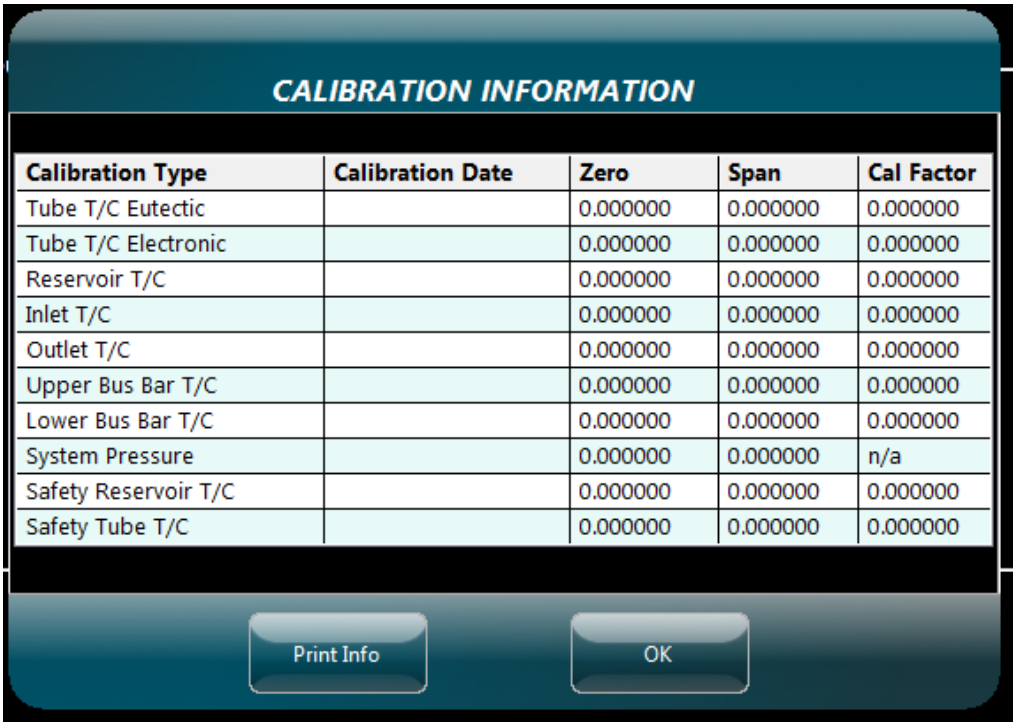


Figure 73 – Calibration Information display

Selecting the 'Calibrate Touchscreen' button will initiate touchscreen calibration process. This is a series of screens that direct the operator to touch designated positions on the display.

Use the navigation buttons to view additional displays or return to the Maintenance Graph display.

4.4.7.6 Manual Controls

The Manual Controls display allows the operator to manually control various devices and set the heater tube thermocouple position offset (figure 74). Manual control functionality can only be done when the machine is at idle (timed test or a hot spot test is not active).

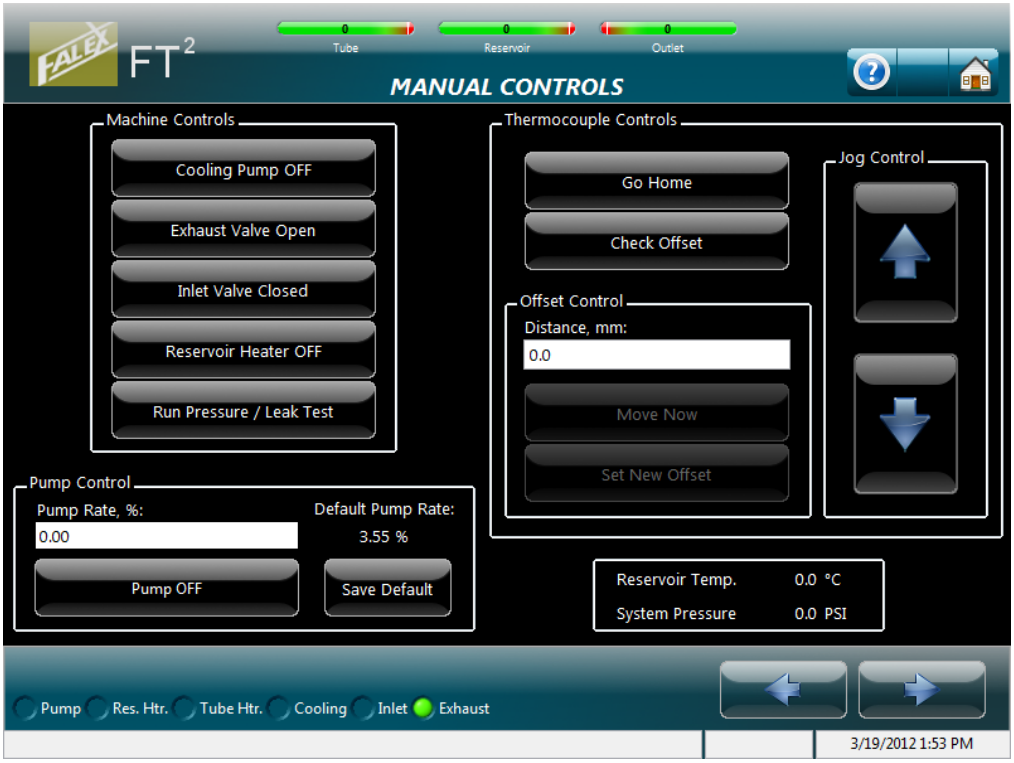


Figure 74 – Manual Controls display

Within the 'Pump Control' area of the display, the operator can:

- Manually turn the sample pump on/off by selecting the 'Pump ON' or 'Pump OFF' button
- Change the sample pump flow rate by selecting the white pump rate box and entering the desired percentage
- Set the default pump rate for pump speed during a duration test or hot spot test (factory set to 3.55%) by selecting the 'Save Default' button. This speed is to be set to achieve a flow rate of 1 ml/min.

Note: Device button on/off or open/close text will change accordingly depending upon the state of the device.

This functionality is useful when purging the system during the cleaning process. See section 3.3 for more details on the cleaning process.

Within the 'Machine Controls' area of the display, the operator can:

- Manually turn the cooling pump on/off by selecting the 'Cooling Pump ON' or 'Cooling Pump OFF' button
- Manually open/close the exhaust valve by selecting the 'Exhaust Valve Open' or 'Exhaust Valve Close' button
- Manually open/close the inlet valve by selecting the 'Inlet Valve Open' or 'Inlet Valve Close' button
- Manually start/stop the reservoir heater by selecting the 'Reservoir Heater ON' or 'Reservoir Heater OFF' button. For safety reasons, the

reservoir heater will automatically turn off after 2 minutes. The reservoir temperature is displayed so that it can be observed increasing when the reservoir heater is manually turned on.

- Initiate a pressure leak test by selecting the 'Run Pressure / Leak Test' button (button will turn gold). This will turn the sample pump on at the default flow rate, close the exhaust valve, open the inlet valve and pressurize the system. After 2 minutes, the inlet valve will close. Check for leaks. The system pressure is displayed to see if the value decreases. Once it has been determined that no leaks exist, the pressure leak test is to be stopped by selecting the 'Run Pressure / Leak Test' button a second time (button will turn black). The sample pump will stop and the exhaust valve will open, releasing pressure. It is recommended that a leak test be conducted prior to starting a timed test or hot spot test.

  Buttons will change to gold when a device change has been initiated that is different from the default state. Default states are shown with black buttons.

Note: Exiting the Manual Controls display will automatically place all devices back to their default state.

Within the 'Thermocouple Controls' area of the display, the operator can:

- Manually 'jog' the heater tube thermocouple up/down by selecting the ↑ or ↓ buttons
- Manually force the heater tube thermocouple to its 'Home' position by selecting the 'Go Home' button
- Manually check the heater tube thermocouple position offset by selecting the 'Check Offset' button. The offset is the space between the tip of the heater tube thermocouple when in the home position and the top of the heater tube (when heater tube properly positioned within the bus bars). When properly determined, the heater tube thermocouple should move the 'offset' so that the tip of the heater tube thermocouple should come in contact with the top of the heater tube.
- Manually set the heater tube thermocouple position offset by:
  a. Verify that the heater tube thermocouple is in its home position. If not, select the 'Go Home' button on the display.
  b. If installed, remove heater tube holder assembly
  c. Remove thermocouple guide
  d. Install a used heater tube between the bus bars making sure that the top of the heater tube is flush with the top of the upper bus bar
  e. From the display, select the 'distance' white box and enter a distance in mm (increments of .25mm are allowed). This is typically between 1 – 4mm.

f. From the display, select the 'Move Now' button to initiate the actuator to move the distance entered (button will become enabled after a valid distance is entered). Be sure to help guide the thermocouple into the heater tube, should the entered distance be too long. Otherwise, the thermocouple could bend. Proper distance is when the thermocouple just touches the top of the heater tube.
g. If distance is not correct, select 'Go Home' button. Follow steps e - g until a satisfactory distance is achieved
h. Select the 'Set New Offset' button to store the new distance as the desired offset
i. Select the 'Check Offset' button to verify the offset was correctly stored
j. Remove used heater tube

Note: It is very important that the heater tube thermocouple position offset be set correctly so that the heater tube thermocouple starts out at the correct position. Otherwise, the captured hot spot will not be determined at the correct position and all subsequent temperature profiles will be inaccurate.

Note: The heater tube thermocouple position offset needs to be verified any time the heater tube thermocouple is removed from the actuator arm. If the heater tube thermocouple position offset has changed, a new offset is to be determined.

Use the navigation buttons to view additional displays or return to the Maintenance Graph display.

5. Calibration

Calibration of the thermocouples and system pressure is done from the System Calibration display (figure 75). The display can be accessed by selecting Maintenance from the Main Menu and using the navigation buttons.

Figure 75 – System Calibration display

A level 1 password is required to access the various device calibration buttons shown in the 'Input Selection' area of the display. Selecting the Falex logo in the upper left corner will allow the ability to type in the password.

The following devices can be calibrated:

- Tube thermocouple
- Reservoir thermocouple
- Inlet thermocouple
- Outlet thermocouple
- Upper bus bar thermocouple
- Lower bus bar thermocouple
- System pressure

Each thermocouple can be calibrated electronically. However, the heater tube thermocouple also has the ability to be calibrated by capturing its lead eutectic point (calibration by the electronic method is the recommended calibration method). The system pressure can also be calibrated electronically. Instructions

are displayed throughout the calibration process to assist the operator. The calibration procedure can be aborted anytime by selecting the 'Abort Calibration' button or the  on the header portion of the active display. Anytime the calibration process is aborted, the previous calibration factors for the particular device being calibrated are restored.

The calibration procedures are outlined below for each device type.

Note: Each device has been calibrated at the factory using the electronic method prior to shipment. If a device calibration is needed and the required calibration equipment is not available, please contact your local Falex representative to schedule a service visit.

Note: At any time, the calibration process can be aborted by selecting the 'Abort Calibration' button. This will abort the process and reinstate the previous calibration parameters.

Note: Calibration factors for the reservoir temperature and the heater tube temperature are automatically applied to the safety controller inputs.

Note: The thermocouple calibration offset factors are factory set to 0. If the end user has the thermocouples certified, they can be entered into the system (refer to section 4.4.7.5).

<u>Electronic Calibration of Thermocouples</u>

This method requires the use of an electronic calibrator. Figure 76 shows the calibrator type used at the factory.

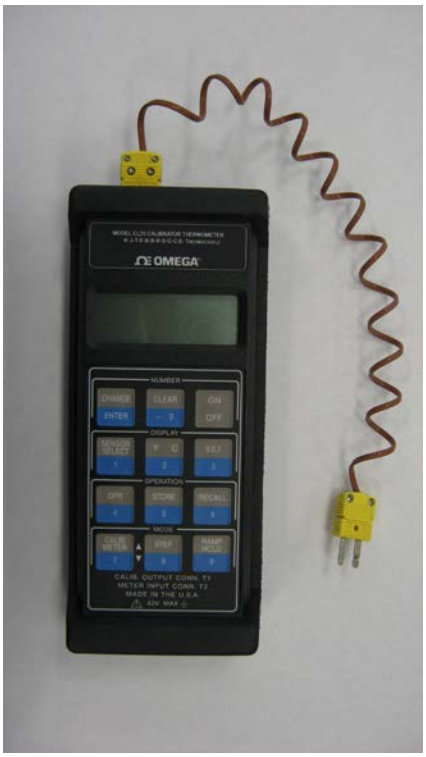


Figure 76 – Thermocouple Electronic Calibrator

The following is the procedure for calibrating any of the thermocouples electronically:

1. From the display, select the desired thermocouple button to be calibrated. If the tube thermocouple is to be calibrated, select the 'Electronic' button when asked for the method to be performed (two (2) methods of calibration exist for the tube thermocouple).
2. Select the 'Begin Calibration' button on the Calibration Wizard display to start the process (figure 77).

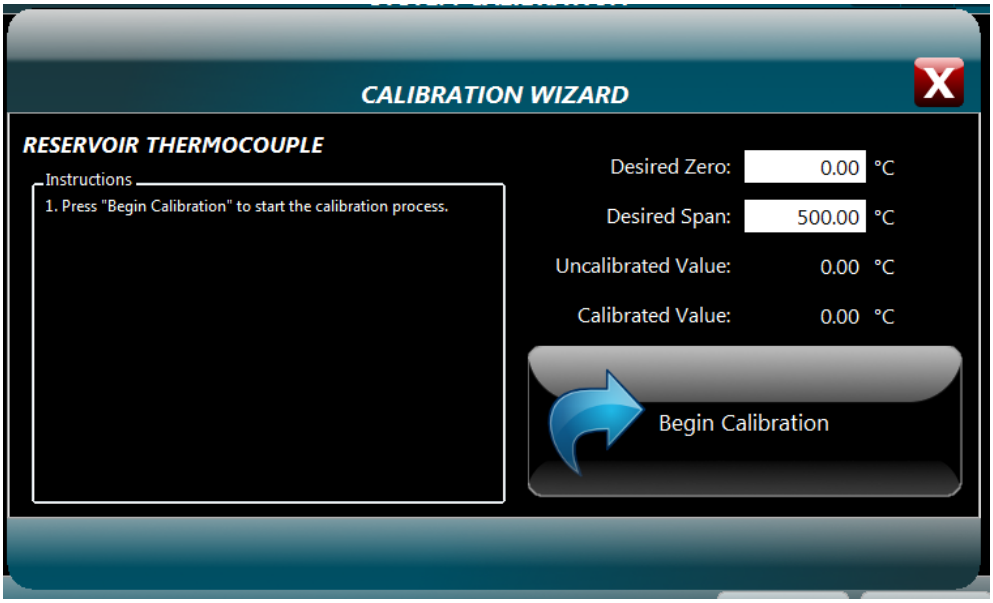


Figure 77 – Thermocouple Electronic Calibration Wizard display with Begin button

3. Connect the thermocouple calibrator to the correct input jack and adjust the output to 0 °C.
4. Verify 'Desired Zero' value is set to match that of the calibrator and correct if necessary (figure 78).

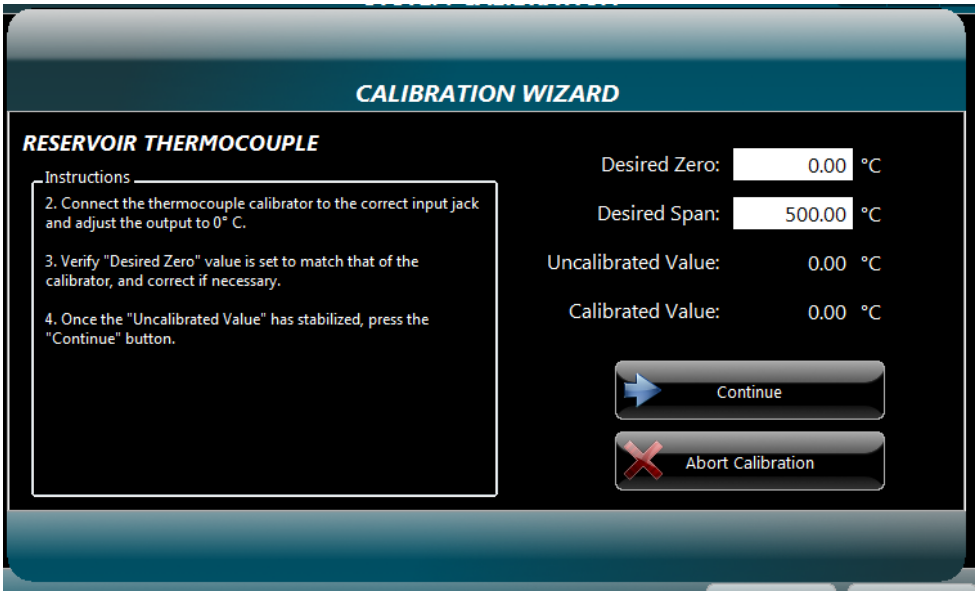


Figure 78 – Thermocouple Calibration Wizard display

5. Once the ‘Uncalibrated Value’ has stabilized, press the ‘Continue’ button.
6. Adjust the thermocouple calibrator to an output of 500 °C.
7. Once the ‘Uncalibrated Value’ has stabilized, press the ‘Continue’ button.
8. Press the ‘Continue’ button to store the new calibration factors.

Eutectic Calibration of the Heater Tube Thermocouple

Note: Heater tube eutectic calibration is selected from the System Calibration display after selecting the ‘Tube T/C button’.

The following is the procedure for calibrating the heater tube thermocouple using the lead eutectic method:

1. Select the ‘Begin Calibration’ button on the Calibration Wizard display to start the process (figure 79).

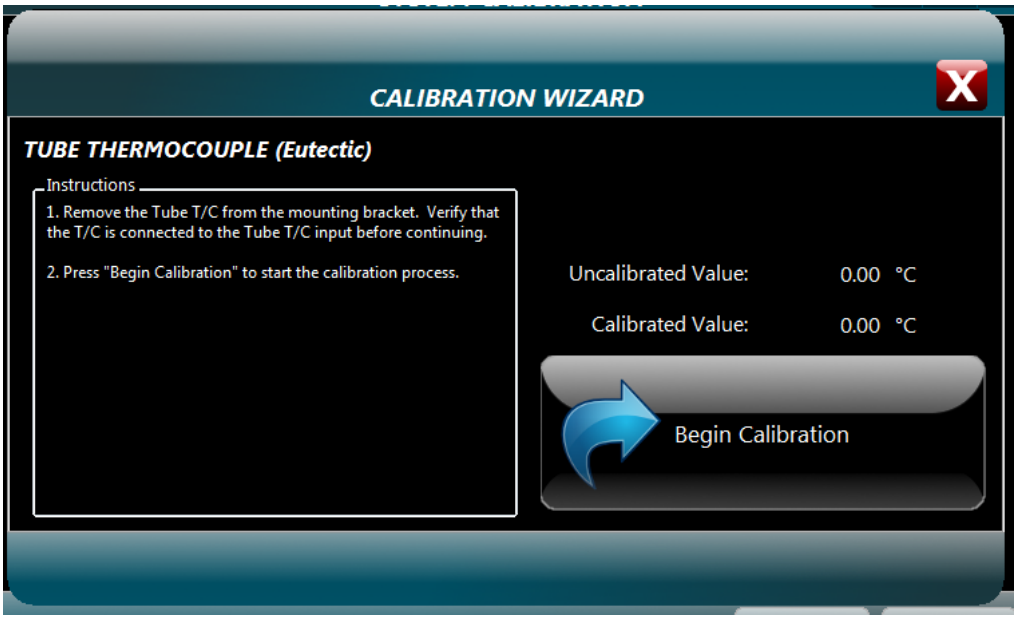


Figure 79 – Eutectic Calibration Wizard display with Begin button

2. Locate the lead calibration assembly and install it into the upper/lower bus bars. Verify that the lead calibration assembly has been pre-loaded with melted lead. Make sure the top of the lead calibration assembly is flush with the top of the upper bus bar and that the bus bar screws are tight.
3. Prepare a low temperature standard, which is an ice bath of distilled water and distilled ice. It is recommended that this be prepared in an insulated cup.
4. Leaving the heater tube thermocouple connected to the machine, carefully remove the heater tube thermocouple from the actuator arm (do not bend the thermocouple). Loosen set screws located on front and side (.050” Allen wrench). If thermocouple does not easily pull out of the actuator arm, use the Allen wrench to push up from the underside of the actuator arm.

5. Insert the heater tube thermocouple into the ice bath.
6. Stir the thermocouple in the ice bath for a few minutes. The 'Uncalibrated Value' will decrease.
7. Once the "Uncalibrated Value' has stabilized (no longer dropping), press the 'Save Ice Point' button to store the low temperature value. The temperature must be 0°C (±2°C) to be accepted. Otherwise, the low calibration process is aborted.
8. Remove the heater tube thermocouple from the ice bath and wipe it dry.
9. Insert the thermocouple through the top shoulder of the lead calibration assembly until the tip touches the lead.

Note: For accurate calibration functionality, the heater tube thermocouple must stay in contact with the lead.

10. Press the 'Start Heating' button when ready to initiate the heating process. The lead calibration assembly will heat to 350°C.

Note: Severe burns could occur from skin contact with the lead calibration assembly during the heating process. Be very careful when handling the heater tube thermocouple during the heating process.

11. Once the lead temperature is >330°C, it will become molten.
12. Carefully press the heater tube thermocouple into the center of the molten lead using caution to prevent contact with the sides or bottom of the lead cup.
13. Once the lead temperature has equalized (45 seconds), the cooling sequence will be initiated so that the eutectic temperature can be detected. Wait for the system to complete the process and display the pass or fail message.
14. Pressing the 'OK' button on the pass/fail pop-up display will initiate the heating process so the heater tube thermocouple can be removed from the lead. The system will apply heat, causing the lead to change to its molten state.
15. Wait for the 'Uncalibrated Value' to be >330°C and then carefully remove the thermocouple and wipe off any molten lead from the thermocouple tip.

Note: Heater tube temperature will only be >330°C for one (1) minute to allow thermocouple removal.

Note: Wear appropriate gloves when handling the hot thermocouple to prevent skin contact.

16. A seven (7) minute cooling timer will start to cool the lead calibration assembly. When timer has timed out, cooling will stop and a pop-up notification (figure 80) will appear notifying the operator that the calibration sequence has completed.

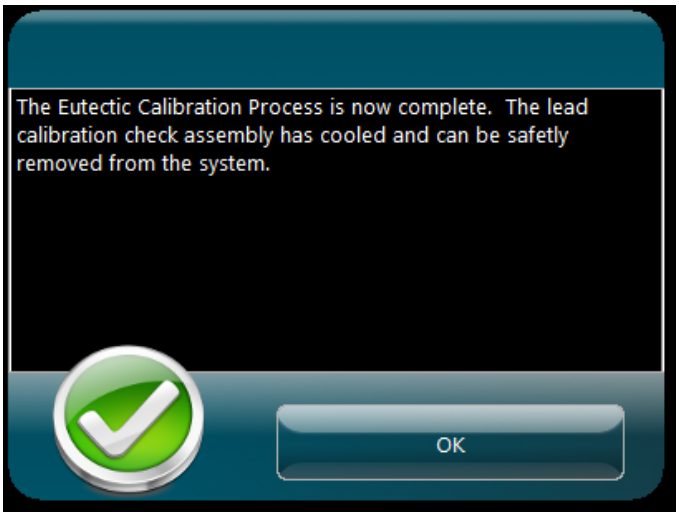


Figure 80 – Eutectic calibration complete pop-up

Note: To be sure that the lead calibration assembly is at a safe handling temperature (<40°C), insert the heater tube thermocouple back into the lead calibration assembly so that the thermocouple tip is in contact with the hardened lead and verify the temperature on the Calibration Wizard display.

17. Press the 'Continue' button to view the calibration information.

Note: Should the eutectic temperature capture fail, it is recommended that the test be repeated to confirm that the thermocouple is defective. If the thermocouple fails eutectic capture again, it should be replaced.

18. Remove the lead calibration assembly and install the heater tube thermocouple back into the actuator arm. Slide the heater tube thermocouple into the hole within the actuator arm until the thermocouple tip is 2 – 4 mm above the bus bar when the actuator is at its home position. Secure the thermocouple into the actuator arm by tightening the front and side set screws (.050 Allen wrench).
19. Verify the heater tube thermocouple position offset and change it if necessary. Refer to section 4.4.7.6 for more details.

<u>Electronic Calibration of the System Pressure</u>

Note: Pressure is to be calibrated using psi units. Conversion takes place within the software to convert psi to KPa.

This method requires the use of a calibrated pressure gauge calibrator and is to be done by Falex personnel or a properly trained Falex representative.

The following is the procedure for calibrating the system pressure electronically:

1. Press the ‘Begin Calibration’ to start the calibration process (figure 81).

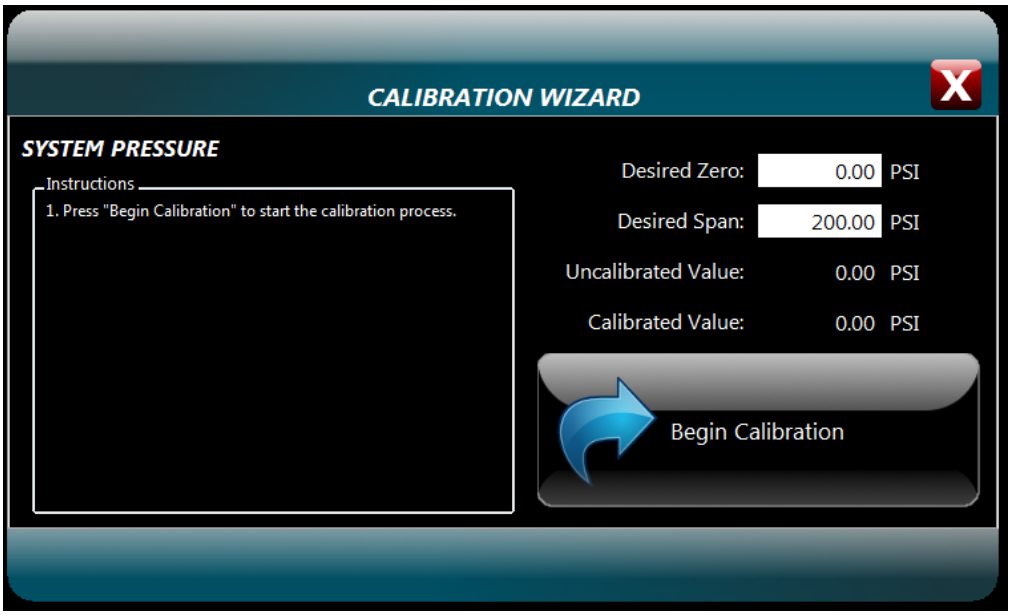


Figure 81 – Pressure Calibration Wizard display with Begin button

2. Connect the calibrated pressure gauge calibrator to the system pressure fitting on the front of the cabinet (above reservoir). Press ‘Continue’ after installation (figure 82).

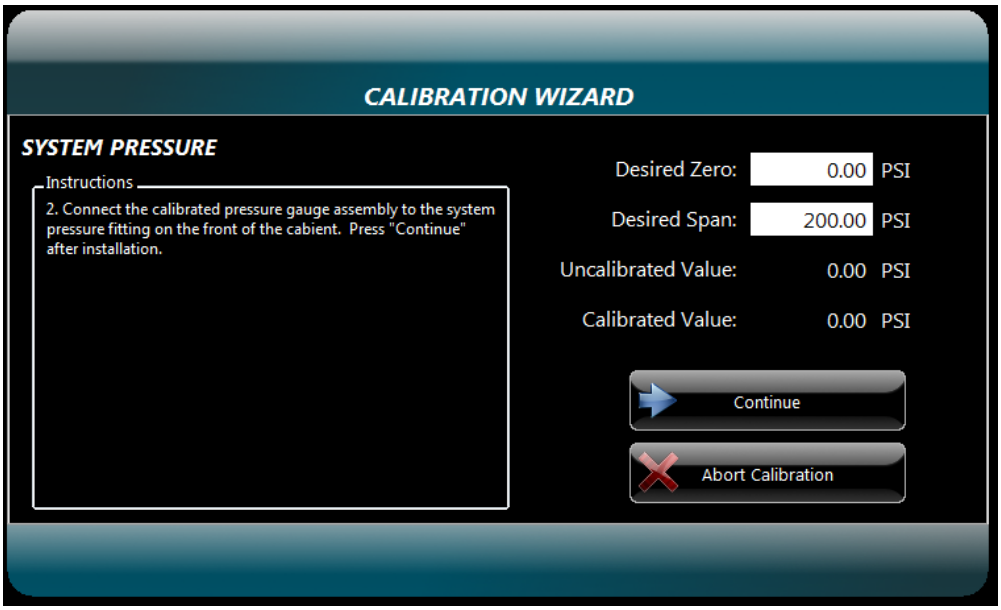


Figure 82 – Pressure Calibration Wizard display

3. Power up the calibrated pressure gauge and enter the displayed value into the ‘Desired Zero’ field on the Calibration Wizard display.
4. Once the ‘Uncalibrated Value’ has stabilized, press the ‘Continue’ button.
5. Set the pressure regulator on the air source to a value between 200 – 250 psi.

6. Verify the manual inlet air valve on the front of the machine is open (left valve below reservoir).
7. Observe the displayed value on the calibrated pressure gauge and enter this number in the ‘Desired Span’ field.
8. Once the ‘Uncalibrated Value’ has stabilized, press the ‘Continue’ button.
9. After the ‘Calibrated Value’ displays zero psi, press the ‘Continue’ button.
10. Press the ‘Continue’ button to store the new calibration factors.

6. Maintenance

Maintenance is to be routinely performed to keep the machine operating at its peak performance and to provide consistent and accurate results. The following is a recommended maintenance schedule:

- Hot spot determination test should be done any time the heater tube thermocouple has been replaced, the heater tube holder has been replaced or whenever a heater tube of a different material is used

Note: In order for the hot spot to be accurately determined, the test fluid should meet the following oil specifications:

- ***MIL-PRF-23699 HTS***
- ***SAE AS-5780 HPC***

Recommended oils are:

- ***BP Turbo Oil 2197***
- ***Aero Shell Turbine Oil 560***
- ***Mobil Jet Oil 254***

- Hot spot validation test should be done after a hot spot determination has been completed or any time when the hot spot location is suspect
- If a thermocouple has been replaced, the new thermocouple is to be calibrated prior to running any tests
- Calibration of all thermocouples should be completed every 6 months
- Calibration of the system pressure should be completed every 6 months
- If thermocouple offset factors are used, the particular thermocouple's value is to be updated whenever a new thermocouple is installed
- Heater tube thermocouple position offset should be verified any time the heater tube thermocouple is removed from the actuator arm. Change accordingly (refer to section 4.4.7.6).
- Heater tube O-rings are to be changed on every hot spot test or timed test
- Heater tube specimen is to be changed on every hot spot test or timed test
- Wipe clean any oil residue that may collect within the upper/lower bus bar clamp area (where heater tube is held into place). This will maintain clean contact between the bus bars and the heater tube.
- Outlet temperature thermocouple O-ring is to be changed on every test (hot spot or timed test)
- Inlet temperature thermocouple O-ring is to be changed on every test (hot spot or timed test)
- All tubing O-rings should be changed every test (hot spot or timed test). This includes the sample input line, sample output line, sample return line and the air inlet line.

- Sample pump inlet and outlet O-rings should be changed every 10 tests (hot spot or timed test) or if sooner if leaks exist
- Sight glass O-rings (3) should be changed every 6 months or if showing signs of wear
- Reservoir O-ring should be inspected after every test (hot spot or timed test) and replaced when deterioration is detected
- Reservoir outlet fitting O-ring should be changed every 10 tests (hot spot or timed test
- Keep all test fluid leaks or spills cleaned up so that they do not seep into the electronic cabinet
- Keep the touchscreen free of test fluid or dust that could damage the surface and its functionality
- Do not let the user interface hard drive fill to capacity with data files. Failure to do so could crash the system. Develop a system where data files are routinely saved to an external source and deleted from the user interface. Refer to section 4.4.6 to determine disk usage and to delete data files.

Note: All O-rings are V123 except sample pump inlet/outlet.

Note: Anytime an O-ring shows signs of deterioration, it is to be replaced.

7. Data Files

As mentioned throughout this manual, temperature profiles, data files and report files are created and stored on the user interface. Temperature profiles are a table of captured heater tube thermocouple temperatures at specific positions within the heater tube. Data files are a table of captured parameters that are captured at a predetermined collection rate for the duration of the test. A report file is a final summary of information for the particular timed test.

The file naming format was discussed in detail in sections 4.4.2.1 for timed tests and in 4.4.3.1 for hot spot tests. Data collection rates can be changed within the User Preferences portion of the user interface, as discussed in section 4.4.5. Temperature profiles, data files and report files can be copied from the machine to an external device within the File Manager portion of the user interface, as discussed in section 4.4.6. The temperature profiles and data files are saved in a format that can be opened within a standard spreadsheet or document application, once transferred to an external PC. The temperature profiles and data files are saved as a .csv formatted file and the report files are saved as a .pdf formatted file.

Note: A report file is only generated at the conclusion of a timed test.

The makeup of the various data files is discussed below.

<u>Temperature Profile</u>

Up to three (3) temperature profiles could be included within the temperature profile data file, depending upon the test type. The temperature profile data file consists of header information and stored data records. A data record is captured and stored for each heater tube thermocouple position. Refer to Addendum C to see a typical temperature profile example.

The header portion contains information that was entered from the Test Information display for the particular test. The type of test the profile represents is also shown.

Each stored data record has five (5) components. They are:

- Date when the data record was captured
- Test time (seconds) when the data record was captured
- Heater tube thermocouple captured temperature (°C)
- Actual heater tube thermocouple position (mm) when the temperature was captured
- Heater tube thermocouple reference to the ‘A’ position when the temperature was captured

Data File

The data file consists of header information and stored data records. A data record is captured and stored at a predetermined collection rate for the duration of the test. Refer to Addendum D to see a typical data file example (due to length of the file, entire file not shown).

The header portion contains information that was entered from the Test Information display for the particular test, along with other useful information.

Each stored data record has eleven (11) components. They are:

- Time stamp when the data record was captured
- Test time (seconds) when the data record was captured
- Heater tube thermocouple captured temperature (°C)
- Power captured reading (amps)
- Inlet thermocouple captured temperature (°C)
- Outlet thermocouple captured temperature (°C)
- Upper bus bar thermocouple captured temperature (°C)
- Lower bus bar thermocouple captured temperature (°C)
- Reservoir thermocouple captured temperature (°C)
- Captured system pressure (psi or KPa, depending on user preference configuration)
- Actual heater tube thermocouple position (mm)

Report File

The report file is a summary of the particular test and consists of information from the temperature profile and the test data file. It contains header information, a test results summary and tube temperature profile graphs. Refer to Addendum E to see a typical report file example.

The header portion contains information that was entered from the Test Information display for the particular test, along with other useful information.

The report file test summary contains the following:

- Mean control temperature that the test ran at for the specified test duration (°C)
- Inlet temperature min/max/avg values during test duration (°C)
- Outlet temperature min/max/avg values during test duration (°C)
- Power level min/max/avg (amps)
- A place for tube weights to be manually entered
- A place for fluid properties to be manually entered

The temperature profile graph area includes a graph representation of selected temperature profiles. At the conclusion of a timed test, a pop-up display appears (figure 83) allowing the current test temperature profiles and the

current hot spot temperature profile to be included on the report. The test temperature profiles will always be included, unless deselected. The current hot spot profile must be selected to be included on the report.

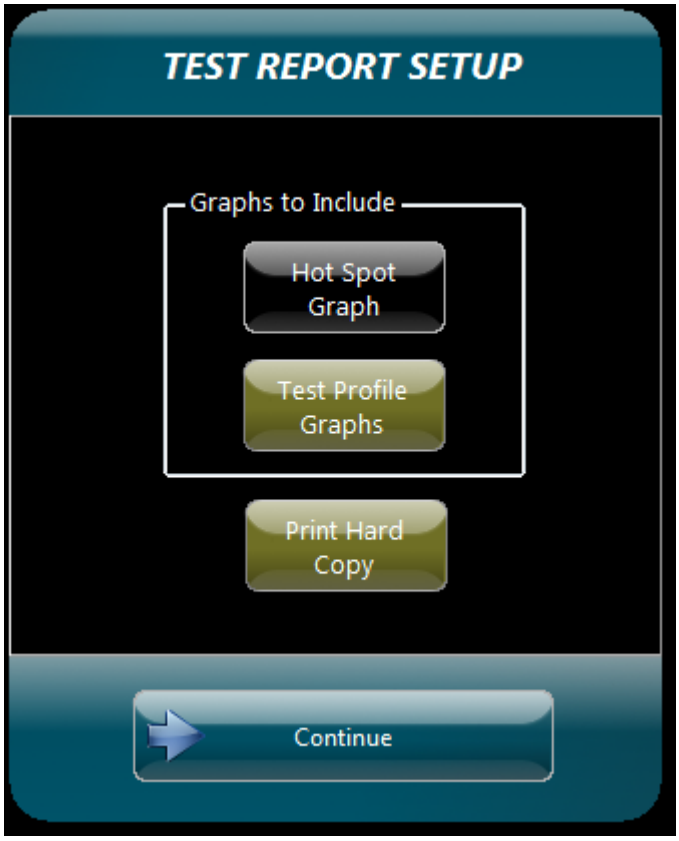


Figure 83 – Test Report Setup pop-up display

If the 'Print Hard Copy' button is selected (button is gold), the report will automatically print to the local printer (if a printer is configured and connected). This is the default position. Deselecting the button (button is black) will configure the report not to print.

The configuration of the buttons will be retained.

8. Specimens

Each timed test or hot spot test requires one (1) heater tube. The heater tube can only be used for a single timed test or hot spot test. It cannot be used for multiple tests or multiple hot spot tests. There are four (4) different types of heater tubes available, each made out of a different material. They are:

- 1020 steel, box of 12 (p/n 400-560-002)
- 316 stainless steel, box of 12 (p/n 400-560-003)
- 304 stainless steel, box of 12 (p/n 400-560-004)
- 440 stainless steel, box of 12 (p/n 400-560-005)

The heater tube typically used for this test is made of 316 stainless steel.

Note: Always wear lint free gloves when handling a heater tube to prevent introducing finger prints or other foreign substances to the heater tube. Always handle the heater tube by the shoulders, do not touch the test area (middle area).

All heater tubes meet all of the SAE ARP5996 requirements for dimensions, surface finish and material.

Each tube must be properly prepared prior to being used for a test. Refer to section 3.4 for the tube preparation procedure.

9. Parts Listing

PART #	DESCRIPTION
400-018-003	Insulation bushing (2 pairs/pack)
400-108-004	Lead calibration holder with melted lead
450-041-002	Tube Holder (for oven and balance)
450-041-003	Heater tube alignment tool
450-097-003	O-Ring Kit, Standard (20 tests)
450-097-006	Sight Glass O-Ring Kit
450-099-001	Heater tube holder assembly
450-103-008	Thermocouple - heater tube (with ball tip)
450-105-006	Tube assembly (inlet air to reservoir)
450-105-007	Tube assembly (pump out to reservoir)
450-105-009	Tube assembly (reservoir to tube holder inlet)
450-105-010	Bypass cleaning line assembly
450-105-015	Tube assembly (tube holder outlet to pump inlet)
450-106-001	Reservoir heater jacket
450-109-004	Thermocouple assembly- inlet/outlet
450-109-006	Remote E-Stop Assembly
450-200-002	Tube Weighing Kit and Analytical Balance
400-200-003	Oven Tube Holder
450-560-003	Heater tubes (316SS) (12 tubes/box)
648-400-007	Hex Socket wrench
648-400-009	Ceramic insulator removal tool
648-450-001	Heater tube cleaning brush
650-030-150	Power Cord (220V)
650-030-161	Power Cord (125V)
650-051-109	Handheld Pushbutton Switch

Addendum 'A' – Alarm Matrix

Main Controller

The following details the alarm/abort conditions that exist in the main controller. The alarm/abort value will be captured and included at the end of the alarm/abort message, where applicable.

Note: When a lead eutectic calibration is active, the heater tube temperature high alarm is set to 400°C and the heater tube temperature high abort is set to 420°C.

Description	Alarm	Abort	Condition	Lo Limit	Hi Limit	Alarm Message (HMI)	Comments
Heater Tube Temperature Fail To Rise		x	5 ºC in 40 sec			Heater Tube Failed to Heat	Checked at beginning of Test. ***Possible Cause: T/C not installed properly, T/C not in heater tube, invalid calibration factors.***
Heater Tube Failed to Reach Temperature		x	12 mins after test start	< SP - 2 ºC (default < 373 ºC)	> SP + 2 ºC (default > 377 ºC)	Heater Tube Failed to Reach Temperature	Checked at beginning of Test. Temp must be within range within allotted time. ***Possible Cause: T/C not installed properly, heater failure.***
Reservoir Heating Failure		x	5 ºC in 5 min			Reservoir Failed to Heat	Checked at start of heating sequence. ***Possible Cause: Heater jacket not installed correctly, Heater jacket not plugged in, heater failure.***
Operator Abort		x				Operator Initiated Abort	Initiated from touchscreen to stop any running devices or active test. ***Possible Cause: Operator hit abort button on display, Operator hit 'X' icon during an active test.***
HMI Communication Failure		x	Test active			Communication Failure With User Interface	Abort after 65 seconds. For PLC purposes only! (HMI detects failure & generates its own message). ***Possible Cause: Network cable disconnected, Network HUB failure, Touchscreen failure.***
Start Permissive Pressure Alarm	x		Start Permissive Active	< SP - 3% (default < 194 PSI)	> SP + 3% (default > 206 PSI)	Start Permissive Alarm - System Pressure Outside of Limits	Active only during start permissive sequence. Alarm after 5 seconds once within press range and then fall out of range before start permissive is achieved. ***Possible Cause: Pressure regulator not set correctly at tank, pressure leak.***
Start Permissive Reservoir Temperature Alarm	x		Start Permissive Active	< SP - 3% (default < 145.5 ºC)		Start Permissive Alarm - Reservoir Temperature Outside of Limits	Active only during start permissive sequence. Alarm after 5 seconds once within temp range and then fall out of range before start permissive is achieved. ***Possible Cause: Reservoir Heater Jacket not installed properly, Reservoir T/C failure..***
Heater Tube 'High' Temp	x		Test active		SP + 30 (default 405 ºC)	Heater Tube Temperature High Alarm	Alarm after 5 seconds. ***Possible Cause: Excessive deposit on heater tube, Heater tube T/C failure.***
Heater Tube 'High' Temp		x	Test active		SP + 45 (default 420 ºC)	Heater Tube Temperature High Abort	Abort after 5 seconds. ***Possible Cause: Excessive deposit on heater tube, Heater tube T/C failure.***
Upper Bus Bar 'High' Temp		x	Test active		50 ºC	Upper Bus Bar Temperature High Abort	Abort after 5 seconds. ***Possible Cause: Cooling system failure, T/C not installed properly.***
Reservoir 'Low' Temp	x		Test active	SP - 10 (default 140 ºC)		Reservoir Heater Temperature Low Alarm	Alarm after 5 seconds. ***Possible Cause: Heater jacket not installed correctly, Heater jacket not plugged in, heater failure.***
Reservoir 'Low' Temp		x	Test active	SP - 15 (default 135 ºC)		Reservoir Heater Temperature Low Abort	Abort after 5 seconds. ***Possible Cause: Heater jacket not installed correctly, Heater jacket not plugged in, heater failure.***
Reservoir 'High' Temp	x		Heater Active		SP + 10 (default 160 ºC)	Reservoir Heater Temperature High Alarm	Alarm after 5 seconds. ***Possible Cause: Heater jacket not installed correctly, heater failure.***

Description	Alarm	Abort	Condition	Lo Limit	Hi Limit	Alarm Message (HMI)	Comments
Reservoir 'High' Temp		x	Heater Active		SP + 15 (default 165 ºC)	Reservoir Heater Temperature High Abort	Abort after 5 seconds. ***Possible Cause: Heater jacket not installed correctly, heater failure.***
System 'Low' Pressure	x		Test active	SP - 20 (default 180 PSI)		System Pressure Low Alarm	Alarm after 5 seconds. ***Possible Cause: Pressure leak, inlet valve failure.***
System 'Low' Pressure		x	Test active	SP - 30 (default 170 PSI)		System Pressure Low Abort	Abort after 5 seconds. ***Possible Cause: Pressure leak, inlet valve failure.***
System 'High' Pressure	x		Test active		SP + 20 (default 220 PSI)	System Pressure High Alarm	Alarm after 5 seconds. ***Possible Cause: Air supply not adjusted to 200 psi.***
System 'High' Pressure		x	Test active or Startup active		SP + 30 (default 230 PSI)	System Pressure High Abort	Abort after 5 seconds. ***Possible Cause: Air supply not adjusted to 200 psi.***
Heater Tube Temp Deviation		x	Test active	< 5 ºC from Mean Temp	> 5 ºC from Mean Temp	Heater Tube Temperature Out of Range	Enabled only during temp control during main test. Temperature must be ***'outside'*** of limits. Abort after 5 seconds. ***Possible Cause: TC failure, excessive buildup on heater tube.***
Heater Tube Temp T/C Failure		x	Test active or Lead Eutectic Calibration Active	+32000 ºC		Heater Tube Temperature Thermocouple Failure	Abort after 5 seconds. ***Possible Cause: TC failure, TC not connected.***
Inlet Temp T/C Failure		x	Test active	+32000 ºC		Inlet Temperature Thermocouple Failure	Abort after 5 seconds. ***Possible Cause: TC failure, TC not connected.***
Reservoir #1 Heater Jacket T/C Failure		x	Heater Active	+32000 ºC		Reservoir Jacket Heater Temperature Thermocouple Failure	Abort after 5 seconds. ***Possible Cause: TC failure, TC not connected.***
Upper Bus Bar Temp T/C Failure		x	Test active	+32000 ºC		Upper Bus Bar Temperature Thermocouple Failure	Abort after 5 seconds. ***Possible Cause: TC failure, TC not connected.***
Lower Bus Bar Temp T/C Failure		x	Test active	+32000 ºC		Lower Bus Bar Temperature Thermocouple Failure	Abort after 5 seconds. ***Possible Cause: TC failure, TC not connected.***
SCR Heater Breaker Trip		x	Digital Output 'On'			Tube Heater Breaker Trip	Device called to start, but after 3 sec delay, status does not confirm action. ***Possible Cause: Opto point failure, blown fuse.***
Sample Pump Breaker Trip		x	Digital Output 'On'			Sample Pump Breaker Trip - reset breaker	Device called to start, but after 3 sec delay, status does not confirm action. ***Possible Cause: Opto point failure, blown fuse.***
Reservoir Heater Breaker Trip		x	Digital Output 'On'			Reservoir Heater Breaker Trip	Device called to start, but after 3 sec delay, status does not confirm action. ***Possible Cause: Opto point failure, blown fuse.***
24V Primary Breaker Trip		x	Digital Output 'On'			Primary 24VAC Power Breaker Trip	Device called to start, but after 3 sec delay, status does not confirm action. ***Possible Cause: Opto point failure, blown fuse.***
Heater Tube Temperature Eutectic Low Calibration Abort		x	Lead Eutectic Calibration Active	-2 ºC	2 ºC	Heater Tube Temperature Eutectic Low Calibration Aborted (Not Within Limits)	Captured low eutectic temperature not within allowable limits. Previous calibration factors are restored. ***Possible Cause: Operator hit 'save ice point' button prematurely, ice bath not cold enough.***
Heater Tube Temperature Eutectic Low Calibration Operator Abort		x	Lead Eutectic Calibration Active			Heater Tube Temperature Eutectic Low Calibration Manually Aborted	Initiated from touchscreen to stop any running devices or active calibration. Previous calibration factors are restored. ***Possible Cause: Operator hit abort button on display, Operator hit 'X' button on display.***
Heater Tube Temperature Eutectic High Calibration Operator Abort		x	Lead Eutectic Calibration Active			Heater Tube Temperature Eutectic High Calibration Manually Aborted	Initiated from touchscreen to stop any running devices or active calibration. Previous calibration factors are restored. ***Possible Cause: Operator hit abort button on display, Operator hit 'X' button on display.***

Description	Alarm	Abort	Condition	Lo Limit	Hi Limit	Alarm Message (HMI)	Comments
Heater Tube Temperature Electronic Calibration Operator Abort		x	Heater Tube Temp Electronic Calibration Active			Heater Tube Temperature Electronic Calibration Manually Aborted	Initiated from touchscreen to stop any running devices or active calibration. Previous calibration factors are restored. ***Possible Cause: Operator hit abort button on display, Operator hit 'X' button on display.***
Inlet Temperature Electronic Calibration Operator Abort		x	Inlet Temp Electronic Calibration Active			Inlet Temperature Calibration Manually Aborted	Initiated from touchscreen to stop any running devices or active calibration. Previous calibration factors are restored. ***Possible Cause: Operator hit abort button on display, Operator hit 'X' button on display.***
Reservoir Temperature Electronic Calibration Operator Abort		x	Reservoir Temp Electronic Calibration Active			Reservoir Temperature Calibration Manually Aborted	Initiated from touchscreen to stop any running devices or active calibration. Previous calibration factors are restored. ***Possible Cause: Operator hit abort button on display, Operator hit 'X' button on display.***
Upper Bus Bar Temperature Electronic Calibration Operator Abort		x	Upper Bus Bar Temp Electronic Calibration Active			Upper Bus Bar Temperature Calibration Manually Aborted	Initiated from touchscreen to stop any running devices or active calibration. Previous calibration factors are restored. ***Possible Cause: Operator hit abort button on display, Operator hit 'X' button on display.***
Lower Bus Bar Temperature Electronic Calibration Operator Abort		x	Lower Bus Bar Temp Electronic Calibration Active			Lower Bus Bar Temperature Calibration Manually Aborted	Initiated from touchscreen to stop any running devices or active calibration. Previous calibration factors are restored. ***Possible Cause: Operator hit abort button on display, Operator hit 'X' button on display.***
System Pressure Electronic Calibration Operator Abort		x	System Pressure Electronic Calibration Active			System Pressure Calibration Manually Aborted	Initiated from touchscreen to stop any running devices or active calibration. Previous calibration factors are restored. ***Possible Cause: Operator hit abort button on display, Operator hit 'X' button on display.***
Lead Eutectic Assembly Temperature Fail To Rise		x	5 ºC in 30 sec			Lead Eutectic Assembly Failed to Heat - Verify Thermocouple In Contact With Lead	Checked at beginning of high temperature calibration. ***Possible Cause: T/C not installed properly, T/C not in contact with the lead.***
Sample Pump Fault		x	Pump starting or running			Pump Fault	Active only when pump being started or is running. ***Possible Cause: Pump blockage, pump over-temperature, pump failure.***
Safety Cover Missing	x		Test active			Safety Cover Missing Alarm	Warning only. ***Possible Cause: Cover removed during test, photo eye failure.***
Safety PLC Abort		x				Safety PLC Initiated Abort	Any of Safety abort limits exceeded. ***Possible Cause: see safety alarm matrix.***

Safety Controller

The following details the alarm/abort conditions that exist in the safety controller. The alarm/abort value will be captured and included at the end of the alarm/abort message, where applicable.

Description	Alarm	Abort	Condition	Lo Limit	Hi Limit	Alarm Message (HMI)	Comments
Outlet 'Low' Temp (hardcoded limit)		x	Alarm enabled	50 ºC		Safety PLC Shutdown - Outlet Temperature Low	Alarm is enabled when test is running and heater tube temp in range (setpoint ± 3 ºC) for 5 minutes. Hardcoded limit. Abort after 5 seconds. ***Possible Cause: cooling system failure, pump failure.***
Outlet 'Low' Temp (user selectable limit)		x	Alarm enabled	default 50 ºC (range 50 - 175 ºC)		Safety PLC Shutdown - Outlet Temperature Low	Alarm is enabled when test is running and heater tube temp in range (setpoint ± 3 ºC) for 5 minutes. User selectable limit. Abort after 5 seconds. ***Possible Cause: cooling system failure, pump failure.***
Heater Tube 'High' Temp (hardcoded limit)		x			485 ºC	Safety PLC Shutdown - Heater Tube Temperature High	Hardcoded limit. Abort after 5 seconds. ***Possible Cause: Excessive deposit on heater tube, Heater tube T/C failure.***
Heater Tube 'High' Temp (user selectable limit)		x			default 485 ºC (range 350 - 485 ºC)	Safety PLC Shutdown - Heater Tube Temperature High	User selectable limit. Abort after 5 seconds. ***Possible Cause: Excessive deposit on heater tube, Heater tube T/C failure.***
Reservoir 'High' Temp (hardcoded limit)		x			225 ºC	Safety PLC Shutdown - Reservoir Heater Temperature High	Hardcoded limit. Abort after 5 seconds. ***Possible Cause: Heater jacket not installed correctly, heater failure.***
Reservoir 'High' Temp (user selectable limit)		x			default 225 ºC (range 0 - 225 ºC)	Safety PLC Shutdown - Reservoir Heater Temperature High	User selectable limit. Abort after 5 seconds. ***Possible Cause: Heater jacket not installed correctly, heater failure.***
Reservoir Heater Jacket T/C Failure		x	Heater Active	+32000 ºC		Safety PLC Shutdown - Reservoir Heater Temperature Thermocouple Failure	Abort after 5 seconds. ***Possible Cause: TC failure, TC not connected.***
Heater Tube Temp T/C Failure		x	Test active	+32000 ºC		Safety PLC Shutdown - Heater Tube Temperature Thermocouple Failure	Abort after 5 seconds. ***Possible Cause: TC failure, TC not connected.***
Outlet Temp T/C Failure		x	Test active	+32000 ºC		Safety PLC Shutdown - Outlet Temperature Thermocouple Failure	Abort after 5 seconds. ***Possible Cause: TC failure, TC not connected.***

Addendum 'B' – Test Time Matrix

The following details the time for each step associated with the particular test.

Hot Spot Determination

NOTE: Once the 'Hot Spot Determination' test is initiated, heater tube temperature will ramp to an allowable range determined by the control setpoint (375 °C = range of 373 – 377 °C). Once within range (~10 minutes), the test timer will start. The following actions will occur at the noted time designation (times are approximate).

Test Time (HH:MM:SS)	Action
00:30:00	Prepare for temperature profile capture
00:30:00	At 'A' position (10mm), begin temperature profile capture
00:31:00	Move to 'A-4' position (6mm)
00:33:30	Store 'A-4' data (6mm), move to 'A' position (10mm)
00:36:00	Store 'A' data (10mm), move to 'A+4' position (14mm)
00:38:30	Store 'A+4' data (14mm), move to 'A+10' position (20mm)
00:41:00	Store 'A+10' data (20mm), move to 'A+14' position (24mm)
00:43:30	Store 'A+14' data (24mm), move to 'A+20' position (30mm)
00:46:00	Store 'A+20' data (30mm), move to 'A+30' position (40mm)
00:48:30	Store 'A+30' data (40mm), move to 'A+40' position (50mm)
00:51:00	Store 'A+40' data (50mm), move to 'A+50' position (60mm)
00:53:30	Store 'A+50' data (60mm)
00:55:00	Stop temperature profile capture
00:55:00	Hot Spot complete, heater tube cool down

Hot Spot Validation

NOTE: Once the 'Hot Spot Validation' test is initiated, heater tube temperature will ramp to an allowable range determined by the control setpoint (375 °C = range of 373 - 377 °C). Once within range (~10 minutes), the test timer will start. The following actions will occur at the noted time designation (times are approximate).

Test Time (HH:MM:SS)	Action
00:30:00	Prepare for temperature profile capture
00:30:00	At ‘A’ position, begin temperature profile capture
00:31:00	Move to ‘A-4’ position
00:33:30	Store ‘A-4’ data, move to ‘A’ position
00:36:00	Store ‘A’ data, move to ‘A+4’ position
00:38:30	Store ‘A+4’ data, move to ‘A+10’ position
00:41:00	Store ‘A+10’ data, move to ‘A+14’ position
00:43:30	Store ‘A+14’ data, move to ‘A+20’ position
00:46:00	Store ‘A+20’ data, move to ‘A+30’ position
00:48:30	Store ‘A+30’ data, move to ‘A+40’ position
00:51:00	Store ‘A+40’ data, move to ‘A+50’ position
00:53:30	Store ‘A+50’ data
00:55:00	Stop temperature profile capture
00:55:00	Hot Spot complete, heater tube cool down

Hot Spot Demo

NOTE: The following actions will occur at the noted time designation once a start permissive is achieved (Demo Mode must be enabled).

Test Time (HH:MM:SS)	Action
00:00:00	Ramping heater tube temperature to setpoint (≈ 10 min)
00:00:30	Heater tube at temperature, equalizing for 30 min
00:01:00	Prepare for temperature profile capture
00:01:30	Move to 'A' position (10mm)
00:02:00	Move to ‘A-4’ position (6mm)
00:02:30	Store ‘A-4’ data (6mm), move to ‘A” position (10mm)
00:03:00	Store ‘A’ data (10mm), move to ‘A+4’ position (14mm)
00:03:30	Store ‘A+4’ data (14mm), move to ‘A+10’ position (20mm)
00:04:00	Store ‘A+10’ data (20mm), move to ‘A+14’ position (24mm)
00:04:30	Store ‘A+14’ data (24mm), move to ‘A+20’ position (30mm)
00:05:00	Store ‘A+20’ data (30mm), move to ‘A+30’ position (40mm)
00:05:30	Store ‘A+30’ data (40mm), move to ‘A+40’ position (50mm)
00:06:00	Store ‘A+40’ data (50mm), move to ‘A+50’ position (60mm)
00:06:30	Store ‘A+50’ data (60mm)
00:07:00	Stop temperature profile capture
00:07:30	Prepare for test completion
00:08:00	Test complete
00:08:30	Stop devices - heater tube cooldown (wait for outlet temp < 40 °C)
00:09:00	Cooldown complete, stop cooler
00:09:30	Demo hot spot test sequence complete, move thermocouple to home position

20 Hour Test

NOTE: Once the '20 hour' test is initiated, heater tube temperature will ramp to an allowable range determined by the control setpoint (375 °C = range of 373 - 377 °C). Once within range (~10 minutes), the test timer will start. The following actions will occur at the noted time designation (times are approximate).

Test Time (HH:MM:SS)	Action
00:30:00	Prepare for temperature profile #1 capture
00:30:00	At 'A' position, start temperature profile #1 moves, move to 'A-4' position
00:31:00	Store 'A-4' data, move to 'A' position
00:33:00	Store 'A' data, move to 'A+4' position
00:35:00	Store 'A+4' data, move to 'A+10' position
00:37:00	Store 'A+10' data, move to 'A+14' position
00:39:00	Store 'A+14' data, move to 'A+20' position
00:41:00	Store 'A+20' data, move to 'A+30' position
00:43:00	Store 'A+30' data, move to 'A+40' position
00:45:00	Store 'A+40' data, move to 'A+50' position
00:48:00	Store 'A+50' data, move to 'A' position
00:51:00	Store 'A' data, move to 'A+40' position
00:54:00	Store 'A+40' data, move to 'A' position
00:57:00	Store 'A' data, move to 'A+40' position
01:00:00	Store 'A+40' data, profile #1 complete
01:01:00	Calculate mean temperature
01:01:00	Prepare for test, control at mean temperature

******** test duration ********

19:01:00	Prepare for temperature profile #2 capture
19:01:00	Initiate temperature profile #2 capture
19:02:00	Move to 'A-4' position
19:04:00	Store 'A-4' data, move to 'A' position
19:06:00	Store 'A' data, move to 'A+4' position
19:08:00	Store "A+4' data, move to 'A+10' position
19:10:00	Store 'A+10' data, move to 'A+14' position
19:12:00	Store 'A+14' data, move to 'A+20' position
19:14:00	Store 'A+20' data, move to 'A+30' position
19:16:00	Store 'A+30' data, move to 'A+40' position
19:18:00	Store 'A+40' data, move to 'A+50' position
19:20:00	Store 'A+50' data, move to 'A+40' position, profile #2 complete
19:20:00	Prepare for test completion, control at mean temperature
20:00:00	20 hr test complete, heater tube cool down

40 Hour Test

NOTE: Once the '40 hour' test is initiated, heater tube temperature will ramp to an allowable range determined by the control setpoint (375 °C = range of 373 - 377 °C). Once within range (~10 minutes), the test timer will start. The following actions will occur at the noted time designation (times are approximate).

Test Time (HH:MM:SS)	Action
00:30:00	Prepare for temperature profile #1 capture
00:30:00	At 'A' position, start temperature profile #1 moves, move to 'A-4' position
00:31:00	Store 'A-4' data, move to 'A' position
00:33:00	Store 'A' data, move to 'A+4' position
00:35:00	Store 'A+4' data, move to 'A+10' position
00:37:00	Store 'A+10' data, move to 'A+14' position
00:39:00	Store 'A+14' data, move to 'A+20' position
00:41:00	Store 'A+20' data, move to 'A+30' position
00:43:00	Store 'A+30' data, move to 'A+40' position
00:45:00	Store 'A+40' data, move to 'A+50' position
00:48:00	Store 'A+50' data, move to 'A' position
00:51:00	Store 'A' data, move to 'A+40' position
00:54:00	Store 'A+40' data, move to 'A' position
00:57:00	Store 'A' data, move to 'A+40' position
01:00:00	Store 'A+40' data, profile #1 complete
01:01:00	Calculate mean temperature
01:01:00	Prepare for test, control at mean temperature

******** test duration ********

39:01:00	Prepare for temperature profile #2 capture
39:01:00	Initiate temperature profile #2 capture
39:02:00	Move to 'A-4' position
39:04:00	Store 'A-4' position, move to 'A' position
39:06:00	Store 'A' data, move to 'A+4' position
39:08:00	Store 'A+4' data, move to 'A+10' position
39:10:00	Store 'A+10' data, move to 'A+14' position
39:12:00	Store 'A+14' data, move to 'A+20' position
39:14:00	Store 'A+20' data, move to 'A+30' position
39:16:00	Store 'A+30' data, move to 'A+40' position
39:18:00	Store 'A+40' data, move to 'A+50' position
39:20:00	Store 'A+50' data, move to 'A+40' position, profile #2 complete
39:20:00	Prepare for test completion, control at mean temperature
40:00:00	40 hr test complete, heater tube cool down

20 + 20 Hour Test

NOTE: Once the '20+20 hour' test is initiated, heater tube temperature will ramp to an allowable range determined by the control setpoint (375 °C = range of 373 - 377 °C). Once within range (~10 minutes), the test timer will start. The following actions will occur at the noted time designation (times are approximate). Test is comprised of two (2) 20 hour sequences.

Test Time (HH:MM:SS)	Action
00:30:00	Prepare for temperature profile #1 capture
00:30:00	At 'A' position, start temperature profile #1 moves, move to 'A-4' position
00:31:00	Store 'A-4' data, move to 'A' position
00:33:00	Store 'A' data, move to 'A+4' position
00:35:00	Store 'A+4' data, move to 'A+10' position
00:37:00	Store 'A+10' data, move to 'A+14' position
00:39:00	Store 'A+14' data, move to 'A+20' position
00:41:00	Store 'A+20' data, move to 'A+30' position
00:43:00	Store 'A+30' data, move to 'A+40' position
00:45:00	Store 'A+40' data, move to 'A+50' position
00:48:00	Store 'A+50' data, move to 'A' position
00:51:00	Store 'A' data, move to 'A+40' position
00:54:00	Store 'A+40' data, move to 'A' position
00:57:00	Store 'A' data, move to 'A+40' position
01:00:00	Store 'A+40' data, profile #1 complete
01:01:00	Calculate mean temperature
01:01:00	Prepare for test, control at mean temperature

******** test duration ********

19:01:00	Prepare for temperature profile #2 capture
19:01:00	Initiate temperature profile #2 capture
19:02:00	Move to 'A-4' position
19:04:00	Store 'A-4' data, move to 'A' position
19:06:00	Store 'A' data, move to 'A+4' position
19:08:00	Store 'A+4' data, move to 'A+10' position
19:10:00	Store 'A+10' data, move to 'A+14' position
19:12:00	Store 'A+14' data, move to 'A+20' position
19:14:00	Store 'A+20' data, move to 'A+30' position
19:16:00	Store 'A+30' data, move to 'A+40' position
19:18:00	Store 'A+40' data, move to 'A+50' position
19:20:00	Store 'A+50' data, move to 'A+40' position, profile #2 complete
19:20:00	Prepare for 1st 20 hr test completion, control at mean temperature
20:00:00	1st 20 hr test complete, heater tube cool down

******** Pause to check heater tube ********
******** Resume 20+20 hr test ********

NOTE: Once the '20+20 hour' test is resumed, heater tube thermocouple will move to the A+40 position and the heater tube temperature will ramp to the mean control temperature. When heater tube temperature is achieved, 2nd 20 hr sequence timing will start. The following actions will occur at the noted time designation (times are approximate).

******** test duration ********

39:01:00	Prepare for temperature profile #3 capture
39:01:00	Initiate temperature profile #3 capture
39:02:00	Move to 'A-4' position
39:04:00	Store 'A-4' data, move to 'A' position
39:06:00	Store 'A' data, move to 'A+4' position
39:08:00	Store 'A+4' data, move to 'A+10' position
39:10:00	Store 'A+10' data, move to 'A+14' position
39:12:00	Store 'A+14' data, move to 'A+20' position
39:14:00	Store 'A+20' data, move to 'A+30' position
39:16:00	Store 'A+30' data, move to 'A+40' position
39:18:00	Store 'A+40' data, move to 'A+50' position
39:20:00	Store 'A+50' data, move to 'A+40' position, profile #3 complete
39:20:00	Prepare for test completion, control at mean temperature
40:00:00	20+20 hr test complete, heater tube cool down

Custom Test

NOTE: Once the 'Custom' test is initiated, heater tube temperature will ramp to an allowable range determined by the control setpoint (375 °C = range of 373 - 377 °C). Once within range (~10 minutes), the test timer will start. The following actions will occur at the noted time designation (times are approximate).

Test Time (HH:MM:SS)	Action
00:30:00	Prepare for temperature profile #1 capture
00:30:00	At 'A' position, start temperature profile #1 moves, move to 'A-4' position
00:31:00	Store 'A-4' data, move to 'A' position
00:33:00	Store 'A' data, move to 'A+4' position
00:35:00	Store 'A+4' data, move to 'A+10' position
00:37:00	Store 'A+10' data, move to 'A+14' position
00:39:00	Store 'A+14' data, move to 'A+20' position
00:41:00	Store 'A+20' data, move to 'A+30' position
00:43:00	Store 'A+30' data, move to 'A+40' position
00:45:00	Store 'A+40' data, move to 'A+50' position
00:48:00	Store 'A+50' data, move to 'A' position
00:51:00	Store 'A' data, move to 'A+40' position
00:54:00	Store 'A+40' data, move to 'A' position
00:57:00	Store 'A' data, move to 'A+40' position
01:00:00	Store 'A+40' data, profile #1 complete
01:01:00	Calculate mean temperature
01:01:00	Prepare for test, control at mean temperature

******** test duration ********

(if profile 2 is enabled by operator, steps are calculated as shown below)

(if profile 2 is not enabled, test will run until value defined in step 15 is completed)

(step 1)	Prepare for temperature profile #2 capture	***(custom time (sec) - 3570 sec)***
(step 2)	Initiate temperature profile #2 capture	***(Step1 + 30 sec)***
(step 3)	Move to 'A-4' position	***(Step 2 + 60 sec)***
(step 4)	Store 'A-4' data, move to 'A' position	***(Step 3 + 120 sec)***
(step 5)	Store 'A' data, move to 'A+4' position	***(Step 4 + 120 sec)***
(step 6)	Store 'A+4' data, move to 'A+10' position	***(Step 5 + 120 sec)***
(step 7)	Store 'A+10' data, move to 'A+14' position	***(Step 6 + 120 sec)***
(step 8)	Store 'A+14' data, move to 'A+20' position	***(Step 7 + 120 sec)***
(step 9)	Store 'A+20' data, move to 'A+30' position	***(Step 8 + 120 sec)***
(step 10)	Store 'A+30' data, move to 'A+40' position	***(Step 9 + 120 sec)***
(step 11)	Store 'A+40' data, move to 'A+50' position	***(Step 10 + 120 sec)***
(step 12)	Store 'A+50' data, move to 'A+40' position, profile #2 complete	***(Step 11 + 120 sec)***
(step 13)	Prepare for test completion	***(Step 12 + 30 sec)***
(step 14)	Control at mean temperature	***(Step 13 + 30 sec)***
(step 15)	Custom test complete, heater tube cool down	

Test Demo

NOTE: The following actions will occur at the noted time designation once a start permissive is achieved (Demo Mode must be enabled).

Test Time (HH:MM:SS)	Action
00:00:00	Ramping heater tube temperature to setpoint (≈ 10 min)
00:00:30	Heater tube at temperature, equalizing for 30 min
00:01:00	Prepare for temperature profile #1 capture
00:01:30	Start profile #1 moves, move to ‘A-4’ position
00:02:00	Store ‘A-4’ data, move to ‘A’ position
00:02:30	Store ‘A’ data, move to ‘A+4’ position
00:03:00	Store ‘A+4’ data, move to ‘A+10’ position
00:03:30	Store ‘A+10’ data, move to ‘A+14’ position
00:04:00	Store ‘A+14’ data, move to ‘A+20’ position
00:04:30	Store ‘A+20’ data, move to ‘A+30’ position
00:05:00	Store ‘A+30’ data, move to ‘A+40’ position
00:05:30	Store ‘A+40’ data, move to ‘A+50’ position
00:06:00	Store ‘A+50’ data, move to ‘A’ position
00:06:30	Store ‘A’ data, move to ‘A+40’ position
00:07:00	Store ‘A+40’ data, move to ‘A’ position
00:07:30	Store ‘A’ data, move to ‘A+40’ position
00:08:00	Store ‘A+40’ data, profile #1 complete
00:08:30	Calculate mean temperature
00:09:00	Prepare for test, control at mean temperature

******** test duration ********

00:10:00	Prepare for temperature profile #2 capture
00:10:30	Initiate temperature profile #2 capture
00:10:40	Move to 'A' position
00:11:00	Move to ‘A-4’ position
00:11:30	Store ‘A-4’ data, move to ‘A’ position
00:12:00	Store ‘A’ data, move to ‘A+4’ position
00:12:30	Store ‘A+4’ data, move to ‘A+10’ position
00:13:00	Store ‘A+10’ data, move to ‘A+14’ position
00:13:30	Store ‘A+14’ data, move to ‘A+20’ position
00:14:00	Store ‘A+20’ data, move to ‘A+30’ position
00:14:30	Store ‘A+30’ data, move to ‘A+40’ position
00:15:00	Store ‘A+40’ data, move to ‘A+50’ position
00:15:30	Store ‘A+50’ data, move to ‘A+40’ position, profile #2 complete
00:16:00	Prepare for test completion
00:16:30	Control at mean temperature
00:17:00	Test complete
00:17:30	Stop devices - heater tube cooldown (wait for outlet temperature < 40 °C)
00:18:00	Cooldown complete, stop cooler
00:18:30	Demo test sequence complete, move thermocouple to home position

Addendum 'C' – Temperature Profile Example

Date: 08/23/2011
Time: 17:02:22

Machine #: 450-1001
Tube ID: 100818C-00117
Sample ID: BP 2197
Test
Name:
Operator: Troy
Hot Spot Offset: 5.0 mm

Temperature Data Profile #1 (20 hr)

Date	Time (sec)	Temp (DegC)	TC Position (mm)	
8/23/2011	1860	370.5	11	A-4
8/23/2011	1980	375.1	15	A
8/23/2011	2100	373.9	19	A+4
8/23/2011	2220	367.2	25	A+10
8/23/2011	2340	359.3	29	A+14
8/23/2011	2460	344.3	35	A+20
8/23/2011	2580	302.4	45	A+30
8/23/2011	2700	235.6	55	A+40
8/23/2011	2880	156.4	65	A+50
8/23/2011	3060	375.3	15	A
8/23/2011	3240	236.7	55	A+40
8/23/2011	3420	375.2	15	A
8/23/2011	3600	238.2	55	A+40

Temperature Data Profile #2 (20 hr)

Date	Time (sec)	Temp (DegC)	TC Position (mm)	
8/24/2011	68640	369.5	11	A-4
8/24/2011	68760	373.6	15	A
8/24/2011	68880	372.6	19	A+4
8/24/2011	69000	365.6	25	A+10
8/24/2011	69120	357.7	29	A+14
8/24/2011	69240	341.6	35	A+20
8/24/2011	69360	300.4	45	A+30
8/24/2011	69480	235.4	55	A+40
8/24/2011	69600	156.7	65	A+50

Addendum 'D' – Data File Example

Note: Due to length of file, entire data file is not shown

Datafile Name: 20110823_1621__20HrData.csv

Test Type: 20 Hour Test

Test Fluid: BP 2197

Lubricant Batch #:

Volume Tested: 100 ml

Average Measured Flow: 20 drops in 30.0 s

'A' Position: 15 mm

Last Heater Tube TC Calibration Date: 05/24/2011
Last System Pressure Calibration Date: 04/15/2011

Test Started: 08/23/2011 04:21:42 PM

Data recorded every 30 s

Operator: Troy
Tube ID: 100818C-00117
Machine #: 450-1001

Pump Flow: 3.60%
Hot Spot Measured Date: 08/23/2011

Reservoir Temperature Set Point: 150°C

Pressure Set Point: 200 PSI
Tube Temperature Set Point: 375°C
Test Duration: 20 h

Comments:

Real Time-HH:MM:SS	Test Time-DD:HH:MM:SS	Tube Temp. (°C)	Tube Power (amps)	Inlet Temp. (°C)	Outlet Temp. (°C)	Upper Bus Bar Temp. (°C)	Lower Bus Bar Temp. (°C)	Reservoir Temp. (°C)	System Pressure (PSI)	Tube Distance (mm)
4:22 PM	00:00:00:00	32.4	1	33.3	32.1	29	29.5	148	199.1	15
4:22 PM	00:00:00:00	63	18.5	33.5	38	29.2	29.5	149	199.1	15
4:23 PM	00:00:00:00	76.6	18.8	34.3	44.2	29.2	29.5	150	199.2	15
4:23 PM	00:00:00:00	91.7	20.8	35	50.4	29.3	29.5	150	199.4	15
4:24 PM	00:00:00:00	108.6	22.7	35.8	57.1	29.4	29.6	149	199.4	15
4:24 PM	00:00:00:00	126.4	24.4	36.7	64.1	29.4	29.7	148	199.5	15
4:25 PM	00:00:00:00	144.5	25.9	37.6	71.7	29.6	29.8	147	199.5	15
4:25 PM	00:00:00:00	163.2	27.5	38.6	79.7	29.7	29.8	148	199.6	15
4:26 PM	00:00:00:00	181.7	29.1	39.7	88.3	29.9	29.8	149	199.8	15
4:26 PM	00:00:00:00	200	31.5	41	99.7	30.1	29.9	150	199.8	15
4:27 PM	00:00:00:00	218.6	33.5	42.3	112.8	30.3	30	150	200	15
4:27 PM	00:00:00:00	237.3	35.4	43.9	125.8	30.6	30.1	149	200	15
4:28 PM	00:00:00:00	255.8	37.3	45.6	140.2	30.8	30.2	148	200	15
4:28 PM	00:00:00:00	274.3	39.3	47.4	154.6	31.1	30.2	147	200.1	15
4:29 PM	00:00:00:00	293.1	41.3	49.4	169.4	31.5	30.4	148	200.2	15
4:29 PM	00:00:00:00	311.8	43.2	51.7	184.1	31.8	30.4	149	200.3	15
4:30 PM	00:00:00:00	330.5	45.2	54.1	198.8	32.1	30.6	150	200.5	15
4:30 PM	00:00:00:00	349.1	46.8	56.8	213.5	32.5	30.8	150	200.5	15
4:31 PM	00:00:00:00	367.8	48.4	59.6	228	32.9	31	149	200.5	15

4:31 PM	00:00:00:22	374.3	46.9	62.4	239	33.4	31.2	148	200.6	15
4:32 PM	00:00:00:52	375.1	46.1	64.6	244.8	33.7	31.3	147	200.7	15
4:32 PM	00:00:01:22	375.3	45.7	66.4	248.7	34	31.5	148	200.7	15
4:33 PM	00:00:01:52	375.5	45.2	67.7	251.7	34.3	31.7	149	200.9	15
4:33 PM	00:00:02:23	375.5	44.8	68.9	253.9	34.6	31.9	150	200.9	15
4:34 PM	00:00:02:52	375.4	44.5	69.9	255.7	34.8	32	150	201	15
4:34 PM	00:00:03:23	375.4	44.4	70.6	257.3	34.9	32.1	149	201.1	15
4:35 PM	00:00:03:52	375.3	44.1	71.3	258.6	35	32.3	148	201.1	15
4:35 PM	00:00:04:23	375.3	43.9	71.9	259.7	35.2	32.4	147	201.1	15
4:36 PM	00:00:04:53	375.2	43.9	72.5	260.6	35.3	32.6	148	201.1	15
4:36 PM	00:00:05:23	375.2	43.7	73	261.4	35.4	32.7	149	201.2	15
4:37 PM	00:00:05:53	375.2	43.5	73.4	262.1	35.5	32.8	150	201.3	15
4:37 PM	00:00:06:23	375.1	43.5	73.8	262.6	35.6	32.9	150	201.5	15
4:38 PM	00:00:06:53	375.1	43.4	74.2	263.1	35.8	32.9	150	201.5	15
4:38 PM	00:00:07:23	375.1	43.4	74.5	263.5	35.8	33.1	149	201.6	15
4:39 PM	00:00:07:53	375.1	43.3	74.8	264	36	33.1	148	201.5	15
4:39 PM	00:00:08:23	375	43.3	75.1	264.5	36	33.3	148	201.6	15
4:40 PM	00:00:08:53	375	43.4	75.3	265.5	36.1	33.3	148	201.6	15
4:40 PM	00:00:09:23	375	43.5	75.6	266	36.2	33.3	150	201.8	15
4:41 PM	00:00:09:54	375	43.5	75.9	266.2	36.3	33.5	151	201.9	15
4:41 PM	00:00:10:24	375	43.4	76.2	266.4	36.3	33.5	150	202	15
4:42 PM	00:00:10:54	375	43.4	76.3	266.6	36.4	33.7	149	202	15
4:42 PM	00:00:11:24	375	43.3	76.5	266.8	36.4	33.7	148	202	15
4:43 PM	00:00:11:54	375.1	43.3	77.8	266.7	36.5	33.8	147	202	15
4:43 PM	00:00:12:24	375.1	43.1	78.8	267	36.5	33.9	148	202.1	15
4:44 PM	00:00:12:54	375.1	43	79.3	267.1	36.6	34	150	202.1	15
4:44 PM	00:00:13:24	374.9	43.2	78.3	267.3	36.6	34	151	202.3	15
4:45 PM	00:00:13:55	375	43.1	78	267.3	36.7	34.1	150	202.3	15
4:45 PM	00:00:14:25	375	43.1	77.9	267.3	36.8	34.1	149	202.4	15
4:46 PM	00:00:14:55	375	43.1	78	267.3	36.9	34.2	148	202.3	15
4:46 PM	00:00:15:25	375	43.2	78	267.4	36.9	34.2	148	202.3	15
4:47 PM	00:00:15:55	375	43.1	78	267.5	36.9	34.3	148	202.4	15
4:47 PM	00:00:16:25	375	43.2	78.1	267.5	37	34.3	149	202.5	15
4:48 PM	00:00:16:55	375	43.2	78.2	267.5	37	34.4	150	202.7	15
4:48 PM	00:00:17:25	375	43.2	78.3	267.4	37.1	34.5	150	202.7	15
4:49 PM	00:00:17:55	375.1	43.1	78.3	267.4	37.2	34.5	150	202.8	15
4:49 PM	00:00:18:26	375.1	43.1	78.3	267.4	37.2	34.5	149	202.8	15
4:50 PM	00:00:18:56	375	43.2	78.4	267.5	37.3	34.5	148	202.8	15
4:50 PM	00:00:19:26	375.1	43.1	78.5	267.5	37.3	34.4	148	202.7	15
4:51 PM	00:00:19:56	375	43.1	78.6	267.5	37.4	34.5	149	202.8	15
4:51 PM	00:00:20:26	375	43	78.6	267.4	37.5	34.6	150	202.9	15

Addendum 'E' – Report File Example

FALEX FT2 REPORT
20110825

TEST DETAILS

Datafile Name: 20110825_1539__20HrData.csv	
Test Type: 20 Hour Test	Operator: Troy
Test Fluid: BP 2197	Tube ID: 100819C-00355
Lubricant Batch #:	Machine #: 450-1001
Volume Tested: 100 ml	
Average Measured Flow: 20 drops in 30.0 s	Pump Flow: 3.60%
'A' Position: 15 mm	Hot Spot Measured Date: 08/23/2011
Last Heater Tube TC Calibration Date: 05/24/2011	Reservoir Temperature Set Point: 150°C
Last System Pressure Calibration Date: 04/15/2011	Pressure Set Point: 200 PSI
Test Started: 08/25/2011 03:39:59 PM	Tube Temperature Set Point: 375°C
Data recorded every 30 s	Test Duration: 20 h

Comments:

TEST RESULTS

Instrument Control Data

			Minimum	Average	Maximum
Mean Tube Temp, (°C)	236.3	Inlet Temp, (°C)	73.6	76.0	76.8
		Outlet Temp, (°C)	269.1	271.9	273.2
		Power Level, (Amps)	43.0	43.2	43.5

Test Tube, (mg)

Final Tube Mass			
Initial Tube Mass		Mass Change	

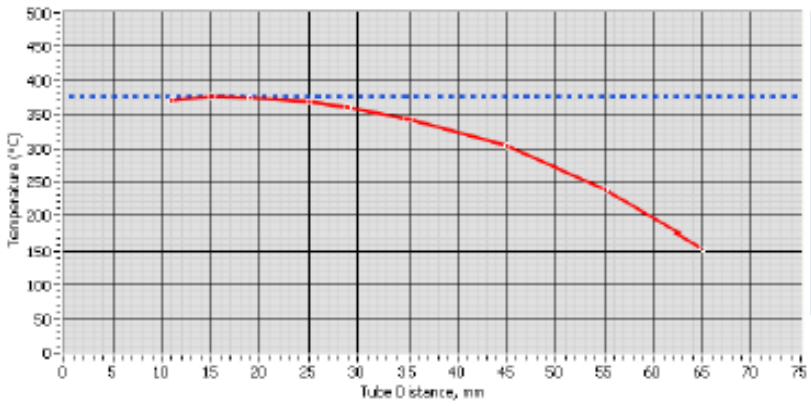
Test Fluid Properties:

Initial Viscosity @ 40°C			
Final Viscosity @ 40°C		Viscosity Change	
Initial TAN			
Final TAN		TAN Change	

FALEX FT2 REPORT
20110825

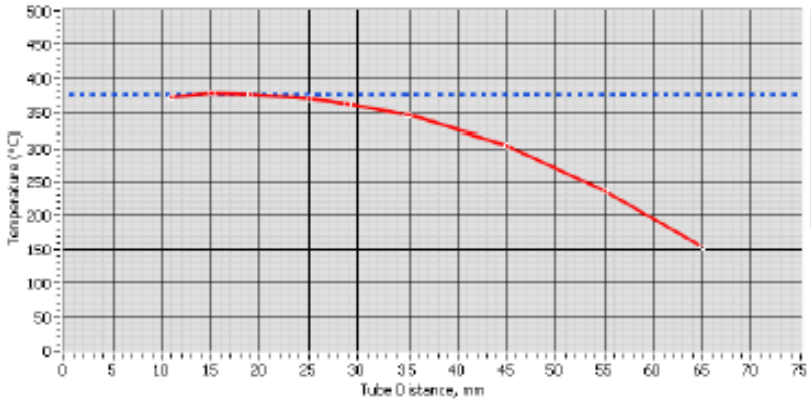
TUBE TEMP PROFILE GRAPHS

Tube Temp Profile Graph # 1



Tube Temp (°C)	TC Position (mm)	
371.0	11.0	A-4
375.1	15.0	A
374.5	19.0	A+4
367.6	25.0	A+10
360.1	29.0	A+14
343.1	35.0	A+20
302.8	45.0	A+30
237.9	55.0	A+40
154.0	65.0	A+50
375.6	15.0	A
235.5	55.0	A+40
375.6	15.0	A
235.7	55.0	A+40

Tube Temp Profile Graph # 2



Tube Temp (°C)	TC Position (mm)	
373.0	11.0	A-4
377.2	15.0	A
376.2	19.0	A+4
369.3	25.0	A+10
361.9	29.0	A+14
345.9	35.0	A+20
303.0	45.0	A+30
235.7	55.0	A+40
153.7	65.0	A+50