Section 9

TECHNICAL NOTES

1.0 SCOPE

1.1 Instructions for the installation of the Model 3984 Isolated Interface Module on an existing furnace with a Bodine Electric drive motor and Model 3911 Motor Speed Board.

2.0 EQUIPMENT AFFECTED

2.1 Motor Speed Board Model 3911

2.2 Isolated Interface Module Model 3984

3.0 ADJUST MOTOR SPEED BOARD MODEL 3911

3.1 Start furnace. On Furnace program Process Screen, set belt speed to zero.

3.2 Using a nonconductive adjustment tool, adjust the each of the pots at the top of the motor speed board:

3.2.1 Set zero. Turn Min pot to full counter clockwise (CCW). Adjust clockwise (CW) until motor starts. Turn CCW until motor stops.

3.2.2 Set Max pot full CW and turn back ¼ turn.

3.2.3 Set Acceleration at between full CCW and midpoint.

3.2.4 Set Deceleration at between full CCW and midpoint.

3.2.5 Set Torque to full CW, adjust slightly CCW.

3.3 For reference, the pots to be adjusted are located from left to right as in the following table.

3911 POTS	MAX	MIN	ACCEL	DECEL	TORQ
Preferred Settings:	just CCW from Full CW	turn CW until motor stops	midway bet CCW and midpoint	midway bet CCW and midpoint	just CCW from Full CW

4.0 INSTALL 3984 ISOLATED INTERFACE MODULE

4.1 Inspect 3984 Board and verify that DS1 dip switches are all in OFF positions.

4.2 Make sure furnace is DISCONNECTED from facility power.

4.3 Remove panels to enable access to drive motor at the exit end of the furnace.

4.4 Using the supplied Mounting Template for the 3984 Isolated Interface Module, mark for 4 holes. Drill using 4 mm (5/32 inch) drill bit. In a convenient place on the motor control panel. (see Figure 1)

4.5 Mount the 3984 Isolated Interface Module using the supplied #8 machine screw fasteners.

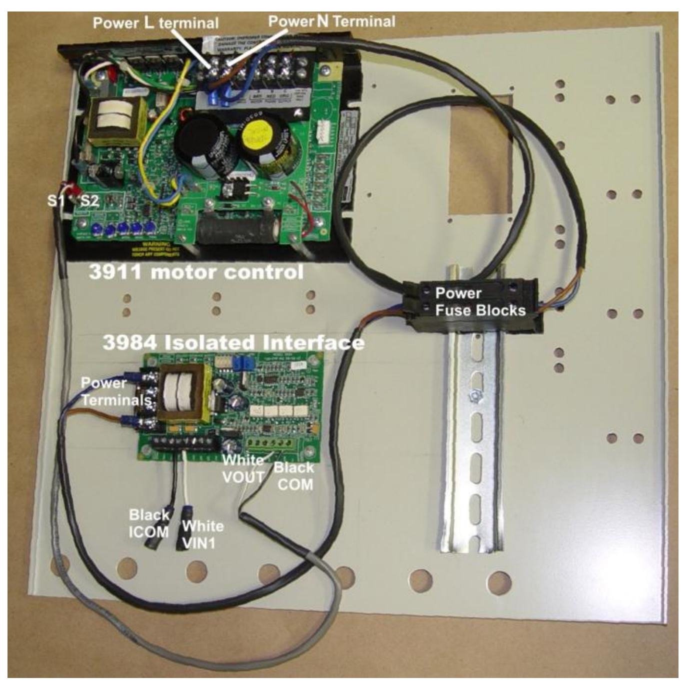


Figure 1 Motor control Panel Layout

4.6 Disconnect the spade wire connections from S1 and S2 on the 3911 Motor Speed board.

4.7 Take these same wires and Plug black S1 into ICOM and white S2 into VIN1 connectors on the 3984 Isolated Interface Module. (see Figure 1)

4.8 Plug connectors coming from the VOUT & COM on the 3984 Isolated Interface Module black S1 and white S2 wires into the 3911 Motor Speed board spade connectors labeled S1 and S2 respectively.

4.9 Connect power (see Figure 2). Loosen screws on the 3911 Motor Speed board terminal block marked L and N. Slip the brown power wire terminal into the L screw then tighten. Slip the blue wire terminal into the N screw then tighten. Snap the two fuse blocks onto the DIN rail next to the existing fuse block.

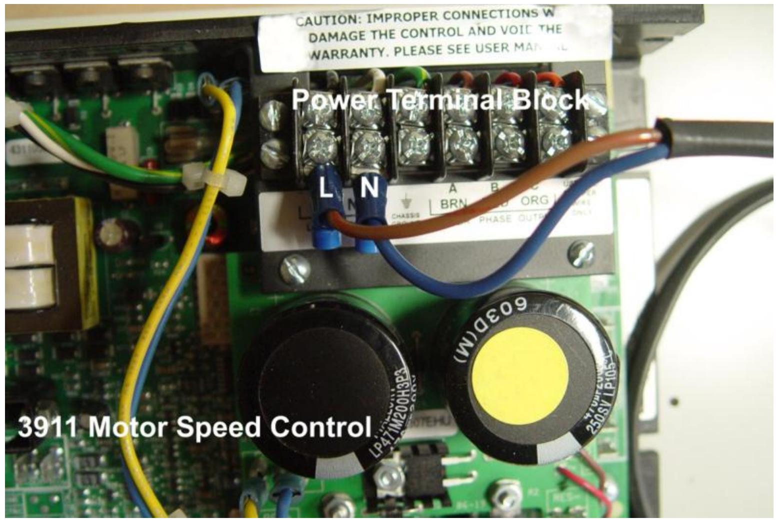


Figure 2 Power connect from 3984 module

5.0 CALIBRATE ISOLATED INTERFACE MODULE MODEL 3984

5.1 Set zero. Using a small flat screwdriver and a DC Voltmeter + on VOUT and – on COM, turn the Min pot CCW until motor stops and Voltmeter reads 0.120 to 0.130. If DC Volts will not go under 0.200 re-adjust MIN pot on the 3911 board until the Volts drop to 0.120-0.130. Adjust 3984 min pot CW until motor starts again. Turn 3984 min pot CCW again until motor stops and DC volts are within range.

5.2 Go to Furnace Calibration screen and click Transport Belt 1 Calibration checkbox to “Set 50% output to calibrate”.

5.3 Adjust Max pot until voltage across Vout and Com equals 5.0 Vdc.

5.4 For reference, the pots to be adjusted are labeled Min and Max as in the following table.

3984 POTS	MIN	MAX
Field Adjustment	turn CW until motor stops	3984 $V_{out\text{-}com}$ = 5 Vdc or 3911 $V_{S1\text{-}S2}$ = 5.0 Vdc

6.0 REPLACE FURNACE PANELS

6.1 Replace all panels and fasteners.

7.0 CALIBRATE BELT SPEED

7.1 Use standard procedure for belt speed calibration.

1.0 SCOPE

1.1 Instructions for the setup and installation of the SNAP-LCM4 Controller on an IR furnace.

2.0 EQUIPMENT AFFECTED

2.1 Snap LCM4 Furnace controller

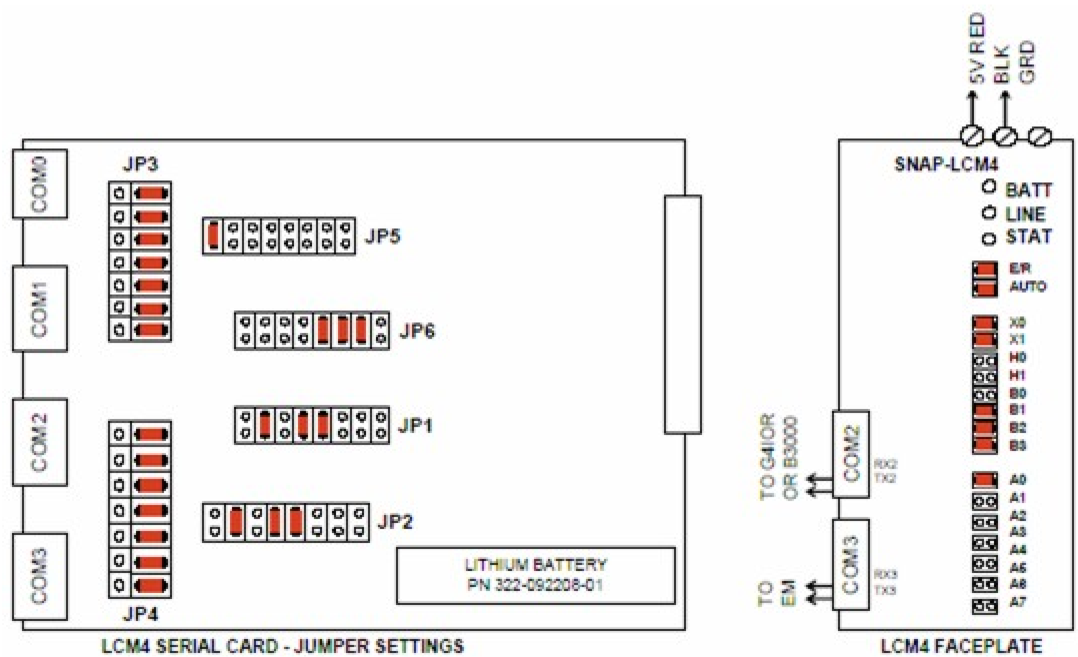
2.2 Power Supply, 5 Vdc

3.0 CONFIGURATION

3.1 Remove blank plate and install M4SENET-100 Ethernet card in any empty slot of the LCM4 controller

3.2 Remove serial card and verify that the jumper settings are as below. Replace serial card.

3.3 Verify jumper settings on LCM4 Faceplate.



4.0 INSTALLATION

4.1 Mount LCM4 horizontally or vertically in a secure location close to 5 Vdc power supply.

4.2 Connect LCM4 to a dedicated 5 Vdc power supply. Supply voltage should be maintained at between 5.1 Vdc -5.2 Vdc.

4.3 Connect the supplied tantalum capacitor across the 5 Vdc and Common terminals of the power supply dedicated to the LCM4 Controller.

CAUTION: The power supply used for the SNAP-LCM4 should not be used to supply any other equipment. Field devices must not be supplied by the same power supply used for the controller, as the optical isolation of the I/O modules would be bypassed and the voltage fluctuations to the controller might cause controller resets.

4.4 Connect cable from G4IOR interface or B3000 or B3000-B brain to COM2.

4.5 If equipped with a serial element monitoring system (EM), connect EM cable to COM3.

4.6 Connect Ethernet TCP/IP cable to M4SENET-100 card if so equipped.

5.0 BATTERY

5.1 The Opto22 LCM4 controller has a lithium backup battery with a 5-year life cycle, but other factors may affect its service time. Storing the unit with the furnace power off shortens the battery lifespan. The battery will actively back up RAM when the Furnace is OFF. When the battery is near the end of its useful life the BATT LED will turn red. Once the battery begins to fail, the furnace controller will often fail to retain program parameters after power is lost to the controller. Eventually the program may not reset or may fail to load. BATT LED is normally green.

5.2 If the battery fails replace with part number 322-092208-01.

6.0 TROUBLESHOOTING

Use the following table to troubleshoot Opto22 PLC communication problems:

Table 6-1 PLC Opto22 Troubleshooting Guide

INDICATION	EXPLANATION	REMEDY
LINE LED is off	No Power.	Check wiring.
LIINE LED is red or Controller resets.	Power may be out of specification	Check the power supply for 5V DC power.
STAT LED is off	Controller is faulty	Call FurnacePros Technical Support.
STAT LED blinks red	Firmware problem	Call FurnacePros Technical Support
BATT LED is red	Backup battery is low	Replace LCM4 controller battery.
RX LED is stuck on	Wiring polarity problem	Call FurnacePros Technical Support.
Controller cannot transmit to PC	Configuration jumpers were changed without cycling power.	Cycle power off/on and retry transmission.
No communication to host PC.	Communication Problems	Check serial port. Check PC IP address (10.192.105.100)
No communication to host PC. RX LED is on, but TX LED is off	Communication Problems	Check controller address (10.192.105.102), baud rate, and ASCII/binary settings.
No communication to host PC. RX and TX LEDs are on	Communication Problems	Try a slower baud rate.
No communication to I/O modules. TX LED is off while trying to communicate.	Communication Problems	Check that I/O port software is configured for correct port. If RX LEDs on I/O modules are off while trying to communicate, check for loose connections, shorts or breakage. IF RX LEDs on I/O are on, check I/O address, baud rate, and protocol setting in software.
Furnace program fails to load with correct parameters, clock is wrong, or furnace controller fails to reset	Backup battery is low (battery has a 5 year life cycle)	Replace LCM4 controller battery.

1.0 Scope

Programmable Logic Control (PLC) devices require specific voltage ranges to assure stable operation. This note provides guidelines for acceptable voltage ranges

2.0 Recommended Voltages

This following table lists preferred and acceptable ranges for select PLC devices. If power supply is adjustable, adjust to Preferred Voltage or slightly above Preferred Voltage. If power supply is not adjustable (PS5), verify the output voltage is within range. If not, replace power supply.

Table 2.1 Power Requirements

Device	Preferred Voltage	Acceptable Range
PAC-S1	24 Vdc	8-24 Vdc (1.24 A to 0.42 A)
LCM4 Controller	5.1 Vdc	5.1 to 5.2 Vdc at 2.0 A max
G432LC	5 Vdc	4.9 to 5.1 Vdc @ 2A
G432LCSX Classic Controller	5 Vdc	4.9 to 5.1 Vdc @ 2A
PAC-SB1	5.1 Vdc	5.0-5.2 Vdc @ 750 mA
B3000-B Brain	5.1 Vdc	5.1 to 5.2 Vdc at 750 mA max
B3000 Brain	5.1 Vdc	5.0 to 5.1 Vdc at 1.0 A max
G4D16R Brick	24 Vdc	23.9 to 24.1 Vdc @ 250 mA
G4A8R	24 Vdc	23.9 to 24.1 Vdc @ 180 mA
G4D32R	24 Vdc	23.5 to 24.5 Vdc @ 220 mA
G4D16R Brick	24 Vdc	23.9 to 24.1 Vdc @ 250 mA

1.0 Scope

This instruction covers installation of the capacitor on an RTC, GBT or FurnacePros furnace power supply. Stable clean power is required for IR furnace programmable logic control (PLC) equipment. Power supplies should include a properly sized capacitor to reduce noise in the dc output.

Typical tantalum capacitor showing polarity, positive (+) is on left

2.0 Capacitor

Parameter	5 V Power Supplies	24 V Power Supplies
Part Number	310-100637-05	310-100637-24
Size	6.3-10 V, 10 µF	25 V, 10µF
Type	Tantalum	Tantalum
Lead	Solid	Solid

3.0 Power Supply with Terminals

If you are installing a B3000-B or B-3000 rack or an LCM4 to a power supply equipped with terminals, install capacitor across dc positive and negative terminals at power supply, Capacitor must be installed with positive (+) lead connected to de positive terminal. Do not install across ground.

4.0 Power Supply with Leads

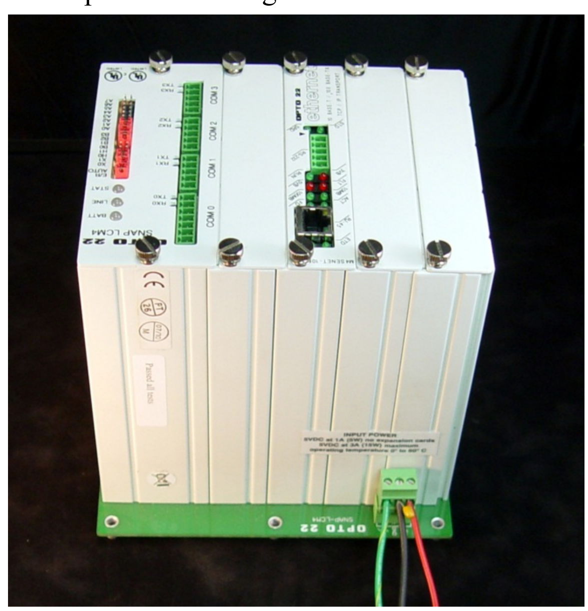
If you are installing a B3000-B or B3000 rack or an LCM4 to a power supply like a PS5 that is equipped with leads (output wires) instead of terminals, install capacitor across dc positive and negative terminals as close as possible to power supply. User terminal blocks if multiple devices are to be installed.

4.1 Single Device

If only one device such as an LCM4 is to be connected to power supply, connection capacitor across positive and negative terminals at LDM4 or other device. Capacitor must be installed with positive (+) lead connected to Vdc positive terminal on device. Do not install across ground.

4.2 Multiple Devices

If multiple devices are to be connected to power supply, use of terminal blocks is recommended. Wire power supply to terminal blocks with capacitor connected across dc positive and negative terminal blocks. Capacitor must be installed with positive (+) lead connected to Vdc positive terminal block. Do not install across ground. Wire devices to terminal blocks.



Tantalum capacitor showing polarity
Positive (+) is on the right

1.0 SCOPE

1.1 Instructions for calibrating the conveyor belt on an RTC Radiant Technology, GreenBridge Technology, or LCI infrared furnace.

2.0 TOOLS REQUIRED

2.1 Tape Measure

2.2 Stop Watch

2.3 Small Object to ride on belt

3.0 PROCEDURE

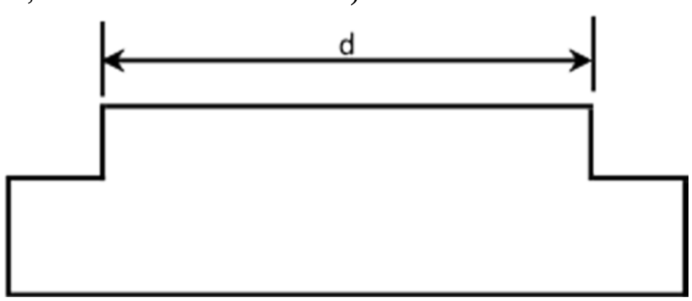
3.1 The belt speed is calibrated by first placing the furnace in the calibrate mode and after measuring the amount of time it takes for an object to travel from the entrance of the furnace to the exit, the speed is calculated and entered on the calibration screen.

Belt speed = distance / time

s = d / t

4.0 DISTANCE MEASUREMENT

4.1 Note the belt speed units on the process screen (in/min, cm/min or mm/min). Measure the distance from the face of the inlet to the outlet of the furnace in the distance units shown on the process screen for belt speed (inches, centimeters or millimeters).



Example: distance s = 315 ¼ inches

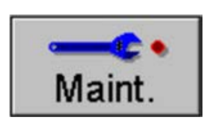
s = 315.25 inches

5.0 FURNACE CALIBRATION SCREEN

5.1 Start furnace normally.

5.2 In the furnace software, access the Calibration screen as follows:

1. To access the Calibration Screen, go the **Maintenance** Screen.



2. Click on the **Calibrate** button:

3. The following pop-up window will appear.

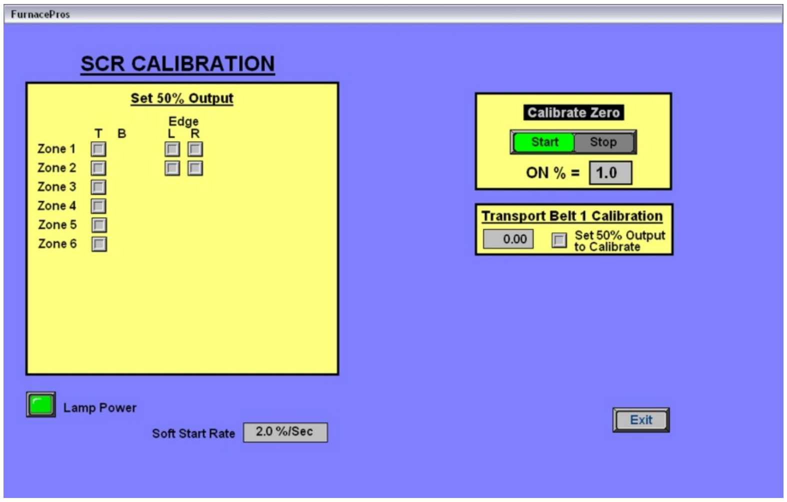


Figure 5.2.1 Calibration pop-up window

6.0 PROCEDURE

6.1 In the **Transport Belt Calibration** window, click on ***Set 50% Output to Calibrate***.

6.2 Place an object on the belt at the entrance of the furnace.

6.3 As the trailing edge of the object passes into the furnace start the stop watch timer.

6.4 As the object exits the furnace, stop the timer as the trailing edge of the object passes out of the furnace.

6.5 Convert the time from minutes and seconds to minutes as in the following example:

t = 15 minutes 24 seconds = 15 +24/60 minutes = 15.40 minutes

6.6 Divide the distance by the time to determine the speed.

Example: s = d / t

s = 315.25 in / 15.4 min = 20.4708 in/min

6.7 Enter the newly calculated speed in the **Transport Belt Calibration** box

6.8 Uncheck the ***Set 50% Output to Calibrate box***.

6.9 Belt speed calibration is complete.

7.0 BELT SPEED CALIBRATION

Distance, inches, decimal	d	
Time, min-sec	t	
Time, minutes, decimal	t	
Speed, inches per minute	s=d/t	

1.0 Application

All LCI and RTC infrared closed atmosphere belt furnaces.

2.0 Scope

To provide the process engineer with guidelines for understanding the primary factors and considerations in adjusting the furnace to achieve a specific result.

3.0 Responsibility

It is the process engineer's responsibility to identify the performance required for each process and/or product. The process engineer must then determine the Furnace Settings required to produce consistently satisfactory process results. The Furnace Settings are recorded as a Recipe for that process so that Operators can produce results that are consistent and repeatable.

4.0 Procedure

Tuning the furnace involves the following steps.

1. Identify the Process Specification required for the product.
2. Determine initial Furnace Settings.
3. Run temperature profiles on product samples in a representative load using a thermal profiler.
4. Analyze product for acceptance.
5. Review profile curve and adjust Furnace Settings, if necessary.
6. Re-run parts profiles (steps 3-5) until an acceptable and repeatable result is achieved.
7. Record Furnace Settings as a Recipe for production Operators.

5.0 Process Specification

The Process Specification defines time and temperature factors and other atmospheric conditions that will process the product in the manner required. Primary process parameters include the following:

Temperature bandwidth durations. Product temperatures and residence times for each specified phase of the process. Units are degrees Celsius and minutes (or seconds).

Rise rates. Heating rate or temperature increase per unit of time. Units are degrees Celsius per minute (or seconds).

Decline rates. Cooling rate or temperature decline per unit of time. Units are degrees Celsius per minute (or seconds).

Oxygen levels. Processes which require an oxygen-free atmosphere may stipulate low oxygen levels. Units are parts per million by volume. Typical values are (20 ppmv, 100 ppmv or 300 ppmv). Some furnaces may be equipped with continuous monitoring systems to provide real time feedback. A cost effective approach to managing O_2 levels can be to employ an analyzer to determine the initial flowmeter settings. Once the flowmeters are adjusted and provided the supply of process gas and pressure are maintained, the Operator can be assured of consistent results.

Moisture levels. Processes which require an oxygen-free may also stipulate maximum moisture levels in the heating chamber. The furnace may be equipped with equipment to sample and display moisture content in real time.

6.0 Process Specification Examples

Following are examples of typical profiles for a number of IR furnace applications.

Profile 1 – Solder Seal

- Nitrogen atmosphere with less than 20ppm O2 levels
- 100˚C to 310˚C in 6 minutes +/- 1 minute
- Maximum temperature not to exceed 330˚C
- Temperature to exceed 305 ˚C for 1.5 to 2.5 minutes
- Temperature to fall from 300˚C to 240˚C in 2.5 minutes or less

Profile 2 – Glass Seal

- Air atmosphere
- 100 ˚C to 400 ˚C in 6 minutes +/- 1 minute
- Maintain 420 to 440 ˚C for 9 minutes +/- 1.5 minute
- Maximum temperature, 430 to 440 ˚C
- Temperature to fall from 400 to 250 ˚C in 2.5 minutes

Profile 3 – PCB Reflow

- Air atmosphere – see profile detail below.

Profile Feature	Pb-Free Assembly
Preheat/Soak Temperature Min (T_{smin}) Temperature Max (T_{smax}) Time (t_s) from (T_{smin} to T_{smax})	 150 ˚C 200 ˚C 60-120 seconds
Ramp-up rate (T_L to T_p)	3 ˚C/second max.
Liquidus temperature (T_L) Time (t_L) maintained above T_L	217 ˚C 60-150 seconds
Peak package body temperature (T_p)	T_p = 260 +/- 5
Time (t_p) within 5˚C of the specified classification temperature (T_c).	30 seconds
Ramp-down rate (T_p toT_L)	6 ˚C/second max.
Time 25 ˚C to peak temperature	8 minutes max.

7.0 Furnace Settings

The primary Furnace Settings include temperature, gas flow and belt speed.

1. **Temperature.** Infrared furnace equipment temperature setpoints are determined through profiling the furnace. Secondary parameters include EDGE HEAT%, % POWER and PID parameters. Adjustment of these secondary parameters can improve operational consistency.

   CAUTION: INFRARED FURNACE TEMPERATURE SETPOINTS AND READINGS DO NOT REPRESENT THE ACTUAL TEMPERATURE OF THE FURNCE OR OF THE PRODUCT, BUT CAN SERVE AS A RELIABLE, REPEATABLE GUIDE IN THE OPERATION OF THE FURNCE ONCE TUNING IS COMPLETE FOR A GIVEN RECIPE.

2. **Gas Flow.** Gas flow settings can have multiple rolls in furnace tuning. Initial considerations may include control of oxygen an moisture levels in low O2 firing. Additional adjustments can move heat forward or toward the exit to change the temperature profile. Finally, often a stream of gas is necessary to stabilize furnace performance by assuring the lamps are always energized during production runs.

3. **Belt Speed.** Belt speed in closed loop systems can be used to provide a reliable and accurate representation of product residence time or time in each segment of the process. Small adjustments in belt speed can be used to increase or decrease time at temperature results in an otherwise good profile.

8.0 TEMPERATURE CONSIDERATIONS

Infrared furnaces have a thermocouple in each zone which provides feedback to the control system. Furnace systems do not measure the temperature of the product. The furnace thermocouples do provide some indication of zone temperatures; their primary function is to supply feedback so the control system can make necessary adjustments in power provided to the IR heating elements. **Therefore, the process engineer must determine the temperature setpoints for the furnace zones that will produce the required Process Parameters.**

As Product moves through each heating zone it absorbs infrared energy supplied by the zones. The product temperature can continue to increase in temperature even if successive furnace zones are set to the same temperature.

9.0 RECIPE ADJUSTMENTS

Once the initial settings have been entered and initial profile has been run, the Process Engineer must make adjustments to the furnace settings and tune the furnace to improve the result. This is an iterative process that is best completed when the end result is clearly stipulated and the deficiencies in the current results are carefully identified.

In tuning the furnace it is imperative that the settings and results are recorded for each test or Run. After a number of runs are made, the results can be compared along with the settings used to produce those results.

Each successive test run should incorporate only small changes, usually to a single parameter. For example, do not change gas flow and zone temperature setpoints all at the same time because it will be difficult to determine which adjustment improved or degraded performance. Also multiple adjustments may influence the result in a conflicting manner.

CHANGE RAMP RATE: Increase or decrease Zone 1 temperature to change the heating rate. The initial zone is often used to introduce energy to the part to get the part up to temperature rapidly. Zone 1 temperature setpoint maybe 50 to 200 C or more above the temperature expected in Zone 1 to assure a rapid rise rate.

INCREASE RESIDENCE TIME. To increase the time at temperature you can:

1. Increase temperature setpoint in the zone (introduces more energy in the problem zone), and/or
2. Increase temperature setpoint in the previous zone (introduces energy to the part earlier);
3. Increase temperature setpoint in the next zone (introduces energy to the part longer);
4. Increase gas flow to the zone (can cause lamps to stay on longer adding energy to the part)
5. Decrease belt speed (increased time part is exposed to energy applied in each zone).

If the profile shape is acceptable, but the part needs more residence time, decrease the belt speed by a small amount.

If the profile shape is acceptable, but the part needs more residence time, increase the temperature of the previous zone temperature by a small amount to achieve a faster rise time and earlier maximum temperature. Also you may be able to increase the temperature in the following zone to slightly delay the start of cooling phase.

If the profile shape is acceptable, but the maximum temperature is too low, increase the temperature setpoint of that zone.

LAST ZONE CONSIDERATIONS. The last furnace zone is often set a little higher than the previous zone to assure adequate energy is available to offset the effects of the transition tunnel and cooling sections. Alternately if peak residence time is already more than adequate and/or a slower or more controlled initial cooling rate is desired, lower the last zone below the previous zone to slow the rate of product cooling.

EDGE HEATERS. Use edge heaters to adjust for temperature variation across the belt. Make EH increases small to avoid reducing IR energy introduced via the lamps.

10.0 Using Multiple Furnaces for a Single Process

The specification for a given process describes the requirements to successfully process each part. These requirements are in terms of time, duration and atmosphere. Sometimes additional requirements can include temperature rise time and cooling rates. Additional requirements may be defined for the characteristics required of the processed part itself. The specification for the characteristics of the final processed part take precedent over all other considerations. If the processed part does not meet its requirements, the process parameters may be incorrect and have to be adjusted to assure a quality-assured result.

Each piece of equipment must be adjusted to produce the specified result. The settings on an IR furnace include zone temperature settings, gas flow rates, belt speed. Advanced settings include settings for PID parameters and applied power. Because of differences in hardware no two furnaces will have the same settings to achieve the desired result.

Differences in hardware include:

- Electronics – device tolerances vary
- Insulation - porosity, surface condition varies.
- Thermocouples and other sensing devices -performance varies within tolerance.

Differences in hardware due to age include:

- Electronics - newer devices are truer to original design, variations in both tolerances and sensitivity.
- Insulation – age affects porosity and surface condition.
- Thermocouples – age affects sensitivity and accuracy.
- Computer – newer operating systems, software and I/O respond differently to input data.

While two different pieces of equipment, even from the same manufacturer, can produce the same result, each piece of equipment must be tuned for its specific age, electronics and processing chambers.

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1. Application

All LCI and RTC infrared closed atmosphere belt furnaces.

2. Scope

To provide the process engineer with guidelines for adjusting the furnace to run a desired thermal process using zone setpoint temperatures, a balanced process gas flow, appropriate zone control settings and alarm/alert levels on an operating, but empty furnace. If a heating zone is not under control in an empty furnace, it will not be under control when you try to run product.

3. Responsibility

It is the process engineer's responsibility to identify the performance required for each process and/or product. The process engineer must then determine the Furnace Settings required for consistently satisfactory process results. The Furnace Settings are recorded as a Recipe for that process so that Operators can produce results that are consistent and repeatable.

4. Summary Procedure

Tuning the furnace involves the following steps. See TEC-620 for assistance with steps marked "*".

- Identify the Process Specification required for the product. *
- Determine initial Furnace Settings. *
- Repeat the next 3 steps until an acceptable and repeatable result is achieved:
  - ✓ Run temperature profiles on product samples in a representative load using a thermal profiler.
  - ✓ Analyze product for acceptance.
  - ✓ Review profile curve and adjust Furnace Settings, if necessary. *
- Record Furnace Settings as a Recipe for production Operators. *

5. Tuning Your Furnace

A. Know Your Furnace.

Refer to your furnace documentation & drawings for details.

1. Confirm proper voltage, as shown on furnace nameplate, is connected.
2. Keep in mind that lengths of RTC and LCI furnace zones may vary.
3. Number of lamps/zone varies by zone length; more lamps mean more power in the zone.
4. Understand the sources of heat in an IR furnace are different from a convection furnace:
   a) 60-70% direct IR from the lamps.
   b) 20-30% convection via process gas heated while passing through furnace insulation.
   c) 10-20% conduction from belt and edge heaters (if present).
   d) Different materials may absorb IR energy at different rates.
   e) Parts hidden from direct IR are heated indirectly by convection and conduction.
5. Gas control flowmeters may supply process gas to more than 1 zone; check flowmeter labels.

6. Locate eductors (exhaust stacks) for flow balancing; each stack can exhaust 15x its flowmeter setting of process gas volume. Pairs of eductors control gas flow within the furnace by setting one eductor flowmeter higher/lower/same compared with the other eductor. Furnaces with a single eductor at the entrance can pull process gas forward toward the entrance at a higher/lower rate depending on its flowmeter setting.

7. Check zone control thermocouple (t/c) height: it should be the same in each zone. Replace oxidized t/c when required to maintain proper zone temperatures.

8. Determine presence/absence of under-belt edge heaters; use caution when using:

   a) Edge heaters are ***not regulated*** by the zone PID control settings.

   b) They generate constant belt edge conduction heat/unit length; amount of added heat ***varies with zone length***.

   c) Settings higher than 15% ***may affect accuracy*** of zone PID control.

9. Make sure zone SCR controllers are set properly, if adjustments are available. Some controllers require manual "zero" (minimizes SCR power leakage) and/or "span" adjustments (limits maximum voltage applied to lamps); other controllers have no adjustments.

10. Locate quartz rods/tubes supporting the belt within the furnace chamber. These supports absorb heat from the bottom lamps and belt, causing local cooling of the belt immediately above the supports. This affects only parts placed directly on the belt (i.e. not in carriers).

Note: Run parts on belt in lanes ***between*** the belt support rods/tubes.

11. No two furnaces are exactly alike, even if they have the same model number. Most furnaces are built by hand as custom assemblies, with continuous small changes due to "constant improvement" programs within the various furnace manufacturers.

Note: The "same model" furnace may need different zone PID, gas flow, edge heat and/or belt speed settings for optimal tuning to meet the process specification.

12. Don't confuse ***display resolution*** with ***display accuracy*** when tuning a furnace. K-type thermocouples are accurate of only about 2% of reading and drift over time with use.

Note: A display of 305.3C means only that the actual value may be about 305C ± 2-3C.

B. Best Control

For best control, the IR lamps must remain ON at all times with constant process gas flow into and out of the furnace. If the lamps are cycling ON/OFF during processing, the furnace is not in control and not processing parts continuously with infrared radiation (heat in the zone is varying).

C. Thermal Profile

Set up a temperature profile using the Recipe Screen. This will allow you to easily save your work to the system hard drive and to access the controls and alarm/alert settings for each zone. Remember to save your work often.

1. Start with an empty furnace, the belt running, and the default gas flowmeter settings.

2. Make sure the furnace gas inflow/outflow is balanced.

3. Enter desired zone setpoint temperatures, and click on WARM UP. Observe the results of setpoint changes on the Process Screen.

4. Conditions that cause problems:

   a) Large setpoint temperature differences between adjacent zones.

   b) Setting the next zone much cooler than the preceding zone.

5. To remedy these problems:

   a) Minimize the difference in setpoints and/or reduce belt speed. Observe the results on the Process Screen.

   b) Control direction of heated gas flow in the furnace by changing exhaust eductor flows (see Section D, below).

D. Balance Gas Flow

A balanced gas flow means the same volume of gas that enters the furnace chambers exits the furnace chambers, helping ensure furnace control stability.

1. Gas flow in any zone must carry away heat when that zone's lamps are off.

2. Be aware that adjacent zones may contribute heat to the affected zone via gas flow.

3. When the zone lamps are OFF and the actual zone temperature stays the same or rises, the zone is not under control.

4. To remedy this condition, try the following adjustments either singly or in combination while observing the results on the Process Screen. Keep in mind that a properly balanced furnace will meet the criteria in item 3, above.

   a) Confirm that the SCR(s) controlling the zone have properly set "Zero" trim pots as per Section A.9, above.

   b) Raise affected zone setpoint temperature so that control of the actual zone temperature depends only on the power delivered to its lamps.

   c) Lower adjacent zone setpoint temperatures to remove excess heat transfer to the affected zone.

   d) Increase gas flowmeter settings to affected zone (more gas gets rid of heat).

   e) Control direction of gas flow in furnace (toward nearest exhaust, toward entrance, toward exit) by changing exhaust eductor flows. Make these changes in small increments, say 3-5%, keeping in mind the 15:1 effect of the exhaust eductors.

      (1) A higher entrance exhaust flow vs. the transition tunnel/exit exhaust flow will pull gas flow toward the entrance of the furnace. Effects include:

         (a) Added heat to zones near the entrance for maximum ramp up in temperature.

         (b) Any zone setpoint that is much cooler than the preceding zone.

         (c) Faster initial cooling in cooling section.

      (2) Conversely, a higher transition tunnel/exit exhaust flow will pull flow toward the exit of the furnace. Principal effect:

         (a) Pulling heat away from entrance may allow higher temperatures to be maintained with less power in zones nearer to the furnace exit.

      (3) Remember to keep the total furnace gas inflow/outflow in balance when you make any gas flow adjustments.

f) Get in the habit of storing your gas flow settings on the Gas Flow screen with each recipe so that they will be available for operator adjustment when the recipe is recalled from storage.

E. Stability

While the default zone PID control settings entered at the factory may be sufficient for most profiles, the furnace allows fine tuning of these settings, if needed. This tuning should be performed only if Sections C & D above are completed.

1. Observe the effect of your changes on the Trends screen for the selected zone and correct PID settings as required. Allow enough time (2-3 minutes) to let the zone controls settle.

2. What happens when "Gain" is adjusted:

   a) The higher the number, the bigger the amount of correction. If gain is too big, the actual temperature will oscillate above/below the setpoint. Reduce gain until the actual temperature settles quickly onto the setpoint temperature with little overshoot.

   b) **Never set gain to 0!** On RTC furnaces, typical settings are 6-30. Factory default is 9.

3. What happens when "Integral" is adjusted:

   a) The smaller the number, the quicker the correction is applied.

   b) **Never set integral to 0!** On RTC furnaces, typical settings are 25-90. Factory default is 45.

4. What happens when "Derivative" adjusted:

   a) Derivative acts on the "rate of change" of the temperature deviation and gives an anticipatory response. May be set to 0 (Derivative has no effect) for a continuous stream of similar parts entering a zone. A setting of 1 or 2 may help a furnace zone respond more quickly to an uneven flow of parts.

   b) On RTC furnaces, typical settings are 0-2; use with caution as the **IR lamps in the furnace respond quickly**. Factory default is 0.

Note: Zone control settings for this recipe are stored with the recipe when it is saved. These control settings load when the recipe loads: there is no involvement required by the operator.

F. Process Alerts and Alarms. Set up alert and alarm levels.

1. Be smart about alerts and alarms

   a) Always leave the audible horn ON . If you are getting Alerts, check temperature settings, observed deviation from setpoint, rate of recovery from the alert and current power to the lamps for the affected zone on the Process screen. Alerts are giving you and your process people valuable information -- they are not nuisances.

   b) On RTC furnaces with PLC control, use the Deviation window on the Process screen to review Alert and Alarm levels for each zone. A furnace under control will show short, green bars or no bars at all in each zone.

   c) Avoid unnecessary furnace shutdowns due to brief temperature deviations (due to uneven furnace loading, etc.). Once in the process READY mode, the control system will shut off the lamps and enter COOL DOWN whenever any zone actual temperature reaches its Alarm limit. Increasing the Alarm limits for sensitive zones from their default setting of ± 20C to ± 30C can make a big difference; the same is true for Alerts.

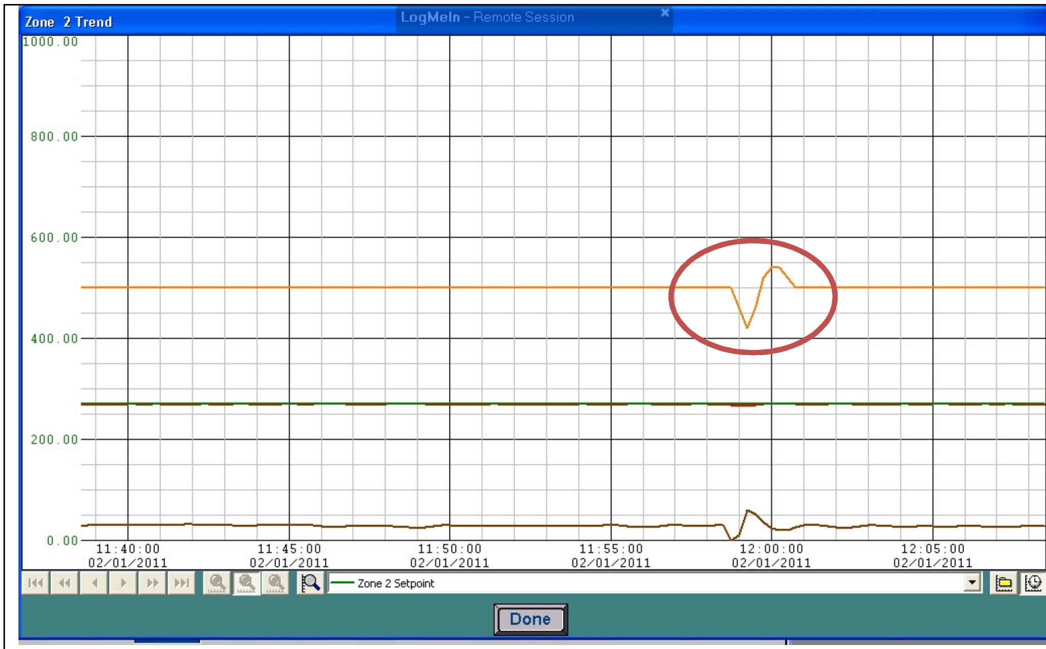
G. Examples of Zone Control

Analysis on An RTC or LCI furnace with PLC control.

1. Process In Control

a) On the Process screen, issues with zones out of control can be spotted quickly via the Deviations window. Use the Trends display assess the zone behavior and to identify a solution.

b) Table 5-1 is a Trends display of a **zone under control**. Here the zone gas flow is being replenished at an appropriate rate and the lamps are on continuously adding energy to the entering gas and belt. The furnace was placed briefly in COOL DOWN mode, then returned to WARM UP to check the control response.



< Temp Deviation

< Setpoint & Actual Temp

< Zone Lamp Power Level

Table 5-1

Observation: This is a stable zone with a balanced gas flow. Note the smooth response in the Temp Deviation trace (circled) to the COOL DOWN command followed by the WARM UP command.

Recommendation: No further adjustment required.

2. Process Needs Adjustment

a) Table 5-2 is a Trends display of Zone 1 out of control due to **gas flow imbalance**. Here the entrance exhaust eductor flow is higher than the transition tunnel exhaust eductor flow causing a net flow of gas toward the entrance of the furnace. This flow is dragging heat from the hotter Zone 2 (setpoint 270C) into Zone 1 (setpoint 210C) on its way to the entrance exhaust stack. Even with the lamps in Zone 1 off, heated gas is entering Zone 2, raising Zone 1 actual temperatures.

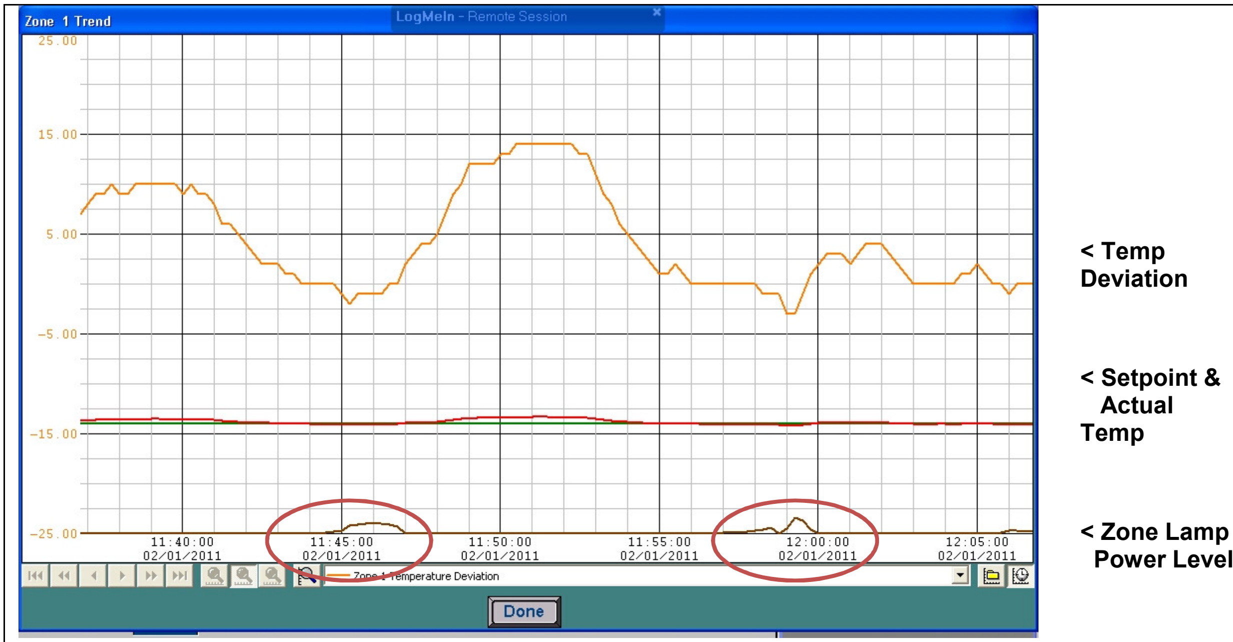


Table 5-2

Observation: Temperature deviation (difference between setpoint and actual) from -2C to + 14C observed. Lamps are on (circled areas, bottom trace) only when deviation is below 0C. During 10 minutes lamps are off, temperature rises due to gas entering from Zone 2.

Recommendation: raise transition exhaust eductor flow (while reducing entrance exhaust eductor flow) to move heated gas toward exit end of furnace. Lamps in both zones will add appropriate heat as required and the zones will be under control.

3. Effect of Changing PID Settings

a) Table 5-3 is a Trends display of the effect of a **change to the control PID settings** in a zone.

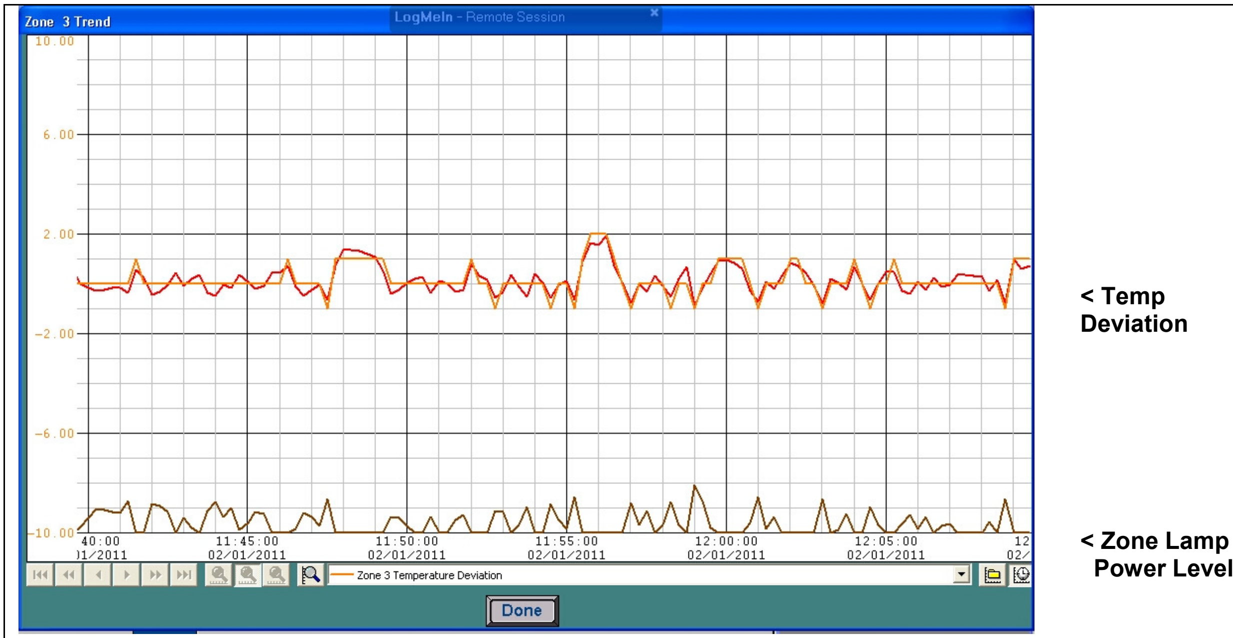


Table 5-3

Observation: Temperature deviations of ± 5C (difference between setpoint and actual) were observed.

Recommendation: by increasing the gain setting from 9 to 18, and reducing the integral setting from 45 to 30, larger and faster corrections reduced temperature deviations in this zone from ±5C to mostly ± 1C.

Additional recommendation: To further improve stability, add slightly more gas flow into the zone or adjust the exhaust eductors at either end of the furnace section to move more heated process gas out of the zone (see 5.D. Balance Gas Flow above).

1.0 Scope

This instruction covers the SuperTrend chart functions supplied as an integral part of the furnace software on many RTC, GBT and LCI infrared furnaces. SuperTrend charts can provide valuable data for fine tuning furnace performance as well as troubleshooting furnace behavior.

2.0 Description

SuperTrend charts present detailed real time charting of five parameters on a zone by zone basis. The charted parameters include:

Setpoint – Zone temperature setpoint, degrees C.

Top Power – Actual power (as percent) supplied to top lamps in zone.

Bottom Power – Actual power (as percent) supplied to bottom lamps in zone.

Temperature – Temperature measured by zone thermocouple, degrees C.

Temperature Deviation – difference between zone setpoint and measured temperatures, degrees C.

The default Real Time SuperTrend screen is shown below:

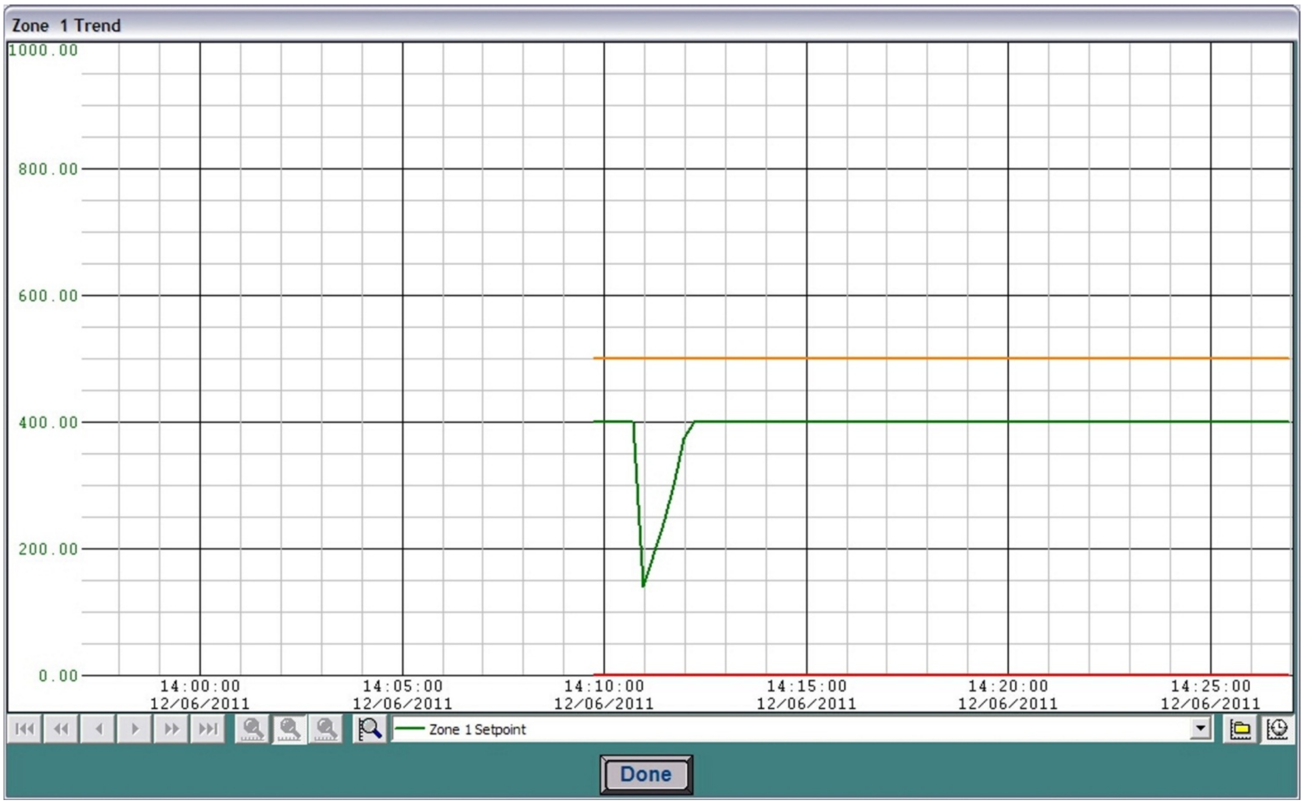


Figure 2.1SuperTrend Real Time Screen

All charts are stored in files on the furnace computer in c:\RTC\Trendlogs directory and can be accessed from the SuperTrend screens.

While these screens allow the viewer to make many changes to the way the data is viewed, the SuperTrending function does not make any changes to the acutal data. Vertical scale changes may be stored as new defaults, however, they can be changed at any time and do not affect the actual stored data.

3.0 Accessing SuperTrend Charts

If the SuperTrend Chart feature is activated, you will see the Trends button on the Process screen.

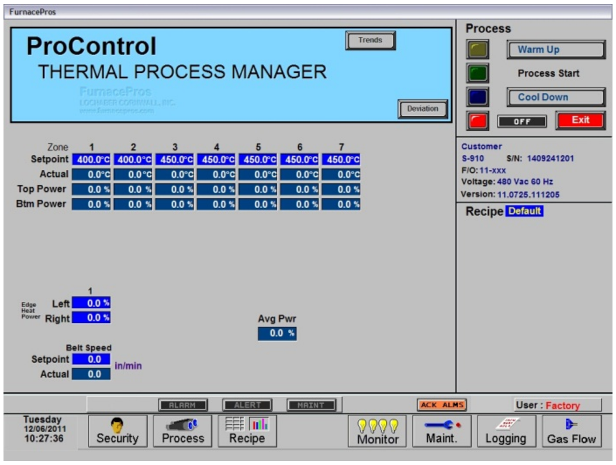


Figure 3.1 Process Screen with Trends button

Press the trends button to see the zone selector popup.

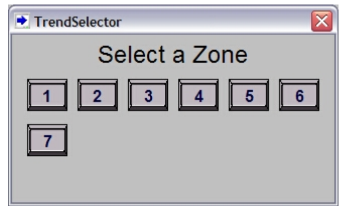


Figure 3.2 Trend Selector popup

3.1 Real Time Charts

Select the number of the zone you wish to view and the real time Chart for that zone will appear. All five charted parameters are shown. Make a selection from the dropdown menu to view the vertical scale that matches the selected parameter. The vertical scales are user adjustable.
The horizontal scale shows a 30 minute duration in real time mode.

Click on the Real Time button  to return to real time view.

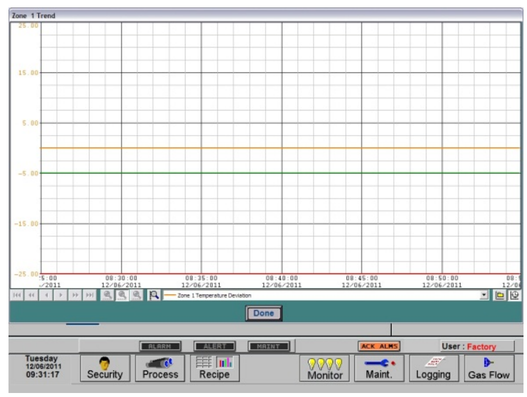
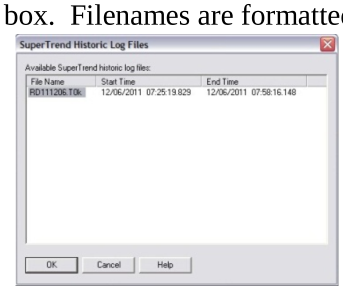


Figure 3.3 SuperTrend Real Time Screen

3.2 Historical Charts

Click on the  button to open the SuperTrend Historical Log Files dialog box. Filenames are formatted as RDyymmdd. File start times and end times are shown. Select the file and click OK to view.



The historical file will be loaded and additional menu bar viewing features will be enabled.

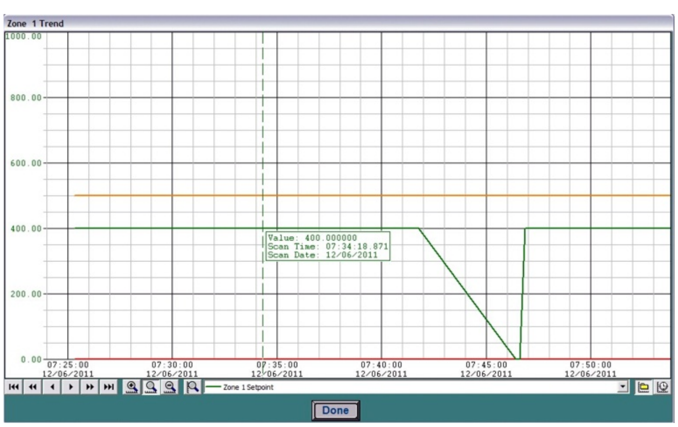
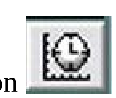


Figure 3.4 SuperTrend Historical Log Screen

Clicking on the face of the screen will reveal the value of the selected setpoint at that time on the chart as shown in Figure 3.4.

Click on the Real Time button  to return to real time view.

4.0 SuperTrends Menu Bar

The menu bar allows users to select and change views of real time and historical log files. In the Real Time mode users can change the vertical scaling to increase or decrease chart resolution. In the Historical Log mode users can also compress and expand the horizontal time scale and move forward and back to view data stored at different times in the file.

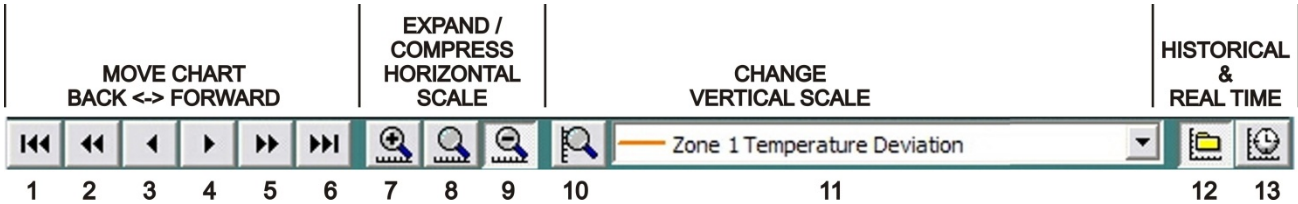


Table 4-1 SuperTrend Charts menu bar			
1	Move to beginning of file	8	Reset horizontal time scale to 30 minutes
2	Move 30 minutes back in file	9	Compress time scale (more time shown)
3	Move 5 minutes back in file	10	Change vertical scale selected in 11
4	Move 5 minutes ahead in file	11	Dropdown to select vertical scale to show
5	Move 30 minutes ahead in file	12	Select historical log file
6	Move forward to end of file	13	Return to view real time chart
7	Expand time scale (less time shown)		

4.1 Changing Parameters

Use the dropdown (Table 4-1, item 11) to change the vertical scale shown. Note when changing parameters, the vertical axis numbers change to correspond to the parameter selected. However, since all 5 parameters are continuously tracked, their relative size and each scale remains the same until its parameter scale is changed.

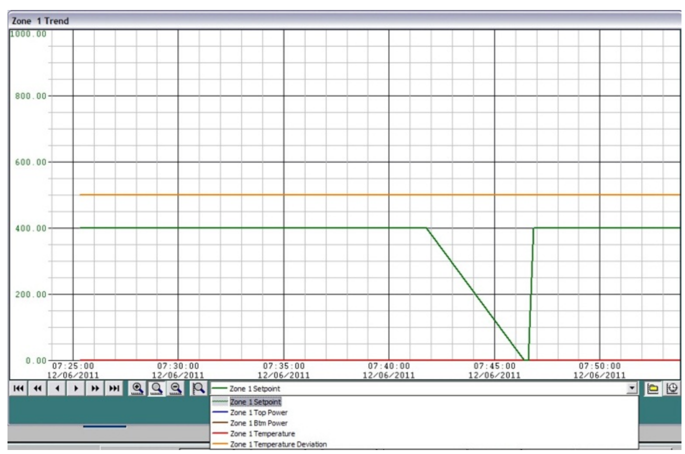


Figure 4.1 Change Parameter Scale

4.2 Changing a Parameter's Scale

Expanding the scale of a parameter allows the viewer to see more of the data that might be out of range. Conversely reducing the scale shows greater detail. For example default scale for Temperature deviation is typically set to +/-25C. After the furnace is setup and stable, the user can reduce the scale to +/-10C or +/- 5C to exaggerate the temperature deviation and allow for finer tuning.

Parameter scales are stored for each zone. So if Zone 1 Temperature scale is changed to 0-200C, Zone 2 Temperature scale will remain at 0-1000C until changed. Each file when opened will be viewed with the current parameter scale settings

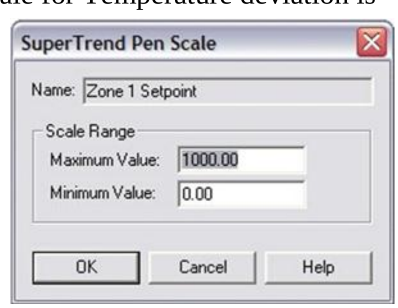


Figure 4.2 Change Vertical Scale popup

4.3 Changing the Time Viewed and Time Scale

In the Historical Log Mode additional views are enabled. Clicking on the forward and back buttons (Table 4-1, buttons 1 through 6) presents the earliest data in the selected file to the last data in the file.

To expand the time scale to see more detail in less time, press the  button (Figure 4.5).

To compress the time scale and see a longer period in one screen, press the  button (Figure 4.3)

To reset the scale to 30 minutes press the  button (Figure 4.4)

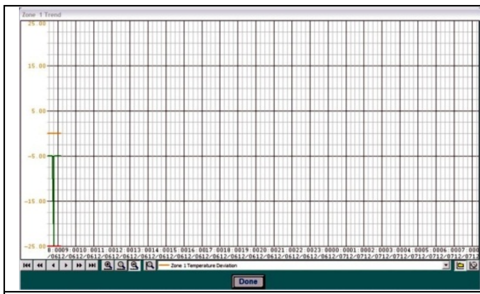
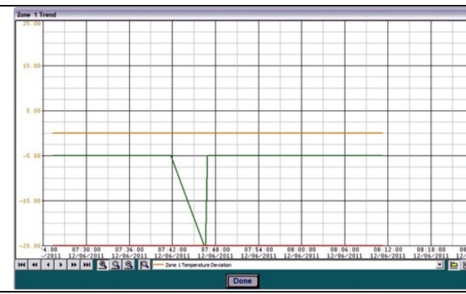
		

Figure 4.3 Compressed time scale	**Figure 4.4 Default time scale (30 min)**	**Figure 4.5 Expanded time scale**

1.0 Scope

This instruction covers use of furnace software to save process control recipes.

2.0 Recipe Editor

The Recipe Editor is a worksheet for creating a new recipe or making changes to an existing recipe. When the Recipe Editor is off-line, changes to the recipe only exist on the worksheet and do not affect furnace operation nor are they stored on the furnace computer.

3.0 Recipe Name vs. Recipe File Name

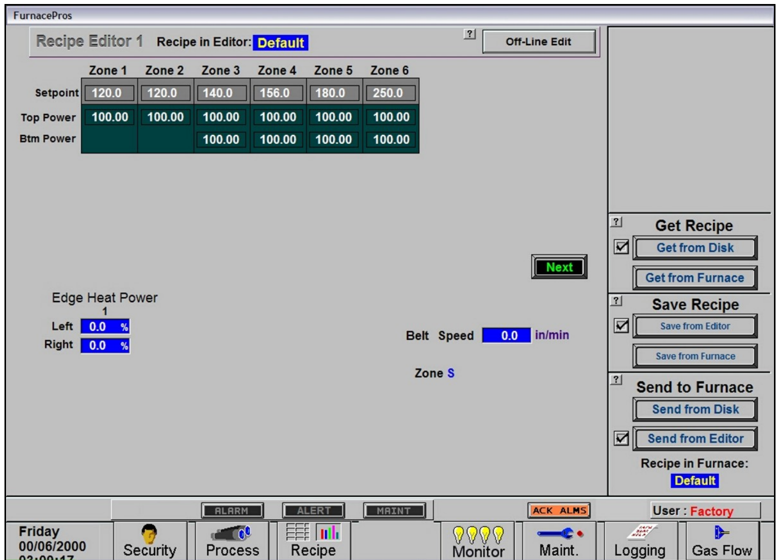


Fig 3-1 Recipe Editor with a recipe named Default

The Recipe Name is a user defined name given to each recipe during the Recipe Save process. The Recipe Name is often the same as the recipe file name (without the .rcp extension). However, it is possible to save a number of recipes with the same Recipe Name but different recipe file names which can cause confusion.

The example in this document starts with a recipe named Default in the editor and in the furnace. The Recipe in Editor name is at the top of the screen in the title bar. The name of the recipe running in the furnace is shown in the lower right hand corner of the Recipe Editor screen.

4.0 Save Recipe – Save from Editor

Fig 4-1 Save from Editor button

To save a recipe that is currently viewed in the editor, select the Save from Furnace button in the save Recipe box on Recipe Editor 1.

The Save Recipe dialog will appear (Fig 4-2a). Change the recipe name to a new name (e.g. NewRecipeName) as in Figure 4-2b.

Click on Save to R: button.

The Select Destination File For Upload dialog box will appear (Fig 4-3a).

Enter the new file name in place of the asterisk (*) and press OK (Fig 4-3b). The file will be saved in the R:\ directory with the new recipe name and with the new file name (RecipeName.rcp) as an rcp file.

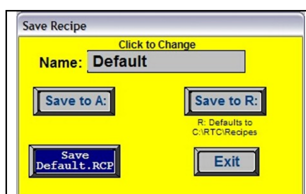


Fig 4-2a Safe Recipe

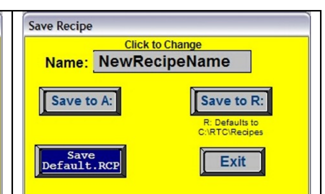


Fig 4-2b Enter new recipe name

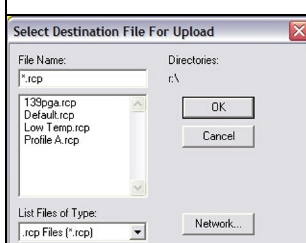


Fig 4-3a Save to R:

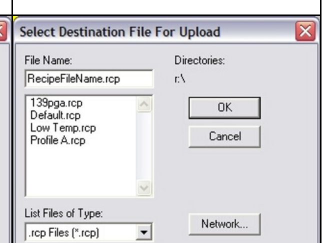


Fig 4-3b Enter new file name

5.0 Apply the new Recipe

After the recipe in the editor has been saved, the Recipe Editor screen will show the name of the new recipe in the title bar at the top of the screen (NewRecipeName in fig 5-1). Note that the lower right hand corner will still show the name of the recipe running in the furnace (Default in fig 5-1)

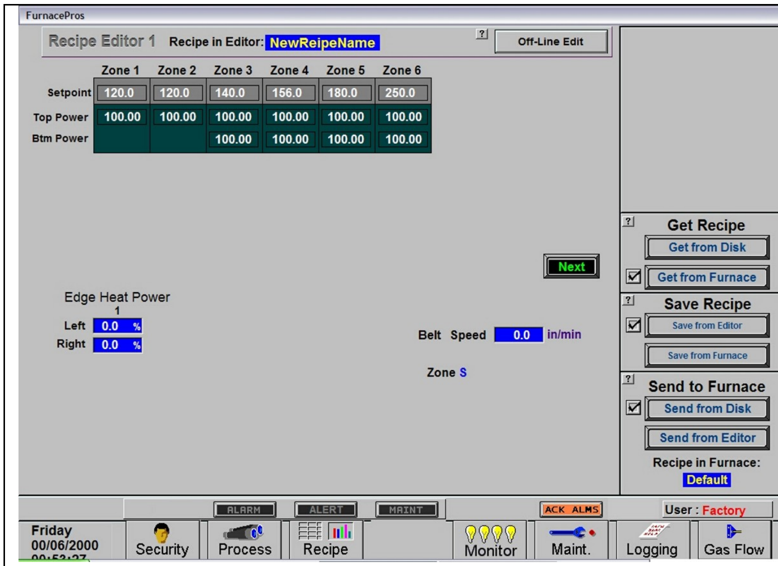


Fig 5-1 Recipe in Furnace different from Recipe in Editor

The recipe in the Recipe Editor must be sent to the furnace in order for it to be used.

To send the recipe in the editor to the furnace, click on Send from editor button in Send to Furnace box (Fig 5-2).

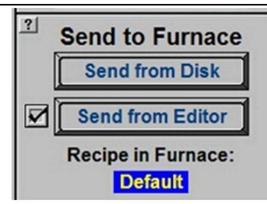


Fig 5-2 Send Recipe in Editor to Furnace

The Recipe Editor screen will now appear similar to fig 5-3. The name of the Recipe in Furnace has changed to the name in the editor as shown in the lower right of the screen in fig 5-3.

Go to the Process screen and verify that the correct recipe values are running in the furnace.

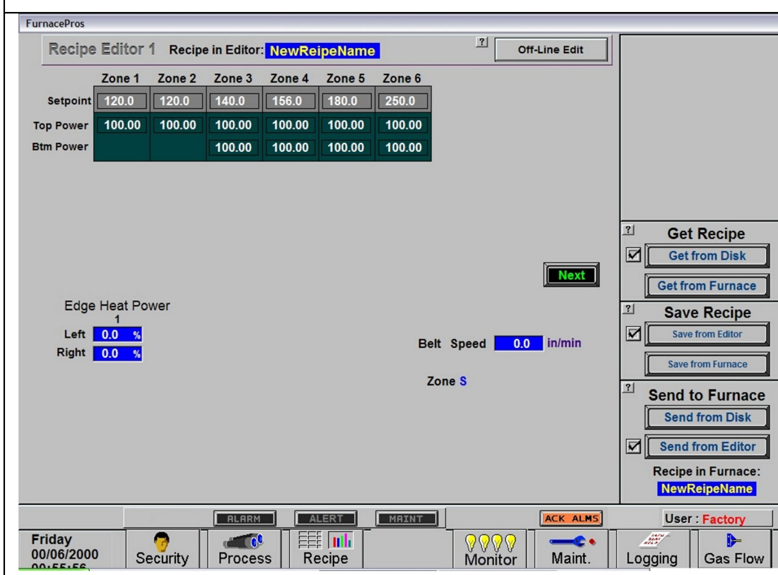


Fig 5-3 Recipe in Furnace sent from Editor