ALSTOM (SCHWIEZ) AG
BROWN BOVERI STRASSE 7
CH-5401 BADEN, SWITZERLAND

CUSTOMER ORDER NUMBER 4500488925

480 GRAPHITE ELEMENT HORIZONTAL FRONT LOADING VACUUM FURNACE

SECO/WARWICK SERIAL NUMBER 122-09V

CE DECLARATION OF CONFORMITY

See following Page

PREFACE

The information given in this manual is as accurate as possible. However, due to variations in field and process conditions, it may be necessary to make minor corrections to the manual.

If changes are necessary, new pages will be issued after the field service technician completes start up of the equipment.

This manual is accurate only for the intended use at the time of sale, and only as installed at the time of purchase. Any changes to the equipment or process may render the manual inaccurate.

The customer is solely responsible for translating the manual, supplier's literature, drawings, and warning signs, to other languages that may be required, in order for the customer's personnel to properly understand and follow the instructions.

When communicating regarding a product covered in this manual, please give the complete nameplate data of the item involved, and state fully and clearly the nature of the problem. Our Renewal Parts Department can answer all your requests for spare and replacement parts for your equipment.

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*PRODUCT INFORMATION

SECO/WARWICK Corporation has designed this equipment for its intended use with safety in mind. Changing either the mechanical or electrical design without prior written authorization from SECO/WARWICK Corporation will result in voiding the warranty and risk of unsafe operation. Our engineers will work with you, within the limits of safety and the machine's intended use, if there is some aspect of the equipment that does not meet your process requirements. It should be remembered, however, that many of the aspects of the design are dictated by safety considerations and should not be changed.

Operators and maintenance personnel should exercise common sense and caution when working around this equipment. They will be exposed to various hazards including electrical, mechanical, moving parts, high temperatures, and possibly non-breathable atmospheres.

Be sure to read ALL of this manual, taking particular note of the requirement for TRAINED, QUALIFIED OPERATORS AND MAINTENANCE PERSONNEL. If unsure of the requirements for the equipment, you can arrange with SECO/WARWICK Corporation to train your personnel.

SAFETY

1) As a user of industrial oven and furnace equipment, you should be aware that the National Fire Protection Association Bulletin 86 Section 1-3 application now requires that all operating furnaces be maintained in accordance with the Chapter entitled "Inspection, Testing, and Maintenance". A copy of NFPA Standard 86 may be purchased from National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

*S/WG3 rev.6-5/26/05 3pg

PRODUCT INFORMATION - Continued

2) Your maintenance personnel should have this manual.

3) Remember, if any safety devices have been tampered with (bypassed), your fire and casualty company may assign a portion of the loss to you for contributory negligence.

4) An essential safety aid is an established maintenance program which ensures that the equipment is in working order. **SOLE RESPONSIBILITY** for establishing, scheduling, and enforcing the frequency of, and the extent of, the inspection/maintenance program (as well as the corrective action to be taken), **RESTS WITH THE USER.**

5) The mere presence of safety equipment on an installation cannot, in itself, assure absolute safe operation. Highly repetitive operational cycling of any safety device may reduce its life span. All safety devices have periodic checks and maintenance procedures, which must be followed. Please refer to the supplier's literature provided as part of this manual. Electric relays and fuel safety shutoff valves are not substitutes for disconnects and main shutoff cocks or valves. This equipment is automatic or semi-automatic. Without proper valves and disconnects this presents a hazard to operators or maintenance personnel.

6) SAFETY DEVICES SHALL NOT BE SHORTED OUT OR BYPASSED. Doing this defeats the purpose of the safety device and renders the equipment hazardous.

7) Never enter any furnace or other equipment that has contained, or could contain, a non-breathable atmosphere without wearing protective apparatus and a person standing outside the furnace to monitor the activity. **Any atmosphere that displaces or removes oxygen in the air, or contains toxic gases, creates a hazard to life.**

PRODUCT INFORMATION - Continued

8) There is no substitute for a diligent, capable, well trained operator.

A. All operating, maintenance, and appropriate supervisory personnel shall be thoroughly instructed and trained under the direction of a qualified person (s) and shall be required to demonstrate understanding of the equipment and its operation to ensure knowledge of and practice of safe operating procedures.

B. All operating, maintenance, and appropriate supervisory personnel shall receive regularly scheduled retraining and testing.

C. Personnel shall have access to operating instructions at all times.

D. Operator training shall include the following where applicable

(1) Combustion of fuel/air mixtures

(2) Explosion hazards, including improper purge timing, purge flow, and safety ventilation.

(3) Source of ignition, including auto-ignition (e.g.., by incandescent surfaces)

(4) Functions of control, safety devices, and maintenance of proper set points.

(5) Handling of special atmospheres

(6) Handling of low-oxygen atmospheres

(7) Handling and processing of hazardous materials

(8) Confined space entry procedures; and

(9) Operating instructions

(10) Lockout/tagout procedures.

ITEMS SUPPLIED BY ALSTOM

1. Freight or transportation from Meadville, Pennsylvania to PURCHASER'S factory.
2. Unloading, proper storage and delivery of equipment to final site in factory.
3. Labor to install equipment, including reassembly of any components that were removed for shipping purposes and all utility connections necessary.
4. Any stacks, hoods, exhaust ducts, etc. if required.
5. Any additional equipment that may be desired or required by law and installation of same.
6. Gas at the required pressure.
7. Sufficient water at a maximum temperature of 22°C as required for operation of the installation.
8. 400 Volt, 3 Phase, 50 hertz current as required for operation of the installation.
9. High pressure air in sufficient quantities at a minimum of 5 bar as required for operation of the installation.
10. Main power disconnect for the furnace.
11. Foundation as required in accordance with information to be supplied by SECO/WARWICK if necessary.
12. Skilled operators during startup operation.
13. Test load, if necessary.

ITEMS SUPPLIED BY SECO/WARWICK

1. Furnace Vacuum Chamber
2. Vacuum Pumping System
3. Instrument Panel
4. Power Transformer
5. Instruction Manuals (2)

*UTILITIES

ELECTRIC: **400** volts, **3** phase, **50** Hz, **50** Kva

WATER: **60** lpm **1** barg min.pressure **2** barg max. pressure

AIR: **0.01** M^3/h **4** barg min.pressure **8** barg max. pressure

INERT GAS BACKFILL: **6** barg max

MAXIMUM TEMPERATURE: **2200°C**

NORMAL OPERATING TEMPERATURE: **2000°C**

WATER REQUIREMENTS FOR VACUUM FURNACE -

COMPONENTS PASSING ELECTRICAL POWER:

SUSPENDED SOLIDS	<10 ppm
CaCO	<100 ppm
CONDUCTIVITY	<300 Micromhos
Ph	From 7.0 – 8.0
TOTAL DISSOLVED SOLIDS	<200 ppm

NAMEPLATE DATA

The operating limits of the equipment as to capacity, control voltage and phase, and maximum temperature are specified on the nameplate.

The power supply must agree with the nameplate rating. All compliance with code standards and service classifications must be maintained. The power connections should be of ample capacity so there is no overheating at the control panel. The main power supply to the equipment must have a disconnect between the equipment and the main power supply entering the building, even if there is a disconnect on the furnace control panel.

*G12 rev.4-11/01 1pg

EQUIPMENT DESCRIPTION

Your horizontal, front loading vacuum furnace is designed for sintering, and heat treating in vacuum or partial pressure inert atmospheres. Work is loaded directly on the furnace hearth up to the rated capacity of 90 kg at 1800°C. The vacuum pumping system and furnace power supply are designed to perform automatic heating cycles to specific process requirements.

The furnace will shut-down in the event of utility failure. On loss of electrical power, all heaters turn off, all motors stop, and all valves close. When power is restored the furnace can be restarted with the cycle start push-button.

On loss of cooling water pressure, air pressure for valve operation, or inert atmosphere backfill pressure, all heaters turn off, the nature of the utility failure is indicated, and an alarm sounds. The alarm can be silenced by depressing the "ALARM ACKNOWLEDGE" pushbutton while the indication continues until the failure is corrected. Heating element power can then be restored with a pushbutton.

The furnace is completely assembled, cold tested, and then dismantled as required for shipment. The system will be ready for operation after assembly, interconnection of subsystems and connection to power, water, and atmosphere supply lines in your plant.

Graphite plate heating elements are supported from water-cooled feedthroughs on either side of the uniform zone.

Rigid graphite fiberboard insulation, supported from a modular structure, prevents direct heat loss to the chamber cold wall. The door insulation is supported from the vacuum chamber front door to provide direct and complete access to the uniform zone when the front door is opened.

EQUIPMENT DESCRIPTION - Continued

The work load is supported by graphite hearth piers supporting a graphite plate hearth.

Modular construction permits convenient removal of elements and assembled hot zone for periodic system maintenance.

The pumping system includes a mechanical blower backed by a mechanical pump. The pumping system is completely assembled for automatically sequenced operation. A pushbutton starts the mechanical pump to begin the vacuum chamber roughing cycle. When the chamber vacuum level reaches 20 torr, vacuum instrumentation starts the Roots type blower.

An inert atmosphere inlet system including a low inert gas supply pressure interlock, gas inlet valve, relief valve, and Bourdon gauge is provided for vacuum chamber backfill. A valved port is provided for connection to your helium mass spectrometer for leak detection.

Electrical devices are interconnected to make a complete operating system. An HMI (Human Machine Interface) on the control panel indicates the operating status of all system pumps and valves.

The furnace controls, vacuum pumping system, and transformer package are mounted to a single base, allowing all interconnecting wiring and piping to be completed in the SECO/WARWICK plant. The PURCHASER needs only to bring electrical power into the panel and connect the inert gas, water supply and drain piping to the appropriate manifolds.

Work can be cooled in vacuum or still inert atmosphere.

*WARNINGS AND CAUTIONS

The following symbols are used in this manual to denote specific precautions the operator must take when using the equipment, or when the operator or other personnel are in the vicinity of the equipment. These warnings must be noted and followed to lessen the chance of injury or equipment damage.

DANGER

This symbol is used to note a hazard or unsafe practice that **will** cause death or severe injury.

WARNING

This symbol is used to note a hazard or unsafe practice that **could** result in severe injury or death.

CAUTION

*S/W 1 7/3103-R2 - 4pg

This symbol is used to note a hazard or unsafe practice that could result in minor injury or machine damage.

CAUTION

CAUTION: Local codes, fire protection, ventilation requirements, color coding, fall protection, and environmental protection codes may require on-site additions by the PURCHASER per local requirements. COMPLIANCE IS THE PURCHASER'S SOLE RESPONSIBILITY.

As noise levels are cumulative and affected by on-site conditions, including resonance frequencies caused by ducting, exhaust systems, general acoustical conditions of the building and surrounding machinery, any additional devices or modifications required to meet local sound level standards are to be provided by the PURCHASER.

It is the responsibility of the customer to ensure compliance with all local environmental regulations.

In general, no person should be authorized to operate the equipment:

1. Who cannot speak the appropriate language or read and understand the printed instructions.
2. Who is not of sufficient maturity to operate this type of equipment.
3. Whose hearing or eyesight is impaired (unless suitably corrected with good depth perception).
4. Who may have any physical or mental condition that interferes with safely operating the equipment.

5. Who has not carefully read and understood this Operation & Maintenance Manual.
6. Who has not demonstrated his/her understanding of the instructions through a practical demonstration of it's operation.

WARNING

Loss of cooling water can create a hazardous situation. Sudden restoration of water to hot equipment may produce steam. Specific procedures for restoring water to hot equipment are contained in the emergency procedures section.

When a closed loop system is provided, the "closed loop" cooling systems must have a means of relief to protect all portions or the system if the system pressure can exceed the design pressure.

CAUTION

Do not restore water to a hot heat exchanger or furnace. The heat may cause steam to form, possibly rupturing the furnace water jacket or piping outside the furnace. Allow the furnace to cool below 200°F (93°C) before restoring water flow.

Do not overheat furnace beyond the maximum operating temperature indicated on the rating plate.

*WARNING SIGNS

Each piece of equipment has various warning signs attached to the equipment to emphasize operator training, precautions, or danger points. These signs are the minimum requirements, and should be augmented by additional warnings required by plant safety, operating conditions, or local laws.

WARNING

INJURY TO PERSONNEL MAY RESULT DUE TO WARNING SIGNS NOT BEING VISIBLE.

These signs must remain attached to the equipment, be in plain view, clean, and free of paint and dirt. If a sign is damaged or defaced, it should be replaced immediately with a good sign.

All electrical boxes contain a warning of high voltage, as does the control panel. The control panel has a sign indicating that only properly trained and properly authorized operators may operate the equipment. All guards have a sign warning not to operate the equipment without the guards.

Additional signs are added for pinch points, hot surfaces, molten metal, and other hazards peculiar to the type of furnace involved. These signs have been selected and placed for your protection, as well as the protection of your employees. Severe bodily injury and death can be avoided if these signs are properly maintained, and the precautions observed by everyone in the vicinity of the equipment.

A drawing listing each sign and its location is included in the instruction manual, or with the reproducible drawings sent with the equipment.

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* G8 rev. 4 11/01- 1pg

*SAFETY PRECAUTION AND WARNINGS FOR WORKING ON OR AROUND THE EQUIPMENT

When performing work, always follow acceptable lockout/tagout procedures for working on electrically or mechanically operated equipment. Always lock-out energy isolating devices, and attach tag that states: "MAINTENANCE BEING PERFORMED - DO NOT OPERATE". Also lock out and tag process gas valves, as well as air or hydraulic valves, or any potential energy source, such as raised doors.

Principal Health and Safety Requirements

In accordance with: EN 746-7: INDUSTRIAL THERMPROCESSING EQUIPMENT - PART 7: SPECIAL SAFETY REQUIREMENTS FOR VACUUM THERMPROCESSING EQUIPMENT

1. At every entrance to the vacuum furnace operating area warning signs designed in accordance with EN 50099-1 should be displayed in a prominent manner as follows:
   - prohibiting the extinguishing of fires with water
   - prohibiting the admittance of non-authorized personnel

DANGER

Persons with pacemakers and metal implants of any kind shall not be employed as the equipment operators and shall not remain in the vicinity of the equipment.

2. Warning signs should be placed inside the vacuum operating furnace area, designed according to the above standard:
   - a warning prohibiting eating, drinking and smoking
3. The following equipment should be available in or immediately accessible to the vacuum furnace location:
   - fire fighting equipment,
   - eye wash station(s).

*S/WG2 rev.2-9/04 1pg

Principal Health and Safety Requirements - Continued

4. During daily operation of the furnace:
   - avoid breathing dust contaminated air
   - do not use compressed air for cleaning
   - minimize skin contact with oils, solvents, fine particles and impurities
   - wash hands carefully before eating
   - clean contaminated clothing etc. after each use

Qualification of the furnace operators

The vacuum furnace should be operated by trained personnel only. Intervals of periodical inspections should be observed and the maintenance carried out in accordance with the schedule indicated. These Instruction Manuals should be available to the furnace operators and maintenance personnel.

The vacuum furnace and its ancillary equipment can be operated by single operator unless local health and safety regulations state otherwise.

Required individual protective safety equipment

In accordance with: prEN 746-7: Industrial Thermprocessing Equipment - Part 7: Special Safety Requirements for Vacuum Thermprocessing Equipment the following equipment shall be worn when operating with vacuum furnace in emergency situations:

- face protection - constructed of self-extinguishing material such as polycarbonate and mounted on a glass fiber helmet so as to protect the face and chin
- protective suits - constructed of flame resistant cotton
- shirts - constructed of cotton, with long sleeves fastened by buttons or Velcro

Principal Health and Safety Requirements – Continued

- protective gauntlets - constructed of heat resistant and fire resistant material. They shall be easily removable from hands.
- protective shoes - constructed of leather with a slip resistant sole.

Requirements for Protection Against Hazard

Protection against electric shocks

The equipment was to protect personnel against electric shocks caused by:

- direct contact
- indirect contact

Independently of the type of protection against electric shock it is strictly forbidden to perform any operation involved with changing of settings, taking of measurements, replacement of operating equipment (fuses, bulbs, etc) by unauthorised personnel. Only a person with proper qualifications and training in furnace operation is authorised to perform such operations.

If damage to any electrical equipment component of the furnace is discovered, it should be reported immediately to appropriate persons responsible for the furnace maintenance. Partial or complete start up of the furnace with any part damaged is strictly forbidden.

Protection against direct contact

Protection against direct contact is provided by use of protective clothing and shields with minimum protection class IP2X.

All components installed on the furnace are protected with appropriate guards or insulation. The guards were designed to provide proper mechanical, chemical, electrical and thermal resistance during standard working conditions of the furnace. Removal or modification of existing guards is strictly forbidden.

Control cabinet and junction boxes are locked with keys and are of IP54 protection class.

Principal Health and Safety Requirements – Continued

During standard operation of the furnace entering the equipment inside control cabinets is strictly forbidden.

Protection against indirect contact

All circuits are provided with devices that provide automatic disconnection from power supply in the event of a short circuit.

Low Voltage Circuits

Independently of measures specified above the control system of the furnace utilizes a control voltage 24V DC. This voltage is provided for all circuits of control system as well as components installed on the furnace, except three phase circuits.

Fire Protection

Fire hazard requires strictly defined procedures during operation, maintenance as well as during fire-fighting actions.

Possible fire hazards include:

1. Short-circuits in electrical installation, fire in control or power supply cabinets:
   - to be extinguished with disconnected power supply (if possible). Use equipment designed for electrical installation fires (carbon-dioxide extinguishers).
2. Fires in the heating chamber:
   - to be extinguished with disconnected power supply (if possible). Use carbon-dioxide extinguishers.

CAUTION

The heating chamber is fabricated from combustible graphite materials (e.g. graphite fibre insulating boards) with an ignition temperature in air of approximately 400 °C.

To avoid a fire caused by short-circuits in electrical installation the end user is required to develop methods and intervals of cleaning of the equipment of dust generated by local conditions in working area. The area around the furnace and its ancillary equipment shall be kept clean.

After fire procedures:

1. Protect the area of the fire.
2. Disconnect supply of all utilities and release energy accumulators.
3. Evaluate damages and make required repairs or replacement of damaged components.
4. Test the furnace and carry out start-up according instructions.

Other Health and Safety Requirements

1. Provide Instruction Manuals in the working area.
2. Provide tools to facilitate loading and unloading operations.
3. Before any repairs in control cabinet make sure that electric power supply is disconnected, tagged, and locked out.
4. Operation of the equipment without drive guards is strictly forbidden.
5. Operation of the equipment with partly or completely dismantled electrical protection equipment or connectors is strictly forbidden.
6. Unattended operation of the furnace is not advised.
7. Keep all warning and information signs clean and clear.
8. The furnace area shall be equipped with properly maintained fire-fighting equipment.

Principal Health and Safety Requirements – Continued

9. All hoods, ducts and tubes should be made from non-flammable materials.
10. Venting ducts should be designed to avoid accumulation of condensate (e.g. water or oil) or should include drainage for such condensate.
11. Venting ducts should be directed outside a building, far from air intakes, opened windows, walkways, roads, etc.
12. Venting system design should provide for easy inspection, cleaning and maintenance.
13. Operators shall immediately report all malfunctions of the equipment to supervising personnel.
14. Operators shall be equipped with individual personal protection equipment.
15. Emergency stops of venting systems should be located in easily accessible area.
16. Working area should be properly lighted.
17. The equipment shall not be operated with the interlocks and safeties provided in the operating program modified or defeated.
18. The furnace operators shall be systematically trained and examined for acquaintance with procedures in emergency situations, e.g. failure of electric power, water or gas supplies, etc.
19. Operators and maintenance personnel shall be trained in first-aid procedures where human life or health is in danger.
20. Electrical equipment should be inspected regularly per the maintenance chart.
21. Electrical equipment is to be serviced by trained and authorized personnel only.
22. Keys to the control cabinet should be under control of authorized persons and kept from unattended use by third parties.
23. Any changes in interlock settings and protections are strictly forbidden.

Principal Health and Safety Requirements – Continued

24. If any component of the furnace control system is replaced with new one, its performance shall be the same as original one (see electrical documentation of the equipment).
25. Any access to the furnace and its control system by unauthorized persons is strictly forbidden.

Other Requirements Specified In Separate Regulations

Only properly trained personnel with a good knowledge of the machine and health and safety regulations are to be permitted to operate the equipment.

1. If work is performed by more than one person, a supervisor shall be appointed.
2. Maintenance and repair staff should be well trained in the design and operation of the machine. All work should be made with proper tools.
3. All work shall be performed in accordance with local regulations, especially with:
   - accident prevention regulations
   - health and safety regulations for heating equipment

Recommended procedures:

1. All electrical work is to be performed by qualified and trained personnel only.
2. The components of the machine being worked on shall be disconnected from power supply and locked out and tagged.
3. The machine shall be locked out against automatic or unintended start.
4. The machine shall be shut down per safety regulations related to the operation of vacuum furnaces.
5. Abstracts from Instruction Manuals of the machine in durable form, containing date of edition, shall be available close to the operating area.

Principal Health and Safety Requirements – Continued

6. Operators shall be trained and competent in operation of the furnace as well as in hazards involved with heat and chemical treatment and their prevention. All problems involved with the process as well as all damages of the machine shall be immediately reported to supervising persons.
7. A maintenance log shall be kept for the equipment. It should include all records on problems, events and failures caused by the machine as well as records of all maintenance operations provided by the user.
8. The end user should maintain all instruction manuals of the machine. They should include a list and description of all modifications made after installation of the machine.
9. The machine shall be started up, operated and shut down in accordance with these Instruction Manuals.
10. If the furnace was shut down due to the operation of a protection device, its restart must be by conscious action of authorised personnel.
11. Location and operation of the installation shall meet requirements of above mentioned requirements and regulations, including local regulations and instruction as to accident prevention.
12. The equipment must not be installed in areas where an explosion hazard exists. Storage of flammable materials in the vicinity of the furnace is prohibited.

DISPOSAL OF THE FURNACE

DISPOSAL

Properly operated and maintained equipment manufactured by SECO/WARWICK has long service life. At the end of its life the vacuum furnace shall be dismantled in the reverse of the installation procedures described in these Instruction Manuals and the materials properly disposed of in accordance with national and local regulations in effect at the time.

1. At the end of service life of the vacuum furnace, the furnace itself and all of its components shall be properly disposed of.
2. Before dismantling and disposal of the furnace proper instructions shall be given to workers, which shall include all safety measures to be adopted during the operation.
3. Personnel appointed to these operations shall wear protective clothing other personal protection equipment.
4. Proper safety equipment shall be used during dismantling of the furnace.
5. All dismantling procedures shall be performed proper attention to safety and environmental factors.
6. Breathing of dust from the furnace components (e.g. thermal insulation of the heating chamber) shall be avoided during dismantling of the furnace.
7. Separation of thermal insulation, ceramic components and solid graphite from the heating chamber shall be performed with the greatest care with proper ventilation.
8. All waste (thermal insulation, ceramics, glass, plastics, etc.) shall be separated and packed in separate containers.
9. Disposal of wastes shall meet appropriate local regulations.
10. Oil is to be removed from vacuum pumps before disposal of the vacuum system components.

DISPOSAL OF THE FURNACE - Continued

11. Dispose of oil in accordance with local regulations as to disposal of fuels and greases.
12. Always observe appropriate environment regulations.

*SAFETY PRECAUTIONS AND WARNINGS FOR ENTERING EQUIPMENT

Following is an example of a procedure to use prior to starting work on any equipment.

1. Make sure the following are turned off, tagged out, and locked out, per established requirements, to be opened only by the person tagging them out.
   a. Electrical power - padlock all disconnect switches in the Off position.
   b. Mechanical equipment - such as air actuated cylinders, etc., which could operate without electrical power. Remove air pressure from air cylinders, and lock cylinder so it cannot move.
   c. All gas supply lines - close manual valves, lock, and tag out.
   d. Pin or block door to prevent closing.
   e. Attach a maintenance tag to each that states: **"MAINTENANCE BEING PERFORMED - DO NOT OPERATE".**
   f. Test the effectiveness of the lockout procedure by attempting to operate equipment.

2. Before entry, analyze the area to be entered to determine that it is not hazardous to health. Minimal acceptable levels are:
   a. Carbon monoxide (CO) level below 50 ppm.
   b. Carbon dioxide (CO_2) level below 5,000 ppm.
   c. Oxygen (O_2) level 19.5%.

*G6 rev. 7 - 9/02- 3pg - special

SAFETY PRECAUTIONS AND WARNINGS FOR ENTERING EQUIPMENT – Continued

d. Solvent levels below Threshold Limit Value (TLV). TLV for solvents can be obtained from supplier.

e. If ceramic fiber insulation is present, protective gear is required. See "SAFETY NOTES" for precautions and protective equipment required.

3. Cool all equipment as required for personnel entry.

4. Place a large fan or man cooler in front of the area to be entered and direct the flow into this area.

DANGER

BEFORE ENTERING A FURNACE, READ AND COMPLY WITH THE FOLLOWING WARNINGS.

5. Almost all gases are toxic and can kill. Even though a gas is not toxic, its presence in sufficient quantities will displace oxygen and can cause death by asphyxiation. **Never enter any area where gases have been used without first:**

a. Make sure all fuel and process gas valves are closed and tagged out.

b. Make sure all gases have been vented out of the area.

c. Make sure all suspected areas have been monitored with proper gas detection equipment.

d. Utilize independent breathing apparatus or provide fresh air ventilation to all internal areas.

SAFETY PRECAUTIONS AND WARNINGS FOR ENTERING EQUIPMENT - Continued.

e. Know the symptoms of gas poisoning:
   Dizziness
   Headaches
   Stiff Neck
   Weakness in Knees
   Nausea

6. Using the "Buddy System", the equipment may now be entered.
7. If any of the symptoms of gas poisoning are experienced, remove all personnel from the area and seal off the area until proper ventilation can be effected. **IF THE MAN IN THE FURNACE IS OVERCOME, DO NOT ENTER THE FURNACE UNTIL ANOTHER MAN IS AVAILABLE TO OBSERVE THE RESCUE. USE PROPER GEAR FOR EFFECTING THE RESCUE WITHOUT ADDITIONAL DANGER TO YOURSELF.**
8. In the event a man is overcome by gas poisoning, employ the following procedure:
   a. Remove victim to fresh air immediately.
   b. Obtain medical aid promptly.
   c. If breathing is stopped or extremely poor, give artificial respiration and administer oxygen, if available.
   d. Keep victim warm.
9. After maintenance is complete and all personnel are out of the equipment, remove the maintenance tags and prepare the equipment for normal operation.

*RECEIVING THE EQUIPMENT

Check all contents of crates immediately after receipt**. DO NOT REMOVE GRAPHITE PIECES FROM THE CRATES EXCEPT TO INVENTORY THEM. THESE PIECES SHOULD BE TREATED AS GLASS. STORE IN ORIGINAL CRATES WITH ORIGINAL PACKING UNTIL INSTALLATION.** Replace the items in the crates and store in cool, dry, covered storage until required on the job site. Failure to do so can result in corrosion and other forms of damage.

A packing list is included with all shipments from the factory. The list is attached to the bill of lading or in a waterproof envelope on the shipping crate. The equipment should be checked against this list to assure the complete shipment was received. If any shortages are noted, SECO/ WARWICK should be notified immediately, so that installation will not be delayed waiting for parts.

There is a 15 day limit after receipt of shipment to report concealed damage claims; therefore, it is necessary to open and inspect immediately, while the carrier is still there, any equipment, boxes, or cartons which arrive on the job site that look as if they have been damaged. If damage is evident, call in an inspector for the carrier immediately to view the damage and make out a damage report. NOTE ON THE CARRIER'S RECEIPT THAT ARTICLES APPEAR TO BE DAMAGED. Keep all packing materials until the shipment is inspected. Do not give the carrier a clear receipt until you determine that the shipment is complete and not damaged.

Handle everything in its original crate until ready for use. Leave all reinforcing on until sections are in final position. Be especially careful with the heat control and power panels. All items of a heavy nature should be handled with dollies or forklifts to avoid vibration and shock.

*S/W 7 rev. 2- 7/31/03 - 2 pg - special

RECEIVING THE EQUIPMENT - Continued

Remember, you are responsible for all damage to the unit caused by moving or storing it. When removing skids from under units, the sides of the units should first be freed of all packing materials.

Care should be exercised to keep pumping units and gearboxes upright at all times, thus avoiding oil spills.

Parts received prior to installation should be stored in a place convenient to the site of erection, and should be protected against weather, dust, heat, and excessive moisture.

*EQUIPMENT INSTALLATION

GENERAL NOTES

As each installation will differ slightly, the following instructions give basic requirements only. Refer to the equipment drawings included for specific arrangement information.

If the customer is doing his own installation, the people doing the work must be familiar with installation of industrial equipment. Normally, if the piece is a single unit, the instructions, along with the drawings, will give enough information to install the equipment.

This unit is shipped with the control panel and vacuum pumps pre-mounted to the furnace base and with all interconnecting wiring completed between the panel and the various components. The customer will be required to make utilities connections to single points on the equipment.

The services of SECO/WARWICK for installation and startup are available if desired. If these services were not bought as part of the initial contract, they may be arranged before installation of the equipment. Contact SECO/WARWICK for further information.

The foundation or floor must be clean, level, and capable of supporting the weight of the equipment and the load. Shim the equipment to level it and provide proper support.

The customer shall provide a suitable ground to the electrical control panel in accordance with local codes and requirements.

* S/W INSTALL1 rev.23 9/30/04 6pg/w- special

WARNING

Protect gas valves from being exposed to freezing temperatures. Although the gas itself will not freeze, water that may be in the line can freeze, preventing valves from opening or closing. In addition, if a valve freezes closed and is then pulled open in operation, it may damage the seal. This will prevent the valve from closing completely when required.

Install heat tapes on gas valves exposed to freezing conditions. Insulate the valve on the pipe portion. **DO NOT PLACE INSULATION OVER THE COIL OF SOLENOID VALVES. THIS WILL CAUSE THE COIL TO BURN OUT FROM EXCESS HEAT.**

All valves have temperature and pressure limitations. See the supplier's literature for these limitations, and follow them. The warranty is not in effect for items damaged by exceeding the pressure or temperature limitations.

Do not blow out gas supply piping with air, and do not use water as a test medium for pressure testing.

For a open loop cooling system, a control/shut-off valve should be installed on the inlet side of water cooled components, and the outlet pipe should be open to a gravity drain. No valves are to be installed on the outlet side of the water circuits.

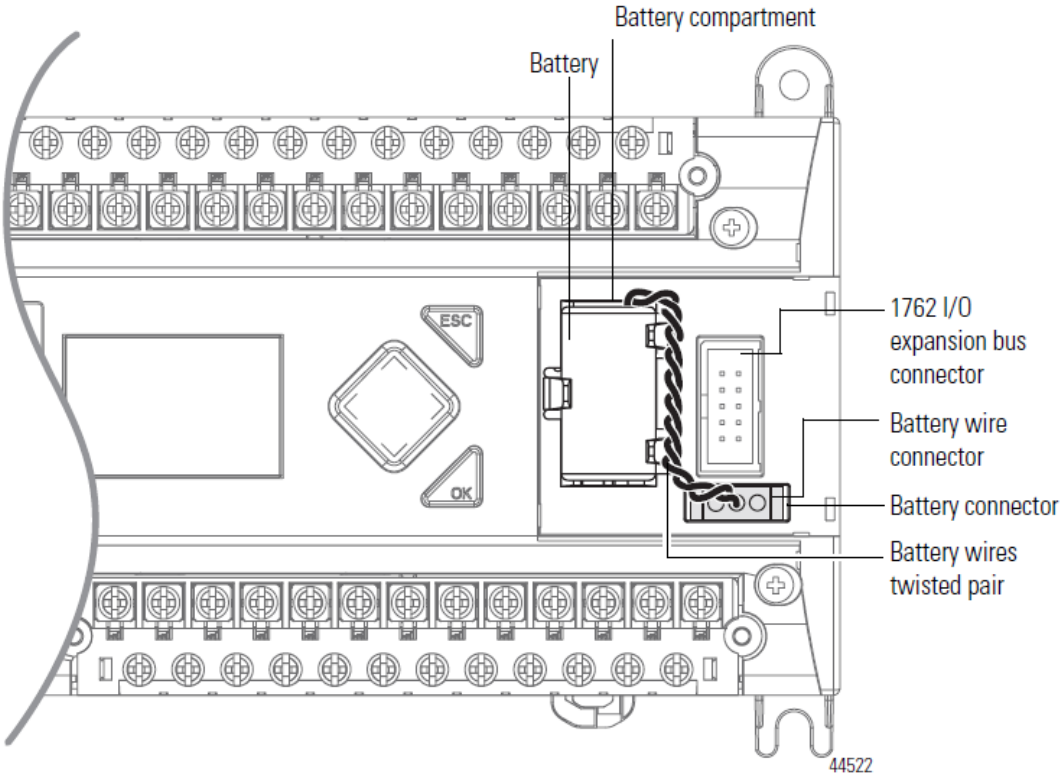
EQUIPMENT INSTALLATION – Continued

CONTROL SYSTEM INSTALLATION

This step must be performed before applying power to the control system. The PLC battery was disconnected to prevent drainage during shipping and storage. The battery can be found under the plastic cover on the right hand side of the PLC base.

Carefully insert the battery connector onto the terminals as shown in the diagram below.

Replace plastic cover when finished.



HOT ZONE INSULATION SYSTEM INSTALLATION

In order to reduce the risk of shipping damage, the furnace was shipped with the main hot zone insulation assembly removed and crated separately.

The insulation is pre-assembled to the stainless steel support framework. The hot zone assembly should be one of the last items installed, and should be left in the shipping container until ready to set it in place on the support angles. The graphite insulation used in its construction is fragile and the assembly should be handled carefully to avoid damaging it.

The furnace's power feedthroughs have been shipped in place on the furnace shell. In order to install the insulation assembly, the current-carrying copper bar of the feed-through must be pulled out approximately 4" to clear the insulation framework as it is slid into position. To withdraw the bar, remove the polycarbonate guard that covers the electrical connections at the outside of the furnace shell. Remove the large knurled brass nut that is used to hold the feedthrough's internals in place, and pull the copper bar out enough to provide clearance between it and the insulation frame.

Open the furnace door and secure it in the open position. It should not be allowed to close until the furnace internals are in their proper positions. The insulation system is then set on the support rails on the bottom of the furnace chamber and slid into position. The assembly must then be positioned by lining up the holes for the hearth piers in the insulation with the corresponding sockets underneath them on the chamber floor.

Each feed-through is provided with a 4" diameter, ½" thick radiation shield (dwg.#105273D, item #26). The shields should be hung over the copper bar while it is pulled out. When the insulation assembly is in position, and the radiation shields are in place, the feedthroughs can be pushed into their operating position.

The large brass nuts at the outside of the power feedthroughs may now be replaced. ***The brass nuts are to be hand tightened only. Over tightening will damage the 'O'-ring seals in the feedthroughs***.

The door insulation has been factory installed. The nuts on the support rods at either side of the frame, however, have been tightened down for shipment. These fasteners must be loose to allow the frame to move as required during heating cycles. All of the nuts on the mounting studs should be backed off approximately one turn and held in position with the jam nut.

HARD GRAPHITE COMPONENTS

The graphite feed-through connector (Drawing105273D, item 8) can now be threaded onto the copper bar, and the graphite plate elements installed. The elements are held in place with ¾"-10 round graphite nuts. ***Threaded graphite components also are to be hand tightened only. Over tightening may crack the element or the fastener. The graphite feed-through connector must not contact the hot zone insulation at any point.***

The 4" dia. by ½" thick radiation shields which were placed over the copper conductors should now be pushed over the graphite section and located approximately ¼ - ½" from the outside surface of the insulation. ***The feed-through shields must not contact any part of the hot zone insulation system.***

The graphite nuts holding the elements should be rechecked after each of the first few heating cycles and retightened if necessary.

The hearth piers are inserted into their holes in the floor of the hot zone assembly. The piers are provided with heat radiation shields fabricated of 1" thick graphite insulation, and held in place with hard graphite pins (Drawing. 105273D, items 27 and 29). The piers are threaded through the in floor insulation and dropped into the sockets at the bottom of the chamber. The hearth plate rests on the top of the piers.

CONTROLS AND THERMOCOUPLES

The control and overtemperature thermocouples have been shipped installed, but withdrawn to allow removal of the hot zone for shipping. The type "C" thermocouple is used for temperature control, and is located in the forward most penetration on the side of the furnace shell. The control thermocouple is pushed through the insulation so that its tip is ¼ to ½" beyond the inner surface of the ***element,*** not the insulation. Compression fittings are used to seal the thermocouple. The fitting must be loosened prior to moving the thermocouples, and retightened when they are in place. Do not overtighten the fitting.

The overtemperature thermocouple is installed in the rearward port on the shell. It should be inserted until its tip just contacts the outside surface of the insulation. The purpose of the overtemperature thermocouple is to protect the hot zone insulation. It is intended that it sense the 'cold' side of the insulation. Pushing it into the insulation will cause it to read a higher temperature, which may cause nuisance shut downs caused by the overtemperature protection system.

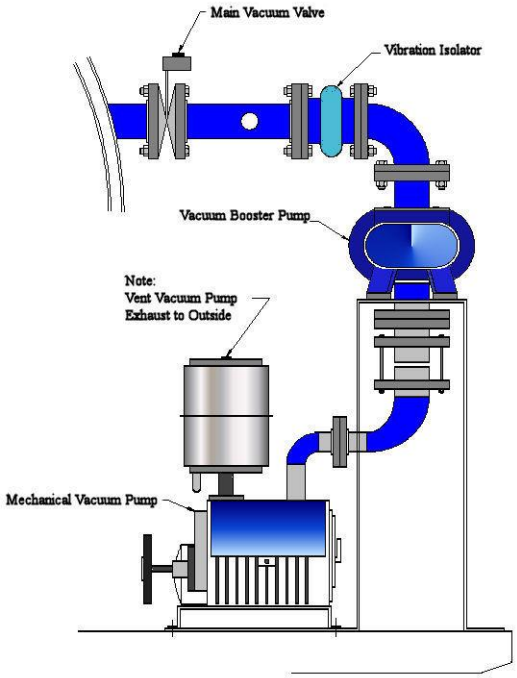
HOT ZONE INSULATION SYSTEM INSTALLATION – Continued

The critical water cooling circuits have been provided with combination flow and temperature sensors. The temperature setpoint should be set to alarm at approximately 57ºC. To set the flow alarm setpoints on the units, it is recommended that the furnace be brought up to temperature with full water flow. The water supply should then be slowly throttled back until the temperature rises above approximately 57°C. The flow setpoint of the sensors should be set to alarm at that point. Consult the IFM Efector supplier literature for sensor setup details.

It is generally recommended that the cooling flows be set up for an average outlet temperature of approximately 50-55ºC with the furnace operating at maximum temperature. The 55ºC outlet temperature was chosen because continuous operation above that level can cause solids to be precipitated out of the water into the cooling passages. Outlet temperatures below that level means that more water is being used than is required.

*ROUGH PUMPING SYSTEM

The mechanical, or rough pumping system, will operate from atmosphere down to approximately 1 micron (1 x 10^{-3} mm mercury). The main portion of this system consists a mechanical (or “rough”) pump, usually of the rotary piston type. This type pump begins to lose its efficiency below approximately 29 inches of mercury vacuum, so a booster pump is placed between the furnace and the rough pump. This booster pump uses a set of rotating lobes which compress the air being removed from the furnace to allow the rough pump to operate at a higher pressure and maintain its efficiency. This decreases the amount of time required to reach a lower vacuum level.



**VAC3 rev. 6- 6/05 - VAC Team - 1pg - special

GENERAL INSPECTION

Prior to charging the work load into the furnace, the operator should do a general inspection of the furnace internals. All of the graphite connections should be inspected for loose fasteners and damage. The fasteners should be hand tightened only. The use of tools to tighten a graphite fastener can damage the fastener, tie bars, or power feedthroughs. The insulation system, along with the interior of the chamber, should be examined for excessive buildup of deposits of materials emanating from the process.

The elements and feedthroughs should be inspected for signs of arcing, which is evidenced by localized erosion in the area of a mechanical connection along with a thin coating of dust in the immediate area, which is actually ash from the degradation of the element. The ash can range in color from gray to nearly white.

The elements and insulation should be inspected for damage from the leakage of air into the chamber. An air leak is generally evidenced by erosion or softening of the graphite insulating materials, or a loss of cross section in the solid graphite in the elements and tiebars.

The ‘O’-ring used to seal the door should be inspected for nicks or cuts. The ‘O’-ring and door flange should be wiped clean. A light coating of vacuum grease should then be applied to the seal. The coating should be only heavy enough to make the surface of the ‘O’-ring appear shiny, with no real thickness of the grease.

The inspection items outlined are intended to highlight those points that can be conveniently checked by the operator during loading. Please refer to the maintenance section of this manual for a complete listing of inspection and maintenance items.

LOADING

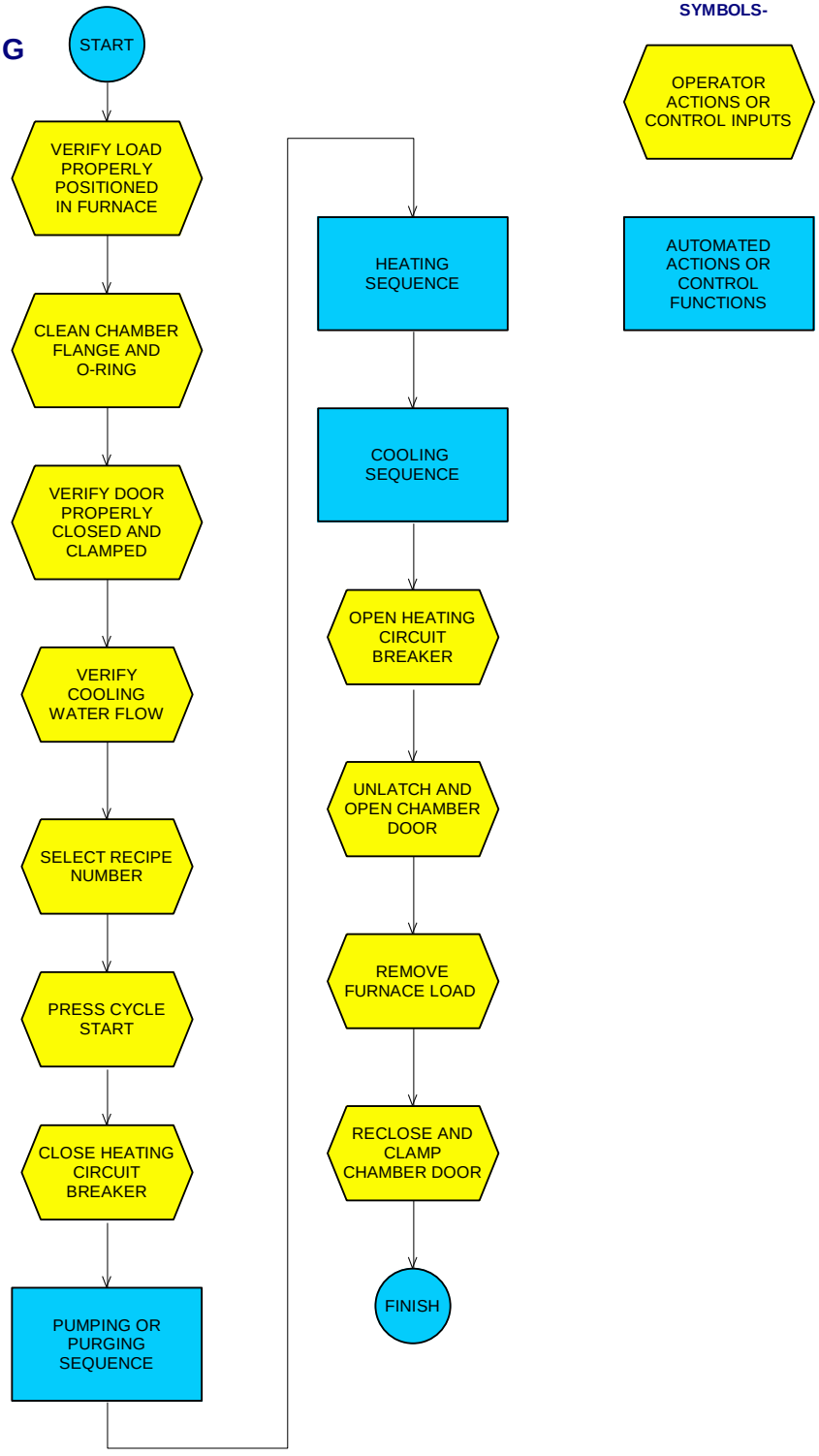
Care should be taken during loading to ensure that the load is properly placed on the hearth plate. The operator should ensure that no foreign objects are in the furnace.

The clamping bolts need to be tightened only enough to pull the door against the ‘O’-ring seal. When pumping begins, atmospheric pressure on the outside of the door will be more than sufficient to produce a seal.

NOTE:
The clamps will loosen during pump down, due to compression of the ‘O’-ring seal. Re-tightening of the clamps is not required. Re-tightening will make them very difficult to loosen when the furnace is returned to atmospheric pressure for unloading.

SEQUENCE OF OPERATION FLOW CHART

GENERAL OPERATING SEQUENCE

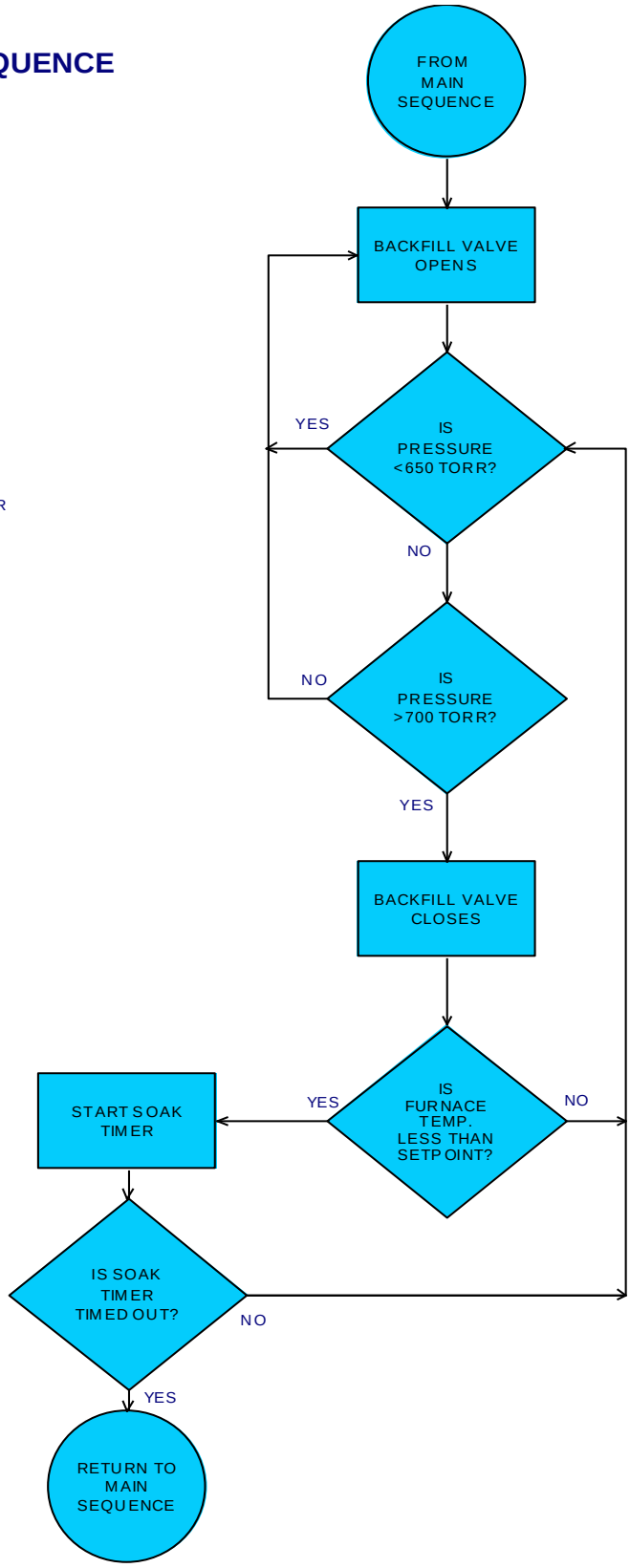


GAS COOLING SEQUENCE FLOW CHART

GAS COOLING SEQUENCE

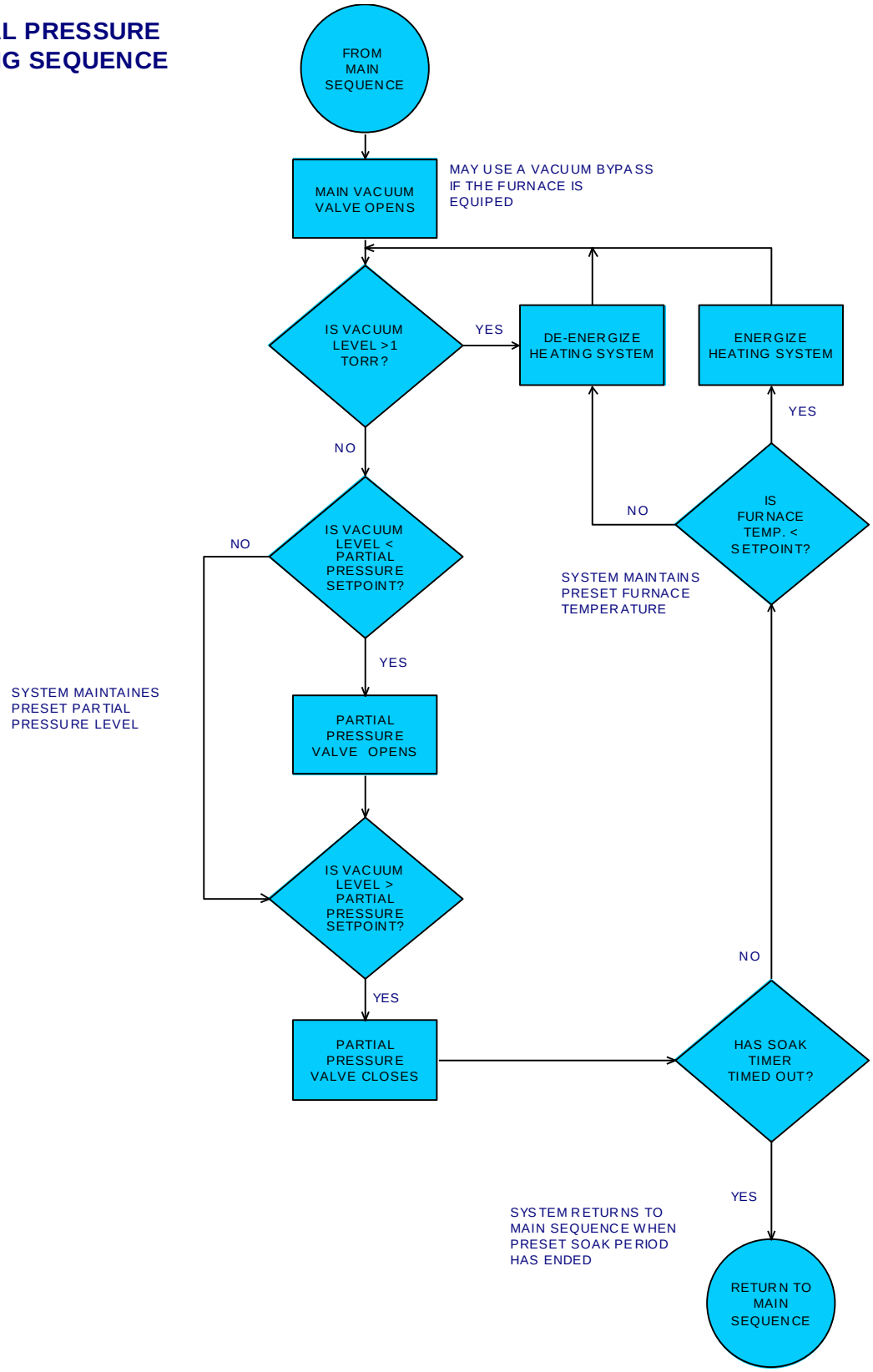
SYSTEM BACKFILLS CHAMBER AND MAINTAINS PRESSURE BETWEEN 650 AND 700 TORR

SYSTEM STARTS TIMER WHEN A PRESET TEMP-ERATURE IS REACHED



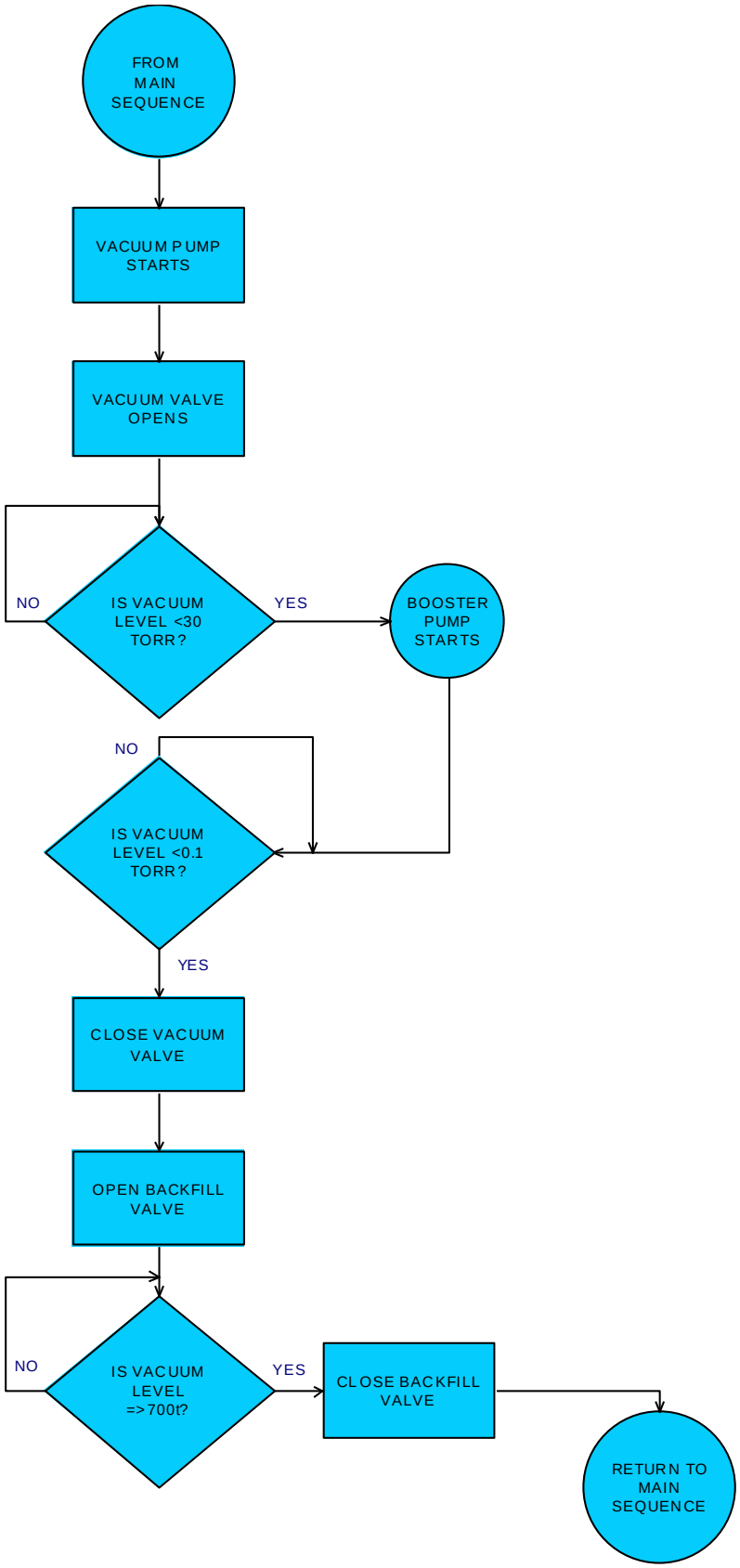
PARTIAL PRESSURE SEQUENCE FLOW CHART

PARTIAL PRESSURE HEATING SEQUENCE



PURGING SEQUENCE FLOWCHART

PURGING SEQUENCE



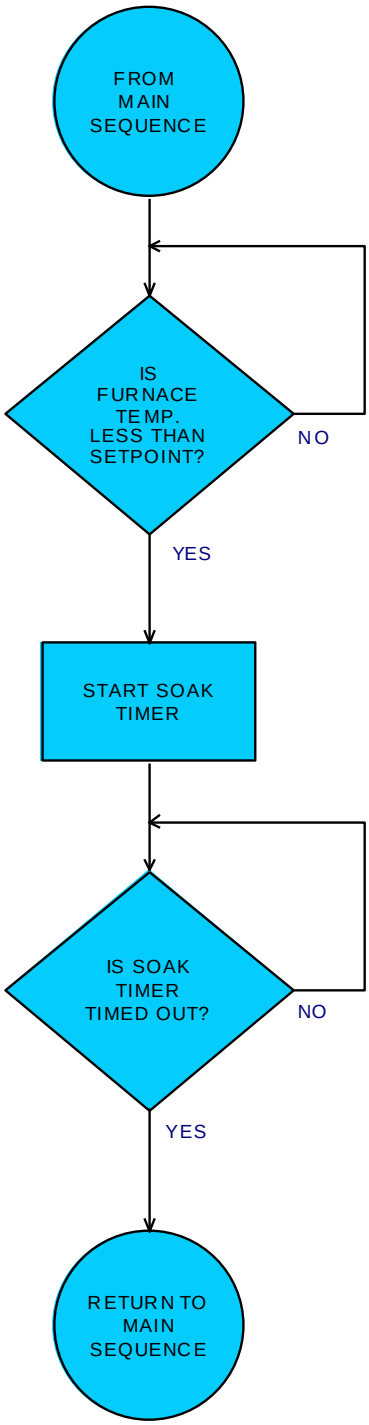
VACUUM COOLING SEQUENCE FLOWCHART

VACUUM COOLING SEQUENCE

FURNACE CHAMBER IS MAINTAINED UNDER VACUUM FOLLOWING HEATING CYCLE

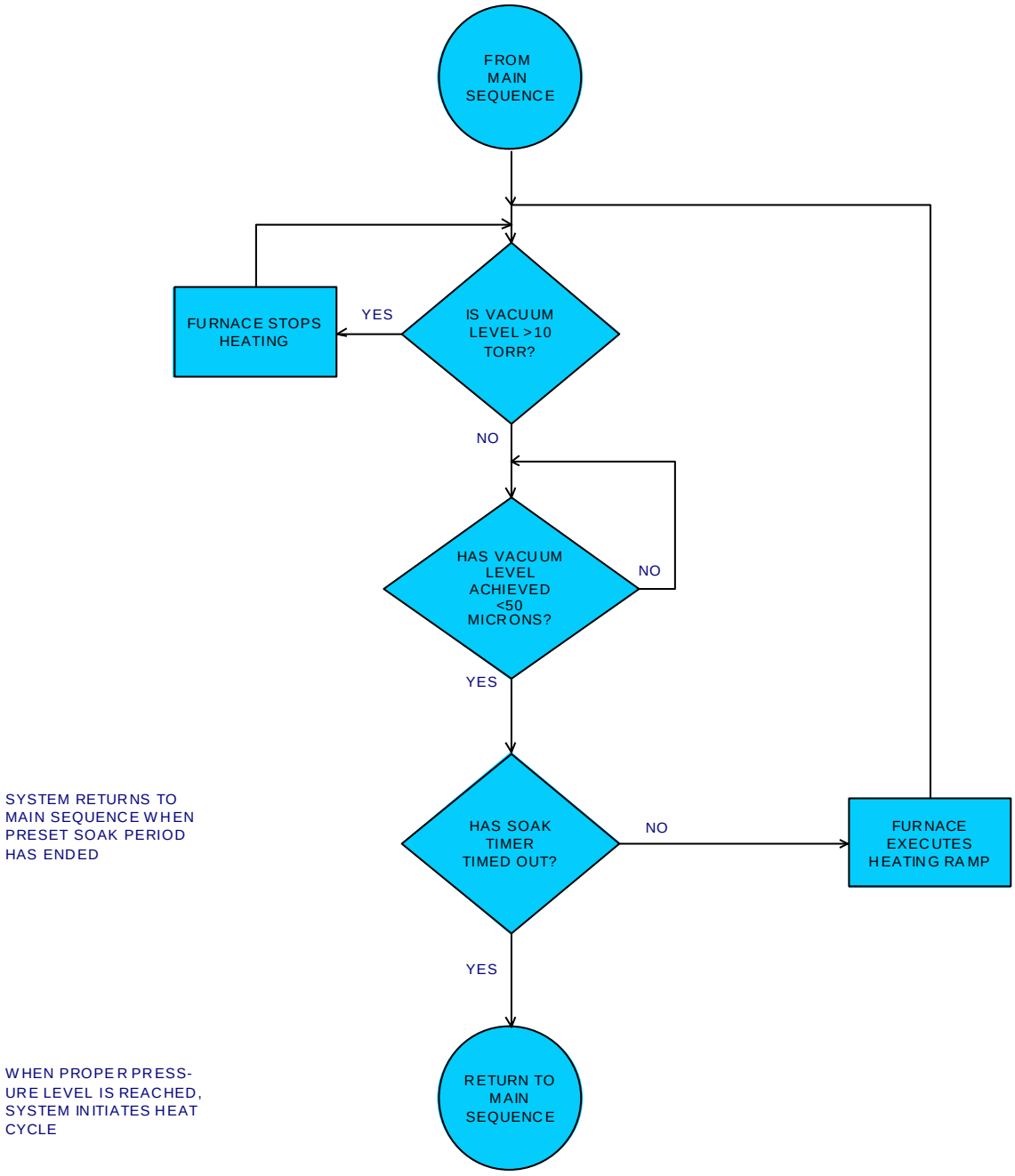
SYSTEM INITIATES SOAK TIMER WHEN PRESET FURNACE TEMPERATURE IS REACHED

ON COMPLETION OF SOAK PERIOD, SYSTEM RETURNS TO MAIN PROGRAM SEQUENCE FOR COMPLETION OF FURNACE CYCLE



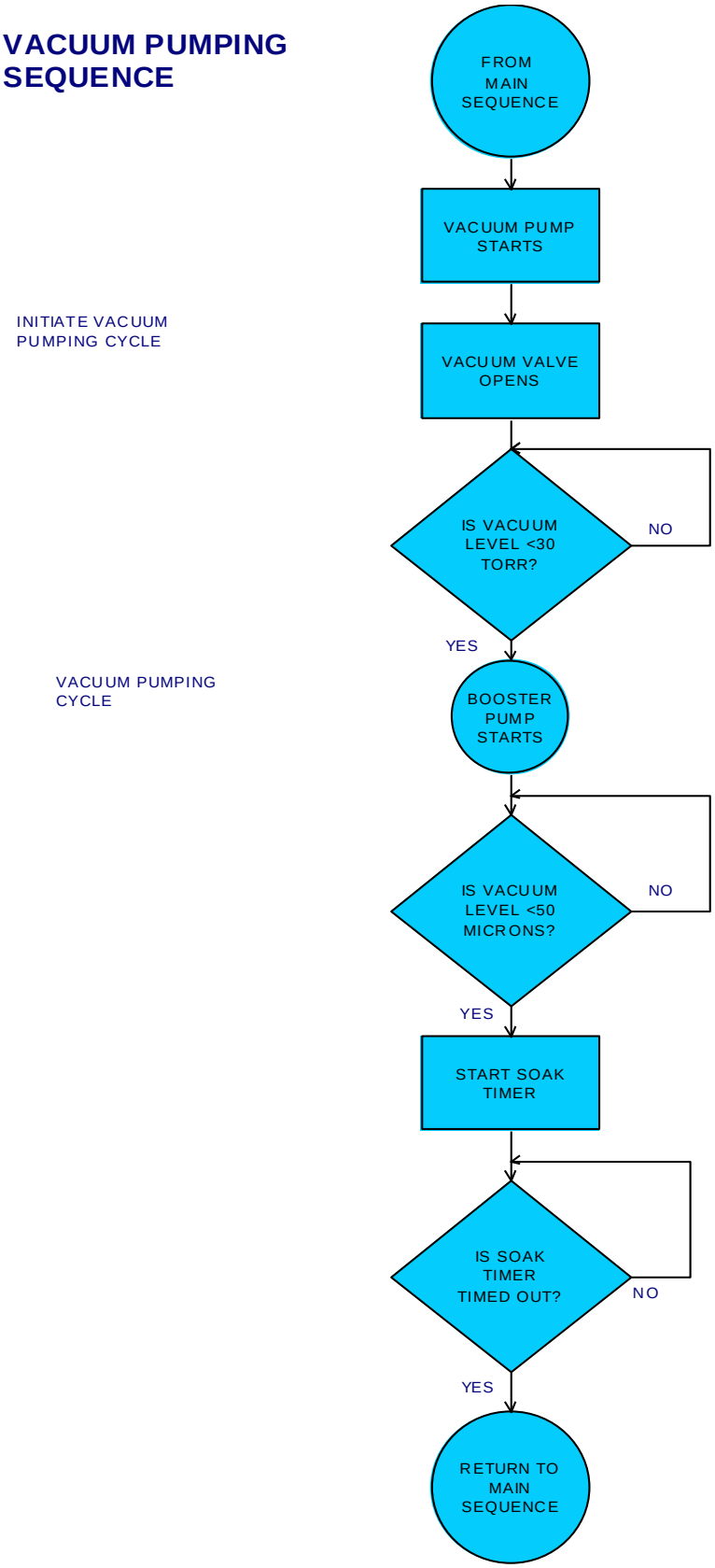
VACUUM HEATING SEQUENCE FLOWCHART

VACUUM HEATING SEQUENCE



VACUUM PUMPING SEQUENCE FLOWCHART

VACUUM PUMPING SEQUENCE



OPERATION

See page **91** for **"EMERGENCY PROCEDURE".**

In this section, CAPITALIZED words show label as it appears on the control panel.

LOADING

CAUTION

When loading and unloading the furnace, its door should be open for the shortest possible time. This will minimize air and moisture absorption in the furnace interior. Excess moisture increases evacuation time.

a. Prepare the workload (degreased and dry).

b. Carefully position the workload on the furnace hearth manually or with an external loader. The workload should sit on a tray or other fixture to avoid direct contact of the workload with the graphite hearth above 1100°C. Check the arrangement of load thermocouples (if any) so they will not come into contact with the heating elements.

c. Close the door and secure it with the manual clamps.

START-UP

a. Turn main power to the furnace on, and press emergency stop reset.

b. Check water flow through the system at the outlet manifold. Re-check and adjust, if necessary, when the furnace reaches operating temperature.

c. Verify inert gas flow to the system and check pressure.

d. Reset all alarms.

e. Check the operation of the mechanical vacuum pump.

FURNACE OPERATION.

DEVELOPING A RECIPE

- Access the RECIPE EDIT screen from the MAIN MENU.
- This screen is secured and will require the operator to enter a password. The default is "0"
- Press the number beside RECIPE EDIT. This accesses the number pad. Input the recipe number you would like to edit or develop, then press ENTER.
- Use the HELP button to access another screen to get details on recipe parameters. This screen lists the different functions (EVENTS) that the furnace is capable of. They are:
  - 1= PUMPING – This is a pumping segment. It is recommended as the first segment of each recipe, but is not required. The only parameter used is SOAK TIME. This is the time the furnace will soak at vacuum (no temperature). The soak timer begins when the vacuum level reaches 0.050 mbar.
  - 2 = PURGING – This is similar to the pumping segment. The only exception is that the furnace pumps down to a vacuum level of 0.050 mbar and holds for the amount of time in the SOAK TIME, then backfills the furnace with nitrogen. Once again, the only parameter used is SOAK TIME.

DEVELOPING A RECIPE – Continued

- 3 = VAC HEAT – This is heating under vacuum. It can be used as the segment following PUMPING. It is possible to have multiple VAC HEAT segments. All parameters are used except PRESS.
- 4 = PP HEAT – This is heating with partial gas flow. It can be used as the segment following PUMPING. It is possible to have multiple PP HEAT segments. All parameters are used.
- 5 = GAS COOL – This is cooling under a still inert gas. At the end of cooling, the furnace backfills to 800 mBar and sits until the SETPOINT is reached. The only parameters used are SETPOINT and SOAK TIME. SOAK TIME can be used, but is not required. It would be used if you would like to ensure that the load cools.
- 6 = VAC COOL – This is cooling under vacuum. When the final heating segment finishes, the furnace continues to pump down throughout the entire segment. SETPOINT and SOAK TIME are the only parameters used. SOAK TIME can be used, but is not required. It would be used if you would like to ensure that the load cools.
- 7 = END CYCLE – This should be the last segment of a recipe. It sounds a siren to alert the operator that the cycle is finished. No parameters are used.

- A matrix is used to develop recipes. Each recipe is broken down into segments (max 10 segments in a recipe) across and parameters (EVENT, SETPOINT, SOAK TIME, G. BAND, PRESSURE, RAMP RATE, down. These determine what operations the recipe will perform. A recipe can be as few as 2 segments (we strongly recommend a END

DEVELOPING A RECIPE – Continued

- OF CYCLE segment) and not all parameters have variables in each segment. For instance a furnace pump down recipe can be developed. It would consist of segment 1 which is a pumping segment with a 5
- minute soak, then segment 2 is EVENT = 11. All other parameters = 0. Any time a 0 is selected as a variable, that variable is inactive.
- The parameters are set up in the following manner with the following limits.
    - EVENT – See EVENT List, page 43.
    - SETPOINT (°C) – Temperature at which soak is to be performed (any number between 0 and 2000)
    - SOAK TIME (min) – Time in which load is to be at setpoint (any number between 0 and 9999)
    - G. BAND (°C) – Temperature range at which furnace is in soak (any number between 0 and 100.
    - PRESSURE (mBar) – Pressure setting to maintain during Partial Pressure Heating.
    - RAMP RATE (°C/min) - Speed at which the furnace heats to the setpoint (any number between 0 and 99)

The following is an example of a cycle that includes almost all of the possible events. We want to:

1. Pump the furnace down to a vacuum and soak it for 5 minutes
2. Heat the furnace to 600°C under vacuum and hold for 10 minutes with the soak timer starting when the furnace reaches setpoint and a G Band of 15°C at a rate of 20°C/min.
3. Heat the furnace to 1000°C under a partial pressure atmosphere and hold for 60 minutes with the soak timer starting when the

furnace reaches the setpoint and a G Band of 5°C at a rate of 10°C/min at a partial pressure of .5 mbar.

DEVELOPING A RECIPE – Continued

4. Vacuum cool the furnace to 400°C.
5. Gas cool the furnace to 50°C.
6. End of cycle

EDIT RECIPE 1						
SEGMENT	1	2	3	4	5	6
EVENT	1	3	4	6	5	7
SETPOINT	0	600	1000	400	50	0
SOAK TIME	5	10	60	0	0	0
G. BAND	0	15	5	0	0	0
PRESSURE	0	0	.5	0	0	0
RAMP RATE	0	20	10	0	0	0

UNLOADING

The cycle typically ends when the load surface temperature reaches 65°C. Open the furnace and unload the fixture off the graphite rails with the external loader.

CAUTION

Do not breathe nitrogen gas remaining in the furnace chamber after the cycle is complete.

Once the furnace is unloaded, check the condition of the heating elements and load supports.

Unload the furnace as quickly as possible.

SHUT DOWN

If the furnace is not to be operated for 24 hours or more, the furnace should be shut down. To shut-down the furnace at the end of the heat treatment cycle, switch off the main power breaker. Close the main inlet valves for the water, compressed air and gas systems. The furnace is then out of operation.

Keep the furnace closed and evacuated, unless maintenance operations are being performed. This will minimize moisture absorption and condensation on the cold parts of the furnace interior permitting shorter evacuation times to the required operating vacuum level when the furnace is re-started.

OPERATION - Continued

OPERATION OF THE OPERATOR INTERFACE PANEL

The operator interface panel is a Touch-screen unit. With this type of interface, the operator touches the membrane screen at different positions. SECO/WARWICK has developed pushbuttons within each screen that perform different functions when the appropriate function key is pressed. Other areas of the screen provide information, but do not perform operator-controlled functions.

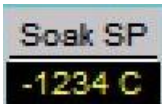
The following pages describe each screen that may appear on the operator interface and the function of each button on those screens.

*An asterisk is used to denote buttons.

Alarm Banner - An alarm banner will appear at the bottom of the window area whenever an alarm exists. For example;

LEGEND;

The following describes typical graphics used throughout the HMI application.



Text shown in yellow, without a border, represents setpoint data. This data is changeable in another area.

Text shown in green represents process value data.

Text shown in yellow, with a raised border represents a data entry value. The operator touches the value to open the data entry keypad.

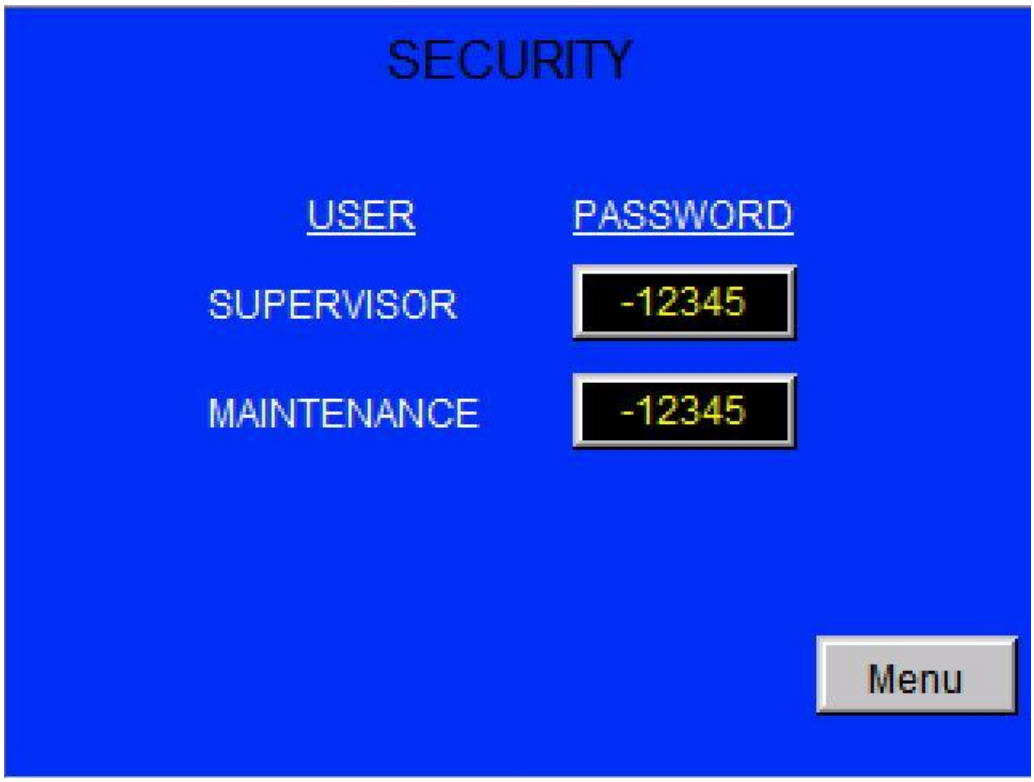
MENU SCREEN

The first is the MENU screen. From this screen you can access all of the information that is tracked by the furnace control system. Each button will be discussed.

MENU - Use the up/down arrows to select the desired screen name, then push the named button.

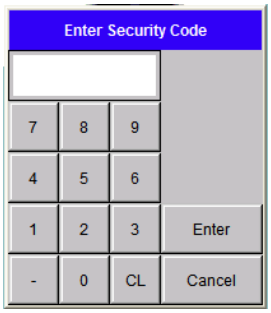
OPERATION OF THE OPERATOR INTERFACE PANEL - Continued

SECURITY SCREEN



The SECURITY screen is used to configure the numerical passwords to be used by each secured user. There are two default users with access to secured screens; Maintenance and Supervisor. The default password for each is "0". Only the Supervisor has access to this screen. If a screen is secured, a password entry pad will appear (see below) when trying to access the screen.

All screens are unsecured except where noted in the descriptions.

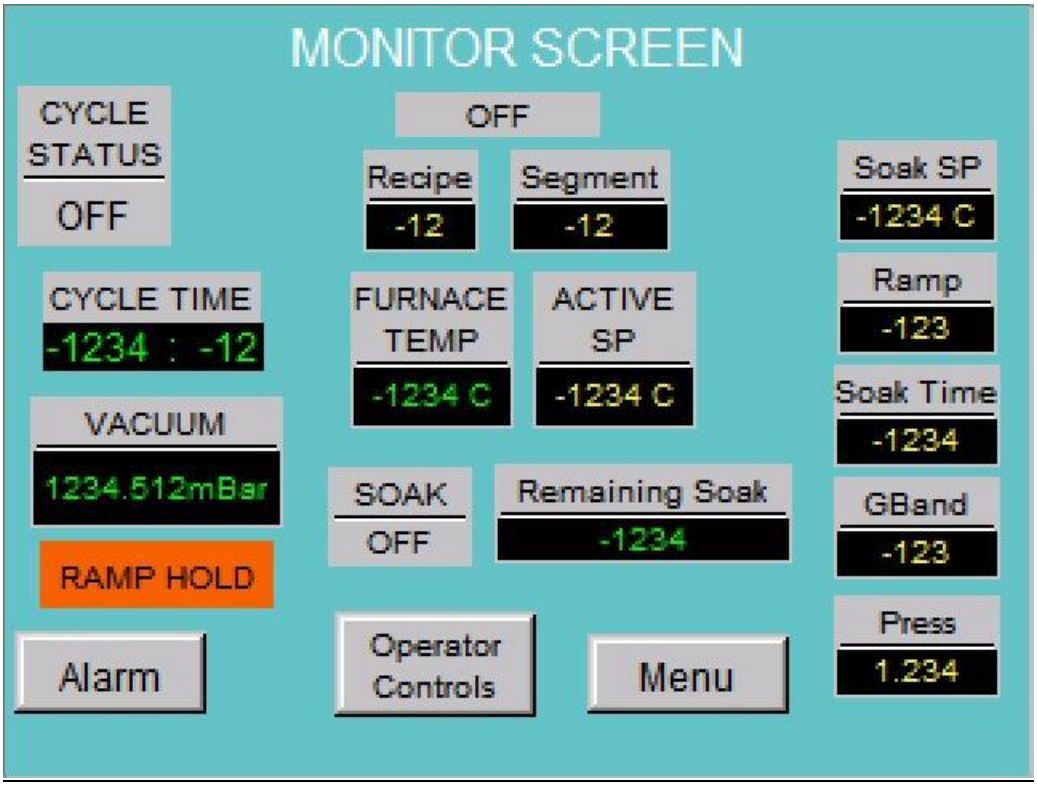


*MENU	-	Accesses MENU screen

OPERATION - Continued.

OPERATION OF THE OPERATOR INTERFACE PANEL – Continued

MONITOR SCREEN



The MONITOR screen provides the most information to the operator during the furnace cycle.

ALARM - This button will alert the operator to the alarm condition of the furnace and will access the alarm screen. It will display either ALARM in gray (furnace is in good operating condition) or ALARM in red (furnace is under an alarm condition).

RECIPE - Displays number of recipe that is actively operating

SEGMENT - Displays the active segment of the active recipe

CYCLE STATUS - - Displays whether cycle is ON, OFF, or

HOLD

OPERATION OF THE OPERATOR INTERFACE PANEL - Continued

MONITOR SCREEN – Continued

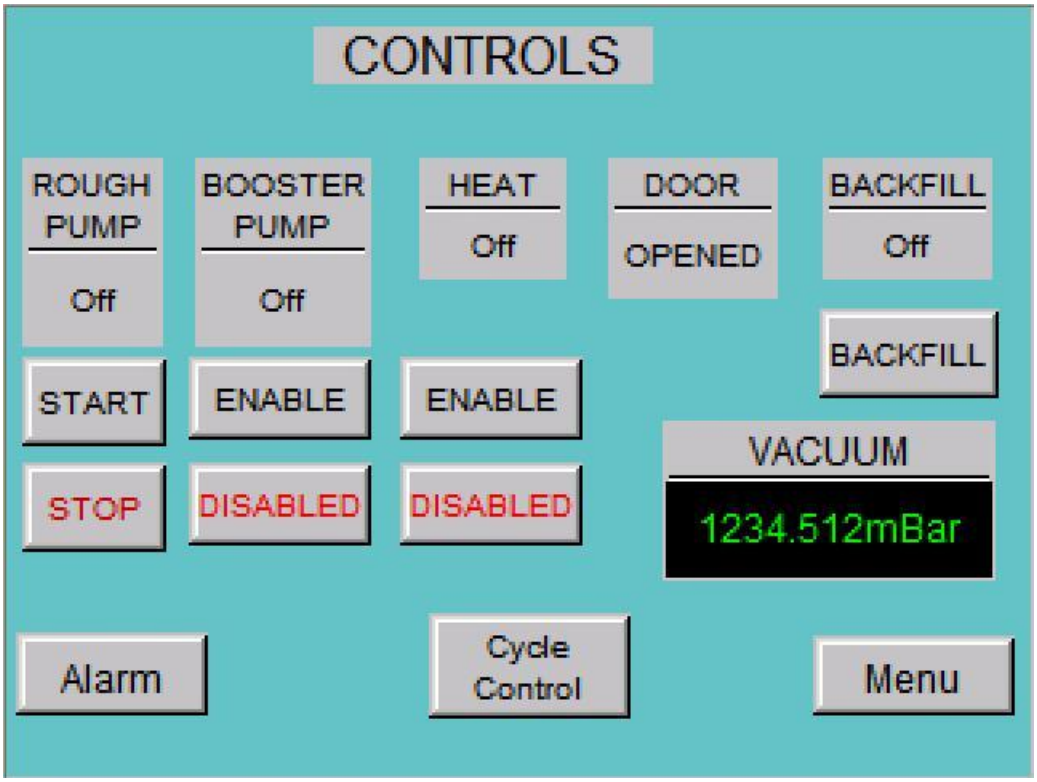
CYCLE EVENT	- Displays name of cycle segment
CYCLE EVENT can be:	- Off - Pumping - Purging - Vacuum Heat - Partial Pressure Heat - Vacuum Cool - Gas Cool - End of Cycle
CYCLE TIME	- Displays elapsed time from start of cycle.
ACTIVE SETPOINT	- Displays the temperature setpoint as it ramps to the soak temperature.
SOAK SP	- Displays temperature soak setpoint for active segment of active recipe
FURNACE TEMP	- Displays current temperature of furnace according to control T/C
REMAINING	- Displays soak time remaining in active segment
SOAK STATUS	- Displays status of soak (either IN SOAK or not displayed at all)
VACUUM (mbar)	- Displays vacuum level in furnace
*MENU	- Accesses MAIN MENU screen
*CONTROLS	- Accesses OPERATOR CONTROLS screen
*ALARMS	- Accesses ALARM screen
RAMP	- Displays the ramp rate of the active segment.
SOAK TIME	- Displays the soak time setting of the active segment. (minutes)
G. BAND	- Displays the active segment guaranteed temperature band.
RAMP HOLD	-Is visible when the vacuum level has risen

out of range and the set point ramp has been paused.

OPERATION – Continued

OPERATION OF THE OPERATOR INTERFACE PANEL – Continued

CONTROLS SCREEN



The CONTROLS screen provides the operator the ability to control the cycle and all major components of the furnace.

From this screen the operator can enable, or disable the pumps and heat. In case of mechanical problems, the following components can be disabled: ROUGH PUMP, BOOSTER PUMP and HEAT. Each button also displays the ENABLED status of the components. Green is ENABLED, red is DISABLED.

*BACKFILL	-	Opens the nitrogen backfill valve in vacuum below 1 Bar after the cycle has been completed
*ROUGH START	-	Press to start rough vacuum pump (out of cycle), this button turns GREEN and displays ROUGH ON, when pressed
*ROUGH STOP	-	Press to stop the rough vacuum pump
*ENABLE BOOSTER	-	Enables operation of the booster pump. It displays GREEN when active, WHITE when inactive
*DISABLE BOOSTER	-	Disables operation of the booster pump. It displays RED when active, WHITE when inactive
*ENABLE HEAT	-	Enables operation of the heating elements. It displays GREEN when active, WHITE when inactive
*DISABLE HEAT	-	Disables operation of the heating elements. It displays RED when active, WHITE when inactive

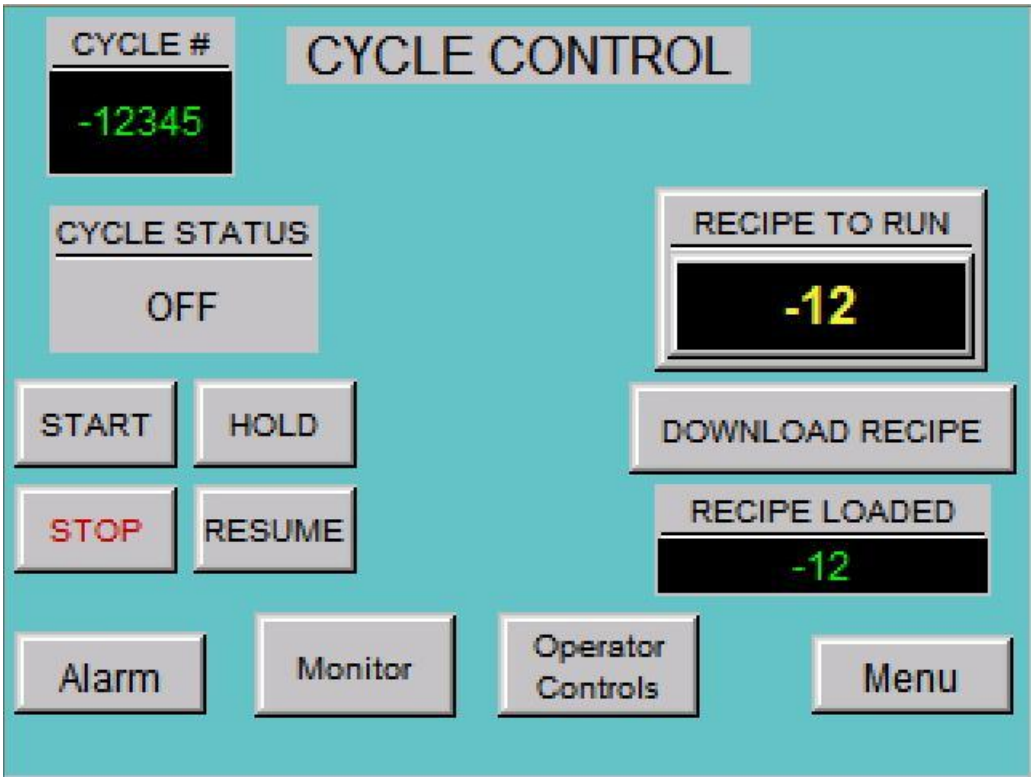
The following information is also displayed:

DOOR	-	Indicates status of the door; "OPENED" in black and "CLOSED" in green.
VACUUM	-	Displays vacuum level in furnace.
*CYCLE CONTROL	-	Accesses CYCLE CONTROL screen
*MENU	-	Accesses MENU screen
*ALARM	-	Accesses ALARMS screen

OPERATION - Continued.

OPERATION OF THE OPERATOR INTERFACE PANEL – Continued

CYCLE CONTROL SCREEN –



The CYCLE CONTROL screen provides the operator the ability to control the cycle. From this screen the operator can start, stop, hold, and resume the cycle, and download the recipe to run for the cycle.

*CYCLE START	-	Press to start the cycle
*HOLD	-	Press to hold cycle in active segment
*CYCLE STOP	-	Press to stop the cycle
*RESUME	-	Press to resume cycle after hold
*RECIPE TO RUN	-	Accesses the RECIPE TO RUN number pad for choosing the recipe to be run. Press the number desired, then ENTER

The following information is also displayed:

*DOWNLOAD RECIPE	-	Download RECIPE to run data to the PLC. Recipes must be downloaded to become active
CYCLE STATUS	-	Displays whether cycle is ON, OFF, or on HOLD
RECIPE LOADED	-	Disables the recipe that has been downloaded to run for the cycle.
CYCLE #	-	Displays the cycle number. This is a sequential number representing the number of cycles run in the furnace.
*OPERATOR CONTROLS	-	Accesses OPERATOR CONTROLS screen
*MENU	-	Accesses MENU screen
*ALARM	-	Accesses ALARMS screen
*MONITOR	-	Accesses MONITOR screen

OPERATION - Continued

OPERATION OF THE OPERATOR INTERFACE PANEL -Continued

RECIPE REVIEW SCREEN

The "REVIEW RECIPE" screen allows the operator to review all segments of the active recipe. The recipe can be reviewed by up to four segments at a time by touching either the >>>> or <<<< buttons.

SEGMENT - Displays the segment numbers of the active recipe in chronological order

EVENT - Displays event from Event Legend (1-11)

SETPOINT - Displays the temperature setpoint (°C) for the segments of the active recipe

SOAK TIME - Displays the soak time (min) for the segments of the active recipe

OPERATION OF THE OPERATOR INTERFACE PANEL - ContinuedRECIPE REVIEW SCREEN – Continued

G. BAND	-	Displays the temperature variance band (°C) for the segments of the active recipe
PRESS	-	Displays the pressure setpoint for Partial Pressure Heating (only).
RAMP	-	Displays the ramp rate (°C/min) for the segments of the active recipe
*BACK	-	Accesses the previously viewed screen
*HELP	-	Accesses the RECIPE HELP screen
*MENU	-	Accesses MENU screen
*<<	-	Scroll segments left
*>>	-	Scroll segments right

OPERATION – Continued

OPERATION OF THE OPERATOR INTERFACE PANEL - Continued

RECIPE EDIT SCREEN

Accessible only by Supervisor.

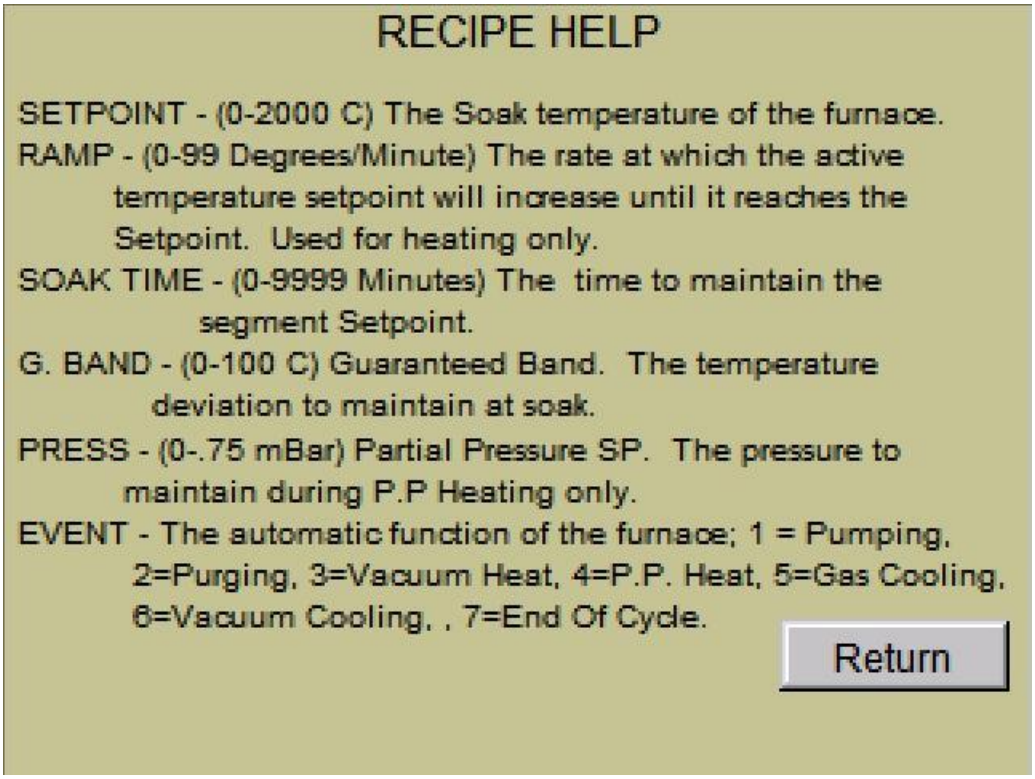
This screen is used to make new recipes and change existing ones. The EVENT legend is used to determine cycle events. The segment parameters are the same as those described under the RECIPE REVIEW screen. There is a RECIPE HELP screen that can assist with problems in determining cycles. There is also a RECIPE TERMS screen that describes each parameter of the segment and what minimum and maximum values that can be used are.

Four (4) segments are shown at a time on the screen. Values for each segment are placed in the number (yellow numbers with black backgrounds) beside each parameter. Use the arrow keys to scroll through the recipe variables. Use the enter key to select the variable to change.

RECIPE EDIT SCREEN – Continued

*RECIPE TO EDIT	-	Accesses RECIPE EDIT number pad, from which the operator chooses a recipe to edit or develop, then presses ENTER.
*HELP	-	Accesses RECIPE HELP screen
*<<	-	Scroll segments left
*>>	-	Scroll segments right
*SAVE AS RECIPE	-	Accesses a number pad in which the operator chooses a number to designate the recipe that has just been edited.
*SAVE	-	Saves the variables for the recipe that has just been edited
*MENU	-	Accesses MENU screen

RECIPE HELP SCREEN



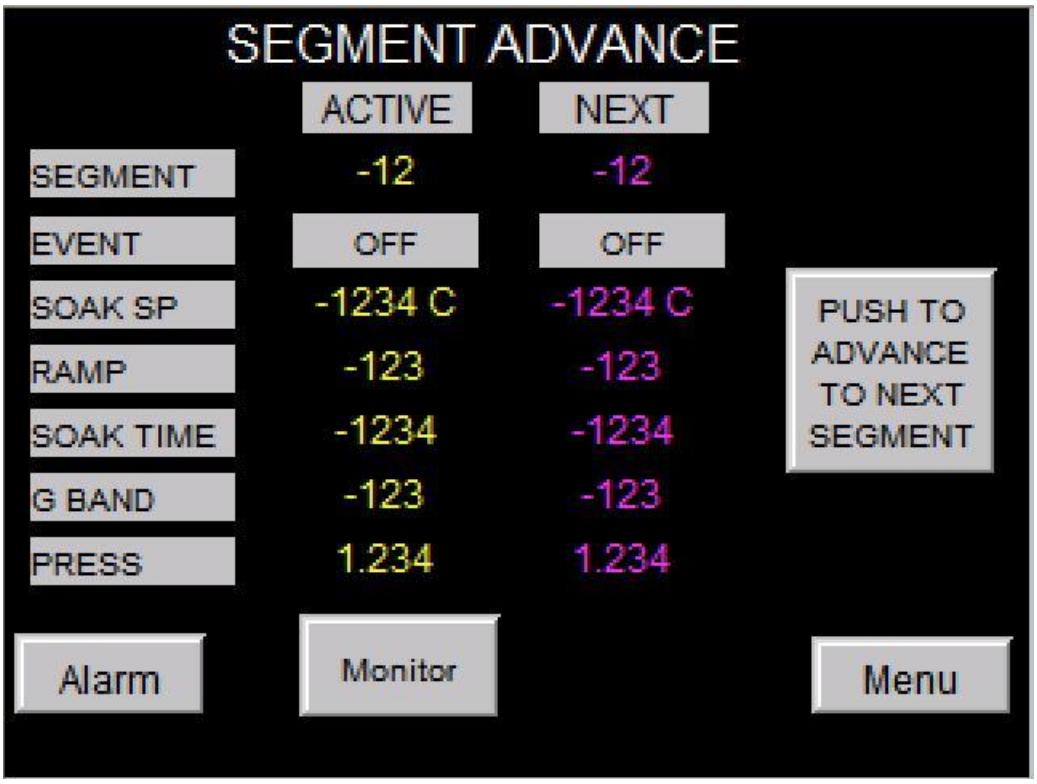
This screen is used to assist operators if they have any trouble with the RECIPE REVIEW screen or RECIPE EDIT screen. The screen is self explanatory.

*RETURN - Accesses the previously viewed screen

OPERATION - Continued

OPERATION OF THE OPERATOR INTERFACE PANEL - Continued

SEGMENT ADVANCE SCREEN



The "SEGMENT ADVANCE" screen provides authorized personnel the capability to "quit" or "skip" a segment. On this screen, you will find the ACTIVE SEGMENT (including all parameters) and NEXT SEGMENT (including all parameters). The segment parameters can not be edited from this screen.

NOTE: If the desired segment has been passed, then the cycle will need to be stopped, and then restarted. Then the operator can advance to the desired segment.

*PUSH TO ADVANCE TO NEXT SEGMENT - Press this button if you would like to advance the segment

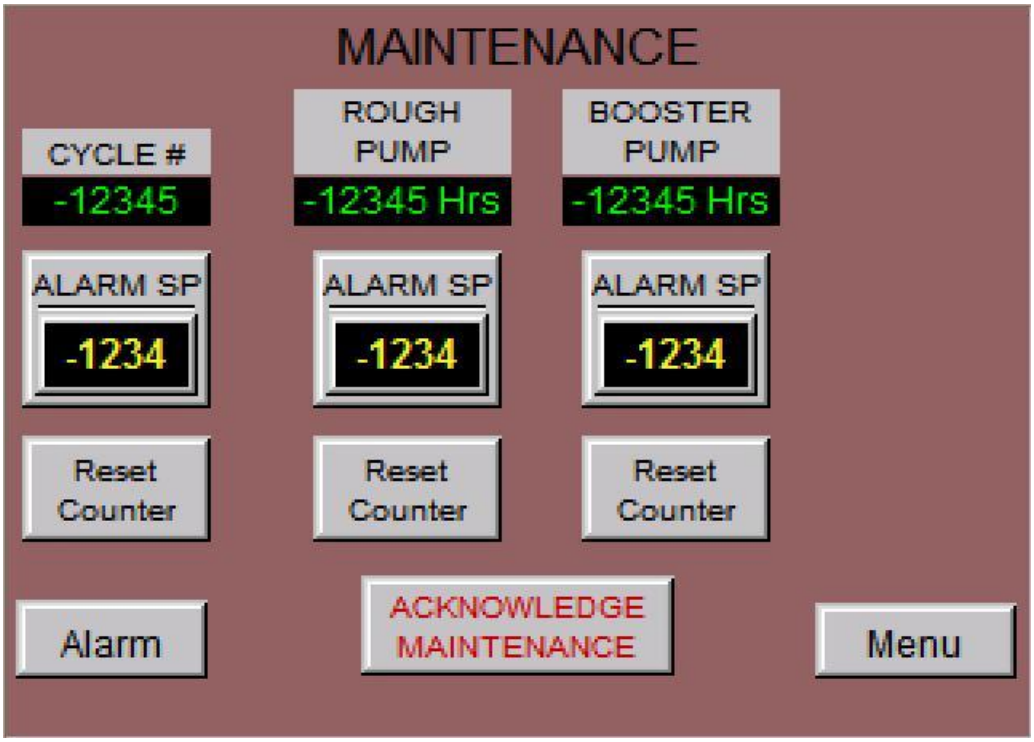
*MENU - Accesses MENU screen

*ALARM - Accesses ALARMS screen

*MONITOR	- Accesses MONITOR screen

OPERATION OF THE OPERATOR INTERFACE PANEL - Continued

MAINTENANCE DATA SCREEN



Accessible only by Maintenance.

The MAINTENANCE DATA screen displays a running total on the number of cycles the furnace has been through. It also displays the number of hours each motor has been running. This is especially useful in maintaining a preventative maintenance routine.

CYCLE NUMBER - Displays a running total of the total number of cycles the furnace has been through.

*CYCLE RESET COUNTER - Allows authorized personnel to reset the number of cycles to "0" for instances such as yearly usage, or to determine

maintenance intervals, etc. This is typically reset after the alarm setpoint has been reached.

*CYCLE ALARM SETPOINT - Accesses the ALARM SETPOINT screen. From this screen, the operator inputs the desired setpoint value, presses ENTER, then DONE to return to the MAINTENANCE DATA screen. This is especially useful if general routine/ preventative maintenance is to be performed after a determined number of furnace cycles.

ROUGH PUMP RUNNING TIME - Displays a running total of the number of hours the rough vacuum pump has been operating.

*ROUGH PUMP RESET TIMER - Allows authorized personnel to reset the timer to “0”, usually after maintenance has been performed.

*ROUGH PUMP ALARM SETPOINT - Accesses the ALARM SETPOINT screen. From this screen, the operator inputs the desired setpoint value, presses ENTER, then DONE to return to the MAINTENANCE DATA screen.

BOOSTER RUNNING TIME - Displays a running total of the number of hours the vacuum booster has been operating.

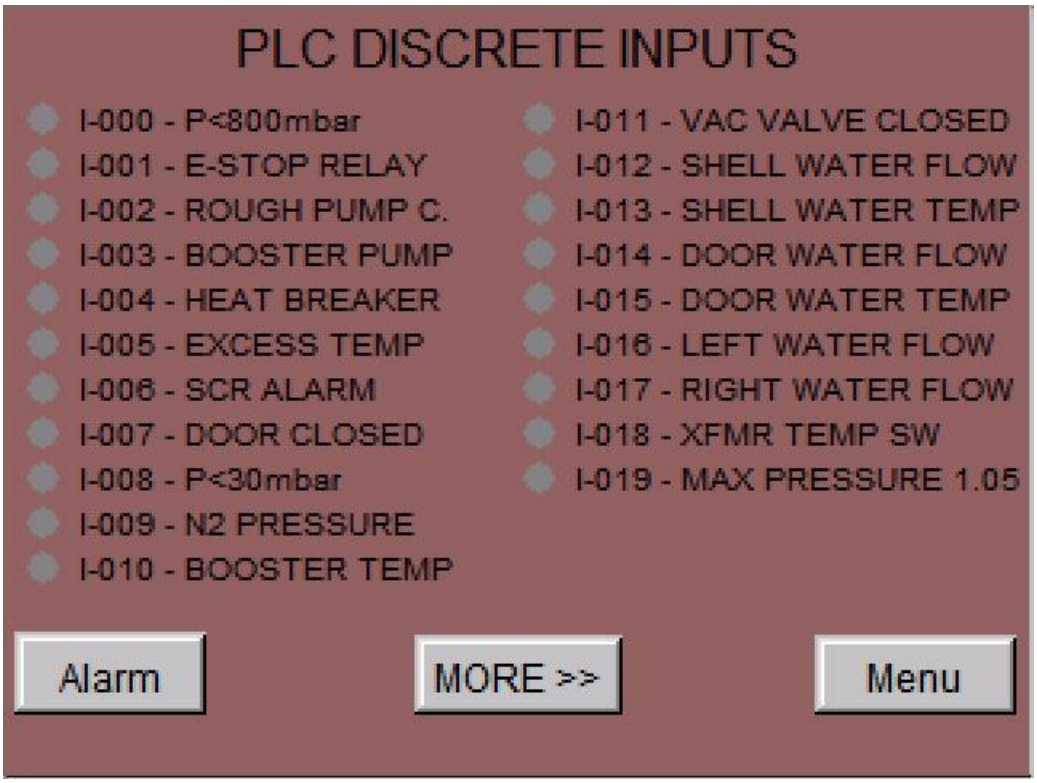
*BOOSTER RESET TIMER - Allows authorized personnel to reset the timer to “0”, usually after maintenance has been performed.

*BOOSTER ALARM SETPOINT	-	Accesses the ALARM SETPOINT screen. From this screen, the operator inputs the desired setpoint value, presses ENTER, then DONE to return to the MAINTENANCE DATA screen
*ACKNOWLEDGE MAINTENANCE	-	Allows authorized personnel to acknowledge any maintenance alarms that occur. Therefore, maintenance alarms can not be acknowledged by the operator, only by authorized personnel.
*MENU	-	Accesses the MENU screen
*ALARM	-	Accesses the ALARM screen

OPERATION - cont.

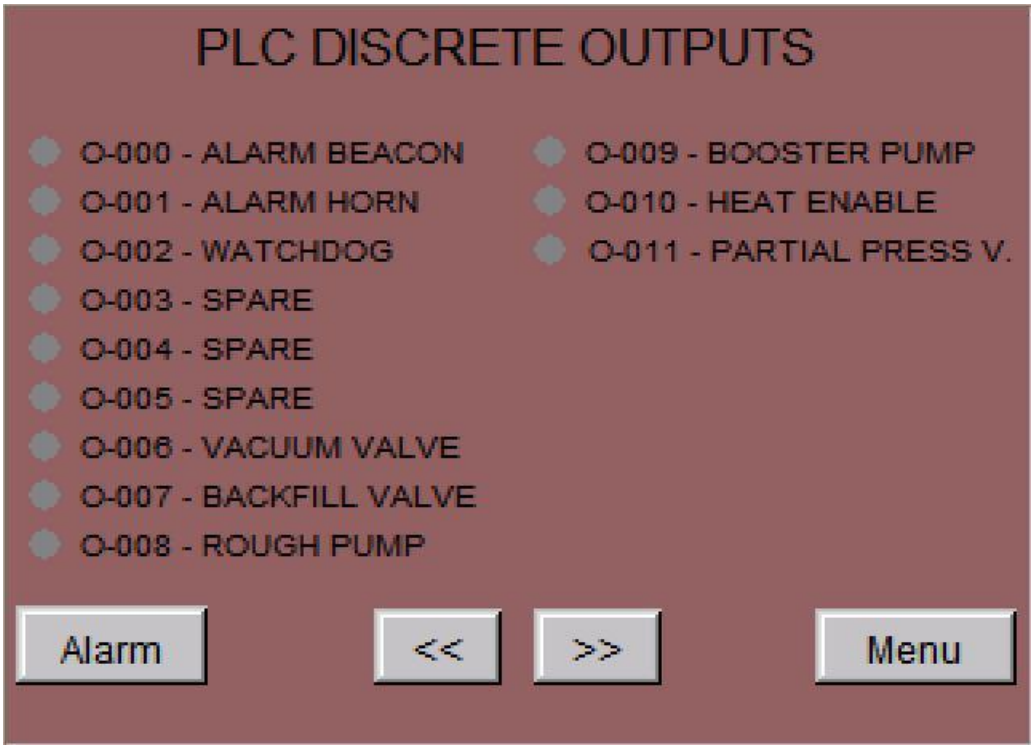
OPERATION OF THE OPERATOR INTERFACE PANEL - cont.

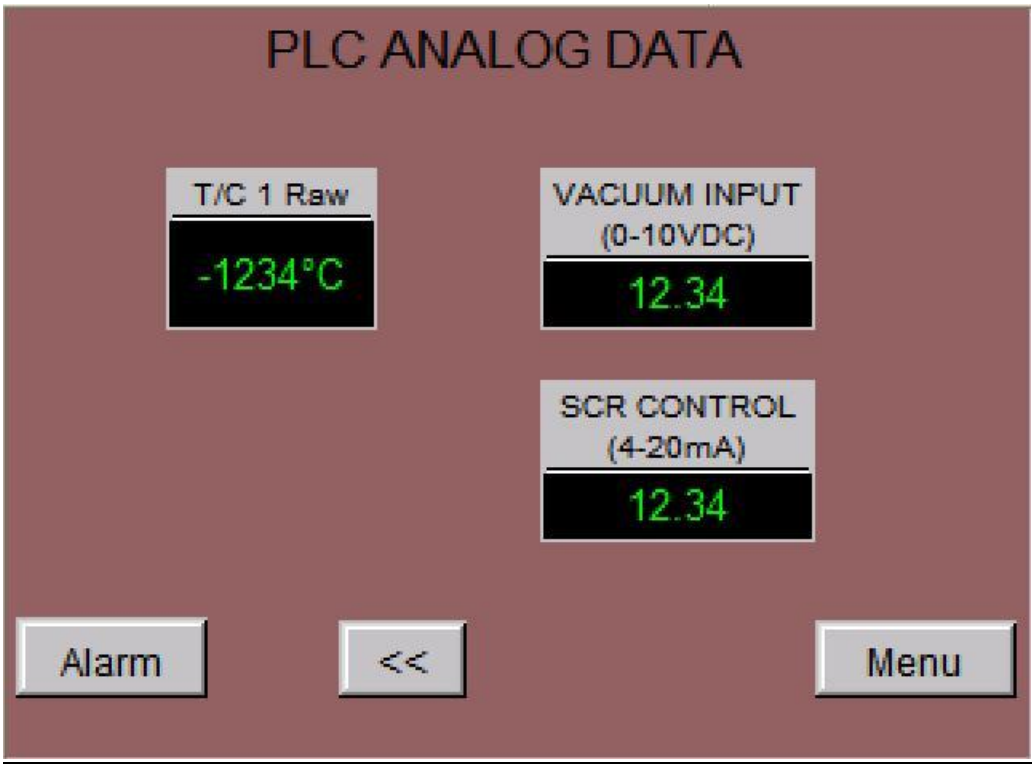
PLC DATA SCREENS



The PLC DATA screens display the status of the PLC hardware inputs and outputs in real time. There are three screens used to show all of the discrete and analog inputs and outputs. Viewing the data on the HMI will eliminate the need to open the panel door for troubleshooting.

*MENU	-	Accesses the MENU screen
*ALARM	-	Accesses the ALARM screen
*MORE	-	Navigates to the other data screens.

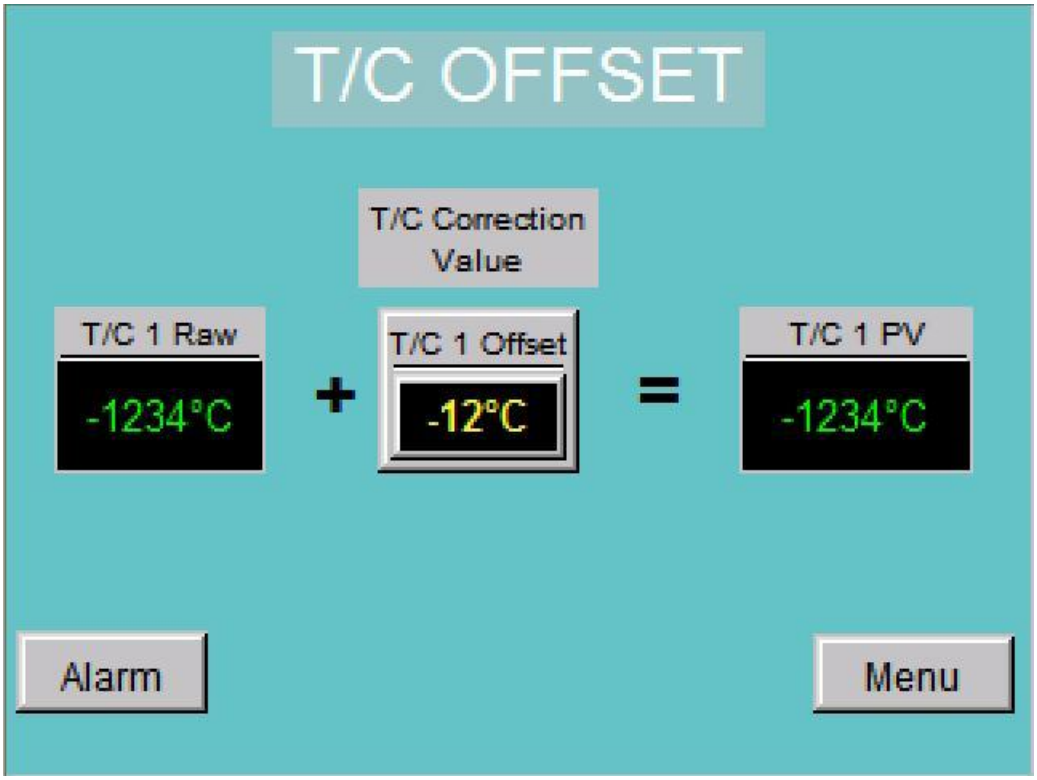

PLC DISCRETE OUTPUTS
O-000 - ALARM BEACON
O-001 - ALARM HORN
O-002 - WATCHDOG
O-003 - SPARE
O-004 - SPARE
O-005 - SPARE
O-006 - VACUUM VALVE
O-007 - BACKFILL VALVE
O-008 - ROUGH PUMP
O-009 - BOOSTER PUMP
O-010 - HEAT ENABLE
O-011 - PARTIAL PRESS V.
Alarm
<<
>>
Menu


PLC ANALOG DATA
T/C 1 Raw
-1234°C
VACUUM INPUT
(0-10VDC)
12.34
SCR CONTROL
(4-20mA)
12.34
Alarm
<<
Menu

OPERATION - Continued

OPERATION OF THE OPERATOR INTERFACE PANEL - Continued

TC OFFSET SCREEN



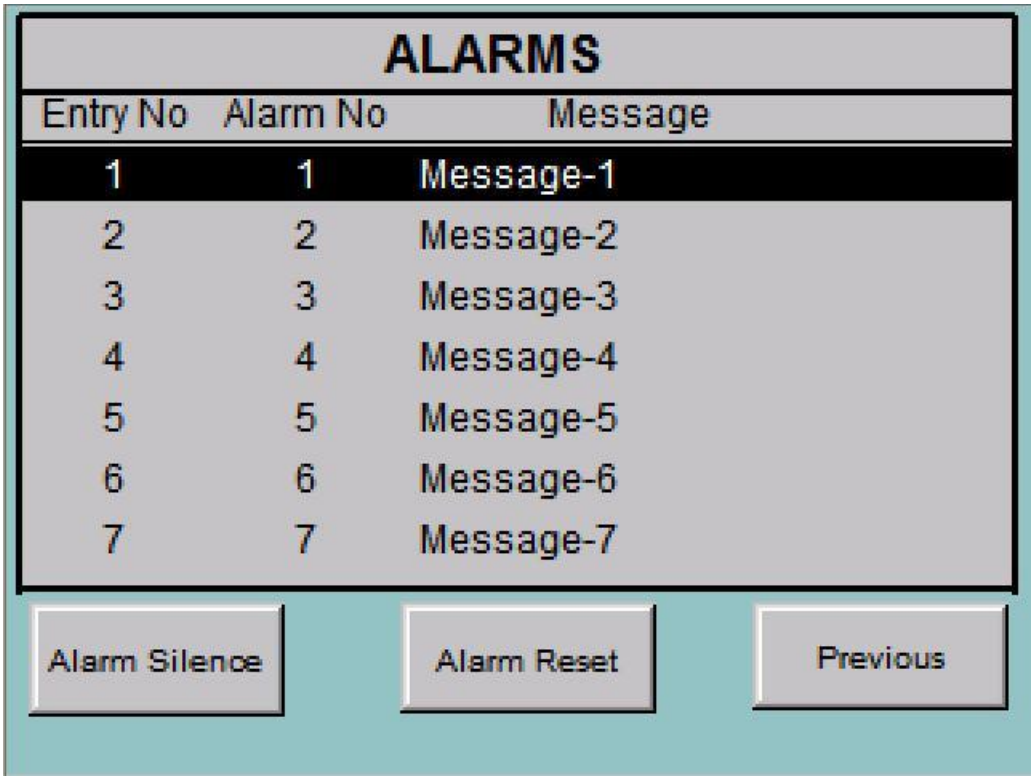
The TC OFFSET screen is used to adjust the furnace temperature reading used for controlling the heating and cooling process. The operator can enter a positive or negative offset value to be added to the raw temperature value.

*MENU	-	Accesses the MENU screen
*ALARM	-	Accesses the ALARM screen

OPERATION - Continued

OPERATION OF THE OPERATOR INTERFACE PANEL - Continued

ACTIVE ALARM SCREEN



This screen displays active alarms.

To eliminate the siren associated with an alarm, the alarm must be silenced. Even after the alarm is silenced, the ALARM indicator on each screen will continue to flash an ALARM condition until the alarm is reset.

To reset an alarm, the cause of the alarm must be removed. Once the cause of the alarm is removed, press and hold the ALARM RESET button for two seconds. The alarm will then disappear from the alarm list.

See listing of all alarms and possible causes can be found in the "Troubleshooting Section" of this manual.

*ALARM SILENCE	-	Used to silence the alarm horn.
*ALARM RESET	-	Used to reset the alarm trigger.
*PREVIOUS	-	Accesses the previously viewed screen

OPERATION - Continued

OPERATION OF THE OPERATOR INTERFACE PANEL - Continued

MANUAL CONTROLS SCREEN

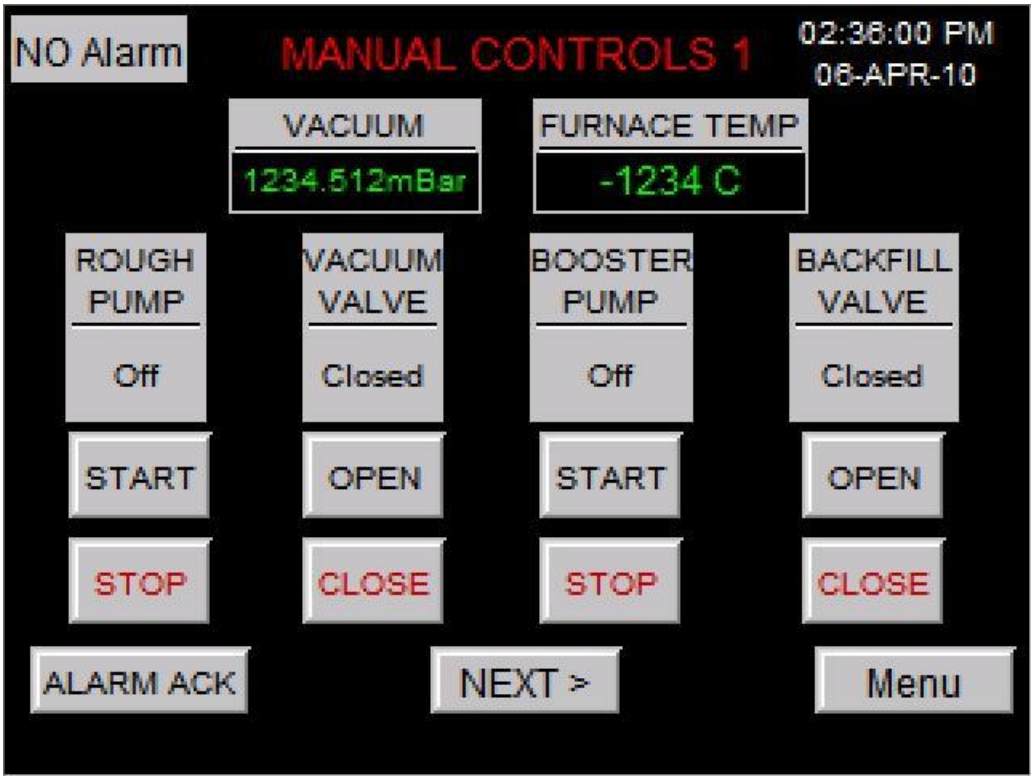
Accessible only by “Maintenance” and “Supervisor”.
This screen is used to warn the operator that all control functions on the following screens are for manual operation only. Equipment safety interlocks have been minimized to allow for true manual control. These functions are to be used by TRAINED PERSONNEL ONLY. The manual control screens are accessible only by “Maintenance” and “Supervisor”. The manual control features are to be used for maintenance purposes only, they are not intended for process control.

Manual controls are enabled when the operator navigates to the Manual Control screens, and are disabled when the operator navigates away from the Manual Control screens.

OPERATION - Continued

OPERATION OF THE OPERATOR INTERFACE PANEL - Continued

MANUAL CONTROLS #1 SCREEN



The MANUAL CONTROLS #1 screen provides the operator the ability to control the furnace components with minimal interlocks.

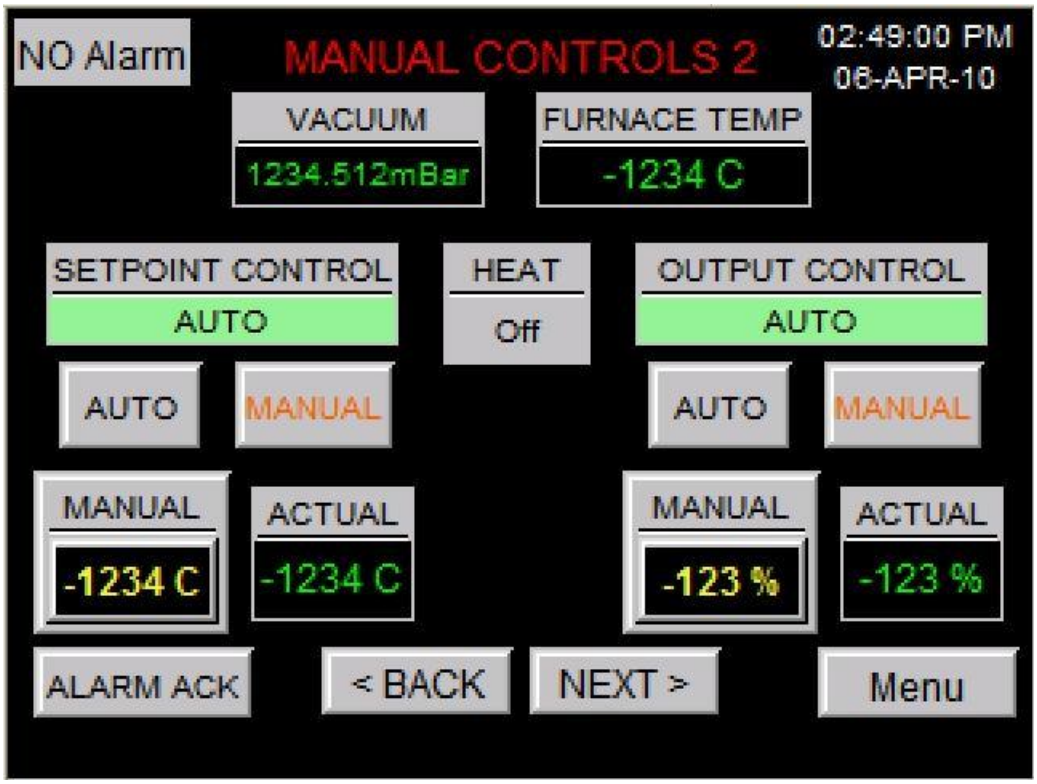
From this screen the operator can start or stop the pumps and valves. Status displays gray when off, and green when on.

*ALARM ACK	-	Silences the alarm horn. Hold for 2 seconds to reset the alarms.
NEXT >	-	Accesses other manual controls screen
*MENU	-	Accesses MENU screen

OPERATION – Continued

OPERATION OF THE OPERATOR INTERFACE PANEL – Continued

MANUAL CONTROLS #2 SCREEN



The MANUAL CONTROLS #2 screen provides the operator the ability to control the furnace heating.

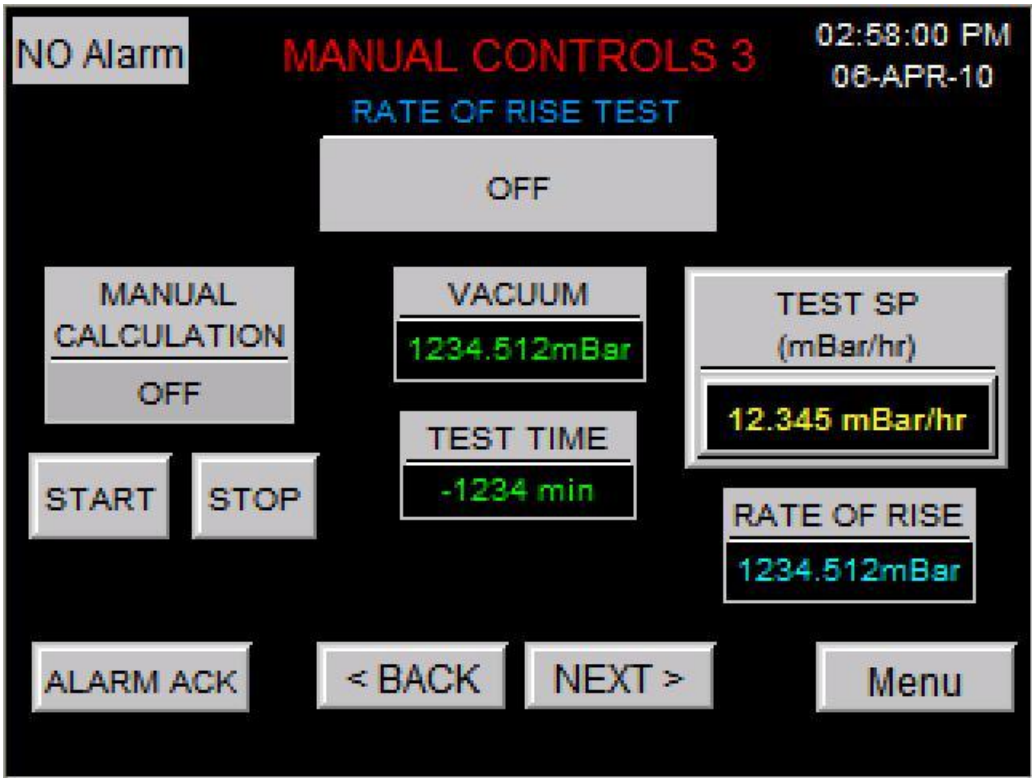
Heating can be controlled by setpoint or by controller output %. Heating is only active below 1.33 mBar.

*ALARM ACK	-	Silences the alarm horn. . Hold for 2 seconds to reset the alarms.
<BACK - NEXT >	-	Accesses other manual controls screen
*MENU	-	Accesses MENU screen

OPERATION - Continued

OPERATION OF THE OPERATOR INTERFACE PANEL - Continued

MANUAL CONTROLS #3 SCREEN



The MANUAL CONTROLS #3 screen provides the operator the ability to check the "rate of rise" of the furnace. The rate of rise value can help determine the amount of moisture in the furnace or the integrity of the vacuum seals.

The operator must first pump down the furnace to the desired vacuum level, then close the vacuum valve. Then push the start button here to start the rate of rise timer. Push stop to calculate the actual rate of rise.

A "Test Setpoint" can be entered to provide a "pass" or "fail" status.

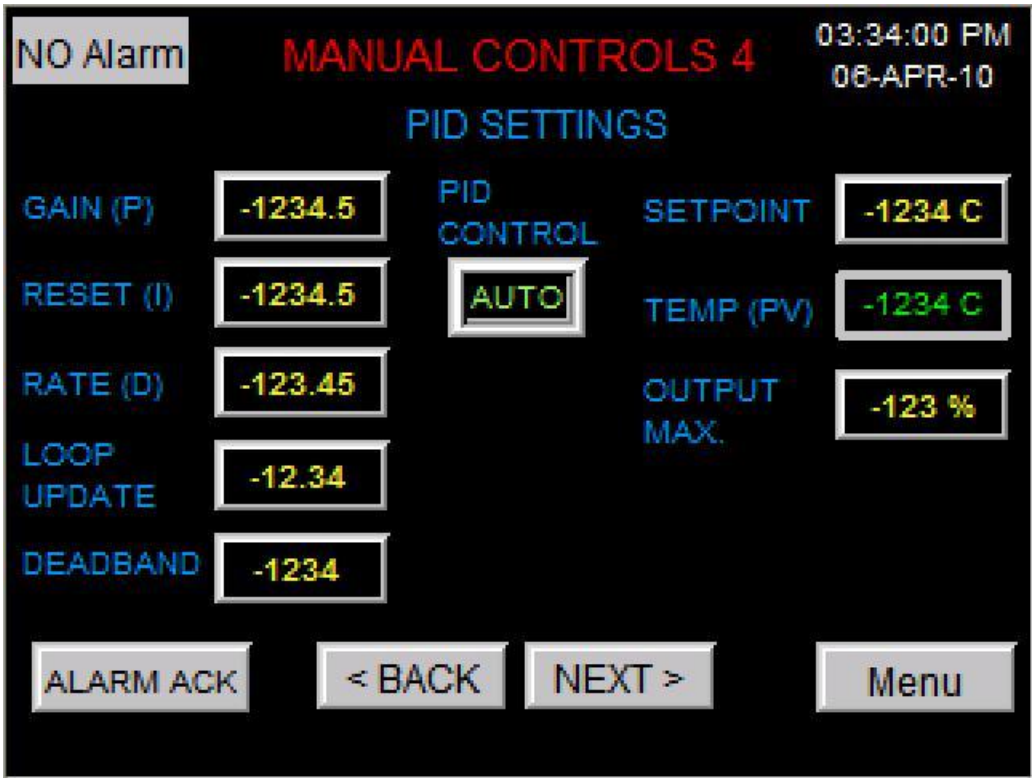
*ALARM ACK	-	Silences the alarm horn. . Hold for 2 seconds to reset the alarms.
<BACK - NEXT >	-	Accesses other manual controls screen

*MENU	-	Accesses MENU screen

OPERATION – Continued

OPERATION OF THE OPERATOR INTERFACE PANEL - Continued

MANUAL CONTROLS #4 SCREEN



The MANUAL CONTROLS #4 screen provides the operator the ability to change the heating control PID (Proportional Integral Derivative) values. Changing the PID values can greatly affect the accuracy and repeatability of the heating control system. It is recommended that the operator read and understand the Allen Bradley PID control functions first before changing any values.

*ALARM ACK	-	Silences the alarm horn. . Hold for 2 seconds to reset the alarms.
<BACK - NEXT >	-	Accesses other manual controls screen
*MENU	-	Accesses MENU screen

EMERGENCY PROCEDURE

DANGER

Nitrogen is a asphyxiant gas and may displace oxygen in an unvented room, causing unconsciousness and death.

LOSS OF NITROGEN

1. In the event of loss of nitrogen cooling gas pressure, determine the cause and rectify.

NITROGEN PIPING LEAK

1. Close the main nitrogen supply valve. Make sure the area is well ventilated before attempting repairs. Use an oxygen analyzer to determine that there is 20% oxygen, or enter the area using a self-contained breathing apparatus. Follow proper lockout tagout procedures; see SAFETY PRECAUTIONS AND WARNINGS FOR ENTERING EQUIPMENT page 16.

LOSS OF POWER

On power loss, vacuum, vent, and backfill valves close and power is removed from the heating elements. Restart cycle from the beginning or use a modified program to obtain the required temperature profile.

LOSS OF COOLING WATER

In the event of loss of cooling to the furnace shell the proper course of action would be to shut off heating power and evacuate the furnace, allowing it to cool slowly under vacuum.

EMERGENCY PROCEDURE - Continued

DANGER

Do not restore water to a hot furnace. The heat may cause steam to form, possibly rupturing the piping outside the furnace. Allow the furnace to cool below 200°F (93°C) before restoring water flow.

*EXAMPLE OF OPERATIONAL AND MAINTENANCE CHECKLIST

This checklist is designed to help you in determining a standard routine for maintenance and inspection of your equipment as required by the NFPA. This checklist IS NOT EXACTING in every detail, but is to be used only as a format to set up your own individual maintenance procedures. Also, all maintenance must be done by well trained, qualified maintenance personnel.

OPERATIONAL CHECKLIST

1. Check for proper operating temperature.
2. Check flow sensors for proper water flow and water temperature.
3. Check for proper operation of ventilating equipment.

REGULAR SHIFT CHECKLIST

1. Take necessary gas analyses; if automatic gas analyzers are used, make sure the manual and automatic readings coincide. Recalibrate automatic gas analyzers.
2. Standardize or balance instruments.
3. Check manual valves for proper positions.
4. Check pumps for unusual bearing noise and shaft vibration; If V-belt driven, check belt tension and belt fatigue.

WEEKLY CHECKLIST

1. Test thermocouples and lead wire for shorts and loose connections.
2. Check settings and operation of all temperature limit devices.
3. Test visual and audible alarms systems, or both, for proper signals.
4. Check all pressure switches for proper settings.
5. Check valve motors and control valves or dampers for free smooth action and adjustment.

*G16 Revision 2 - 6/02 2pg - special

EXAMPLE OF OPERATIONAL AND MAINTENANCE CHECKLIST

– Continued

MONTHLY CHECKLIST

1. Test interlock sequence of all safety equipment. Manually make each interlock fail, noting that related equipment closes or stops as required.
2. Test pressure switch settings by checking switch movements against pressure settings, and compare with actual impulse pressure.
3. Inspect all electrical switches and contacts; clean if necessary.
4. Test all amplifier and thermocouple fail-safe devices, making certain that the instrument drives in the proper direction.
5. Clean the control panel air blower filters.
6. Check all flow indicators, meters, gauges, and pressure indicators; clean or repair if necessary.
7. Test automatic or manual turndown equipment.
8. Check equipment interior, for cleanliness and signs of arcing.
7. Test pressure relief valves; clean if necessary.
10. Inspect air, water, and atmosphere piping for leaks.
11. Verify all control and sensing devices including settings of instruments, pressure switches, temperature switches and regulators etc

PERIODIC CHECKLIST

1. Lubricate the furnace components per the individual manufacturer's instructions.
2. Test and calibrate instrumentation, check battery, verify instrument calibration (every 90 days).
3. Examine electrical wiring for physical damage such as scraping, chafing, insulation deterioration, overheating, and similar problems.

*MAINTENANCE

A vacuum furnace is a precision piece of equipment which requires good operating techniques and regularly scheduled maintenance. A maintenance schedule follows, with discussion of several points following that. This entire section should be read before the need for repairs arises. Frequently, following the maintenance procedures will reduce the amount of repair work needed.

Following the operating instructions explicitly will aid greatly in reducing the amount of maintenance and repair work required. Changing the operating procedure by attempting to speed up valve operation or other methods may result in shorter service life for many of the pieces of equipment on the vacuum furnace.

KEEP A SERVICE LOG OF ALL MAINTENANCE PERFORMED AND RESULTS OF ALL INSPECTIONS, USING THE ABOVE AS A GUIDE.

The following pages give an explanation of the maintenance points, by number as shown in the following Maintenance Schedule chart.

*VAC8 rev. 6 - 1/99 - VAC Team - 5pg - special

MAINTENANCE SCHEDULE

		DLY	WK	1 MO	3 MO	6 MO
1	Check oil level all pumps	X				
2	Leave chamber under vacuum after last run	X				
3	Check elements and shields for wear or damage	X				
4	Check door O-ring and flange for marks or scratches	X				
5	With all valves closed, run pump with gas ballast open 15 minutes before first run	X				
6	Perform rate of rise test (clean, dry, empty, & outgassed)		X			
7	Check mechanical pump oil for contamination		X			
8	Remove, clean, re-install thermocouple vacuum gauges			X		
9	Check belt tension on mechanical vacuum pump			X		
10	Check calibration of vacuum instruments			X		
11	Check all furnace control instrument calibration				X	
12	Replace or recalibrate control & overtemp. thermocouples				X	
13	Replace mechanical pump oil				X	
14	Remove, inspect, check vacuum valve for wear & proper operation					X
15	Replace door ‘o’ ring & clean flanges					X
16	Make all necessary repairs to					

	hot zone					X

MAINTENANCE – Continued

1. The oil levels in the large mechanical pump, and vacuum booster and/or blower if used, are usually checked by means of a sight glass. Should the oil become contaminated, break down, or drop in level, the applicable service manual will describe the location of the drain and fill ports, plus the correct type of lubricant to be used. Be very careful to use only the recommended oil for each piece of equipment. NOT ALL PUMPS CAN USE THE SAME TYPE OIL.
2. Many vacuum furnaces are used in areas occupied by large hot wall heat treating furnaces, or in other areas where the humidity or dust levels of the surrounding air are uncontrolled. In order to obtain the best condition for heat treating, the vacuum furnace should be kept evacuated when not in use. A rough vacuum (50 - 100 micron) should be sufficient.
3. The heating element insulators are extremely brittle and susceptible to breakage from shock. A simple visual check with a flashlight will usually reveal any damage to the insulators. Broken insulators should be repaired immediately.
4. The main door seal, or O-ring, more than any other, is likely to be damaged due to exposure to the room area, and loading procedure. Any rust on the flanges should be removed with #320 grit emery cloth, followed by a thorough wiping with clean acetone applied with lint-free cloth or paper. The O-ring should then receive an extremely light coating of high vacuum silicone grease.
5. The large roughing pump uses a gas ballast valve, or valves, to separate condensed water from the oil in the pump reservoir. Open the gas ballast for 15 minutes each day (or as recommended in the pump supplier's literature), with the pump running, prior to beginning to pump down the main chamber. This procedure will increase oil and pump life.

MAINTENANCE – Continued

6. Using the chart titled RATE OF RISE TEST, empty the furnace of all work fixtures and all objects not a part of the delivered furnace. Run the furnace to just under the maximum use temperature for one hour or longer under the best vacuum obtainable. Cool the furnace with the pumping system still connected and pumping on the chamber. Once the furnace is back to room temperature, close the high vacuum valve and measure the time the vacuum takes to rise from 2×10^{-4} torr to 7×10^{-4} torr (1/2 micron). Use the rate of rise curve to determine the actual leak rate. Keep a record of rate of rise tests in a maintenance log.
7. Contamination of the oil in the roughing pump or the holding pump can occur when scale or foreign matter or vapors leave the heat treated parts and are pumped into the oil reservoir of the pump. Water contamination will appear as a milky white color and can be removed by opening the gas ballast valves for a period of time as required. Solid and dense materials or particles in the oil can be removed only by flushing out the old oil and replacing with new oil. Consult the applicable maintenance manual for specific instructions.
8. Refer to pump manual for proper belt tension.
9. Refer to the vacuum instrumentation manuals for calibration procedures.
10. Refer to the various furnace control and excess temperature instrument manuals for calibration instructions.
11. The control and overtemperature thermocouple are the heart of the vacuum furnace control system. Reference standards labs are available to provide certification for thermocouples. In the case of inexpensive thermocouples, such as Chromel-Alumel, it is less expensive to replace thermocouples every 1 to 3 months, then to recertify existing assemblies.

MAINTENANCE – Continued

12. Refer to pump manual for oil grades and procedures.
13. NOTICE - Failure to perform the preventive maintenance on vacuum valves could result in permanent damage to the furnace, or loss of an expensive work load. Refer to the supplier's literature for each valve for assembly and disassembly information.
14. Replacement O-rings and gaskets may be ordered from SECO/WARWICK. Clean flanges and reinstall O-ring with extremely light coating of high vacuum grease.
15. Using the hot zone assembly drawings, remove and inspect the entire hot zone assembly for electrical shorts, fatigued insulators, cracks or perforations in elements or insulation, or any components which are heavily coated with foreign material. This inspection may be performed on an annual basis depending on usage and contaminant level.

*INSTRUMENT AND THERMOCOUPLE MAINTENANCE

1. Always use proper type extension wire for each thermocouple. The chart below lists the most common thermocouple types, leadwire, and color identification.
2. Install thermocouple leadwire in grounded metal conduit separate from all other wiring. Do not run across or parallel to AC wiring within 1 foot.
3. Never splice thermocouple leadwire. Run wire in continuous runs from the thermocouple to the instrument.
4. Be very careful to avoid thermocouple reversals. Connect positive to positive and negative to negative in the thermocouple head and the instrument.
5. Check thermocouples regularly. In most applications, once a month is reasonable. Check thermocouples by comparison, or by inserting in a test oven.
6. If you remove the thermocouple for checking, be certain to insert to the same depth.
7. Replace burned out protection tubes immediately to avoid damage to thermocouples.
8. Do not contaminate thermocouples with oil, grease, or solvents.
9. Perform instrument maintenance and calibration as recommended by the manufacturer's manual. We recommend a maintenance contract with the instrument manufacturer.

THERMOCOUPLE LEADWIRE IDENTIFICATION				
MATERIAL	TYPE	COLOR IDENTIFICATION		
		POSITIVE	NEGATIVE	OVERALL
Chromel/Alumel	K	YELLOW	#RED	YEL or BR
Iron/Constantan	J	#WHITE	RED	BLACK
Plat/Plat/Rhod	S&R	BLACK	RED	GREEN
Ni/Ni/Moly		USE TYPE K LEADWIRE		

*MAINT5 rev. 6 - 1/03 - 1pg

*INSPECTION AND MAINTENANCE

A definite schedule of point-by point inspection and lubrication should be set up to assure that no piece of equipment needing periodic attention is overlooked. Where supplier's literature is issued, follow their instructions implicitly. Inspection should be made of at lease the following items.

THERMOCOUPLES

The controlling thermocouples must be dependably accurate. The entire success of the heat operation depends on the thermocouple. New thermocouples are usually accurate within one-half of 1%. If critical control is required, the actual deviation from true should be known, and the thermocouple so tagged. A reliable method of thermocouple checking should be used, and the check made frequently. Spare couples should be kept on hand and replaced at the first sign of inaccuracy.

INSTRUMENTS

The temperature reading and controlling instruments should be checked regularly for calibration. See supplier's literature for recommended calibration schedule and procedure. A calibration check every 90 days is recommended. An instrument contract with one of the major instrument supplier's should be considered if you are not equipped for the procedure.

*MAINT9 rev. 8 1/99 2pg - SPECIAL

*VACUUM FURNACE TROUBLESHOOTING

The following is a list of each alarm that is in the **control system**. Also listed is a probable cause of the alarm with a suggested corrective action to take. Every possible cause and/or action is listed. These are only the most common ones.

ALARM	CAUSE	ACTION
Booster pump circuit failure	Booster pump does not turn on	Check contactor (4047C), motor starter (1003MPS), then booster pump
Booster pump maintenance	Maintenance setpoint alarm was reached	Perform booster maintenance according to supplier literature. Reset hour counter, or change alarm setpoint.
Cycle number maintenance	Maintenance setpoint alarm was reached	Perform furnace maintenance (good overall furnace and hot zone inspection). Reset hour counter, or change alarm setpoint.
Feedthrough water flow	Not enough water flow through sensor	Check inlet flow indicator (open manual valve if necessary), check flowsensor, check hose for leak or clog
Furnace excess temp	Furnace overtemp T/C exceeded 650°C	Check control t/c reading, then check overtemp t/c reading, then check overtemp device
Low nitrogen pressure	Under 2 bar supply pressure	check pressure gauge (adjust regulator or manual valve if necessary), then pressure switch

*VAC12 rev. 4 - 1/99 - VAC Team - 9pg - SP

VACUUM FURNACE TROUBLESHOOTING - Continued

ALARM	CAUSE	ACTION
Booster Pump overtemperature	Overtemp switch open	Check pump oil and pump
Thermocouple Fail	No signal from t/c	Check for short in t/c, or open circuit t/c
Rough pump circuit failure	Rough pump does not turn on	Check contactor (4045C), motor starter (1000MPS), then rough pump
Rough pump maintenance	Maintenance setpoint alarm was reached	Perform rough pump maintenance according to supplier literature. Reset hour counter, or change alarm setpoint.
Furnace door water overtemperature	Door water temp exceeded 80°C	Check temps on outlet manifold, then t/c
Shell water over temp	Shell water temp exceeded 80°C	Check temps on outlet manifold, then t/c
Heat breaker fault	Breaker off or tripped	Check breaker (1013CB), then check connections
Transformer over temp	Transformer temp switch tripped	Check vrt temp switch (I018), then water pressure switch (both within vrt)
Long pump down	Pump down longer than 30 minutes	Check oil color, then check for leaks, then pump(s) operation
Out of soak range	Loss of heat or excess heat	Auto reset when temp goes back into soak range or when segment advances
PLC battery low	Voltage level is insufficient in PLC battery	Replace battery according to supplier literature
Heating lost	Water flow alarms, water temp alarms, vrt or fce temp, vrt breaker	Check and eliminate cause and reset heat breaker
End of cycle	Cycle had ended	Unlock door and remove load
Emergency stop circuit	Emergency stop button was pushed	Find out reason(s) the button was pushed and rectify situation
Vacuum valve not closed	Closed limit switch not made	Check for valve blockage or failure

VACUUM FURNACE TROUBLESHOOTING – Continued

The following is a list of problems that can arise with the furnace with some suggested solutions to the problems.

PROBLEM	CAUSE	SOLUTION
Mechanical pump spurting oil	Air release valve for pump line open	If mechanical valve, close it. If electric valve check to see if solenoid working properly. Inspect the valve seat & test, if necessary
	Gas Ballast Valve left open	Close gas ballast valve
	Contaminated oil	Remove & replace with clean oil of proper type
	Through leakage in rough valve	Remove rough valve assembly, inspect & repair
	Gasket seal on pump housing leaking	Leak test entire pump for gasket or seal leakage
	Oil Level too high	Check pump oil level, remove excess oil
	Leakage in foreline valve	Remove foreline valve assembly, inspect & repair
High readings of vacuum gauge	Contaminated oil in diffusion or mechanical pump	Check oil in both pumps, replace if needed
	Lost power to vacuum system	Check fuses and motor starter heaters
	Air leaking into furnace	Helium leak test suspected area
	Door seals leaking	Check seals with acetone. Note deflection in high vacuum gauge reading if leak pinpointed
	Instrument malfunctioning or detector defective	Check appropriate instrument manual. Substitute known good detector
High thermocouple reading	Bad thermocouple	Replace thermocouple
Low thermocouple	Thermocouple short outside	Check thermocouple leadwire & thermocouple

reading	chamber, or grounded	

VACUUM FURNACE TROUBLESHOOTING - Continued

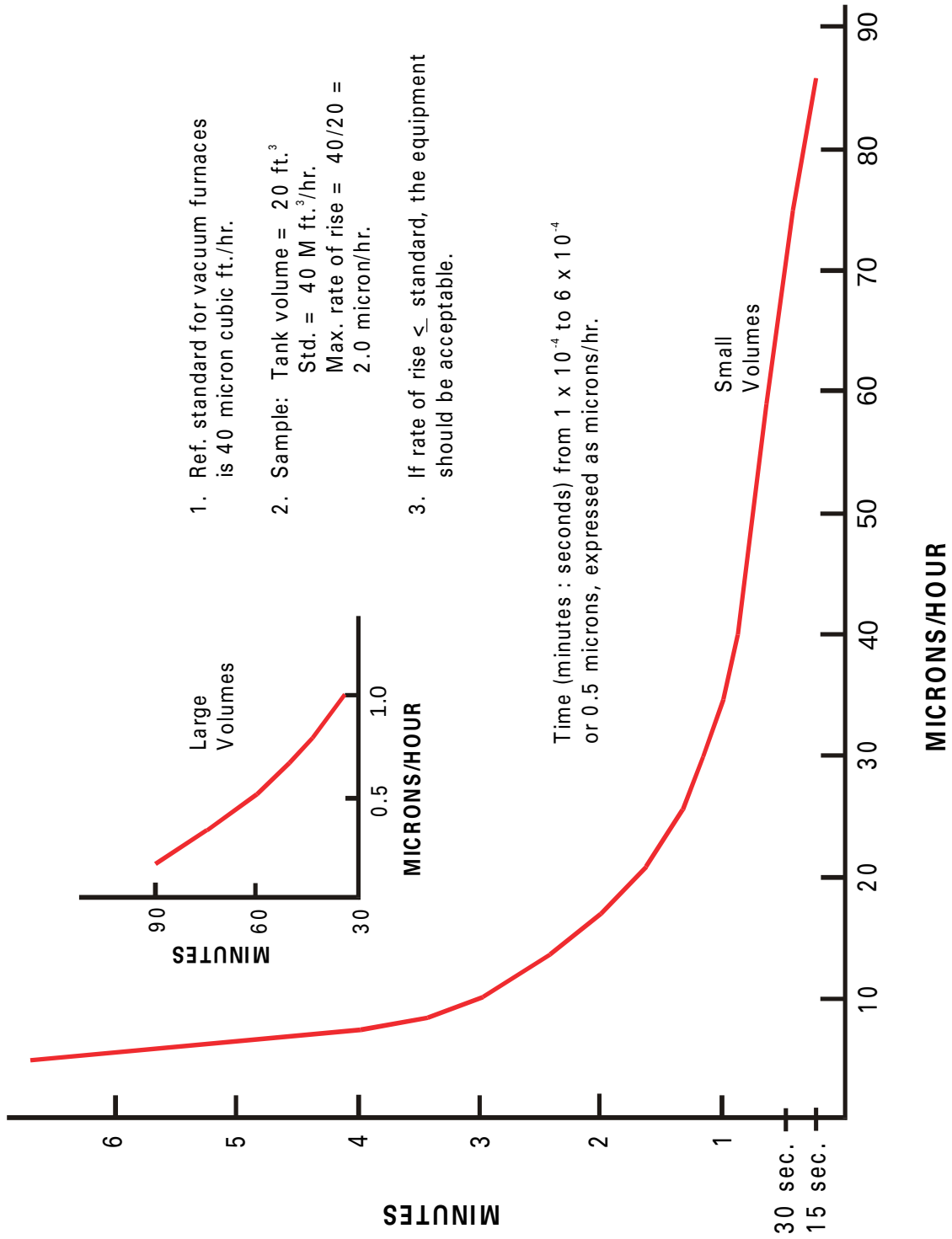
PROBLEM	CAUSE	SOLUTION
Erratic thermocouple readings	Thermocouple shorted or partially open	Check for contact with heating element
System under known good vacuum and vacuum gauge fails to read	Loose electrical connection or sensor connection	Check connections and cables
	Instrument or detector defective	Replace detector with known good detector. If problem remains, check instrument
Ammeters or voltmeters indicating furnace power unstable or erratic	Short in hot zone or water-cooled leads	Shut down and inspect
	Shorted Transformer or diode in power controller	Check transformer and diodes in controller following manufacturer's instructions
	Bad t/c causing erratic input signals to controller (note erratic indication on chart)	Replace thermocouple
Furnace power will not come on	Low water flow	Check water flow
	Furnace pressure too high	calibrate pressure transmitter
	Electrical malfunction	Check fuses, transformer & all connections necessary to insure circuit continuity
W/max. command signal into VRT, power level too low to reach max. temp.	Current limit set too low	Reset current limit following manufacturer's instructions & maximum current as shown on wiring diagram
	One or more	Repair or replace broken heating

	open heating elements	elements

VACUUM FURNACE TROUBLESHOOTING - Continued

PROBLEM	CAUSE	SOLUTION
Pressure rises in main chamber when furnace water is turned on	Water leak in an internal heater connection or feedthrough	Remove all external connections from water leads which penetrate into chamber, including power feed-throughs. Blow out water and helium leak test the chamber. If no leak is found, try the same technique on the double wall shell. If a shell leak is found, the services of a qualified field service engineer may be required
Chamber pumps down very slowly but shows good rate of rise characteristics	High humidity in work area	Keep the main chamber pumped down when not in use to prevent moisture from condensing on cold surfaces
	Water Vapor pressure in me-chanical pump oil	Close off all vacuum valves and idle the mechanical pump with the gas ballast valves open for 30 minutes or longer, to remove the water vapor. If the oil has become contaminated, remove and replace.
	Low oil level	Add oil to correct level as shown in manufacturer's instructions
Main chamber rate of rise is 300-1000 microns/min (.3 - 1 torr/min or .4 - 1.33 mbar) from high vac range into low mm range, and abruptly changes to extremely low rate	Differential pressure leak	These leaks are the hardest to find. They are, however, sometimes caused by sheath type thermocouples. By removing the suspected cause of the leak and re-checking the rate of rise, the cause of the leak can be found

*RATE OF RISE TEST CHART



*VAC11 rev. 3 - 2/99 - VAC Team - 1pg

*HELIUM LEAK TESTING

When testing components, or an entire furnace assembly, for leaks, the same basic techniques apply. In addition, the furnace itself may be tested, in whole or in part, without the aid of a leak detector to find the leaking components. This will be discussed later.

Vacuum system components with evacuated volumes ranging from one cubic inch to five cubic feet may be tested on a vacuum test stand which is in turn connected to a helium mass-spectrometer. The manual for the helium mass spectrometer covers the technique involved to a greater detail than this report. This section will cover the methods used to test O-ring seal, weld, and component leaks on the furnace.

Most leak detectors can be used to find leaks when the item to be tested can be pumped down to under 150 microns mercury. Since conductance is a problem in testing techniques, it is advisable to have the leak detector as close as possible to the pumping source (the foreline adjacent to the holding or roughing pump). Helium is used as the sample gas when testing for leaks because of its unique properties. Helium is a very light molecule and is readily ionized. When a sample of a mixture of air and helium passes through a leak detector, the helium is separated from the air by means of a magnet which is part of an accelerometer tube assembly. After passing through the accelerometer, the helium strikes a target which then amplifies the impact electronically. A conversion can be used to compare the helium leak to a known leak of air in cubic centimeters per second of flow (cc/sec).

Helium is lighter than air, so start at the TOP of the furnace and work downward to prevent the helium from registering a leak above where it is being applied. Very small quantities of helium may be used. A hypodermic syringe on a length of ¼" tygon tubing makes an excellent tool for applying helium.

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*VAC13 rev. 3 - 1/99 - VAC Team - 3pg

HELIUM LEAK TESTING - Continued

Another technique often used is referred to as "bagging" the system. After all leaks are eliminated from a component, or it is desired to isolate one component from another in a system, a plastic bag is sealed over the component and helium is used to fill the bag. If no leak is found, it can be assumed that all suspected welds and O-rings inside the bag are tight.

One word of caution is necessary, in that if the helium mass-spectrometer is not operating at peak efficiency, properly tuned, and highest sensitivity, a leak could easily be bypassed. This means that as coarse leaks are found and eliminated, and the vacuum in the overall system improves, it will be necessary to go over the entire unit again to make sure that the unit is vacuum-tight.

Silver solder and welded joints are, by their very nature, excellent sources of leaks. It is much easier to test as few joints as possible, and eliminate the leaks during the production phase. All fluxes, moisture or oils, MUST be cleaned off prior to testing. Once a leak is found, the best method is to repair it before looking for more, as two leaks may be so close together as to appear as one leak.

On extremely large leaks, it may be necessary to pressurize the components with nitrogen and check with soap bubbles or a commercial liquid tester, prior to a helium test. The area tested this way should then be cleaned with clear water, as the solution may cause a pinhole leak to temporarily close, preventing the helium from passing through, and hiding the leak.

HELIUM LEAK TESTING - Continued

WARNING

THE FOLLOWING METHOD USES A HIGHLY FLAMMABLE SUBSTANCE, AND SHOULD NOT BE USED NEAR OPEN FLAME. NO SMOKING, WELDING, OR OPEN FLAMES SHOULD BE ALLOWED WITHIN 100 FEET OF THE TEST AREA WHEN USING THE FOLLOWING TESTING METHOD. ADEQUATE FRESH AIR MUST BE SUPPLIED TO THE AREA.

Acetone is a highly volatile, low density solvent which may be used as a "leak detector" when a helium mass-spectrometer is not available, providing that a vacuum can be maintained in the range of 1 to 50 microns. By spraying acetone on the suspected leak, a reaction can be obtained on a thermocouple vacuum gauge, and will appear as an increased pressure indication. The time to react and recover is a lot longer, and is not always a positive test, as occasionally acetone will temporarily seal a leak. The leak must be relatively large to pass enough acetone to change the thermal conductivity of the remaining gas inside the chamber. This method works well for leaks in small chambers, but may not give an indication of a leak in a large chamber.

*VACUUM TECHNOLOGY

MICRON CUBIC FEET

Visualize a chamber exactly 1 x 1 x 1 foot at atmospheric pressure that holds 1 cubic foot of air. Attach a pumping system to it and evacuate the 1 cubic foot volume to a pressure of 1 micron. We have, in effect, removed a large percentage of the molecules that originally existed in the 1 cubic foot volume. The number of molecules left can be expressed in vacuum terminology as 1 micron cubic foot. Think of this 1 micron cubic foot as an entity, with so many millions of molecules of air.

MICRON CUBIC FEET PER HOUR

Let us say we have a 10 cubic foot vacuum chamber that leaks through the vacuum welds, and let us say that it leaks at a rate of 5 micron cubic feet per hour. Visualizing the entity of 1 micron cubic foot, let us take 5 of these entities and introduce them into the 10 cubic foot volume. We have then introduced 5 micron cubic feet. This means that the term 5 micron cubic feet per hour is the in-leakage rate; i.e., number of molecules entering the system in one hour. This in-leakage rate is called leak rate in micron cubic feet per hour.

PRESSURE RISE

What happens to the vacuum inside this 10 cubic foot volume when the in-leakage rate is 5 micron cubic feet per hour. Naturally, the pressure rises. Let us say the initial pressure was 1 micron. Therefore, the number of molecules inside the 10 cubic foot volume can be expressed as 10 micron cubic feet. Five micron cubic feet leaked in, in one hour. The number of molecules now in the system can be expressed as the total, or 15 micron cubic feet. These molecules are still in the 10 cubic foot space, and they are bouncing around faster because they are now a little closer together, so the pressure must rise.

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*VAC9 rev. 5 - 1/02 - VAC Team - 3pg

Therefore, if we divide the 15 micron cubic feet by the 10 cubic foot volume, we can say the pressure rose from 1 micron to 1.5 microns. This description of pressure rise does not include any discussion of virtual leak, or outgassing. Every material in existence has an outgassing rate (micron cubic fee/hour) of molecules of gas that are given off from its surface. The pressure in a vacuum chamber has a relationship to the number of molecules that are given off the interior surfaces of the vacuum chamber. Temperature also has a relationship to the outgassing rate. The hotter the part, the more energy its molecules have. The better the vacuum, the better chance a molecule has to bounce off the surface, thereby becoming a gas molecule or vapor. As far as a vacuum gauge is concerned, it cannot differentiate between molecules that leak into the vacuum chamber and those that outgas off the inside.

MEASURING LEAK-RATE MICRON RISE PER HOUR

The usual procedure here is to evacuate the system to a specific pressure, usually 1 micron. Valve off the vacuum chamber from the pumping system and watch the vacuum gauge indicate a rise in pressure. If the vacuum gauge goes from 1 micron to 6 microns in one hour, the leak rate is said to be 5 microns rise/hour. This leak rate is the total of in-leakage plus outgassing, and is not strictly a term indicating vacuum tightness.

MEASURING LEAK RATE MICRON CUBIC FEET PER HOUR

This method is more scientific and is a direct indication of in-leakage only. This is done with a mass spectrometer and a calibrated leak. There are various kinds of calibrated leaks. No matter how they are made, they all have a known in-leakage rate expressed in micron cubic feet per hour. This means that the calibrated leak will allow so many molecules to pass through it in an hour. This calibrated leak is attached to the vacuum chamber to be tested, as is the mass spectrometer leak detector. The whole

unit to be tested is hooded, and helium is introduced under the hood from the helium

bottle. Helium leaks through the calibrated leak at a known rate, and leaks through all of the leaks in the unit to give a certain percent of full scale reading in percent is proportional to the total in-leakage (total in-leakage is equal to in-leakage through the calibrated leak, plus the unknown in-leakage through the unit being tested). The next step is to isolate the calibrated leak from the vacuum chamber and take a second reading. The percentage of the scale reading on this will be less than the first reading, and is proportional to the unknown in-leakage. These two proportions under the same conditions are equal to each other, and by solving the equation, we come out with an answer that is as follows:

$$Unknown\ Calibrated\ \in\text{-}leakage = \frac{Number\ 2\ reading}{Number\ 1\ reading - Number\ 2\ reading}\ x\ Leak$$

This answer is a direct expression of in-leakage only, and is a definition of vacuum tightness.

CONVERT PRESSURE RISE (MICRONS RISE/HOUR INTO MICRON CUBIC FEET/HOUR

An easy way to visualize what occurs is to use an example. Let us say we have a vacuum chamber of 3 cubic feet, and we note a pressure rise of 12 microns/hour. If we reduced this vacuum chamber to 1 cubic foot and assumed it had the same leaks (not pressure rise), it is easy to see that the in-leakage would be 36 micron cubic feet per hour. All the molecules that entered the 3 cubic foot volume resulted in an indicated pressure rise of 12 microns per hour. With the same leaks in the 1 cubic foot volume, we will get the same number of molecules leaking in, the in-leakage will be 36 micron cubic feet per hour, and the pressure rise for one cubic foot would be 36 microns rise per hour.

*PRECAUTIONS FOR VIEWING HEATING ELEMENTS AND LOAD

WARNING

Whenever heating a furnace, avoid looking at the elements or load without eye protection when the element or load temperature could be above 2550°F (1400°C). Use dark glasses such as used for light metal cutting or welding to observe the elements or parts in the furnace above this temperature. POSSIBLE EYE DAMAGE COULD OCCUR WHEN VIEWING OBJECTS WITH A TEMPERATURE ABOVE 2550°F (1400°C).

Be aware that the actual temperature of a heating element can be well above the temperature indicated on the furnace control instruments. This difference could be 200-300°F higher than the control temperature in a vacuum furnace, and could be even higher in an atmosphere furnace. For instance, if the furnace temperature shows as 2550°F (1400°C), the actual element temperature could be 3000°F (1649°C).

*SAFETY6 R1 – 8/05 1pg

*COMMON VACUUM CONVERSION FACTORS

PRESSURE:

1 atmosphere = 760 mm mercury = 760 torr

1 atmosphere = 14.69 pounds/sq.in. absolute

1 millimeter mercury absolute = 1 torr

1 millimeter mercury = 0.0193 psi = 1333 dynes/sq.cm.

1 micron = 0.001 torr or 10^{-3} torr

1 millimicron = 0.000001 torr or 10^{-6} torr

TEMPERATURE:

°C = 5/9 (°F - 32)

°F = 9/5 (°C + 32)

°K = °C + 273.2

°R = °F + 459.7

VOLUME:

1 cubic foot = 28.3 liters

1 cubic foot = 1728 cubic inches

1 cubic foot = 7.43 U.S. gallons

LENGTH:

1 millimeter = 0.1 centimeter

1 millimeter = 0.03937 inches

1 micron = 0.00039 inches

1 angstrom = 0.0001 microns = 0.00000001 cm

PUMPING SPEED:

1 cubic ft./minute = 2.12 liters/second

1 cubic ft./minute = 1.699 cubic meter/hour

1 micron-liter/sec = 1 liter/sec @ 1 micron pressure

1 micron-CFM = 1 CFM @ 1 micron pressure

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*VAC7 rev. 2 - 1/99 - VAC Team - 1pg

1 micron-CFM = 0.472 micron-liters/second

RECOMMENDED SPARE PARTS LIST

We want you to have years of reliable operation of your equipment; however as with any piece of equipment, some parts will need to be maintained and/or replaced.

We recommend that you keep spare parts available to minimize equipment down time.

Please contact our Renewal Parts Department for a list and current price for parts recommended to be kept in stock for the problems that may be encountered during or shortly after startup and for long range repairs and maintenance.

In the event it is necessary to communicate regarding this equipment, please refer to the serial number.

DRAWING INDEX

107095-D2	General Assembly
106180-D3	Hot Zone Assembly
106181-D1	Hot Zone Assembly (Side)
107097-D1	Pump Stand Assembly & Details
109096-D1	Water Piping Schematic
107618-C1	Inert Gas Piping
105277-D1	Warning/Information Signs
E01-D 2	Bill of Material
E09-D 2	Shop & Field Notes
E10-D2	Power Schematic Diagram
E30-D 2	Control Schematic Diagram
E31-D 2	Control Schematic Diagram
E40-D 2	I/O Schematic Diagram
E41-D 2	I/O Schematic Diagram
E100-D2	Power Panel Assembly
E110-D2	Interconnection Diagram

SUPPLIER'S LITERATURE

Included in Operating/Maintenance Manual

ASCO	Solenoid Valve
Bray Controls	Wafer Butterfly Valve Solenoid Valve Pneumatic Actuator
Elhand Transformatory	Power Transformer
IFM Effector	Pressure Switch SL Water Flow Sensor
Kinney Pump	Mechanical Vacuum Booster Booster Systems Rotary Piston Vacuum Pump
Kunkle	Pressure Relief Valve
Sola	Power Supply
Watlow	Limit Controller SCR

Separate Binder

Allen Bradley	MicroLogix 1400 Programmable Controller MicroLogix Analog Input/Output Module MicroLogix 1200 T/C Input Module