BM-2468

DS 12x12x24 2 bar

How to Navigate

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2. Please note that when opening any linked drawings or bills of material, they will appear in a new window. To return to the previous page, simply close out or minimize the newly opened window.
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1. Information

1.1. Notice

This manual has been released for private information only, with the understanding that any other use of or duplication of the subject matter, in whole or in part, by reference or otherwise, shall be used only with the written knowledge of Ipsen and with the approval of that company first obtained. This manual is prepared and submitted for informative purposes only; suggestions and recommendations contained herein shall not be understood or construed as, in any sense, guarantees or warranties of any method, product or device unless specifically stated.

Any questions concerning the content of this manual should be directed to:

Ipsen, Inc.
984 Ipsen Road
Cherry Valley, IL 61016
Attention: Technical Communications Group

1.2. Preface

This Ipsen vacuum furnace is manufactured with high-quality equipment and materials, designed for many years of trouble-free service for the intended application.

The information and instructions in this manual are intended to facilitate and maintain your system safely and economically.

Any questions concerning the operation of this equipment should be directed to our Field Service or Engineering Department.



NOTE

All persons authorized to operate the Ipsen vacuum furnace must first read this manual and thoroughly understand the correct operating procedures for all phases of operation.

Refer to the Vendor Component Data, supplied in a separate manual, for detailed information on component equipment.

If the proper operating sequence is not followed, or the design specifications are exceeded, the warranty is void.

Maintenance and service records must be maintained to demonstrate that all the manufacturer's recommended procedures for service and calibration for all pumps, gauges and other equipment have been followed.

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1.3. Manual Information

This manual was prepared and written for all persons associated with or using this Ipsen vacuum furnace. The manual contains the necessary instructions and information for start-up, operation, and maintenance of the equipment. For optimum performance and service, the personnel who operate and maintain this equipment should have access to these operating instructions at all times.

Three levels of cautionary notes are used throughout this manual:

NOTE
Provides important or additional information about the topic

CAUTION
Indicates that damage to equipment may occur

WARNING
Indicates a potentially dangerous situation for personnel

Information about component equipment not manufactured by Ipsen, but incorporated into the vacuum furnace, can be found in a separate section titled Vendor Documentation.

1.4. General

The Ipsen vacuum furnace should only be used within its design parameters. The owner is responsible for the proper operation and maintenance of this system in a manner to avoid personal injury, as well as equipment and environmental damage.

Special attention should be given to:

- Training of personnel to know general and specific sources of danger (e.g., automatic starting sequences, as well as paying attention to safety alarms, lights, etc.)
- Checking mechanical, electrical, acoustical, and optical safety elements regularly for proper operation
- Checking piping regularly for tightness, especially pressurized systems
- Handling of hazardous materials for storage and use, such as oils, acids, etc.
- Training of personnel in operating and maintaining the system
- Adhering to company rules and regulations

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Use only qualified and skilled personnel for maintenance and repairs of the Ipsen vacuum furnace.

By doing so:

Achieve:	Avoid:
• Longer system life	• Reduced system life
• Higher reliability	• Production stops
• Reduced repair cost	• High repair costs
• Quality production	• Defective production
• Warranty coverage	• Loss of warranty

Ipsen, Inc. offers complete support for the Ipsen vacuum furnace including:

- A custom-made service contract to ensure periodic inspections and quality service work by individuals who are experts with the equipment
- A recommended spare parts package, prepared specifically for the furnace, for the initial stock of spare parts

Each of these may be purchased with the initial purchase of the furnace

Ipsen, Inc. will always be a reliable partner for:

- Future furnace requirements
- Technical support
- Training of personnel
- Furnace inspections, adjustments, preventive maintenance, and repairs
- Spare parts recommendations, supplies and installation
- Service

If you have question concerning the operation, inspection, maintenance, or repair of the Ipsen vacuum furnace, please contact Ipsen Field Service.

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BM-2468

DS 12x12x24 2 bar

2. Equipment Specifications and Utility Data

Model	DS 12x12x24 2 bar

2.1. Heating Chamber

Hot Zone Load Size	12″ W x 12″ H x 24″ L
Number of Hot Zone Trim Zones	2
Heating Elements	Curved Graphite
Heat Shields	2" Graphite Felt & CFC Hot Face
Misc.	Cooling Nozzle Covers
Maximum Load	400 lbs.
Operating Temperature Range	500°F to 2,550°F
Cleanup Temperature 2 Hrs. Max	2,650°F
Ultimate Vacuum Range	20 Microns (CDE)
Mechanical Pump	Leybold Trivac D65B
Vacuum Booster	N/A
Holding Pump	N/A
Diffusion Pump	N/A
Maximum Quench Pressure	2-bar
Gas Cooling	15 HP
Quench Gas	Argon

2.2. Controls

Control System	Vacuprof
Over Temperature Instrument	Honeywell UDC-1200
Recorder	N/A
Vacuum Instrument	Inficon
Convection Heating (Option)	No
Controlled Cooling (Option)	Via VFD (Without Heat)
Variable Frequency Drive on Vacuum Booster Pump	Yes
Hydrogen Partial Pressure (Option)	No
Isothermal Hold (Option)	No

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2.3. Utilities

Electric

Connection point from customer	460 V, 3 phase, 60 Hz
Control Cabinet Load	85 AMPS During Heating Mode
Hot Zone Load	76 A (Through Control Cabinet)
Gas Blower Motor Load	16.5 AMPS (Through Control Cabinet)
Maximum Amperage Draw	87 A

Electric

Connection point from customer	400 V, 3 phase, 50 Hz
Control Cabinet Load	100 AMPS During Heating Mode
Hot Zone Load	87 A (Through Control Cabinet)
Gas Blower Motor Load	19 AMPS (Through Control Cabinet)
Total Connected Load	100 A



NOTE

The customer's main disconnect may need to accommodate an amperage higher than the total connected load to meet local or national codes and requirements.

Water

Peak Demand	60 GPM
Inlet Pressure at Peak Demand	50 PSIG
Max. Inlet Temperature	60°F Max
Max. Inlet Temperature (During Cooling)	95°F Max
Furnace Inlet	2" 150# ANSI Flanged
Furnace Drain	2" 150# ANSI Flanged
Maximum Backpressure (At drain manifold connection)	5 PSIG

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Inert Gas

Inlet Pressure	100 PSIG Max
Connection	1 NPT Inlet
Backfill	33 SCF* Internal Furnace Volume
	66 SCF* Used for a 2 BAR Quench**

NOTE: IF FURNACE IS TO BE OPERATED AT POSITIVE PRESSURE THE ACTUAL BACKFILL VOLUME GIVEN ABOVE SHOULD BE MULTIPLIED BY THE FACTORS AS FOLLOWS:

NOTE 2: PLUS COOLING MOTOR SEAL PURGE GAS (APPROXIMATELY 120 STANDARD CUBIC FEET FOR A 60 MINUTE QUENCH)

5 PSIG = 1.34

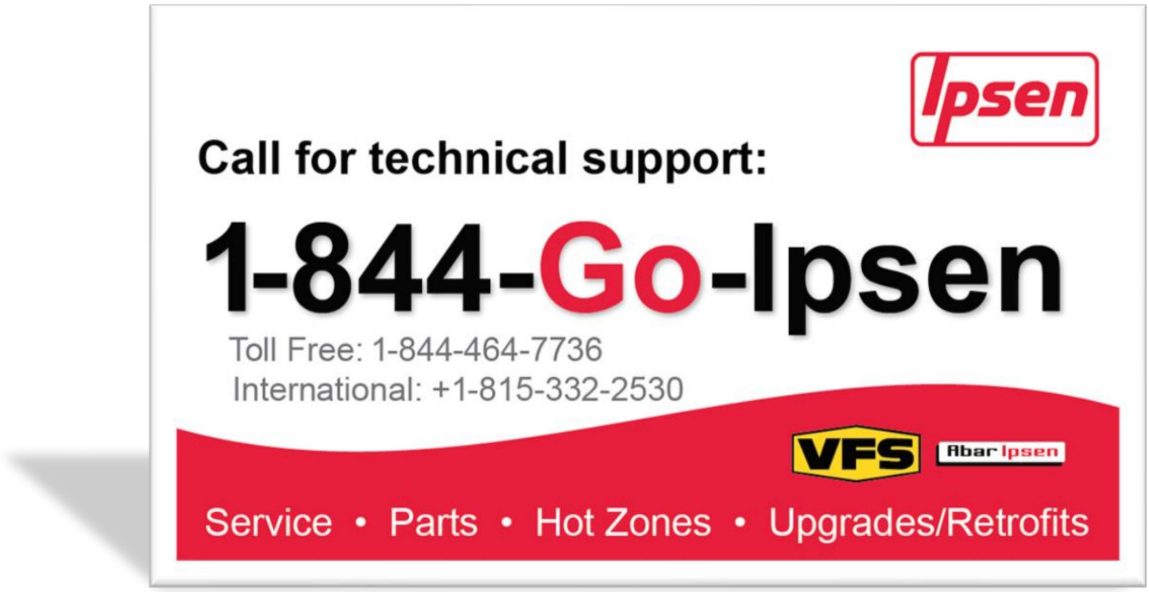
10 PSIG = 1.67

15 PSIG = 2.01

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3. Service Information

If there are any questions concerning this Furnace System, or its operation, call your Ipsen Representative or call direct to the service department at:



If assistance is required for an operational procedure, it is helpful to have all pertinent information readily available prior to calling.

The caller should be prepared to supply specific information such as:

- The serial number and type of equipment
- The operating conditions, including:
  - The type of load
  - The heat-treating process undertaken
  - The phase of operation (start-up, load, heat, etc.)
- Whether the operator activated any control(s) immediately preceding the furnace function noted
- Any immediate actions the operator took when the problem developed
- Events that occurred after the immediate action was taken by the operator

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4. Warranty

The IPSEN warranty is precisely defined in our order confirmation Terms and Conditions. Claims under guarantee can be asserted only if all the issues laid down in the maintenance instructions were heeded in full and the system defects or damage to the system can be attributed to IPSEN. If claims under guarantee are asserted, these must be reported to IPSEN in writing immediately after the defect was noticed with specification of the order number and the exact designation of the aggregate or component. If defects or damage are/is repaired by the customer himself or by third parties before being granted authorization to do so by IPSEN, IPSEN shall not be liable to recognize any claims.

Defective components must be made available to IPSEN for the purpose of assessing claims under warranty.

An operator's log must be maintained detailing all system maintenance and alarms. Any malfunctions such as failure of a component or alarms with date and time must be noted in the logs. The measures taken to repair the malfunction and clear the alarm must be documented. Under warranty claims the system logs must be forwarded to IPSEN.

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5. Safety Information

5.1. Safety Precautions

All points and suggestions regarding safe operation of the Furnace set forth in this manual are offered as a guide in defining responsibilities for safety in the use of heat-treating equipment. It is the responsibility of the equipment user management to delegate the responsibility and to promote and organize an effective safety program. Management should encourage safe operating practices and maintenance procedures, regular preventive maintenance, inspection schedules and effective guarding of equipment.

Management must see that this manual is understood by all personnel involved with the Furnace Facility.

This manual is intended to supplement all general safety standards currently maintained at the furnace site. Additional safety information and training aids can be obtained from the National Safety Council, your local safety council, the American National Standards Institute, trade associations, insurance carriers and the Department of Labor.



CAUTION

At no time should a furnace be in operation without a trained operator in attendance.

All equipment and safety devices provided by Ipsen are in accordance with guidelines established by Factory Mutual (FM), the National Fire Protection Association (NFPA) and all other appropriate insurance specifications.

Reference (use updated edition if available):

- NFPA 86 (2019) – Standard for Ovens and Furnaces
- NFPA 70B (2019) – Standard for Electrical Equipment and Maintenance
- NFPA 70E (2021) – Standard for Electrical Safety Requirements for Employee Workplaces
- NFPA 79 (2021) – Standard for Industrial Machinery

Available from:

National Fire Protection Association, Inc.
Batterymarch Park
Quincy, MA 02269
NFPA FIRE CODE

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5.2. Safety Signs

Ipsen has attached warning signs at various locations on the furnace equipment. These signs are meant to warn or caution personnel of potentially dangerous conditions. It is important that these signs not be removed, defaced, hidden, or covered.

The American National Institute (ANSI Z35.1-1972) and the Occupational Safety and Health Administration (OSHA 1910.145) Specifications for Accident Prevention Signs require the use of safety signs of consistent design to indicate and define specific hazards that without identification, may lead to accidental injury to workers and/or the public or to property damage. Sign classifications are as follows:

Figure 5-1 Warning Sign Explanation



WARNING

It is the employer's responsibility to interpret and explain all warning signs to employees who do not read or understand English.

Additional signs, if required, may be obtained from Ipsen at a nominal charge.

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5.3. Safe Handling of Atmosphere

Several potentially dangerous gases are used in heat treatment. Many are colorless, odorless, and tasteless, so they are difficult to detect readily.



WARNING

If gases are not purged, a hazardous condition may exist that could result in accidental suffocation (asphyxiation) or serious injury to personnel. Allow sufficient time for process gases to diffuse into the air or purge thoroughly before allowing personnel to enter a pit or breathe inside a furnace chamber. It is strongly recommended that the end user purchase a hand-held oxygen sensor (test instrument) to validate that the atmosphere is able to support human life prior to entering (i.e., confined space entry requirements).

Due to the different characteristics of these gases, it is important to know the gases you utilize and how to handle them safely. The following characteristics are important:

1. Combustibility – In certain rare cases, combustible gases (such as hydrogen) are used as a protective atmosphere and should be completely purged to eliminate an explosion hazard.
2. Density – Gases are either lighter or heavier than air, and in either case, the gases displace oxygen and pose a definite asphyxiation hazard.
    a. Lighter gases (e.g., nitrogen and helium) will rise and therefore become trapped in any enclosure open on the bottom and closed on the top (such as a vertical furnace chamber).
    b. Gases that are heavier than air (e.g., argon) become trapped in enclosures closed on the bottom and open on the top (such as top-loading furnaces, service pits and diffusion pumps).
3. Ability to support life – Any atmosphere that does not consist of at least 19.5% oxygen is a potential asphyxiation hazard (an oxygen percentage in excess of 23.5% could cause impairment and disorientation).

In any situation, always purge an area with air completely before entering. Never enter an enclosed area without first checking the oxygen content of that area. It must be at least 20.9% of available atmosphere. Sensing devices are available that check for the presence of various gases.

Use special care when working with gases heavier than air as they do not behave as other gases do. Check all depressions around the furnace for proper oxygen level. Check areas of the furnace (e.g., chambers and pumps) and purge completely. Once inhaled, these gases are difficult to remove from the lungs and will cause asphyxiation.

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5.4. OSHA Confined Space Regulations

OSHA Regulation 1910.146 requires employers to establish a confined space entry program for any confined space that contains, or has the potential to contain, a hazardous atmosphere. Atmosphere furnace chambers and certain other associated tanks and vessels are classified as confined spaces under federal regulations. All these components, under various circumstances, have the potential to contain a hazardous atmosphere of non-life-supporting gases, making them subject to the provisions of the OSHA Permit Confined Space Program. The intention of OSHA regulations is to prevent injury to employees involved with the operation and maintenance of these components by requiring specific safety training and the establishment of documented procedures for entry into those potentially hazardous spaces. Statistics from the National Institute for Occupational Safety and Health indicate that, of the confined space fatalities during a recent ten-year period, only 6% of the victims had received safety training specifically oriented toward confined spaces and 34% of the victims had received no safety training at all. It was also shown that rescuers accounted for 36% of the fatalities.

The following information is excerpted from OSHA 1910.146, entitled Permit Required Confined Spaces. Ipsen strongly recommends that furnace users obtain a copy of OSHA 1910.146 and fully comply with its provisions (available from the U.S. Government Printing Office).

5.4.1. General

The requirements of OSHA 1910.146 provide that the employer shall:

- *Evaluate the workplace to determine if any spaces are permit-required confined spaces*
- *Inform exposed employees by posting danger signs and outlining of the existence and location of, and the danger posed by, the permit spaces*
- *Take effective measures to prevent employees from entering the permit spaces*
- *Develop and implement a written permit space program that complies with this section*
- *Designate persons who are to have active roles in entries into confined spaces and to provide each employee with training*
- *Provide testing and monitoring equipment*
- *Provide rescue and emergency equipment*
- *Develop and implement procedures for summoning rescue and emergency services*

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5.4.2. Definition of Entry (into a Confined Space)

Entry means the action by which a person passes through an opening into a permit-required confined space. Entry includes ensuing work activities in that space and is considered to have occurred as soon as any part of the entrant's body breaks the plane of the opening into the space.

5.5. OSHA Lockout Program for Industrial Equipment

OSHA Regulation 1910.147 requires employers to establish an energy control (lockout) program and to utilize procedures for affixing lockout devices to energy-isolating devices (e.g., circuit breakers, disconnect switches, valves and so on), and to otherwise disable machines or equipment during servicing and maintenance to prevent unexpected energizing, start-up, or release of stored energy to avoid injury to employees. Energy sources involved include electrical, mechanical, hydraulic, pneumatic, chemical, thermal or other energy. The OSHA standard establishes the minimum performance requirements for the control of such hazardous energy.

The following paragraphs are a summary of, but are not the complete requirements of, OSHA 1910.147, entitled The Control of Hazardous Energy (Lockout/Tagout). For completed details, refer to the official OSHA standard available from the U.S. Government Printing Office.

5.5.1. General

The lockout procedures developed and utilized by the employer must include:

- *A specific statement of the intended use of the procedure*
- *Specific procedural steps for shutting down, isolating, and securing the equipment to control hazardous energy*
- *Specific procedural steps for the placement, removal, and transfer of lockout devices and who is responsible for them*
- *Specific requirements for testing equipment to determine and verify the effectiveness of lockout devices*

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5.5.2. Training Program

The employer must provide a training program to ensure that the energy control (lockout) program is understood by employees. Employees must understand that they are required to have the knowledge and skills necessary for the safe application, usage, and removal of lockout devices.

Employees authorized to install lockout devices (authorized employees) must be trained to recognize applicable hazardous energy sources, their magnitude, and the means necessary for their isolation and control.

All employees affected by lockout procedures (affected employees) must be instructed in the purpose and use of the energy control program. All employees whose work may require them to be in an area where energy control procedures may be utilized must be instructed about such procedures and the prohibition relating to attempts to re-energize equipment which is locked out.

Retraining must be provided for all authorized and affected employees whenever there is a change in their assignments, a change in equipment, an addition of new equipment, a change in the energy control procedures or deviation or inadequacy in any authorized or affected employee's knowledge of the use of energy control (lockout) procedures.

The employer is responsible to certify that the training has been performed. The certification must contain each employee's name and dates of training.

5.5.3. Employees Authorized to Lockout Equipment

The installation and removal of lockout devices on equipment should be done only by the persons performing service and maintenance on that equipment.

5.5.4. Lockout Devices

The employer shall supply devices identified as lockout devices, such as key- or combination-type locks to isolate equipment from its energy sources. These lockout devices must not be used for other purposes. They must be capable of withstanding the environment to which they are exposed, be standardized in appearance, be substantial and indicate the identity of the employee applying the device.

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5.5.5. Inspection Program

The employer must have an authorized employee, other than those utilizing the lockout procedure, conduct a periodic inspection of the energy control procedure at least annually to review each employee authorized to install lockout devices on equipment and the employee's responsibilities under the energy control (lockout) program. Any deviations or inadequacies observed must be corrected. The employer is responsible for certifying that the periodic inspections have been performed. The certification must identify the equipment, the date of the inspection, the employees included and the person who performed the inspection.

5.5.6. Notification

Employees affected by locked out equipment must be notified when lockout devices are applied and when lockout devices are removed from the equipment. That notice must be given by the employee performing the operation or by the employer.

5.5.7. Lockout Procedure Steps

1. *Determine the type of energy to be controlled, the hazards of that energy and the methods necessary to control that energy.*
2. *Notify all employees affected by the removal of energy from the equipment before the application of the lockout devices.*
3. *Shut down the equipment in an orderly manner so as not to endanger employees during the shutdown process.*
4. *Operate all energy-isolating devices (e.g., disconnect switches, valves and so on) to isolate the equipment from its energy source(s).*
5. *Apply lockout devices are applied to hold the energy-isolating device(s) in the off or safe position,*
6. *All potential hazardous energy sources should now be rendered safe.*
7. *The employee who installs the lockout device(s) must verify the isolation and de-energizing of the equipment.*
8. *Maintenance or service on the equipment may now commence.*

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5.5.8. Release from Lockout Procedure Steps

1. *The equipment shall be inspected to ensure that it is operationally intact, that all guards and covers have been reinstalled and that all nonessential items have been removed.*
2. *All employees affected by the reapplication of energy to the equipment shall be notified before the removal of the lockout devices.*
3. *The work area shall be checked to ensure that all persons, present have been safely positioned.*
4. *Each lockout device is to be removed by the person who applied it. (Only under certain specific circumstances may someone other than person who applied the lockout device remove it. For those specific requirements, refer to the official OSHA standard.)*
5. *The equipment may now be restarted.*

5.5.9. Additional Requirements

When maintenance is performed by a crew, craft, or other group, primary responsibility may be vested in a single authorized employee for a specific number of employees working under the protection of a group lockout device. Each employee of the group performing service or maintenance on the equipment shall install and remove his or her personal lockout device to the group lockout device as required.

Whenever outside service personnel are involved with, or affected by, the lockout of equipment at a site, the on-site employer and the outside employer shall inform each other of their respective lockout procedures. Both employers shall ensure that their employees understand and comply with the other employer's lockout procedures.

During shift or personnel changes, specific procedures shall be utilized to ensure continuity of lockout protection.

NOTE

The preceding paragraphs are a summary of, but are not the complete requirements of, OSHA 1910.147, entitled The Control of Hazardous Energy (Lockout/Tagout). For complete details, refer to the official OSHA standard available from the U.S. Government Printing Office.

5.6. Application of OSHA Lockout Procedures to Vacuum Furnaces

A furnace system may have one main electrical disconnect device (circuit breaker or switch) or may have its power supplied from several electrical sources each having a separate disconnect device. Complete isolation of all electrical energy from the vacuum furnace may involve the lockout of more than one electrical disconnect device. Consult the electrical schematic diagram for details.

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After installing electrical lockout devices, verify that electrical power has been successfully isolated from the furnace by observing the control cabinet instruments and attempting to operate system components such as the roughing pump or holding pump. Lack of control system response to these actions confirms the isolation of electrical power.

In addition to electrical energy, vacuum furnaces normally utilize energy from pneumatic, inert gas atmosphere and sometimes hydraulic sources. Any service or maintenance on one of those specific furnace systems would also require the lockout of the energy to that system. In many cases, lockout of electrical power to the furnace has the effect of disabling another energy system if they are electrically controlled. However, even when electrically disabled, certain furnace components may be inadvertently manually actuated causing unexpected, and possibly hazardous, operation (e.g., manual operation of a pneumatic control valve). Complete and certain isolation of all potentially hazardous energy to the furnace system involves the lockout of each energy source.

In the interest of maximum safety, Ipsen recommends that, whenever service or maintenance is to be performed on a vacuum furnace; each energy source (electrical, pneumatic, pressurized inert gas and so on) is separately and positively locked out.

5.7. Operational Safety

The customer should follow end users established safety program. The following are suggestions for a good operational program:

- Appoint a Safety Coordinator to be a central point of reference for all safety regulations, requirements, and suggestions.
- Establish a "Furnace Facility Safety Guide." Ensure heat-treating area personnel know and understand what is expected of them.
- Review and inspect furnaces to ensure compliance with current safety standards mandated by state and federal laws.
- Train all operators and maintenance personnel in the proper use of the Atmosphere Furnace System.
- Ensure that the work area is clean, safe, and uncluttered.
- If a malfunction is reported, follow the recommended procedures outlined in this manual.
- Develop and follow a confined space entry procedure.
- Maintain records of all accidents and "close calls." Investigate and record all details of each situation.
- Require the use of appropriate personal protective equipment when operating or maintaining the furnace system. Items such as safety glasses, safety shoes, gloves, hard hats, breathing apparatus and lockout devices are common.
- Provide adequate and proper fire protection.

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- Post names, addresses and phone numbers of physicians, hospitals, and emergency squads to be called in case of emergency.
- Ensure that all equipment is electrically connected according to the National Electric Code and consistent with other accepted practices.

5.8. Preventive Maintenance and Visual Inspection

Routine inspections and a preventive maintenance schedule will help the Furnace System to operate more efficiently and will help to eliminate costly repairs. All maintenance and inspection personnel must understand the correct procedures for inspecting and maintaining the system.

Since all equipment has limited life, experienced maintenance personnel are necessary to obtain maximum usage of the equipment.

Following are some preventive maintenance suggestions:

- Set up a daily, weekly, and monthly inspection program. Use a checklist to verify that the job is done, and records are maintained.
- Establish a preventive maintenance program using a checklist. Record and maintain a record of all maintenance work performed.
- Release the Furnace System for production only after it has been inspected and serviced by qualified personnel.

5.9. Safety Enforcement

To have an effective safety program, personnel at all levels must enforce every safety rule and regulation. All infractions must be reported and recorded. The reason for the infraction should be analyzed to take corrective action. Strong disciplinary measures are sometimes required.

5.10. Training

For supplemental information pertaining to Training, refer to NFPA 70B, Electrical Equipment Maintenance, Appendix D. This is a guideline on "How to Instruct" and will assist in developing a comprehensive instructional plan and provide ideas for measuring performance standards.

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5.10.1. Supervisor Training

It is the responsibility of management to provide the appropriate instruction for their supervisors on safety, relating correct job instructions, determining accident causes and building safety attitudes among the operators.

5.10.2. Operator Training

A specific training program must be instituted to instruct operators in safety, the proper use the equipment and the correct operational procedures for performing each job. The operator must be familiar with proper guarding devices of the equipment and the use of atmospheric gases. An operator must never start a job without complete operating instructions.



NOTE

Ipsen, Inc. provides classes in the operation and maintenance of their furnace equipment. Instruction is available through the Rockford, Illinois facility.

5.11. Good Housekeeping

Maintain a clean, orderly workplace. Good housekeeping contributes to a safer workplace by reducing the potential for fire and reduces accidents caused by slipping and falling.

Combustible materials should be kept only in places isolated by fire-resistive construction.

Rubbish should be disposed of regularly. If it is necessary to store combustible waste materials, a covered container must be used.

Cleaning materials can create hazards. Combustible sweeping compounds such as oil-treated sawdust can be a fire hazard. Floor coatings containing low flashpoint solvents can be dangerous, especially near sources of ignition.

Oily rags and mops must be stored in closed metal containers.

Falling is one of the chief contributors to injury in all industry. Accumulations of waste and scrap and spills of slippery materials must be cleaned up promptly.

Good housekeeping also contributes to safety during materials handling and storage. An orderly workplace with unobstructed aisles and passageways can significantly reduce injuries and improve production.

Hot surfaces may be present whenever the system is in operation. Use caution in contacting all component surfaces when the unit is running as well as when it is shut down.

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These instructions are meant to supplement the normal safety regulations currently in effect within your facility. Eye, ear, and body protection are to be used as required by your facility management.

5.12. Safety Awareness

Ipsen furnaces use one or more process gases (many of which are odorless and colorless) which if inhaled can cause asphyxiation and/or death.

The following procedure is to be used prior to entering a furnace, a furnace pit (if applicable) or other confined spaces near the furnace.

1. Shut off or disconnect all process gas/purge lines.
2. Stop all mechanical equipment.
3. Remove yellow pipe sections (2).
4. Allow equipment to cool (as required) prior to personnel entry.
5. Shut off electrical power (padlock all disconnect switches in the Off position).
6. Attach lockout tags to all valves and switches that read "Maintenance work being performed — DO NOT OPERATE."
7. Direct the airflow of a large fan toward the area to be entered.
8. Using an oxygen sensing device to sample the atmosphere and check if it is safe.
9. Sample the atmosphere using an oxygen-sensing device to insure a safe atmosphere.
10. Engage all doors and elevators safety pins.
11. Follow plant confined entry procedures.



WARNING

Do not enter the area in question until the oxygen content is between 19.5% and 23.5%.

Never work alone on this equipment. Persons entering a suspect area must have supervisor approval and wear lifelines so they may be pulled to safety in the event of any emergency.

Symptoms of gas poisoning:

- Dizziness
- Headache
- Stiffness in neck
- Weakness in knees
- Nausea

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If any of these symptoms are detected, remove all personnel from the area and seal it off until proper ventilation can be affected.

In the event a person is gassed, employ the following procedures:

1. Remove the victim to fresh air immediately.
2. Administer medical air promptly.
3. If breathing is poor or stopped, give artificial respiration, and administer oxygen.
4. Keep the victim warm with a blanket.
5. Contact emergency services.

Hot surfaces may be present whenever the system is in operation. Use caution in contacting all component surfaces when the unit is running as well as when it is shut down.

Caution should be used when entering or servicing the interior of a ceramic-fiber-insulated hot zone. Commonly, silica dust, glass fibers, carbon, graphite, and dusts from the ceramic fiber insulating materials are airborne and may present a health hazard.

Appropriate respirator equipment should be used to limit personnel exposure to these hazards. Heavy metal fumes from brazing may also present some hazards and the materials used in these processes must be reviewed from time-to-time to ensure proper handling and exposure procedures are being followed.

These instructions are meant to supplement the normal safety regulations currently in effect within your facility. Eye, ear, and body protection are to be used as required by your facility management.

5.13. Melting Due to Eutectic Formation

The operator must be aware of the possibility of reaction between parts and the furnace fixtures, trays, or baskets.

When different metals are heated in contact with each other in vacuum at elevated temperatures, they can diffuse into each other. Such diffusion can lower the melting point at the surfaces to a point that is below the operating temperature of the furnace. The minimum temperature that can occur by such diffusion is known as the *Eutectic Temperature*, predicted by phase diagrams, many of which can be found in reference books. Because of the bright, metallurgically clean surfaces formed in a vacuum, this problem is more likely to occur in vacuum furnaces than in atmosphere furnaces.

When work pieces in the furnace come in contact with the work fixture, baskets, furnace shields, element or hearth, the potential for eutectic melting exists. When eutectic melting occurs, severe damage to the furnace's hot zone components can result. Care must be taken when using the same work basket for a variety of metals. Surface deposits on the basket may react with one metal and not another.

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This can be avoided by keeping the parts separated with known metals, ceramics, ceramic, paper, or a painted slurry of ceramic oxide that do not react at the maximum process temperature.

In Figure 5-1, eutectics are listed with the critical melting temperature. Care must be exercised when operating temperatures are near or above these points. Note that Figure 5-2 is for two component (binary) alloys. Most fixtures are multi-component, and the melting points may be still lower than shown.

CAUTION

Carbon is especially likely to form eutectics. Since carbon readily diffuses into alloys and can be transferred by gas reactions (carburizing), as well as solid diffusion, care must be exercised when using the furnace at high temperatures in the presence of carbon, or carburized, components.

5.14. Diffusion Bonding

In vacuum, it is possible for parts and metal materials to stick together or be contaminated by the transfer of metal from one surface to another. This is the result of metal-to-metal transfer (diffusion). The conditions necessary for this to occur are:

- Metals are soluble in each other
- High temperatures
- Extremely clean surfaces
- Low furnace pressure (high vacuum)
- Some contact pressure (which may be the weight of the part itself)

The exact condition is a function of all of these and needs to be analyzed on a case-by-case basis. The effect can be avoided by keeping the parts separated with a proper metal, using a ceramic, as outlined in prevention of eutectics, or utilize partial pressure to negate sticking. Some of these critical reaction temperatures are listed in Figure 5-1 and Figure 5-2.

5.15. Metals Contamination

Metals can also be contaminated due to their clean surfaces in vacuum by reaction with metal vapors. Since materials can vaporize more readily in vacuum, consideration of vapor pressure and evaporation rate should be given when processing contamination sensitive materials. See Figure 5-3 for vapor pressures of various elements.

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5.16. Property Tables

Figure 5-1. Eutectic melting point chart

Eutectic Melting Points (Values shown in °F)							
	W	Mo	Ta	Ti	Ni	Fe	C
W					2650	2800	
Mo					2400	2650	
Ta					2400	2500	
Ti					1700	2000	3000
Ni	2300	2300	2400	1700		2600	2400
Fe	2200	2200			2600		2100
C					2400	2100	

Eutectic Melting Points (Values shown in °C)							
	W	Mo	Ta	Ti	Ni	Fe	C
W					1455	1537	
Mo					1315	1455	
Ta					1315	1371	
Ti					926	1093	1647
Ni	1260	1260	1315	926		1426	1315
Fe	1204	1204			1426		1148
C					1315	1148	

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Figure 5-2. Reaction temperatures in vacuum between oxides, metals and carbon

Temperature of Onset of Reaction in Vacuum Between Refractory Oxides, Metals and Carbon (All values shown in °F)									
Material	C	W	Mo	$Al2O_3$	BeO	SiO_2	MgO	ThO_2	ZrO_2
C		2550	2700	3250	4150	2550	3750	3500	3250
W	2550		4150	3600	3800	2900	3600	4150	3800
Mo	2700	4150		3600	3450	2700	3250	3450	3900
$Al2O_3$	3250	3600	3600		3450	2800	3500	3150	3050
BeO	4150	3800	3450	3450		3000	3250	3900	3600
SiO_2	2550	2900	2700	2800	3000		2800	3000	3000
MgO	3250	3600	3250	3500	3250	2800		3800	2700
ThO_2	3500	4150	3450	3150	3900	3000	3800		4850
ZrO_2	3250	3800	3900	3050	3600	3000	2700	4850	

Adapted from: "Thermocouples for High Temperature Measurement", V. P. Wasan and C. L. Gupta

Temperature of Onset of Reaction in Vacuum Between Refractory Oxides, Metals and Carbon (All values shown in °C)									
Material	C	W	Mo	$Al2O_3$	BeO	SiO_2	MgO	ThO_2	ZrO_2
C		1398	1482	1787	2287	1398	2065	1926	1787
W	1398		2287	1982	2093	1593	1982	2287	2093
Mo	1482	2287		1982	1898	1482	1787	1898	2148
$Al2O_3$	1787	1982	1982		1898	1537	1926	1732	1676
BeO	2287	2093	1898	1898		1648	1787	2148	1982
SiO_2	1398	1593	1482	1537	1648		1537	1648	1648
MgO	1787	1982	1787	1926	1787	1537		2093	1482
ThO_2	1926	2287	1898	1732	2148	1648	2093		2676
ZrO_2	1787	2093	2148	1676	1982	1648	1482	2676	

Adapted from: "Thermocouples for High Temperature Measurement", V. P. Wasan and C. L. Gupta

NOTE

Tantalum forms carbide at 1,832°F (1,000°C).

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BM-2468

DS 12x12x24 2 bar

Figure 5-3. Element vapor pressures

Vapor Pressures of Various Elements						
Symbol	Element	10-4 mm Hg 0.1 Microns (F)	10-3 mm Hg 1.0 Microns (F)	10-2 mm Hg 10 Microns (F)	10-1 mm HG 100 Microns (F)	760 mm HG 760,000 Microns (F)
Al	Aluminum	1486	1643	1825	2053	3733
Sb	Antimony	977	1103	1251	1434	2624
As	Arsenic	-----	428	-----	590	1130
Ba	Barium	1011	1157	1321	1524	2557
Be	Beryllium	1884	2066	2275	2543	-----
Bi	Bismuth	997	1128	1290	1328	2588
B	Boron	2084	2262	2471	2712	-----
Cd	Cadmium	356	428	507	610	1409
Ca	Calcium	865	982	1121	1292	2709
C	Carbon	4150	4480	4858	5299	8721
Ce	Cerium	1996	2174	2381	2622	-----
Cs	Caesium	165	230	307	405	1274
Cr	Chromium	1818	1994	2201	2448	4500
Co	Cobalt	2484	2721	3000	3331	-----
Cb	Columbium	4271	4602	-----	-----	-----
Cu	Copper	1895	2086	2323	2610	5003
Ga	Gallium	1578	1769	1999	2278	-----
Ge	Germanium	1825	2034	2284	2590	-----
Au	Gold	2174	2401	2669	2995	5424

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DS 12x12x24 2 bar

Vapor Pressures of Various Elements						
Symbol	Element	10-4 mm Hg 0.1 Microns (F)	10-3 mm Hg 1.0 Microns (F)	10-2 mm Hg 10 Microns (F)	10-1 mm HG 100 Microns (F)	760 mm HG 760,000 Microns (F)
In	Indium	1375	1544	1746	1990	-----
Ir	Iridium	3909	4244	4633	5092	-----
Fe	Iron	2183	2390	2637	2916	4955
La	Lanthanum	2057	2268	2518	2820	-----
Pb	Lead	1018	1148	1324	1508	3171
Li	Lithium	711	822	957	1125	2502
Mg	Magnesium	628	716	829	959	2025
Mn	Manganese	1456	1612	1796	1868	3904
Mo	Molybdenum	3803	4163	4591	5448	10056
Ni	Nickel	2295	2500	2750	3054	4950
Nb	Niobium	4271	4602	-----	-----	-----
Os	Osmium	4107	4444	4833	5288	-----
Pd	Palladium	2320	2561	2851	3198	-----
Pt	Platinum	3171	3459	3794	4159	7965
K	Potassium	253	322	405	509	1189
Rh	Rhodium	3299	3580	3900	4274	-----
Rb	Rubidium	190	253	329	423	1254
Ru	Ruthenium	3736	4046	4408	4831	-----
Sc	Scandium	2122	2340	2593	2903	-----
Si	Silicon	2041	2233	2449	2705	4149
Ag	Silver	1558	1688	1917	2120	4014

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DS 12x12x24 2 bar

Vapor Pressures of Various Elements						
Symbol	Element	10-4 mm Hg 0.1 Microns (F)	10-3 mm Hg 1.0 Microns (F)	10-2 mm Hg 10 Microns (F)	10-1 mm HG 100 Microns (F)	760 mm HG 760,000 Microns (F)
Na	Sodium	383	460	556	673	1638
Sr	Strontium	775	887	1020	1182	2523
Ta	Tantalum	4710	5108	-----	-----	-----
Tl	Thallium	862	932	1123	1220	2655
Th	Thorium	3328	3630	3985	4408	-----
Sn	Tin	1692	1850	2172	2318	4118
Ti	Titanium	2280	2523	2815	3168	-----
W	Tungsten	5013	5461	5988	-----	10701
U	Uranium	2885	3146	3448	3808	-----
V	Vanadium	2887	3137	3430	3774	-----
Y	Yttrium	2484	2721	3000	3331	-----
Zn	Zinc	478	554	649	761	1665
Zr	Zirconium	3020	3301	3634	4014	-----

This chart indicates that the vapor pressure of metals is fixed with probable values at a given temperature and that the temperature at which the solid is in equilibrium with its own vapor decreases as the pressure it is exposed to decreases.

For example, iron (Fe) must be heated to 4,955°F at atmosphere before its vapor pressure is greater than atmosphere (760 mm Hg); however, as shown above, this point is reached at 2,390°F of 1 micron (10^{-3} mm Hg)

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6. Furnace Installation

6.1. General

Use care in unpacking all vacuum components and check sealing surfaces for scratches, dents, etc., which can result from rough handling during shipment.

Before assembling any flanges with "O" Rings, Seals, make certain the face and "O" Ring groove of the flange is thoroughly cleaned, and free from all dirt, grease, and grit.

Proper greasing of "O" Rings and self-contained single unit type seals (BG20 Vacuum Grease) is essential for a good vacuum seal. Make sure the "O" Ring is clean. Good vacuum practices call for just enough vacuum grease to produce a sheen on the "O" Ring surface.

The lifting eyes on the furnace are to be used to lift the unassembled chamber only. Do not use these eyes to lift the frame and other components assembled on the tank.

Ipsen coats some of the exposed flanges with a preservative to prevent rusting during transit. This preservative should remain on the flanges until the re-assembly of the furnace. A solvent like kerosene will dissolve this coating.

Check all the containers and their packing lists for parts and components shipped as loose items.

6.2. Chamber and Components

See the Equipment Arrangement and/or Foundation drawings and any of the other reference drawings as needed.

Ipsen fully assembles the furnace on a level floor prior to shipment. The aligning components of the major systems (Dresser Coupling, Rubber Vacuum Couplings, etc.) are included to ensure ease of re-assembly at the customer's plant to avoid force-mating the sub-assemblies.

If difficulties are experienced in fitting the sub-assemblies, call the factory before cutting, binding, or welding of any structures and/or manifolds.

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6.2.1. Foundation

The accurate location of the foundation and anchor bolts is the sole responsibility of the customer. Prior to placement, measure the anchor bolts' location to make sure that the furnace will fit. Chalk-line the centerlines of the furnace, on the floor. Check to ensure that the foundation (if included) for the guide rails is reasonably level (within 1/2") with no irregularities in level and that the anchor bolts are the right size and length. When it is determined that the anchor bolts are on the correct centerline (± 1/8"), placement of the furnace may begin.

6.2.2. Chamber

At this point, the tank should be positioned. Check the tank for level using a 4' level or transit. After the tank has been leveled and all bolts have been tightened, the base plates should be grouted in place (if necessary). Use the front chamber flange for plumb and the main valve flange for plumb (side to side).

Note: Since the unit was assembled in the shop, no adjustments should be required to make the component parts fit, and any mismatch in holes should be taken as an indication that the structure has not been properly assembled.

In no case should a torch be used to correct a mismatch. The cause of the error should be found, and the furnace system should be assembled without modification.

After the above alignment has been made and checked, all the bolts should be tightened

6.2.3. Hot Zone Power Supply

Set the transformer power supply on the structure provided and secure with hardware.

6.2.4. Gas Blower Step-Down Transformer

If supplied, set the step-down transformer as shown on the equipment arrangement drawing, and secure. A step-down transformer is not used if the gas blower is wired for 380V, 415V or 460V operation.

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6.2.5. Recirculating Gas Blower

Set the Blower/Heat Exchanger unit in position but do not anchor this unit (HR Furnaces only).

6.2.6. Recirculating Gas Manifold and Valves (if supplied)

Without Valves - bolt the water jacketed transitional piece to the tank flange and heat exchanger flange of the unit, but do not tighten. Install Hi Hat piece in the tank flange, then bolt one end of the gas piping to the tank flange and secure the other end to the blower pipe with the Dresser Coupling, but do not tighten. Take care as not to allow any of the vacuum D-rings to slip out.

When all the piping is assembled and aligned, tighten all the flanges and couplings.

The above also applies to the Gas Backfill piping and tubing.

With Valves - bolt one end of the water-cooled valve to the tank flange and the other end to the heat exchanger flange unit, but do not tighten. Then bolt the other valve to the tank flange and the gas piping, then secure the other end of the gas piping to the blower pipe with the Dresser Coupling, but do not tighten.

When all the piping is assembled and aligned, tighten all the bolts on the flanges and couplings.

A furnace with the Internal Heat Exchanger and Gas Blower as part of the chamber requires only the services to be connected.

6.2.7. Diffusion Pump and Related Vacuum Valves

The Main High Vacuum Valve, Diffusion Pump, Roughing and Foreline Valves are removed for shipment. Reassemble them referring to the Pumping System assembly drawing. Check for alignment marks on mating flanges and tighten the bolts.

6.2.8. Pumps

Set the Roughing, Vacuum Booster, and Holding Pumps in place. Do not lag the pumps at this time.

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6.2.9. Vacuum Piping

Assemble the Vacuum Piping to all the vacuum components, but do not tighten. When all the piping is in place and aligned, tighten all the bolts and couplings.

6.2.10. Water System Assembly

Re-assemble the water manifold (as necessary). Do not tighten the unions.

Note: After the water manifold is in place and aligned, tighten all the unions and couplings. See the Water System Schematic.

If the furnace does not include a Recirculating Water System, proceed to Control Cabinet.

6.2.11. Recirculating Water Cooling System (if supplied)

Set the system in place, then level and fasten components. Also mount the cooling tower as shown on the Water System Schematic, located under Mechanical Drawings.

Complete the water piping between the water system, furnace, and cooling tower.

6.2.12. Control Cabinet

Set the control cabinet in place and lag to the floor using lead anchors.

6.2.13. Air, Water, and Gas Feed Lines

Re-assemble the air, water, and gas lines on the furnace. Connect the air, water and gas lines as shown on the Equipment Arrangement Drawing.



NOTE

Prior to connecting the furnace to a treated water system, a 24 hour flush is recommended. Fill the system with water, run the pumps, drain, and refill with the required water treatment.

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6.2.14. Hot Zone Packing

Fiberboard inserts have been placed within the furnace hot zone prior to shipment to minimize vibration during transit. If preliminary pumping is to be done by the customer without assistance for Ipsen personnel, remove all the inserts and restraints. If Ipsen service engineers are scheduled to perform the preliminary start-up testing, they will remove the inserts and restraints.

6.3. Electrical Connections

See the Electrical Schematic, located under Drawings, and connect the power lines as indicated. Where possible, wiring is completed at the Ipsen plant. In some cases, the customer is responsible for supplying the interconnecting wiring. The wire sizes and numbers to be used are indicated on the schematic.

Connect the pump motors as indicated on the Schematic. The phase sequence of the three phase electrical feed to the motor determines the direction of rotation. Check for proper rotation as noted on the pump pulley, guard, or manufacturer's instruction manual by operating the motor momentarily.

Note: Prolonged improper rotation may result in damage to the pump mechanism. The rotation can be changed by interchanging any two of the three phases to the pump motor.

In some cases, the control panel instrumentation is removed from the panel and shipped separately. See the Control Panel Assembly drawing when installing these instruments to insure proper location.

The terminal strip locations and wire numbers are indicated on the Electrical Schematic.

6.4. Water Systems

The following information pertains to the normal Open Drain Water Systems and the normal Closed Loop Water System. See the appropriate Drawings and Schematics accompanying the Operator's Guide for detailed information of the system.

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6.4.1. Open Drain System

- Provide a filtered cold water supply at 85°F. (30°C.) maximum temperature to the female inlet water connection.
- When hot water is required, the customer supplies a filtered hot water supply at 140°F (60°C.) to 160°F. (72°C.) to the hot water inlet connection.
- Provide a water supply shut-off valve near the furnace water inlet. A pressure gage is installed on the downstream side of that valve.
- Provide an open sight drain to collect water from the several drains at the rear of the furnace. The drain must be capable of handling full flow at the required pressure without backing up.

6.4.2. Closed Loop System

- Provide a filtered cold water supply at 85°F. (30°C.) to the Water Make-Up Solenoid, located on the side of the reservoir tank.
- It is recommended that a water supply shut-off valve be installed ahead of the cold water make-up.
- Connect the Overflow Drain Connection.

Important Note: For best cooling efficiency and component longevity, the water supply in either system should be treated to prevent corrosion, mineral formation, algae buildup, etc.

6.5. Mechanical Vacuum Pump Exhaust

The exhaust port of the mechanical pump(s) can be connected to any exhaust system to conduct the oil-laden air to the outside. This will prevent filling the room air with oil vapors. Provide a drip leg adjacent to the pump to prevent water vapor condensate from entering the pump discharge port.

6.6. Compressed Air Connections

Connect a source of regulated compressed air to the air inlet fitting located on the air manifold. This supply should be lubricated, filtered and dry according to standard practice for operation of air components.

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6.7. Inert Gas Connection

Connect a source of clean, dry, inert gas as indicated on the Equipment Arrangement drawing.

Your furnace has one or all the following connections:

- Gas Backfill Valve
- Recirculating System Make-Up Valve
- Partial Pressure Valve

Note: Use a Hi-Capacity regulator of maximum 200 C.F.M. w/1-1/2" FPT outlet or equivalent, to be piped to gas backfill valve.



WARNING

Attention is required when setting the backfill speed. A cold furnace must not backfill to maximum pressure in less than 60 seconds or damage to hot zone may occur.



NOTE

Adjust the throttling valve to a minimum and increase the setting incrementally until proper timing is achieved.

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7. Component Details

This Ipsen, Inc. vacuum furnace is designed to process a workload at a desired vacuum and temperature with the capability of introducing inert gas to a specified partial pressure range during the heating process, or, in furnaces equipped for positive pressure, to a specified positive pressure for gas cooling. This positive pressure furnace is designed for cooling with inert gas at pressures of 1.3 bar up to maximum operating pressure (See Specifications section for details). Cooling may be under forced or static gas or under vacuum. Guaranteed soak is a standard event. Refer to your furnace specifications for a full listing of pressure values and any optional or special equipment on your furnace.

When the pumping system reaches a ready state (where no critical alarms are active), a complete pumpdown cycle, heating cycle, partial pressure cycle and cooling cycle occurs automatically in the sequence specified by the selected recipe when the process cycle start button is pressed.



WARNING

Never enter a furnace unless another person is stationed at the furnace while a maintenance procedure is being conducted.

Most gases used in furnaces are colorless and odorless and will remain in the furnace after the doors have been opened. Before entering any furnace, be sure the unit has been well ventilated with air and that all gases have been removed, or suffocation (asphyxiation) may occur.

When racks and/or doors are raised for any purpose other than normal operation, the safety locking devices provided must be used to prevent accidental damage or injury in the event of a power or system failure.

The use of an appropriate fused disconnect or circuit breaker with this unit is required to ensure the safety of operating personnel.

Hazardous voltages exist anytime input voltage is connected. This condition exists when the component is set to deliver zero output.

Perform checks and/or maintenance on equipment with power off. If the procedure requires operation of a component with power on, make sure a second person is at the control panel to execute emergency procedures.

All furnace and equipment structures must be correctly grounded to either plant or earth ground according to the National Electrical Code. Failure to do so may endanger life through electrical shock.

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7.1. Hot Zone

7.1.1. Description

The chamber has a number of individual heating zones, each powered by a variable reactance transformer (VRT). Each VRT has a trim control to adjust the percentage of total available power desired in each heat zone. The trim controls are screens within the OIT/control system. Ammeters indicate the amperage from each VRT.

The hot zone may be graphite, all metal (e.g., molybdenum and stainless steel), or a combination thereof (refer to Specifications). The hot zone may include an optional convection heating system.



CAUTION

In hot zones containing graphite, the contact of metal with graphite can cause eutectic melting at temperatures well below the normal melting point for the metal in use.

7.1.2. Heating Elements

The modular design of the element package for the resistance heated hot zone offers faster heat-up and cooling rates and easy disassembly for maintenance. The wide band heating elements deliver optimum heat transfer to the workload and are segmented for easy repair.

7.1.3. Hot Zone Insulation

The insulation consists of multiple layers of shields that are optical barriers. This isolative shielding helps to retain the maximum heat in the hot zone.

7.1.4. Hearth

The workload support hearth is removable and constructed of pins, caps, and rails. The pins fit into sockets or cups affixed to the chamber wall. Support caps are fitted on top of the vertical support pins and are notched to accept the workload support rail. The support caps are larger in diameter than the support pins to help eliminate breakage at the notch. . Since the hot zone is not employed in support of hearth and workload, premature hot zone deterioration is eliminated.

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7.1.5. Convection Heating System (Optional)

The optional convection heating system (if the furnace is equipped with one - see Specifications) consists of a Fan Motor that can circulate inert gas through the workload and back to the fan.

The convection heating system assists in the transfer of heat from the elements to the load by circulating heated inert gas. To maximize efficiency of the convection heating process, the convection fan is used at positive pressures and temperatures below 1600° F.

7.2. Chamber

The cylindrically shaped chamber is double walled, water-cooled and constructed of high quality boiler grade carbon steel or, optionally, stainless steel. All necessary penetrations through the chamber's double-wall jackets are welded in accordance with specific required codes based on resting working pressure. The chamber door is a fully opening door for complete access to the hot zone.

Door locking can be accomplished by either:

- Manual clamp for negative quench furnaces
- Rotating door, with manual, pneumatic, or electromechanical power.
- A rotating autoclave ring with pneumatic power.

On vertical furnaces, a rigid support structure holds the chamber in place and includes a lifting mechanism to raise and lower the bottom head of the furnace, thereby opening and closing the furnace chamber. At floor level, the bottom head can be moved out from under the chamber for loading and unloading of work on the head mounted hearth. The chamber door is motor driven for complete access to the hot zone.

The seal will wear and will need replacing to prevent heat loss around the door. The service life of the seal will depend on how often the door is opened and the temperature of the furnace.

7.3. Pumping System

The basic pumping system consists of a roughing pump and vacuum booster pump, along with the necessary vacuum valves, controls, and instrumentation. If the high vacuum option is purchased, a holding pump and diffusion pump will also be included.

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7.3.1. Roughing Pump

The roughing pump is an oil-sealed rotary piston type. It employs an eccentrically mounted piston-slide assembly. The vacuum "seal" is maintained by a wedge of oil ahead of the piston. This prevents blow-by of gases. The oil is also used to lubricate the pump. In operation, the piston never contacts the housing wall, as is the case in a rotary vane pump, so the rotary cam and piston pump will deliver long and relatively trouble-free operational life.

The roughing pump is water-cooled. When pumping on a vacuum vessel, the roughing pump will pump out the air without difficulty so that rapid evacuation is possible until the pressure has been reduced to the point where water vapor, if present, begins to come out in large quantities.

At 70°F (21°C), water will begin to migrate from the vacuum vessel at a pressure of approximately 20 Torr (2.7 kPa). This water migration causes several problems as it mixes with the oil and eventually prevents the evacuation of any gases. To overcome the effects of condensables, (such as water), the oil inside the roughing pump must be kept at a temperature high enough to keep condensation to a minimum, but not so high as to reduce the viscosity of the oil. A system called a water miser has been provided to maintain the oil temperature at optimum level. This is an auxiliary oil temperature control device, consisting of a mechanically operated modulating valve on the pump water line, controlled by a sensing bulb, located in the pump oil reservoir. The mechanical pump also includes a gas ballast feature. Gas ballast is a controlled bleed of air or inert gas into the compression side of the pump, to mix with the vapor during compression. Gas ballast reduces the partial pressure of the water vapor, and prevents condensing the vapor in the pump oil. In addition, the air bleed causes a rise in the operating temperature of the pump, further aiding the reduction of contamination. As pressure is reduced, the gas ballast bleed, which is in effect a controlled leak, becomes the limiting factor in reaching the low pressures required. The gas ballast valve must therefore be closed off at pressures below 5 Torr (.67 kPa) and should always be closed at 1 Torr (.13 kPa) to prevent serious reduction of pumping capacity.



WARNING

Gas ballast should never be utilized while in an actual heating process

7.3.2. Vacuum Booster Pump

For operating pressures in the micron range a mechanical booster pump is provided. Based on the roots principle these are bi-lobe rotary blowers operating at speeds up to 3500 rpm to provide high volumetric flow at low pressures. The booster is, in effect a system supercharger. It increases the system pumping capacity by a factor of ~10 with very little increase in size or horsepower.

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In operation, the roughing pump runs first, pumping through the booster, with the booster lobes windmilling, until the vacuum reaches the 20 Torr (2.7 kPa) preset (approximately). At this point, the programmable logic controller (PLC) starts the booster motor. Once the booster is running, the unit becomes a two-stage system, and the capacity increases significantly. The first stage booster pumps the gases from the system, then discharges into the second stage oil-sealed pump, which re-compresses them to atmosphere. Coincidentally, it is at this cut-in pressure [20 Torr (2.7 kPa)] that the extra capacity is needed for handling water vapor since water migration from the system is rapidly increasing and creating a heavy vapor load on the roughing pump.

The *Vacuum Booster Off/Auto* switch, when in the off position, disables this booster during processing; soft vacuum pumping is handled entirely be the roughing pump. The *Partial Pressure Vacuum Booster Enable* switch, when in the off position, disables the vacuum booster during the partial pressure event.

CAUTION

The mechanical pumping system must be purged with inert gases when pumping hazardous gasses (i.e., hydrogen).

NOTE

Check all pumps for correct oil levels.

7.3.3. Diffusion Pump (High-Vacuum Option)

The diffusion pump has an Off/Auto button on the Operator Interface Terminal (OIT) Controls Screen. The diffusion pump operates on the principle that molecules, in their random motion, will tend to become entrained in a high velocity vapor stream and be carried with it into the pump. In practice, oil is boiled under vacuum from the holding pump in the bottom of the pump vessel. The vapor rises to a jet assembly near the top of the pump body. The vapor is then directed at supersonic velocities in a downward umbrella shaped curtain toward the cooled outer walls of the pump where it condenses to liquid and runs down to the reservoir for re-boiling. Molecules entering the top of the pump that strike the "curtain" are entrained and carried with the vapor to the wall. When these molecules "re-emit" into free motion, they are below the curtain and have been removed from the system. A diffusion pump has three (3) stages, each being larger in diameter than, and located below, its upstream predecessor on the same center line. The gas molecules then are progressively moved down through each stage to the bottom of the pump.

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The pumping capability of a diffusion pump is rated in "pressure volume / time" units such as torr and liters per second and is commonly referred to as pumping through put. All diffusion pumps contain built in over temperature protection thermal switches. At the top of the diffusion pump is the O-ring sealed main valve. A special shaft seal is designed to isolate the pneumatic cylinder seals from the vacuum seal assembly. The vacuum seals are mounted in the pneumatic cylinder surrounded by an oil filled cavity. The vacuum seals are double quad seals mounted in grease or oil filled cartridge. Utilization of greases and or oils that are specifically designed for vacuum exposure is paramount.

7.3.4. Holding Pump (High-Vacuum Option)

The holding pump is an oil-sealed, rotary vane type with provisions for gas ballasting. The holding pump is used to evacuate the diffusion pump to 200 microns or less to permit the diffusion pump heat to be activated. The holding pump keeps the diffusion pump evacuated during rough vacuum pumping through the holding valve, which opens when the holding pump starts, and closes during high vacuum pumping or when the holding pump stops. The valve closes when the pump stops to maintain the diffusion pump vacuum integrity.

The holding valve has an Off/Auto button on the OIT Controls Screen. Selecting the switch in the closed position closes the valve, effectively blanking off the holding pump. A coupling in the holding line (between the valve and the holding pump) allows a gauge head to be connected to check pump performance with the valve closed.



NOTE

Check all pumps for correct oil levels.

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7.4. Water System

The cooling water system supplies the necessary cooling water to the individual water-cooled components. All systems contain the necessary components for operation and protection as shown on the appropriate water system and electrical schematics. See the water schematic drawing for connections. The Water System Schematic shows the required flow through each particular circuit.

NOTE

See water schematic drawing to ensure correct water pressure.

For best cooling efficiency and component longevity, the water supply should be treated to prevent corrosion, scum formation, algae build-up, etc. The following are recommended water specifications:

- pH 7.0 to 8.0
- Conductance 300 micro mhos/CM or less
- Suspended solids 10 PPM
- Use a suitable scale and corrosion inhibitor (control by phosphonate test, range 15-20 PPM)
- Use a suitable biocide for algae control
- Total hardness as CaCo 3-100 PPM
- Total dissolved solids 200 PPM

NOTE

The water relief valve can be connected to an external hose which will allow for over pressured water to be released outside of the working zone.

7.5. Gas Cooling System

The gas system consists of the gas blower, backfill valve, vacuum switches, partial pressure valve, service switch, backfill gas, heat exchanger, and the necessary controls. The gas supply lines and components must be leak-free, and the gas must be of necessary purity, i.e., 99.8% or better. The gas blower accomplishes forced gas cooling. The gas cooling system consists of a gas blower, which may be mounted either externally to the vessel or internally. The gas blower system cools the workload by circulating gas through the workload then to a heat exchanger located behind the hot zone within the chamber. The backfill valve opens to backfill the chamber to the selected positive pressure set point. Either a forced or static cool segment can be utilized to achieve varying speeds of quench (force fan on and static fan off). At the completion of the cooling cycle, the chamber release valve activates to equalize the vacuum chamber pressure with room atmosphere pressure for door opening and load removal. Pressure gauge verification closes the backfill valve at the positive pressure setting for a specific forced or static cool mode.

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7.5.1. Backfill

The furnace uses inert gas for backfill. The backfill valve opens to backfill the chamber for the programmed cooling. A chamber pressure gauge tells the PLC to close the backfill valve at the selected pressure setting for the cooling cycle.



WARNING

Attention is required when setting the backfill speed. A cold furnace must not backfill to maximum pressure in less than 60 seconds or damage to hot zone may occur.



NOTE

Adjust the throttling valve to a minimum and increase the setting incrementally until proper timing is achieved.

7.5.2. Partial Pressure

The furnace includes an inert gas partial pressure system. Partial pressure is an event selectable option applicable to any heat segment. Partial pressure level is set through a setting in the furnace recipe.

- The selected partial pressure valve opens when the partial pressure event is selected, and the pressure is controlled at the desired partial pressure level (0 to 1000 microns).
- The partial pressure vacuum booster enable off/auto switch can stop the vacuum booster during partial pressure. The switch is a global value attached to the recipe. Disabling the vacuum booster during partial pressure will reduce the amount of gas used while maintaining the desired pressure set point.

7.5.3. Positive Pressure

This furnace is capable of positive pressure quenching. Refer to your furnace specifications for the furnace's positive pressure capabilities.

7.5.4. Controlled Cool (Optional)

The controlled cooling system provides a mechanism to control the rate of cooling by controlling the rate of gas flow and, if so equipped, by applying heat to the cooling load. When using the controlled cooling option and/or Guaranteed Load Soak, a load thermocouple must be plugged into the TC-spot #1 on the inner jack panel for the options to work properly.

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7.5.5. Isothermal Hold (Optional)

Isothermal Hold is usually used to prevent distortion when quenching large parts, in conjunction with maintaining a controllable temperature differential across the core and surface of said part(s). In Isothermal Hold, the quenching is interrupted (indeed, in some literature, the term "Interrupted Quench" is used) and the *process* held at temperature to bring the part core to within a specified deviation from the surface temperature before proceeding with cooling.

In the typical variant of Isothermal Hold, it is programmed as a cooling event in a segment. This event is to be programmed by itself in a segment with the maximum pressure of the furnace and a suggested soak temperature of no less than 315°C. The remaining segment variables are programmed like any other segment (ex. ramp rate, soak temp., etc.).

7.5.6. Convection Heating System (Optional)

The optional convection heating system if the furnace is equipped with one (see Specifications) consists of a Fan Motor that can circulate inert gas through the workload and back to the fan.

The convection heating system assists in the transfer of heat from the elements to the load by circulating heated inert gas. To maximize efficiency of the convection heating process, the convection fan is used at positive pressures and temperatures below 1,600°F.

7.6. Electrical System

The main power supply is run through the main circuit breaker then through the hot zone circuit breaker to the primary side of the variable reactance transformers (VRT), through a circuit breaker in the control cabinet, then through a power distribution block to the motors and the power control unit (PCU).



CAUTION

The main circuit breaker is located either on the VRT or on the control panel with a red handle and yellow background.

Main power is run through a step-down control transformer and a DC power supply for the control circuits.

A power line filter/suppressor filter from the 110 volt line is used to feed voltage prior to entering the over-temperature controller, digital vacuum gauge VG-1, PC and PLC.

The emergency stop push-button de-energizes power from the programmable logic controller (PLC) relay output modules.

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CAUTION

An adequate supply of water must run though the VRT as long as primary power is applied, and must continue to run after the power is shut off until the VRTs are cool. Boiling water will damage this equipment.

To avoid condensation on the VRT and their cooling water hoses, water to the VRT should not be allowed to flow for long periods of time without some power being drawn from the system, particularly when the water supply temperature is below the dew point.



WARNING

The VRT produces Electromagnetic Fields; the necessary precautions must be taken.

7.7. Instrumentation and Controls

A NEMA 12-type enclosure cabinet houses all machine tool grade controls and instrumentation. Full opening hinged doors allow easy access to all wiring and the rear of all instruments. The following are standard features:

- Integral safety interlocked motor load and control circuit breaker
- A programmable logic controller (PLC) for furnace sequencing, alarm functions, and recipe control
- Emergency stop button located on cabinet opens the power circuits to the PLC preventing operation of the controls
- All components are permanently identified
- Control transformer, 115V, single phase, 50/60Hz cycle for instrumentation
- DC power supply for controls

Most operational controls have been incorporated into a PC-based operator interface terminal (OIT) that uses a touchscreen interface, though commands can also be entered with a keyboard and mouse, if supplied. The operator of the furnace can mouse click the OIT screen to select functions and enter data.



NOTE

Color of wire inside enclosures follows all local and international codes.

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7.7.1. Temperature Controls

The PLC controls the time and temperature cycles (recipes) for the furnace system. Trending capability is built into the software.

A discrete over-temperature controller (a separate instrument) switches off power to the hot zone at a preset maximum temperature. It can be set for any temperature within the safe operating limits of the furnace.

Normal set point is 50°F (28°C) above normal process operating temperature. The over-temperature controller senses and monitors the furnace temperature, shutting off power to the heating elements if a failure in the temperature control system should cause the furnace to overheat.



NOTE

The heating elements cannot be energized unless the vacuum chamber has been initially evacuated to 80 microns (10.7 Pa) or less. The door limit switches must also be satisfied as well as several other common utility interlocking devices.



CAUTION

DO NOT EXCEED the maximum temperature rating for this furnace as noted in equipment specifications.

7.7.2. Vacuum Controls

A vacuum gauge is provided on the chamber. In the High-Vac option, additional vacuum gauges are supplied for the foreline and chamber manifold. All sensors are brought into the OIT for display purposes.

7.7.3. Thermocouples

Within this furnace system there are provisions for three thermocouples (control, over-temperature, reference) per zone of control. Provision for additional work thermocouples is available as an option.

Standard thermocouples are:

- T/C-1 Over temperature
- T/C-2 Primary control
- W T/C's Customer provided work T/Cs

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7.7.4. Broken Thermocouple Protection

If the control thermocouple loses continuity, the PLC will respond by reducing its output to zero (known as upscale burnout).

7.8. Pneumatic System

The inert gas supply is run to the connection at the filter/regulator unit (FR) near the solenoid operated valve manifold. This gas supply actuates the pneumatic-operated components of the furnace system. A pressure switch is included to activate the pneumatic pressure low alarm circuit. The use of inert gas for pneumatic component actuation prevents air from entering the chamber in the case of pneumatic system component failure.



NOTE

It is important to periodically check the FR. The filter should be cleaned or replaced as necessary. Also check the manual valve to ensure it is open.

7.9. Alarm System

A warning alarm horn and light is mounted on the cabinet and process warning indicators are displayed on the OIT main screen and alarm screen. If the alarm dropped the furnace out of cycle, the operator must then correct the alarm condition before restarting. All operators and maintenance personnel must be familiar with the alarm conditions and how to correct them. The alarm screen is displayed on the OIT with each unacknowledged and acknowledged alarm. A light bar is located on top of the control cabinets to give a visual cycle status.



WARNING

Do not ignore or bypass any warning device! Determine the cause for the warning and correct it before proceeding. Failure to do so may result in damage to the furnace or to the process material, thus negating the system warranty.

7.10. Programmer Events

7.10.1. Vacuum Cool

As the furnace pumps down to vacuum, the load begins to cool until the load temperature reaches the unloading temperature, which allows the load to be removed.

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7.10.2. Static Cool

In static cooling, the positive pressure quench recipe is selected. The chamber is backfilled to -5" Hg (-16.9kPa). The load is then allowed to cool to the unloading temperature without the circulation of gas in the furnace. The furnace has the option to perform positive static cool, which is set at the beginning of the cycle to the specified temperature.

7.10.3. Forced Cool

In forced cooling, the positive pressure quench recipe is selected. The chamber is backfilled to -5" Hg (-16.9kPa). The inert gas is circulated by the gas blower motor until the load temperature reaches the unloading temperature. The furnace has the option to perform positive static cool, which is set at the beginning of the cycle to the specified temperature.

7.10.4. Controlled Cool (Optional)

Controlled cooling permits using pressure and the variable speed blower motor to control the rate at which the workload cools. The cooling is controlled by a preselected work TC.

7.10.4.1. Controlled Cooling Without Heat

Controlled gas cooling uses a gas cooling motor with variable frequency drive. The heating elements are not powered.

7.10.4.2. Controlled Cooling With Heat

Controlled gas cooling in conjunction with a gas cooling motor that has variable frequency driving and configurable power to heating elements.

7.10.5. Positive Pressure Quench

This event is used in conjunction with either static cooling or forced cooling. However, the set point of the gas cooling is placed up to the maximum positive pressure of the furnace. The gas blower starts at 5" Hg (-16.9 kPa) and continues to run until and after the chamber has backfilled to the desired positive pressure.

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7.10.6. Convection Heating (Optional)

A convection heating segment begins with an evacuation to 80 microns. The furnace will then backfill with inert gas to the selected positive pressure set point and begin heating the elements, as well as spinning the fan to circulate the gas. During the ramp, the gas in the furnace will begin to expand causing the vent valve to open periodically to maintain the selected pressure set point. When the final soak temperature is reached, the process should switch to vacuum.

- Reasons for switching from convection to vacuum:
- Better temperature uniformity
- Less wear and tear on the fan and motor
- Improved temperature transfer (only heating hot zone and parts, not all gas)

7.10.7. Low Speed Gas Blower

The Low Speed Gas Blower Event starts the gas blower at low speed and -5" Hg. This feature allows the motor to be run with less current and wear when higher motor speeds (and quench gas velocities) are not required.

7.10.8. Hydrogen Partial Pressure (Optional)

The Hydrogen Partial Pressure Cycle is programmed to start at the temperature Partial Pressure as desired. Before the Hydrogen process cycle, a leak test is performed automatically to ensure integrity of the vacuum system. During the Hydrogen Partial Pressure Cycle, the vacuum pump (top of roughing pump) is purged to keep the Hydrogen diluted in the pump exhaust. During the event, the chamber is filled to the Partial Pressure setpoint with up to 3% Hydrogen. A throttle valve on the Partial Pressure Line is set to minimize the oscillation around the desired setpoint.



CAUTION

Hydrogen, methane, and propane gases are safe to use in controlled environments. However, they can develop into combustible and explosive mixtures in the presence of oxygen. Safety precautions must be taken to help prevent the possible formation of these explosive mixtures.

The furnace is equipped with a safety purge system that reduces the formation of a combustible gas mixture while the Hydrogen Partial Pressure Cycle is operating. Different actions are taken depending on the status of the process cycle.

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7.10.9. Isothermal Hold (Optional)

Isothermal Hold allows the part core temperature and surface temperature to come within the user determined band width.

7.10.10. Load T/C Guaranteed Soak

Guaranteed TC Soak operates through the GSOAK band width within the recipe. The timing of the guaranteed soak segment does not begin until all guaranteed soak work thermocouples read within the deviation band. The guaranteed soak function ensures the hot zone temperature, and the load temperature are within a desired temperature spread.

The event is programmed in any soak segment related to heating. The PLC places the programmer in HOLD. The operator must modify the recipe to provide for the desired deviation band and to include the desired work T/Cs in the guaranteed soak.

7.10.11. Leak Test

This event specifies the performance of a leak test during the segment. The specifications of the leak test are taken from the values entered in the parameter control screen. Given a specific pumpdown time and leak-up time the software will determine the furnaces leak rate based on the vacuum readings before and after the pre-selected time.

7.10.12. Partial Pressure

This event causes the chamber to be backfilled to a pressure designated through the recipe, and is intended to be used during the heating cycle. The partial pressure value must be entered before the cycle can start. During the cycle, the roughing valve is open, and the roughing pump pumps a low bleed of gas through the chamber. A throttle valve adjacent to the partial pressure solenoid valve should be gradually opened until the pressure in the chamber shows a minimum of oscillation around the desired set point.

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8. System Interlocks

8.1. General

The vacuum furnace is designed to operate automatically once the pumping system is ready and the process cycle start button is pressed. Interlocks are incorporated to avoid damage and minimize human error as the operating procedures must be performed in the proper sequence.

8.2. Electrical

Hot zone power de-energizes when:

- Process cycle is off
- Hot zone water is low or off
- Power supply (VRT) is over temperature
- Exterior tank temperature too high
- Furnace is over temperature
- A cooling cycle is activated
- Under voltage trip coil is deactivated
- Door is opened

Process cycle cannot start unless:

- Door locked
- Roughing pump is on
- Program is reset
- Key switch in auto
- End of cycle event is off
- Pneumatic pressure, diffusion pump and holding pump alarms are off
- High vacuum is disabled until diffusion pump is above minimum operating temperature (set point)
- Gas blower(s) fail alarm is not on
- Heat exchanger alarm is not on
- Cooling pressure less than minimum is not on

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8.3. Vacuum

Roughing valve cannot open unless:

- Roughing pump is on
- Process cycle is on
- The valve is not in static, forced or positive pressure cool
- Chamber pressure is less than 1 PSIG
- Leak test is enabled but not below crossover
- Main valve is closed
- Foreline valve is closed (High-Vacuum option)

With the high vacuum option, foreline and main valves cannot open unless:

- Chamber pressure is 80 microns and below
- Partial pressure is not in operation
- Diffusion pump is on, above minimum operating temperature and not over maximum temperature
- Roughing valve is closed

Booster pump cannot start unless:

- Roughing pump is on
- Process cycle is on
- Vacuum system is enabled
- Booster selector switch is in auto
- The pump not in partial pressure, unless PP VAC booster switch is in auto

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8.4. Gas

Chamber gas backfill valve cannot open unless:

- All vacuum valves are closed
- Cooling cycle is activated
- Chamber pressure is below 5 inches Hg vacuum
- Door seal alarm is not on



NOTE

The backfill valve can be opened at any time by pressing the process cycle stop button and then pressing the chamber release button. The valve automatically closes when the chamber reaches atmosphere to satisfy the vacuum switch. The furnace has an interface to prevent the operator from manually backfilling and opening the door above 300°F (149°C).

Chamber vent valve cannot open unless:

- Process cycle is off
- Chamber pressure is positive
- Pressure release button is pressed when the furnace is out of cycle
- If positive cool is on, then not in a cooling event
- Chamber pressure is greater than atmosphere
- If "Open Door" is pushed and the furnace is out of cycle

Gas blower cannot start automatically unless:

- A forced cool event is on
- Vacuum valves are closed
- Heat exchanger flow switch is actuated and is greater than minimum
- Heat exchanger water temperature less than maximum
- Chamber pressure is 5" Hg vacuum or above
- Cooling pressure less than minimum alarm is off

8.5. Partial Pressure

Partial pressure valve cannot open unless:

- Partial pressure event is programmed
- Partial pressure adjustable component is set at desired pressure level less than 20 microns.
- High vacuum valve is closed

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8.6. Heat

Heat cycle cannot start automatically unless:

- Power contactor is energized
- If a partial pressure event is not in cycle, and the chamber pressure drops below the outgas setting and crossover setting (e.g., 80 microns)
- All interlocks are satisfied

8.7. Water

8.7.1. Pressure Relief Valve

Located on the manifold, the pressure relief valve is set to relieve at 15.5 psi. Adjust the tank water valve to provide no more than 6-8 psi in the tank water jacket with the heat exchanger water off.

8.7.2. Chamber Water Pressure Switch

The chamber water pressure switch turns the hot zone power off if the water pressure is too low or the flow is insufficient.

8.7.3. Heat Exchanger Flow Switch

The heat exchanger flow switch senses insufficient flow to prevent the gas blower from starting during forced cool.

8.7.4. Heat Exchanger Water Valve

A solenoid air valve that opens automatically when the forced cool event is activated and closes when the event has ended. A bypass line around this valve supplies water to the heat exchanger when the valve is closed. This bypass line negates steam from forming during heating cycles.

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8.8. Switches

8.8.1. Vacuum and Pressure Switches

- Pressure switch is set to open the vent valve at 16.5 psig (over pressure safety)
- Pneumatic pressure switch is set at a minimum to close the vacuum valves and sound an alarm
- Chamber water pressure switch is set at a minimum to turn hot zone power off and sound an alarm
- Inlet water pressure switch is set at a minimum to sound an alarm
- VRT water pressure switch, in series with the VRT temperature guards, is set at minimum flow to turn hot zone power off and sound alarm
- Motor seal pressure limit switch is greater than 30 psig

8.8.2. Limit, Flow and Current Switches

- Door closed limit switch permits process cycle start
- Heat exchanger water flow switch sets a minimum flow to stop gas blower start and sound an alarm
- Gas blower motor current software switch opens to cause the auto vent function that reduces motor current
- Under voltage trip coil (UV) deactivates when there is not low voltage to the control system sensed, and during an over temp condition within the hot zone; the UV deactivates power to the hot zone when the main disconnect on control cabinet is switched to off and must be included if the main circuit breaker to the hot zone was not provided by Ipsen, Inc.

8.8.3. Temperature Switches

- External chamber temperature switch (TAS) is set at a maximum of 125°F (52°C) to turn hot zone power off and sound an alarm
- Power supply over temperature switches (in series) are set at a maximum temperature to turn the VRT power heat off and sound an alarm

8.9. Audible and Visual Alarms

A bell sounds when an alarm condition exists.

NOTE

Pressing the alarm acknowledge button stops bell and flashing lamp.

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9. Operation

9.1. General

The Ipsen Vacuum Furnace operating sequence begins with a pump down to an initial vacuum range followed by a heat up of the load followed by a cooling process. The Vacuum Furnace is designed to run automatically with minimal operator intervention.

The Operator Interface Terminal (OIT) is a device which allows the furnace operator to both enter data and view pertinent information about the furnace process. The operator uses a trackball to select furnace function and data fields. The OIT software provides several display screens containing indicators, furnace controls, navigation controls, and program development and management system. These move you from screen to screen to access the different control groups, or move the cursor from one screen element to the next.

Refer to the OIT manual (separate section in this manual) for details of screen navigation and recipe programming.



WARNING

Read and understand all operating and safety information before attempting to operate the furnace.

The basic operating sequence, detailed in the sections of this chapter, is as follows:

- Preliminary checks
- Load Furnace
- Prepare furnace systems and controls
- Start cycle
- End cycle
- Unload furnace
- Furnace shut down

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9.2. Preliminary Checks

Check through listed items to ensure furnace will run properly:

- Inspect the furnace loading area to ensure all foreign parts have been removed
- Make sure none of the following are in the hot zone:
  - Loose element connectors
  - Loose hot zone parts
  - Slag and melted parts
  - Discoloration (evidence of oxidation)
- Check all the electrical equipment and controls to verify that the controls are operating correctly
- Check prior cycle for previous alarms
- Front door seal and mated surface are clean and clear of debris
- Inspect control and over temperature T/C's
- Check all utilities, gas, water, and power systems for correct operation
- Conduct a visual walk around the furnace to check for any alterations which may have occurred in the previous cycles.



NOTE

Personnel who operate and maintain the furnace must have access to complete operating instructions at all times.

9.3. Load Furnace

First step in loading the furnace is to open the door. This is done by navigating to the home screen on the OIT, clicking "Chamber Door Unlock," holding until door begins to open. Likewise in closing the door, on the home screen, click "Chamber Door Lock," holding until door has rotated closed.

Before loading the chamber, inspect the interior and hot zone for dirt or foreign matter. Check the elements, insulators, hearth, and the other hot zone components for cracks or any possible signs that could cause problems or contamination. Inspect the control and over temperature thermocouples for signs of damage.

If a lift truck is used to load the furnace, the floor must be smooth and free of debris. If this is not done properly, the heating elements or thermocouples may be damaged by the load suddenly shifting during loading. IPSEN can provide an optional Loader System configured for use with the Vacuum Furnace.

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Load the furnace as follows:

- Carefully place the workload on the center of the hearth (front to back and side to side). Make sure it is stable and no part of the load is close to or touching the heating elements.
- Plug work T/C's if required into jack panel.
- Bundle T/C wires to be sure they will not contact heating elements or door pack through the allotted T/C channel.
- Check to make sure T/C's are displaying a value on the HMI screen.
- Close door.



CAUTION

Only high temp. T/C plugs are to be used inside the furnace.

9.4. Prepare Furnace Systems and Controls

Set the OIT Controls as follows:

- All switches are set
  - Roughing pump turned On
  - Roots (booster) pump turned to Auto
  - Furnace heat turned Enabled
- Choose preferred data screen
- Select or Create a recipe (refer to OIT manual)
- Send program to furnace
- Clear all alarms
- Start cycle

9.5. End of Cycle

When end of cycle occurs, check to see if any alarms occurred during run of cycle. If no alarms are issued, load is complete, and ready to be unloaded.

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9.6. Unload Furnace

When unloading the furnace, follow these guidelines:

- Open the door.

NOTE

Furnace automatically returns to atmosphere when door is opened.

- Withdraw any thermocouples that interfere with the load.
- Remove the thermocouple plugs.
- Clear work area for removal of load.
- Remove processed workload being careful not to touch the heating elements.

9.7. Furnace Shutdown

Good vacuum practice requires the Chamber be closed and evacuated to the 100 Micron (13.3 Pa) range when not in use. If no subsequent runs are planned, Close the Chamber and evacuate it to this pressure.

- Turn the Diffusion Pump (if supplied) and Vacuum Booster Pump off.
- Stop and Air Release the Roughing Pump.
- Keep the Holding Pump (if supplied) on and the Diffusion Pump (if supplied) cooling water on for at least on (1) hour.
- Stop and Air Release the Holding Pump and turn the Diffusion Pump water off.
- Turn all services off.

CAUTION

Never air-release the holding pump when the pump is running, and the holding valve is Open. The inrushing air will cause an explosion inside the diffusion pump which results in damage to the pump.

This is true even using specified non-hydrocarbon oils. Hydrocarbon oils can be more explosive. Never use hydrocarbon oil in the diffusion pump.

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9.8. Shutting Down the Computer from the Control Cabinet

After all pumps and services have been turned off, the computer may be shut down through the orderly Windows shutdown procedure (START>Shut Down). After the computer has turned off, you can switch the control cabinet electrical disconnect to the OFF position. To turn on the computer, switch the cabinet disconnect to ON.

9.9. Furnace Idle

Contact Ipsen Inc, for suggested idle settings.

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10. Maintenance

10.1. General

The vacuum furnace is wired in accordance with JIC standards. However, there are exposed terminals in the control cabinet and junction boxes that may have dangerous voltage potentials.



WARNING

When performing any maintenance, with power energized, be careful to avoid a harmful or lethal shock. The furnace is cooled with inert gas. Refer to specifications for gas type.



WARNING

Before working in the vacuum chamber, be sure that all inert gas has been properly purged/ removed and standing atmosphere verified capable of supporting human life. Refer to confined space entry procedures as mandated by OSHA.

Refer to standard safety procedures and to the Safety section of this manual.

10.2. Preventative Maintenance

Keep a running log of the maintenance check schedules and system performance; ultimate vacuum, leak-up rate and pump-down times, cooling rates temperature survey data steady state power consumption readings of hot zone and all ancillary electrical equipment

When the furnace vacuum levels and or cleanliness of cycled parts deteriorate, a clean-up cycle may be required.

The following items should be checked on regular schedules as follows: These checks should be considered as the "minimum requirements" and is not limited to the following items.

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10.2.1. Daily

- Check the level and condition of the roughing pump oil. Cloudy or discolored oil indicates the presence of moisture or other contamination. The oil should then be changed. Refer to the manufacturer's manual for the correct oil changing procedures. Check that the oil is at the correct level.
- Check the condition of the hot zone elements and shielding. Especially look for missing or broken element retainers, or loose/broken graphite nuts.
- Check element resistance to ground
- Check water and/or oil lines for leaks
- Check for hoses that are hotter to the touch, perhaps indicating low flow rate
- Check all water lines for proper flow and temperature profiles
- Clean the chamber door seal and use graphite powder on the lip seal and or vacuum grease on standard O-ring sealed systems
- Check vacuum gauges by comparing two to each other and or a known traceable standard
- Check chamber pressure switch settings. (these are generally adjustable vacuum switches)
- Check gas cooling motor for vibration and excessive noise

10.2.2. Weekly

- Clean the chamber of all foreign matter. Brush or blow out with clean, dry air or compressed inert gas. Wipe the inner tank walls and head surfaces using a lint free cloth or wiper dampened with a suitable solvent. If the shields and heating elements show signs of discoloration, and furnace clean up cycle may be required.
- (**For first month of new hot zone or replacement of heating elements**): check all graphite nuts for tightness. Tighten if loose. Do not over tighten. Contact the Ipsen field service department for assistance on choosing suitable tools and tightening torques.

CAUTION

Loose graphite nuts may lead to electrical arcing that can damage the furnace or workload

- Check all pneumatic lines for leaks. Check the pneumatic line regulator and filter for proper operation and pressure adjustment
- Check all pressure switches for proper operation. Adjust if necessary.
- Check oilers if provided for proper level
- Clean control panel and indicators
- Inspect the power feed-through bars for tightness
- Clean door seal and apply fresh graphite powder when the parent color of orange is bleeding through the graphite color more than 40%

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WARNING

Remove the power from the VRT and discharge the circuit before checking the feed-through bars. Failure to do so could result in an electrical shock hazard.

10.2.3. Monthly

- Check all lines, fittings, and connections of backfill gas for leaks from the point of origin to the backfill valve assembly at the furnace.
- Check tension and condition of all pump belts.
- Check all secondary power cables for wear and heat deterioration.
- Check Hot Zone ceramic insulators for any deposition that could cause excessive drain of power, to ground, which would affect the heating cycle.
- Vacuum out dust and dirt from the control cabinet.
- Check the blank off pressure of the vacuum pump(s) and change the oil if necessary.
- Check the operation of the water flow switches and the other safety interlocks.

10.2.4. Every 2 Months

- (After first month for new or replaced elements – for first month perform weekly) Check graphite nuts for tightness. Tighten if loose. Do not over tighten.
- Check pressure relief valve for dirt, wipe face of flange and seal.

10.2.5. Every 3 Months

- Check secondary cables to the transformers (VRT) for wear.
- Check all cables to and from the VRT for tight connections.
- Check all cabinet and junction box wires and connections.
- Check all transformer resistors for discontinuities.
- Check all fuses for continuity.
- Grease the chamber door hinges.
- Clean the inside of the power supply with compressed air.

10.2.6. Every 6 Months

- Clean holding pump oil filter.

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10.3. Clean-Up Cycle

10.3.1. Contamination

The clean-up cycle is known to many people under different names, such as burn-out cycle, bake-out cycle and clean-out cycle, but they all mean the same thing.

NOTE

This cycle should be run once a week to maintain the efficiencies and cleanliness of your Ipsen vacuum furnace.

The furnace may become contaminated due to any of the following conditions:

- Accumulation of contaminants from treat cycles

NOTE

This type of contamination usually results from improperly cleaning heat treat parts.

- Inadvertent introduction of foreign materials into the furnace during a heat cycle
- Dirt, grease, etc. Left in the furnace during internal maintenance or repair procedures
- An air or internal water leak occurring at operating temperature

10.3.2. Clean-Up of Contamination

When the furnace is contaminated, a clean-up cycle must be run according to initial pump-down and heat-up procedures. Listed below are general notes:

- Fix all leaks prior to running a clean-up cycle.
- Remove all work thermocouples and fixtures from hot zone.
- Contaminates formed under heat generally must be removed at a temperature equal to, or greater than, the temperature at which they were formed. It may become necessary to raise the furnace temperature higher than the process temperature.

CAUTION

Do not exceed the maximum temperature rating for the furnace.

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10.3.3. Clean-Up of Condenser & Condenser Bucket (if applicable)

During use, contaminants will accumulate along the condenser, specifically the condenser bucket/ cones, and require regular cleaning according to the user's maintenance schedule. Ipsen recommends daily maintenance on parts to develop a long-term maintenance strategy for future use. Ensure the below are inspected and cleaned accordingly:

- Visually inspect if cones are clean and remove all foreign debris/ contaminants.
- Remove bucket from condenser and dump contents. Bucket shall be cleaned and free of debris/ contaminants.
- A maximum of 1-2 inches of debris/ contaminants is allowable but should be cleaned as quickly as possible.

10.3.4. Clean-Up of Binder Trap(s) Assembly (if applicable)

Impurities and binders tend to accumulate and condense when they come into contact with a cold surface. Certain sections of the trap are designed to be water-cooled, and the unique geometry of the palls (i.e., Raschig rings modified with surface openings and grooves to enhance the available space and liquid distribution during use) provides an extended surface area with a convoluted path. This design facilitates the cooling of exhaust gases beyond their condensation point. Per the user's maintenance schedule, it is essential to perform routine cleaning. Ipsen advises incorporating daily maintenance of these components into your long-term maintenance plan for future usage. Make sure to inspect and clean the following items as follows:

- After loosening the latches, take off the trap cover from the trap canister.
- Remove the pall ring basket from the canister and the inside of the canister to ensure contaminants/ debris build up is removed. Note: If a 2nd basket is included it may be switched over out at this time. If not clean the basket/palls accordingly.
- Ensure the trap cover is in the correct orientation and the latches are fully engaged.

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10.3.5. Clean-Up Cycle Procedure



CAUTION

Make sure that all foreign materials are out of the furnace.

- Close the furnace and pump down to a high vacuum.
- Perform a leak check using a helium mass spectrometer or suitable rough checking means.



CAUTION

Do not proceed with the cleaning cycle until all gross leaks have been repaired.

- Heat the furnace to 100°F (56°C) above your normal continuous operating temperature and hold for at least two (2) hours using partial pressure of 1000 microns, then (2) more hours under a high vacuum condition.



CAUTION

<u>DO NOT EXCEED</u> the furnace maximum continuous operating temperature.

- Turn off furnace power and allow to vacuum cool to 150°F (66°C) or less. Allow the furnace to cool overnight if possible
- At the completion of the cleaning cycle, immediately check the furnace leak rate by closing the vacuum valves and timing the rate of rise in vacuum level. A furnace is considered vacuum tight and out gassed when the leak rate averages 5 microns (.665 PA) per hour, or less, during a four (4) hour period.
- If the leak rate is excessive, after a thorough cleaning and out gassing, check for vacuum leaks using a helium mass spectrometer. (a fitting to connect the mass spectrometer to the furnace is provided at the roughing pump inlet connection)
- If a mass spectrometer is not available, a rough check can be made by evacuating the chamber and spraying the suspected fittings and joints with acetone and noting any changes in system pressure on the vacuum gauge. A repeatable change in the indicated pressure indicates a leak.



NOTE

See below for a summary of different system's maintenance requirements.

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DS 12x12x24 2 bar

Vacuum Furnace Maintenance Interval Matrix

Table 1: Maintenance Interval Matrix - Pumping System

Pumping System	Daily	Weekly	4 weeks	8 weeks	12 weeks	26 weeks	As needed (see mfr. info)
Check the level and condition of the roughing pump oil. Cloudy or discolored oil indicates the presence of moisture or other contamination. The oil should then be changed. Refer to the Manufacturer's Manual for the correct oil changing procedures. Check that the oil is circulating and at the correct level. Per the motor Operation & Maintenance Instructions, relubrication (under standard service conditions) is 6 months.							
Check tension and condition of all pump belts.							
Check/add/change Roughing Pump, Booster Pump, Diffusion Pump Oils							
Check Holding Pump oil							
Clean holding oil filter							
When diffusion pump (Varian) is cold, check that the heaters are bolted snugly to the boiler plate and that all heater terminal connections are fastened tightly inside the junction box. ***(if applicable)***							
Clean the diffusion pump - Varian ***(if applicable)***							
Check vacuum booster pump (BOC) oil; add if required.							
Check roughing pump (BOC) oil level; add if required							
Check vacuum booster pump (BOC) couplings and belts for wear; replace if required.							Every 300 hours

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Table 2: Maintenance Interval Matrix - Hot Zone, Vessel & Structures

Hot Zone, Vessel & Structures	Daily	Weekly	4 weeks	8 weeks	12 weeks	26 weeks	As needed (see mfr. info)
Check the condition of the hot zone elements and shielding. Especially look for missing or broken element retainers, or loose/broken nuts.							
Clean the chamber of all foreign matter. Brush or blow out with clean, dry air. Wipe the inner tank and head surfaces using a lint free cloth or wiper dampened with a suitable solvent.							
*Check all nuts for tightness. Tighten if loose. Do not over tighten. Contact the Ipsen Field Service Department for assistance on choosing suitable tools and tightening torques.  ***Loose connections may lead to electrical arcing that can damage the furnace or workload.***							
Clean the chamber door and use graphite powder on the lip seal.							
Grease the chamber door hinges.							

****Perform weekly for first month on new hot zone or replaced elements; monthly thereafter.***

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Table 3: Maintenance Interval Matrix - Water System

Water System	Daily	Weekly	4 weeks	8 weeks	12 weeks	26 weeks	As needed (see mfr. info)
Check water lines for leaks.							
Check hoses that are hotter to the touch, indicating low flow rate.							
Check all water lines for proper flow and temperature.							
Check the operation of the water flow switches and the other safety interlocks.							

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Table 4: Maintenance Interval Matrix - Electrical System & Controls

Electrical System & Controls	Daily	Weekly	4 weeks	8 weeks	12 weeks	26 weeks	As needed (see mfr. info)
Check that vacuum gauges are responding properly to pump down pressures.							
Clean control panel and indicators.							
Inspect the power feed-through bars for tight connections. ***Remove the power from the VRTs and discharge the circuit before checking the feed-through bars. Failure to do so could result in an electrical shock hazard.***							
Check all secondary power cables for wear and heat deterioration.							
Vacuum out dust and dirt from the control cabinet.							
Check secondary cables to the transformers (VRT) for wear.							
Check all cables to and from the VRTs for tight connections.							
Check all cabinet and junction box wires and connections.							
Check all transformer resistors.							
Check all fuses for continuity.							
Clean the inside of the power supply with compressed air.							
Take voltage output readings of the power control unit (PCU) at different percentage outputs from the programmer (PLC). Adjust if necessary. (Refer to PCU Data sheet in the Supplementary Data Section.)							

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Table 5: Maintenance Interval Matrix - Gas Cooling, Backfill, & Pneumatic Systems

Gas Cooling, Backfill & Pneumatic System	Daily	Weekly	4 weeks	8 weeks	12 weeks	26 weeks	As needed (see mfr. info)
Check backfill valve switch settings. (These are generally adjustable vacuum switches.)							
Check cooling blower for vibration and excessive noise.							
Check all pneumatic lines for leaks. Check the pneumatic line regulator, lubricator, and filter for proper operation.							
Check all pressure switches for proper operation. Adjust if necessary.							
Check all lines, fittings, and connections of backfill gas from the point of origin to the backfill valve assembly at the furnace.							
Check the blank off pressure of the vacuum pump(s) and change the oil if necessary.							
Lubricate cooling blower motor (internal cooling – e.g., HR/VR models)							Every 300 hours
Furnaces with Spencer gas blower motors (external cooling – e.g., HR/VR models)							Sealed bearings – contact Ipsen for replacement
Ipsen blowers with Baldor motors							Refer to motor manufacturer instructions
All other motors							Refer to motor manufacturer instructions
Check pressure relief valve for dirt, wipe face of flange and seal.							



This general reference is not intended to supplant, conflict with, or exclude any individual manufacturer's recommendations for non-Ipsen equipment. Always read the manufacturer's manual in full and follow their recommendations. Contact Ipsen Service with questions.

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10.4. Lubrication Schedule

The following items should be checked at regular intervals.

- Diffusion Pump
- Holding Pump
- Vacuum Booster Pump
- Mechanical Pump
- Gas Cooling Motor
- Gas Blower Motor Bearings (for a Spencer Blower)
- Gas Blower Bearings (for a Spencer Blower)
- Air Line Lubricator
- Flange Bearing on Dolly Drive
- Pneumatically operated valves with grease cups
- Ball Screw Drive (Vertical Furnaces only)



WARNING

Many commercially available greases and lubricants are not compatible with the grease supplied with the equipment by the manufacturer. Failure to use a compatible lubricant can cause binding or other damage to the equipment.

For recommended checks, lubrication and maintenance procedures for peripheral equipment not manufactured by Ipsen Inc., refer to the manufacturers' instructions in the vendor documentation manual.

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10.4.1. TurboTreater® Gas Blower Lubrication

Even in normal operation, the TurboTreater® Gas Blower Motor experiences wide extremes in both temperature and pressure conditions. It is therefore necessary to follow the published lubrication recommendations closely to ensure maximum life from the cooling motor:

- Lubricate the motor every 300 hours of operation using the lubricant noted on the motor nameplate. If the lubricant is not noted on the plate, contact Ipsen International for the correct type prior to adding any grease.
- Use the two grease couplings, if supplied, on the motor chamber cowling. If there are no couplings, the motor cover will have to be removed. With a grease gun, pump one (1) ounce of the recommended grease into the rear bearing and one (1) ounce into the front (shaft end) bearing. NOTE: Ounces are by volume, not weight. Also, an additional amount of grease may have to be injected in order for the correct amount to clear the tubes and actually enter the bearing cavity.
- If the motor has gone significantly past the 300-hour lubrication interval, it should receive new bearings before being placed back into service.
- Lubricate the motor every 300 hours of operation
- Check balance and vibration of the motor every six months. This should be done after the motor is lubricated. Correct vibration in all planes to 0.5 mils or below.
- The motor should be allowed to run for 1/2 hour prior to resting trim balance.
- When the motor is sent for repair or refurbishment and before installing the motor back into the furnace, check with Ipsen International for motor upgrades and other necessary specifications. The repair shop must rebuild the motor to original (and upgraded) Ipsen specifications, and must balance the fan and motor assembly prior to returning it to the furnace
- Refurbish the Gas Blower Motor every three years, provided that the motor has been maintained and operated properly during that time frame.

10.4.2. Other Recommendations

- When the motor is sent for repair or refurbishment and before installing the motor back into the furnace, check with the Ipsen International Inc. Engineering Department for motor upgrades and other necessary specifications. The repair shop must rebuild the motor to original (and any upgraded) Ipsen specifications, and must balance the fan and motor assembly prior to returning it to the furnace.
- It is recommended that the motor and fan assembly be returned to Ipsen International for repairs, to ensure that the above mentioned items are addressed properly.

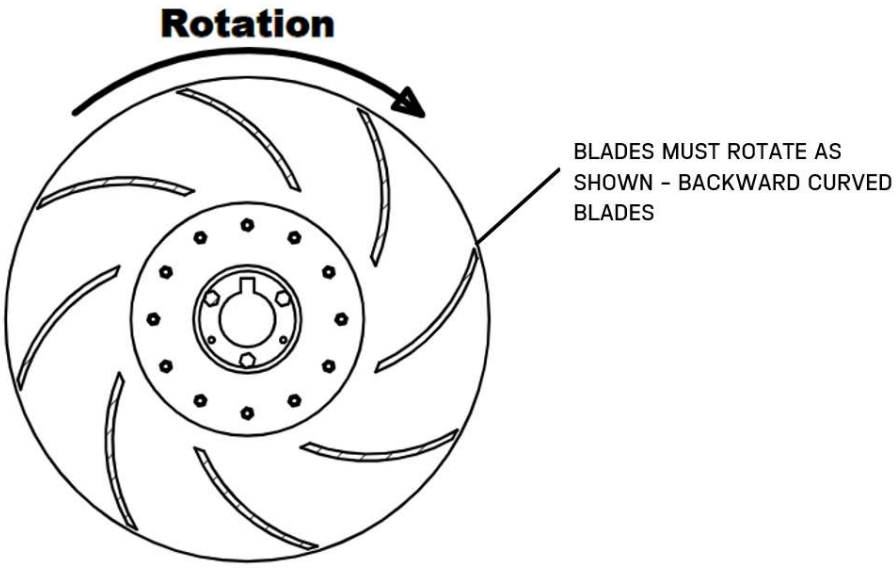
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10.4.3. Motor Replacement Procedure

When the Gas Blower Motor is returned, install the motor into the furnace according to the following procedure:

1. Reassemble the motor and fan assembly. Ensure the fan is on the shaft at the correct position (dimension). Refer to the Cooling System Assembly drawing.
   a. Ensure the fan inlet cover is installed on the shaft and in the inlet side of the fan.
   b. Ensure the water-cooled plate is attached to the shaft end of the motor.
   c. In some cases, the Controlled Cooling damper plate must be installed between the motor and fan inlet cover (if the furnace is equipped with the optional Controlled Cooling feature).
   d. The bolts of the taper-bushing mounting the fan to the shaft must be evenly torqued to 75 ft/lbs. Rotate the tightening sequence to ensure the bolts are tightened evenly. The socket-head bolt heads must be drilled and safety-wired to prevent them from loosening.
   e. Install three setscrews in the fan bushing, one screw above the keyway and two screws buried into the motor shaft.
2. Install the motor and fan assembly into the furnace.
   a. Pay close attention to shimming under the motor feet to protect against a potential "soft-foot" condition.
   b. Tighten all four bolts, then loosen one bolt at a time while the other three remain tight. The motor foot must not rise. If any upward movement of the motor foot occurs, shim the gap to compensate and recheck. "Soft-foot" is considered corrected if each of the bolts can be loosened (one at a time while all others remain tight) and the motor foot does not rise.
   c. Check motor mounting bolts for tightness.
   d. Mount the fan inlet cover to the flange. Replace O-ring seal at this time.
   e. If applicable, attach the Controlled Cooling damper plate to the actuation rods.
   f. Check the motor for proper rotation. Refer to the following diagram.

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a. Tape all exposed conductive surfaces of the electrical leads and power feed throughs with silicon rubber tape.

10.4.4. Motor Replacement Procedure

Balance the Gas Blower Motor according to the following procedure:

1. Check the vibration level of the fan and motor assembly.
   a. Check both front and rear bearings in the vertical and horizontal planes.
   b. The vibration level in all areas must be 0.5 mils or below.
   c. If balance correction is necessary, first attempt to trim balance the fan and motor assembly at the rear cooling fan on the motor, if the motor is a TEFC style.
   d. If the balance at the rear cooling fan does not yield 0.5 mils or below, then the hot zone must be removed, and balance weights must be attached to the large fan.
   e. Refer to the Hot Zone Removal and Reinstallation procedure for this more information.
2. Close furnace, ensuring that all removed covers are replaced. Connect all water lines.
3. Perform a leak test on the furnace.
4. The Ipsen International, Inc. TurboTreater® is now ready for production.

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10.5. Corrective Maintenance

Discoloration – workload discoloration can be directly attributed to impurities in the internal chamber. These impurities may be caused by:

- Air or water leaks
  - Use helium mass spectrometer to locate leaks
  - Search for areas on cold wall of vessel that indicate streaking or water lines
- Impurities entering the furnace during the cooling cycle
  - Ensure that the inert cooling gas supply and associated piping are not contaminated with rust/moisture
  - Verify system is leak free using soapy water to bubble test (any positive pressure leak during moments of high flow will result in a Venturi effect that will leak oxygen into process gas, making it not 99.999% pure, causing oxidation of your parts and hot zone)
- Products in the heat chamber reaching their vapor pressure and depositing on the furnace or work during cooling
  - Consult the vapor pressure chart. The process must be adjusted to prevent materials from reaching their vapor pressures. (follow furnace decontamination procedure)
- Dirty work loads going into the furnace
  - Make sure all parts entering furnace have been cleaned of debris and any cutting oil, water, gloves and so on
- Air leaks in the process gas delivery lines
- Parts carrying in contaminants
- Diffusion pump back streaming
  - Ensure proper water flow and oil level of pump
  - Make sure cross over setting isn't too high
- Clogged roughing pump exhaust filter
  - Drain oil out of filter
  - Remove and inspect if replacement is necessary
- Wet braze paste or anti sticking fluids being utilized in excess

The process must be adjusted to prevent materials from reaching their vapor pressure (following the furnace burn-out cycle procedure will clean all of the previously mentioned issues).

NOTE

The burn-out cycle will not correct the leak/problem; it will only clean the effects of the problem on the hot zone after the issue is resolved.

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10.6. Additional Maintenance Items

10.6.1. Thermocouples

Thermocouples are two wires of dissimilar metals welded together at the extreme end and encased in ceramic insulators forming the thermocouple assembly. These thermocouple junctions produce a small millivolt signal that is sent to the controller (PLC). The controller uses this signal to indicate the sensed temperature and to control temperature about a predetermined set point. With instrument power on, temperature readings should be approximately at room temperature. Very high or low readings could indicate open or shorted thermocouple junctions or lead wires. Thermocouples should be inspected periodically and replaced whenever there is any visual or operational sign of deterioration or according to set procedures of the process.



CAUTION

Correct polarity must be observed at all connections



CAUTION

Do not place thermocouple lead wires in conduit containing power lines



WARNING

The internal insulation of thermocouple assembly might include beryllia (beryllium oxide, BeO), which is carcinogenic in a powder form. Dispose of the insulation carefully if a sheath is broken.

10.6.2. Vacuum Sensing Heads

Replace vacuum sensing heads when the action of the vacuum gauge indicates a possible malfunction. Keep spare heads on hand for this purpose. This can be verified by noting the current vacuum readings and swapping with a new gauge, then verifying the values have changed or remained the same.

10.6.3. Low Water Pressure Alarm

Check the low water pressure alarm by turning off the furnace main water valve. The alarm will sound (power will be interrupted to the heating elements) immediately open the main water valve and press the reset button to restore power and turn off the alarm.

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10.6.4. High Temperature Limit

Check the high temperature limit by setting the over-temperature controller set point below the indicated temperature. This will interrupt power to the heating elements, sound the alarm, and trip the under voltage breaker to the VRT. This will then restore power by resetting the under voltage trip and over-temperature controller to its normal setting. The over-temperature as well as the VRT must be manually reset.

10.6.5. Power Controller

The Power Control Unit (PCU) is a silicon-controlled-rectifier used to apply the temperature controller (PLC) output to the variable reactance transformers (VRTs) and, in turn, the heat zones. The PLC controller 4-20 ma signal which the PCU converts 0 to 100 volts must be checked yearly

10.6.6. Power Feed-Through Terminals

The power feed-through terminals to the heating elements are water-cooled. Silicon O-rings provide the vacuum seal between the insulated feed through bar and the mounting plate. If heavy deposits are encountered, mechanical brushing must be completed.

10.6.7. Gas Ballasting

The gas ballasting feature on the roughing pump provides a means for removing condensed vapors from the pump oil without shutting down the pump. Gas ballasting may be used any time the furnace is not at high vacuum or pumping down. Under high humidity conditions, ballast the pump between each furnace cycle while the furnace is being loaded or unloaded. To gas ballast the roughing pump, open the manual valve located on the pump, refer to the vendor manual for more details on gas ballasting.

10.6.8. Pneumatic Cylinders

Pneumatic cylinders may be pressurized with inert gas from the cooling gas supply. This prevents internal oxidation of the furnace if a cylinder rod seal should fail while the furnace is at operating temperature. If the internal seals leak, replace seals with a seal repair kit.

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10.7. Vacuum Leak Checks

10.7.1. Leak-Up Rate Checks

Leak-up rate is the rate of pressure rise in a vacuum chamber with the vacuum valve closed. It has two components—leak rate and out gassing. The leak rate is the pressure rise due to the flow of gas through actual leaks in the chamber and is constant. Out gassing, which includes virtual leaks, approaches zero as the chamber is evacuated. A virtual leak is a trapped volume in a pocket of the vacuum chamber that leaks gas slowly into the chamber. If the rate of rise is unacceptable, make another measurement to confirm the previous reading. No change in the rate indicates an actual leak rather than out gassing.

Leak-up rate is measured in microns per hour, and is typically measured over a 10 to 15 minute period. An Ipsen Inc. furnace with an all-metal hot zone should have a leak-up rate no greater than 2 microns (.266 Pa) per hour. The leak-up rate in a soft-pack hot zone should be no greater than 5 microns (.665 Pa) per hour.

To measure the rate of rise in a chamber, evacuate the cold chamber until the pressure remains constant (ultimate vacuum) and then close all the vacuum valves to isolate the chamber by pressing the cycle stop push-button. Wait one minute before taking the first vacuum reading. This minimizes the effects of closing the valve(s). It also allows the system to reach equilibrium. Measure the vacuum again after a suitable interval, and calculate the rise in pressure per unit of time. For example, if the initial pressure measurement was 10 (1.33 Pa) microns, and after 15 minutes it was 12 microns (1.57 Pa), the rate of rise would be 2 microns (.266 Pa) per 15 minutes or 8 microns (1.06 Pa) per hour. A minimum of 15 minutes must be allowed for an accurate leak-up rate check. Preferably, a 30 minute check should be made.

A leak-up rate check should be performed on the furnace periodically to determine whether the vacuum leak-up rate is within acceptable limits. The furnace must be clean, cold and out gassed to obtain accurate values.

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10.7.2. Locating Vacuum Leaks

Locating a vacuum leak can be done in several ways, depending on the equipment available. Using a mass spectrometer is the preferred method, though any of the following methods are acceptable:

- *Mass Spectrometer Leak Detector* – a mass spectrometer is used to detect the presence of helium that has been sprayed on a suspected leak. The small size of the helium gas molecule allows it to penetrate a leak easily. The leak detector is usually connected to the gas ballasting valve, not the roughing line, on the mechanical vacuum pump. On a system with a diffusion pump, this arrangement allows the maximum sensitivity of the leak detector to be used assisted by the vacuum chamber diffusion pump. If the leak appears to be internal, all internal cooling lines may be drained of water and flooded with helium gas. This procedure may also be used to check suspected leaks in the furnace water jackets.



NOTE

Leak detectors must be calibrated prior to leak checking.



CAUTION

Do not pressurize the jacket to more than 15 psi (103kPa).

- *Solvent Leak Detection* – a simple but effective method for locating intermediate sized leaks uses a solvent such as acetone or alcohol. This technique can be used only if the system pressure is below 200 microns (27 Pa). It consists of careful spraying of the suspected area with a fine stream of the volatile solvent, and watching for a sudden change in pressure (up or down). It may be necessary to wait 5 to 30 seconds before proceeding to the next suspected area. The sensitivity of this technique improves greatly with lower pressures. Care is required to avoid spilling the solvent on the painted surfaces because acetone will remove many commercial paints.
- *Soap Bubble Test* - a gross leak in a pressurized system can be pinpointed using soapy water. When the soap solution is brushed on the leak, a bubble will form.

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10.7.3. O-Rings Leaks

Vacuum seals are the most frequently disturbed items on a vacuum system. Wear is unavoidable and consequently, regular maintenance is required. If a leak is found at an O-ring vacuum seal:

- Clean the seal ring and its bearing surfaces and inspect for cuts, nicks, and gouges.
- Replace damaged O-rings. Check seal splices if present for joint integrity and smooth outer surface.
- Correct irregularities in seal bearing surfaces to within 63 micro-inches.
- Coat the seal with a light coating of a quality vacuum grease before assembling.

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11. Troubleshooting

The following is a list of possible faults, probable causes, suggested corrective action. This section is for universal troubleshooting. The following items should be considered when identifying and correcting a system problem:

- Check with the operators to find out if there have been any unusual recent occurrences (process changes, pneumatic pressure loss, power failure, cooling water problems, spillage, etc.) that may have contributed to the problem.
- Compare the present system performance with the accumulated data in the performance log to determine where changes have occurred.
- When a component is to be removed for maintenance:
    - Study the component manual and drawings beforehand.
    - Use the proper tools for the job
    - Be careful! Avoid tools or techniques that may damage the system components
    - Ensure that you have seals, lubricants, or other replacement parts that will be required for reassembly
- Lubricate items as required with proper lubricant. Avoid the use of a lubricant where none is required
- If uncertain how to proceed, call Ipsen Field Service for assistance.

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Table 11-1 Troubleshooting Chart

Fault	Probable Cause	Action
Poor ultimate vacuum	Leak in chamber or pumping system	Locate and repair
	Furnace hot zone dirty	Perform clean-up cycle
Vacuum pump and/or blower will not come on	Overload tripped	Reset motor starter
	Fuses blown	Check and replace
	Switch not set to auto on screen	Set Switch to Auto
Vacuum pump will not meet specifications for blank-off	Leak in piping to pump	Perform leak check
	Vacuum valve not sealing properly	Check pneumatic pressure, check seals, check bolts at flanges
	Gas ballast valve open	Close gas ballast valve
	Inaccurate vacuum instrument or gauge sensing head	Clean and or replace, check instrument, check connection, check cables
	Oil is milky white (presence of water in pump oil)	Gas ballast the pump
	Oil is black	Change oil
	Worn-out roughing pump. Refer to pump manual	Check blank off pressure (pressure when roughing valve is closed)
Furnace not pumping down	Rough Valve not opening (Auto mode)	Check pneumatic supply
	Vacuum leaks	Perform leak check
	Vent valve open	Close vent valve if forced open
Slow pump down	Vacuum leaks	Perform leak check
	Condensation on chamber walls	Check and do not allow
	Water in chamber	Check for water leaks (Consult Ipsen)
Hot zone no voltage, high current	Element shorted to hot zone or load	Clear short
Hot zone high voltage, no current	Element open	Replace element
	Bus or electrode is open	Repair as necessary
Hot zone will not reach rated voltage or current	Power connections not hooked up correctly	Check connections
	Power controller not delivering rated output	Readjust power controller

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Fault	Probable Cause	Action
Diffusion pump not pumping properly	Valves	Check ultimate pressure with mechanical pump
		Check vacuum TC tubes and ion tubes
		Check if vent valve or mass spec valve is closed
	Heaters not on or faulty	Check and correct
	Oil leak	Check for oil leak
	HiVac valve	Check HiVac valve is fully open
	Foreign material in the chamber	Check for wood, tools, or anything left in chamber
Power supply will not come on (contactor not staying on)	Cooling water off or low flow	Check water flow
	Over temp controller set too low	Set over temperature set point higher
	Insufficient vacuum (initial)	Pump system down below 80 microns
	Under voltage trip coil in circuit breaker not energizing	Check interlocks to U/V trip, see electrical schematic
		Apply proper voltage to U/V trip for operation
		Check main wall disconnect
	Holding pump off	Turn on holding pump
No voltage or current	Power cables are broken	Measure at power supply to check for broken power supply
	Control device has no output	Check output limits on control device
	Bad meters	Check/Replace meters
Temperature instrument drives in minus direction	T/Cs are wired incorrectly	Check connection on TC wiring
HMI and over temp controller are reading temperature full scale	Open thermocouple	Check connection of TC wires at back of instruments and connectors
		Replace TC

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Fault	Probable Cause	Action
Water alarm on	Loss of water	Turn water on
	Clogged or faulty flow switch	Clean, Check, and replace if necessary
Water alarm(s) off, but no water flow	Faulty flow switch	Check flow switch and replace
Water alarm on and good water flow and pressure	Faulty plumbing or incorrect wiring	Check that the flow switch is plumbed correctly
		Check electrical current
Valves will not operate	Loss of pneumatic pressure	Set pneumatic pressure to 80 psia minimum
Pneumatic pressure 80 psia but valves will not open	Loss of electrical power or signal to pneumatic solenoids	Check Electrical circuits
Pneumatic pressure set and electrical circuits working, valves won't open	Valve malfunction	Check valves manually for correct movement
		Make sure oil and water separators are working correctly
Unsatisfactory ultimate vacuum	Leaks in vacuum system	Locate leaks and repair
	Low oil level in pumps	Check and add oil
	Contaminated vacuum system: experiencing workload contaminates from cleaning operations, or out gassing of processed materials	Perform clean up cycle. Observe proper work cleaning procedures
	Malfunctioning pump assembly	Inspect and correct
Furnace temperature related problems	Poor heat control	Adjust PCU as outlined in supplemental data
		Check calibration and control instruments and thermocouples
	Inadequate heat	Check condition of hot zone
		Check element voltage and current
		Check for broken heating elements or insulators

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Fault	Probable Cause	Action
Temperature related problems	Poor uniformity	Check insulators for contamination
		Check for broken heating elements or insulators
		Check work couples, control couple jack panel and instrumentation for accuracy
Oxidized work	Contaminated gas	Check gas purity, repair any leaks in gas system
	Contaminated furnace	Repair all air leaks to prevent oxidation
		Correct improper operating or maintenance procedures which introduce impurities into the system
Vacuum leak repairs	Thread fittings	Check all penetrations. Perform clean up cycle, re-seal with Teflon pipe thread sealant
	O-Rings	Use vacuum grease lightly on O-rings. Check O-ring integrity
	Gaskets	Install dry and tighten bolts evenly on flanges.
Heat Failure	Check VRTs, PCU, and Temperature controls	Repair/Replace as necessary
Cooling fan not operating	Check circuit breakers	Repair/Replace as necessary
High chamber contamination	Improper system operation and air release procedures	Check valve sequence. Do not air release roughing line thru pump ballast valve

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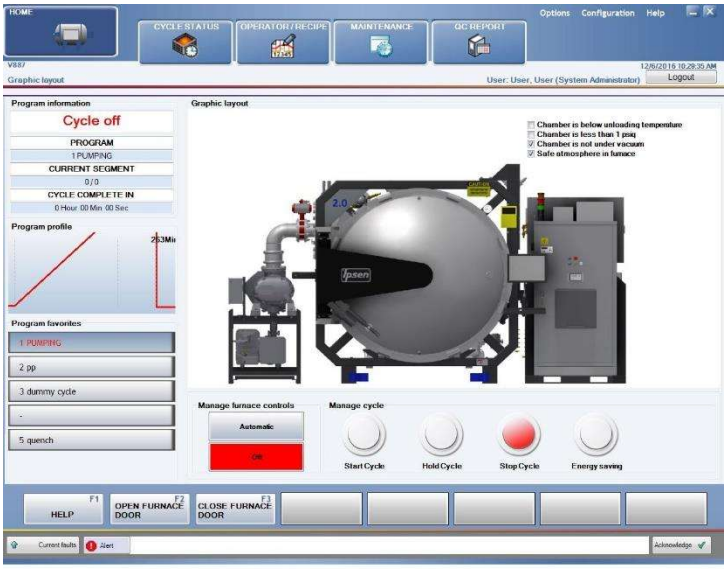
12. VacuProf Operation

12.1. Introduction to VacuProf

The purpose of this overview manual is to provide a sampling of the VacuProf screen images utilized on the vacuum furnace. It is not intended as a replacement to the VacuProf user manual that is provided with each furnace.

12.2. Home

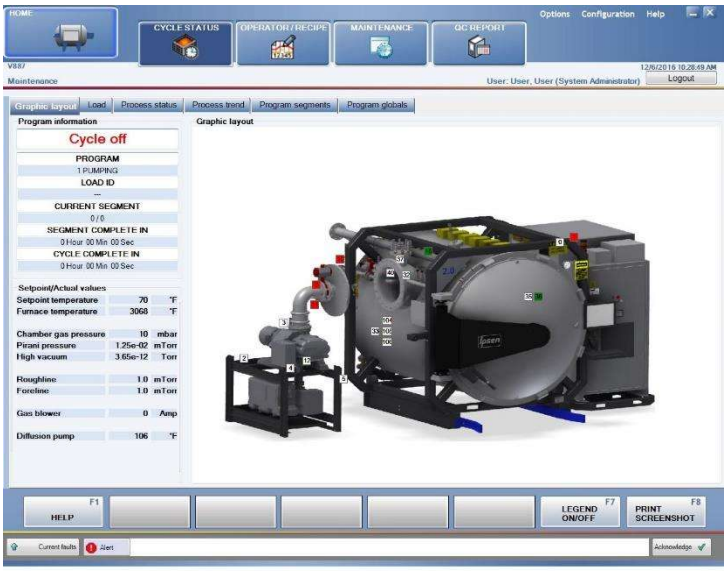
This screen provides a general overview of all the navigation modules and general information on cycle and segment statuses. Navigation modules represent the highest level in the navigation hierarchy and are oriented to reflect the most important and frequently used tasks. Shown on the screen are five program favorites, along with autoclave operation and pump controls.



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12.3. Alerts

The alerts bar informs the operator to furnace operational issues. All faults that have occurred are displayed in the current faults area until they have been acknowledged and are no longer active.



12.4. Cycle Status

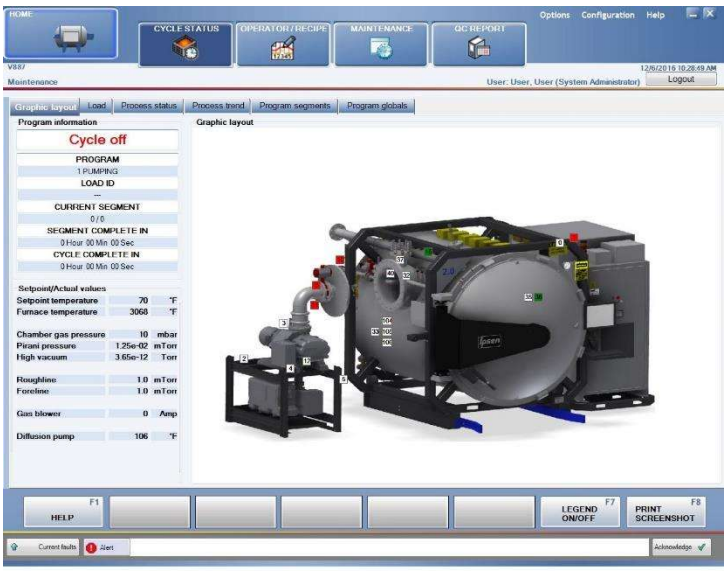
Cycle status is subdivided into six tabs.

- Graphic Layout
- Load
- Process Status
- Process Trend
- Program Segments
- Program Globals

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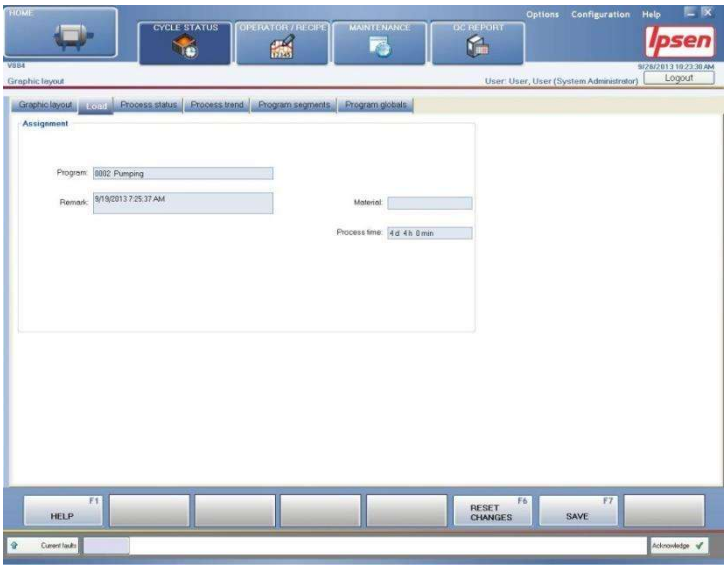
12.4.1. Graphic Layout

The current set points/actual values of the program are displayed here.



12.4.2. Load

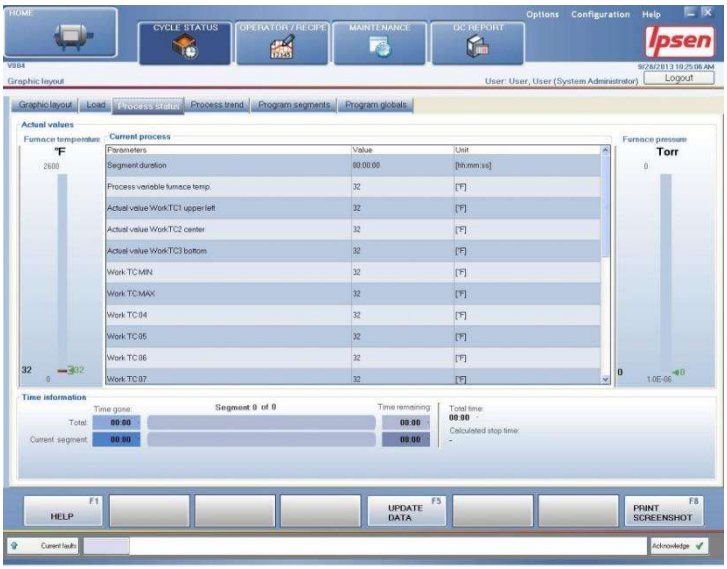
This screen is used to provide a general description of the load including program, remarks, material, and process time.



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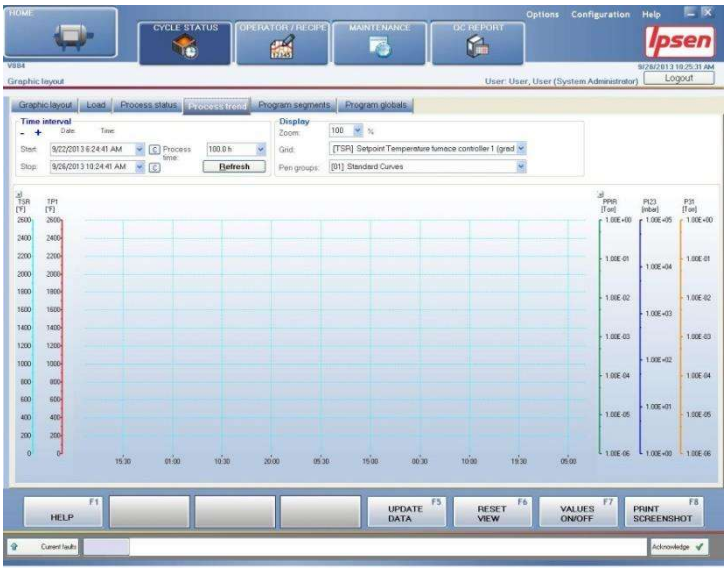
12.4.3. Process Status

This displays the current actual values such as furnace temperature, load temperature and furnace pressure of the load selected in the overview window. Relevant time information is shown at the bottom of the screen.



12.4.4. Process Trend

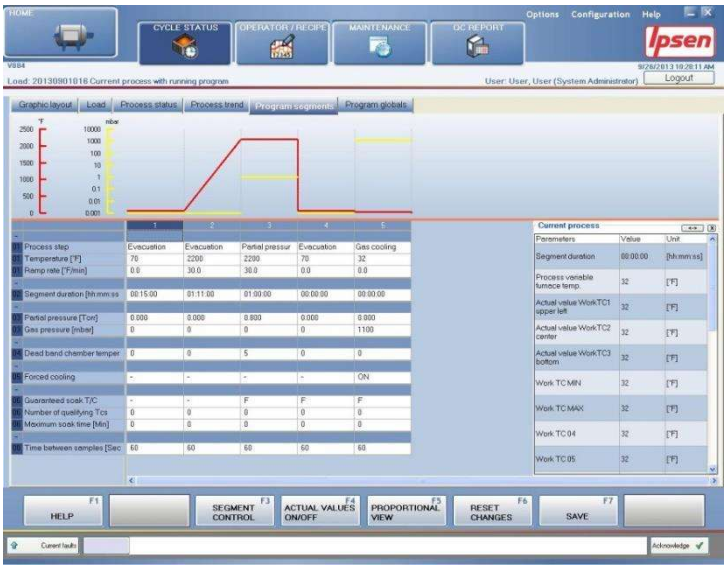
This screen shows a graphical representation of the furnaces actual temperatures and pressures over a fixed period of time. Specific time intervals can be user defined.



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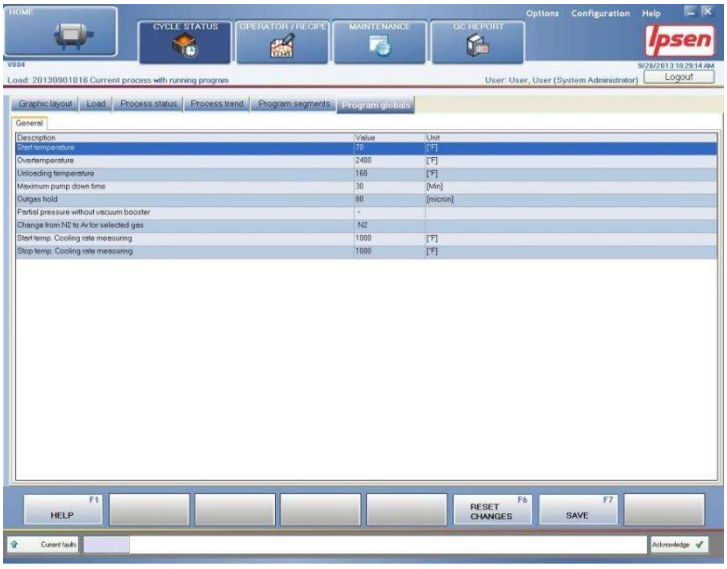
12.4.5. Program Segments

This illustrates all segments that make up the current recipe. The current segment is displayed with a yellow background when the furnace is in cycle. Any of these values can be changed during furnace operation.



12.4.6. Program Globals

The program globals (program parameters), which are not segment-specific, are displayed below. In this window, the operator has the option to change the values during the cycle and send them to the PLC.



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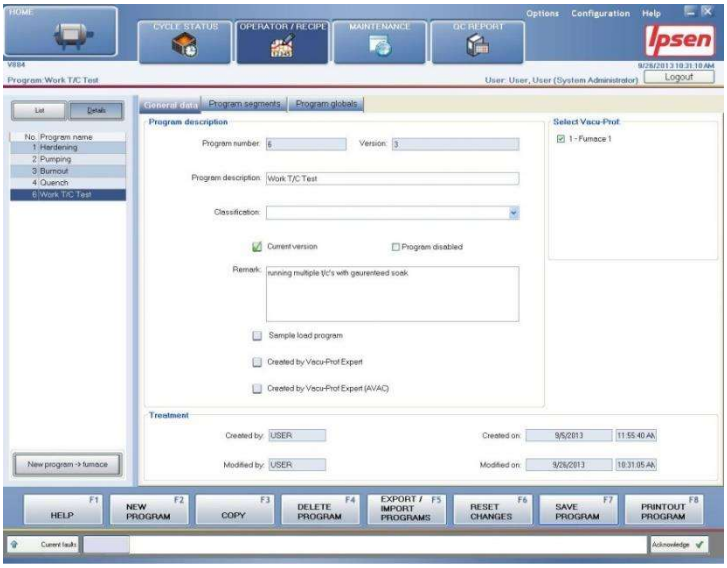
12.5. Operator/Recipe

Operator/Recipe is subdivided into three tabs.

- General Data
- Program Segments
- Program Globals

12.5.1. General Data

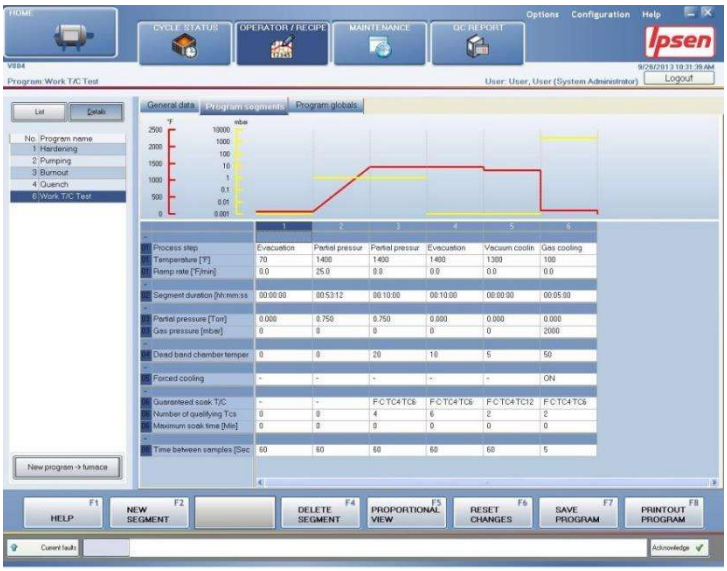
This is the starting point for the creation of a new program recipe. The operator has the option to display the information in a list or details view. Inputs or changes with respect to materials only apply to the relevant program.



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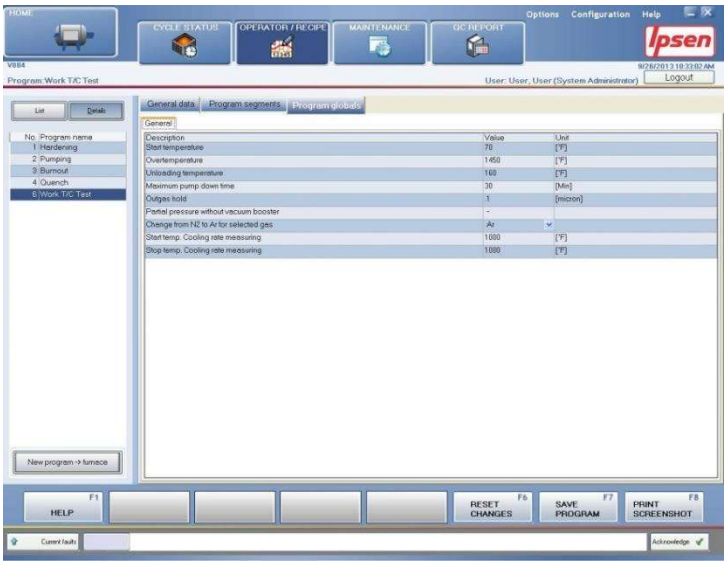
12.5.2. Program Segments

This screen allows the operator to create the individual segments within the recipe. The graph illustrates the results of the operator's temperature and pressure choices.



12.5.3. Program Globals

The program globals (program parameters), which are not segment-specific, are displayed below. In this window, the operator has the option to change the values of the permanent program.



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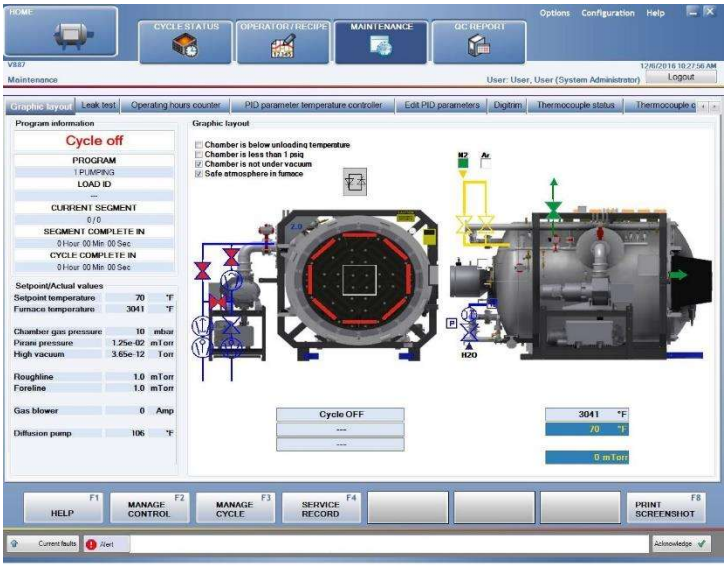
12.6. Maintenance

The maintenance screen is subdivided into ten tabs.

- Graphics Layout
- Leak Test
- Operating Hour Counter
- PID Parameter Temperature Controller
- Edit PID Parameters
- Digitrim
- Thermocouple Status
- Thermocouple Calibration
- Device Settings
- PLC IO

12.6.1. Graphic Layout

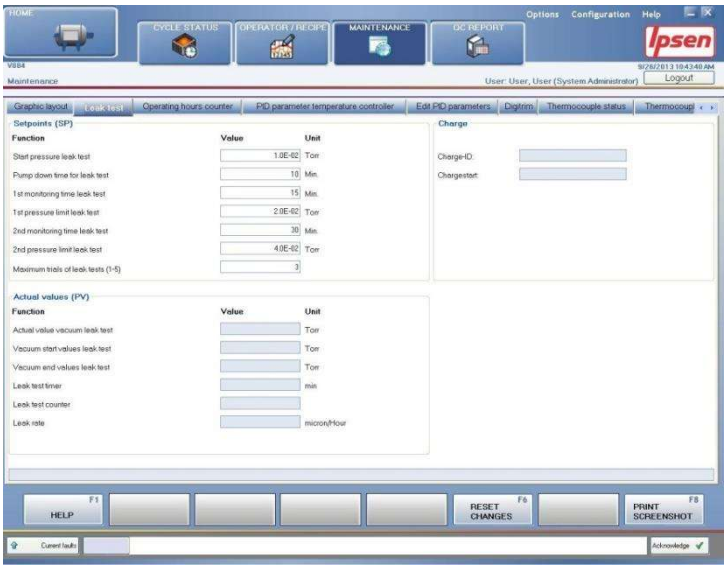
The essential furnace information is displayed on this screen. In addition, this window offers the option of managing the furnace cycle and displays the home screen.



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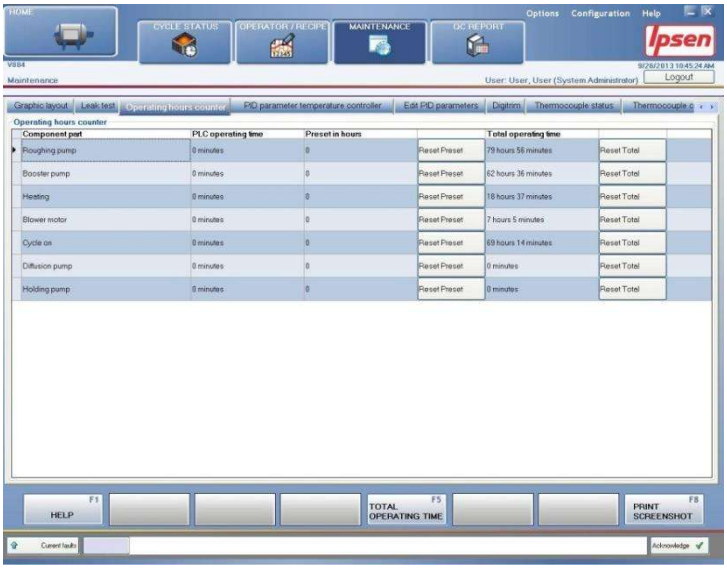
12.6.2. Leak Test

This window contains the set points and actual values section. The operator can specify the settings for leak test parameters.



12.6.3. Operating Hours Counter

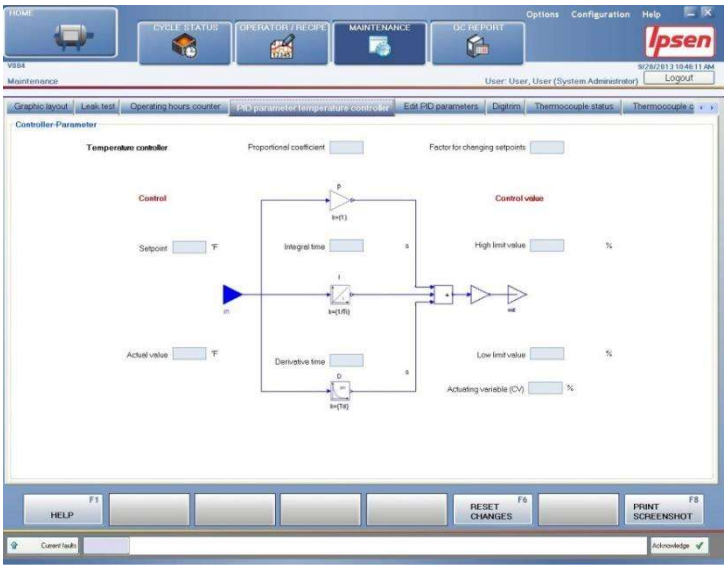
This screen displays the operating hours for the individual furnace components and is helpful in the development of preventative maintenance procedures.



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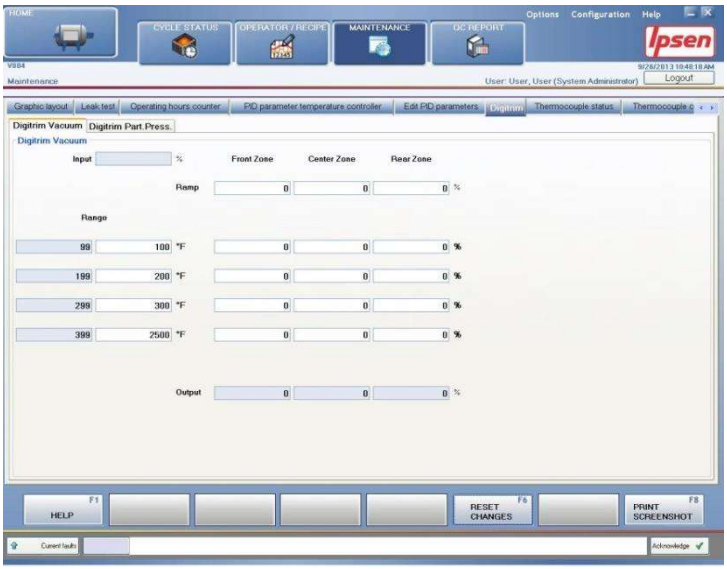
12.6.4. PID Parameter Temperature Controller

The regulating variables of the temperature controller are defined on the PID (Proportional Integral Derivative) screen.



12.6.5. Digitrim

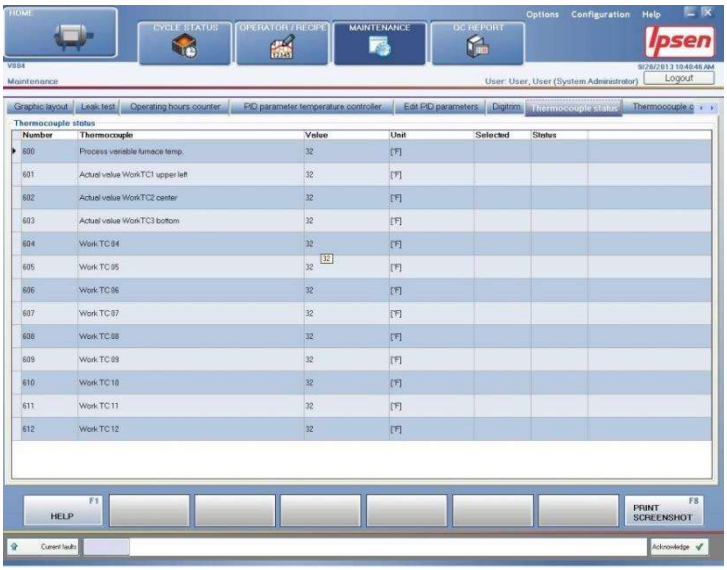
The factors for trimming the heat zone variables are defined on this screen.



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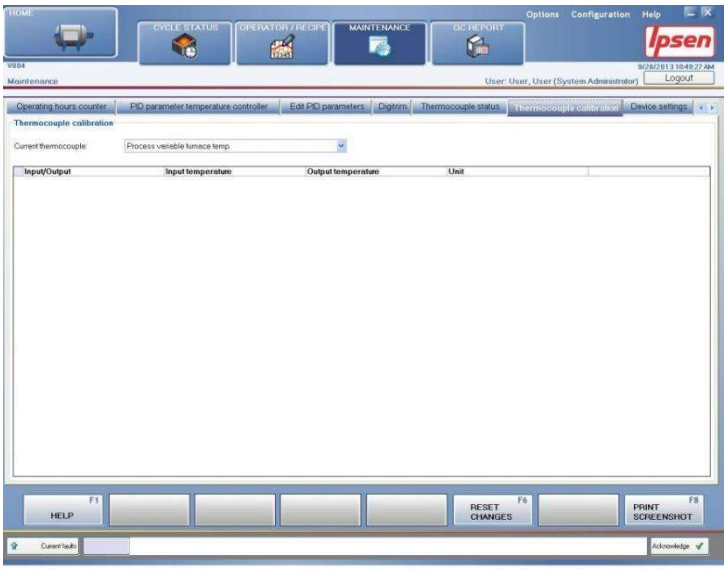
12.6.6. Thermocouple Status

The temperatures of the active thermocouples are displayed below.



12.6.7. Thermocouple Calibration

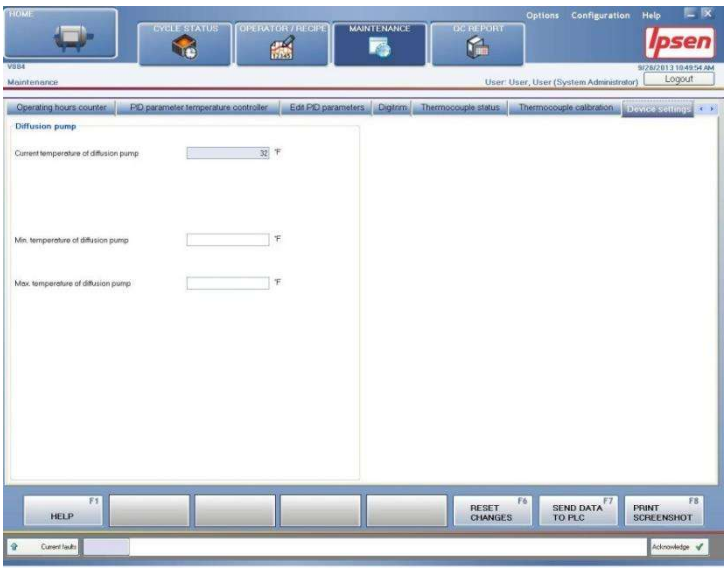
The desired thermocouples can be selected and calibrated.



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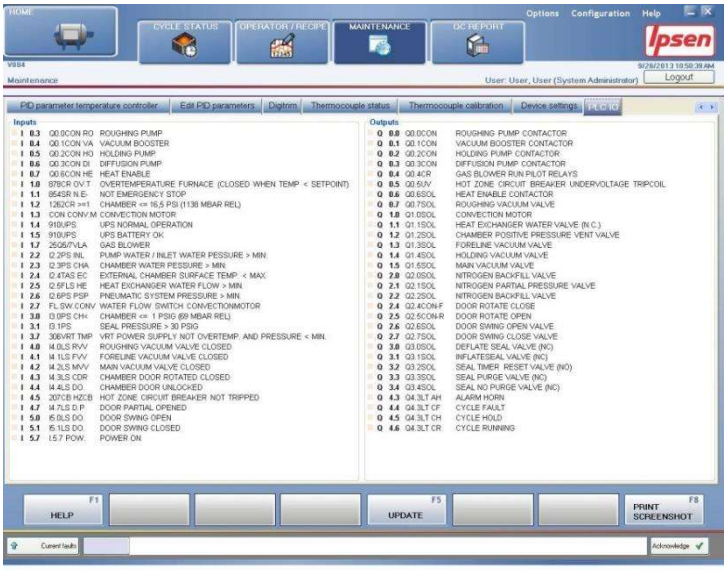
12.6.8. Device Settings

The desired thermocouples can be selected and calibrated on this screen.



12.6.9. PLC IO

This screen displays the PLC (Programmable Logic Controller) inputs and outputs, including remarks and status. Red indicates a fault and green indicates proper operation.



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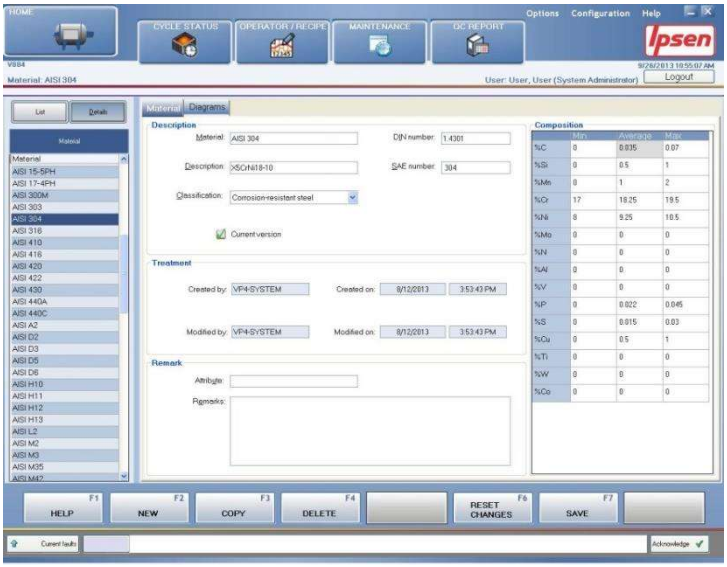
12.7. Options

This screen illustrates the options drop down menu for master data, event logger, and remote test.



12.7.1. Master Data: Material

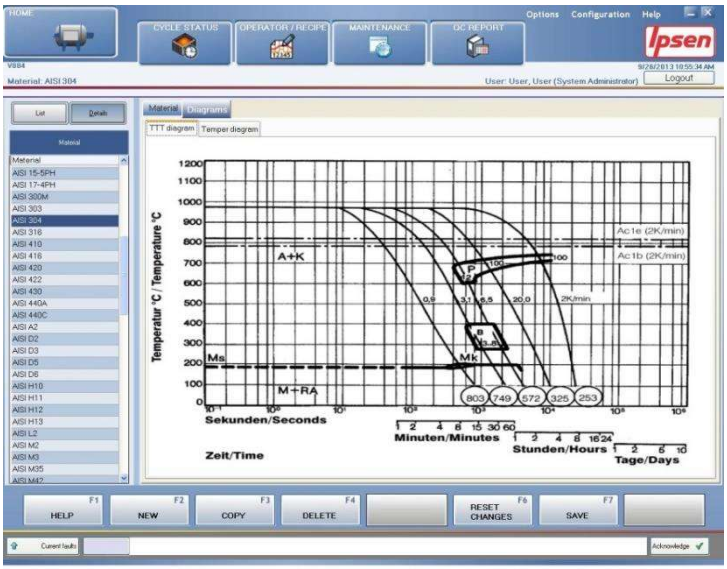
The operator has the option of choosing a list or details view for the data. In the list view, the possible filter functions are displayed. The details tab displays the specific data pertaining to the material selected in the overview window.



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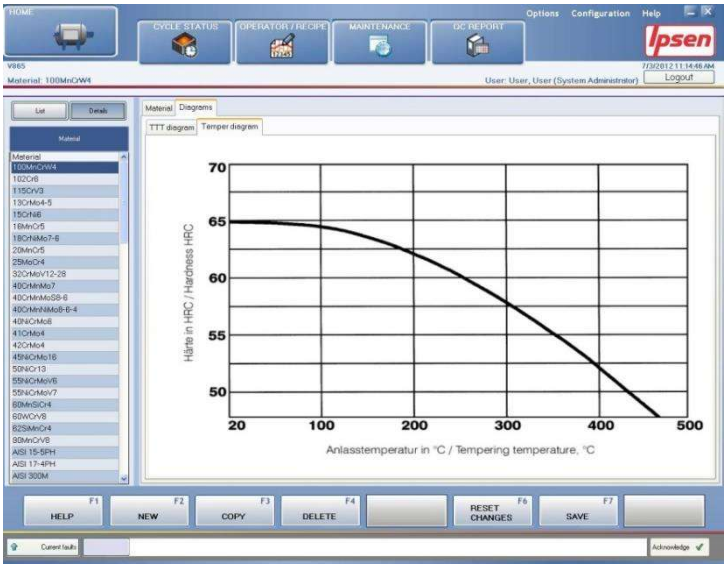
12.7.2. Master Data: TTT Diagram

The diagrams of the selected material are loaded on this screen. New diagrams can be added for materials are not included.



12.7.3. Master Data: Temper Diagram

The diagrams of the selected material are loaded on this screen. New diagrams can be added for materials not included.



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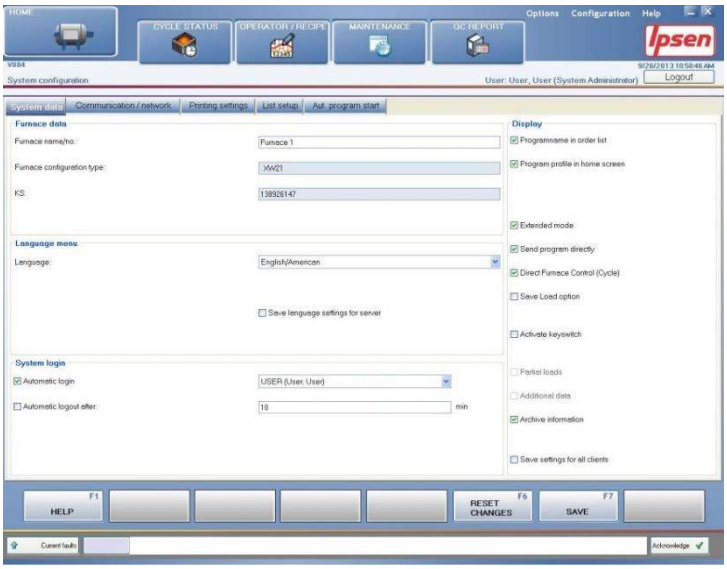
12.8. Configuration: System

The system window is subdivided into three tabs: system data, communication/network, and print settings.



12.8.1. System Data

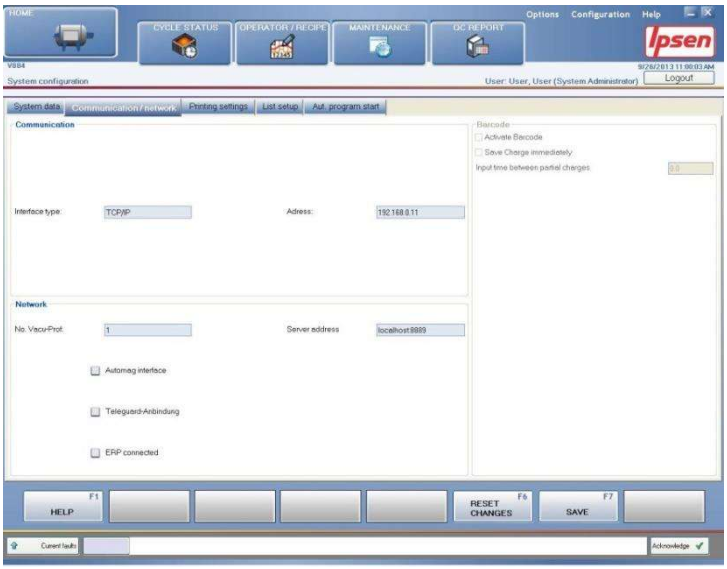
This screen is divided into four sections: furnace data, language menu, system login, and display.



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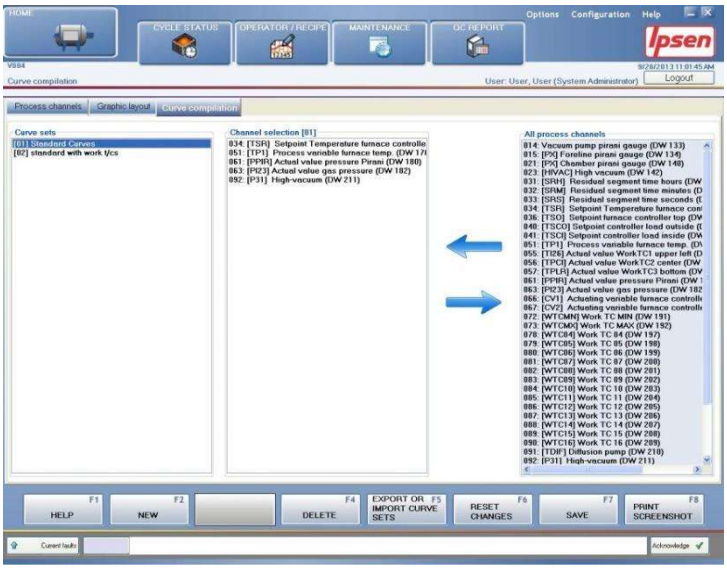
12.8.2. Communication/Network

This section is divided into communication and network. Under communication, the operator has the option to select different interface types. Under network, the VacuProf 4.0 number is displayed.



12.8.3. Curve Compilation

This screen allows the operator to group together several process channels to create a curve compilation (a custom pen grouping).



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12.9. Help

Program help allows users to access the current version of the user manual for the VacuProf software. Program info contains details about the VacuProf version. Furnace info provides information about the most important furnace properties.



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13.Supplemental Data

13.1. Thermocouple Data

THERMOCOUPLE AND EXTENSION GRADE WIRE COLOR CODES

ANSI Code	Alloy Combination		Maximum Useful Temperature Range ++	Maximum Thermocouple Grade Temperature Range	EMF (mV) Over Max. Temperature Range	Standard Limits of Error (above 0°C)	Special Limits of Error (above 0°C)
	+ Lead	– Lead					
J	IRON Fe (magnetic)	Constantan Copper-Nickel Cu-Ni	Thermocouple Grade 32 to 1382°F 0 to 750°C Extension Grade 32 to 392°F 0 to 200°C	-346 to 2193°F -210 to 1200°C	-8.095 to 69.553	greater of 2.2°C or 0.75%	greater of 1.1°C or 0.4%
K	Chromel Nickel–Chromium Ni-Cr	Alumel Nickel–Aluminum Ni-Al (magnetic)	Thermocouple Grade -328 to 2282°F -200 to 1250°C Extension Grade 32 to 392°F 0 to 200°C	-454 to 2501°F -270 to 1372°C	-6.458 to 54.886	greater of 2.2°C or 0.75%	greater of 1.1°C or 0.4%
V▼	Copper Cu	Constantan Copper-Nickel Cu-Ni	Extension Grade 32 to 176°F 0 to 80°C				
T	Copper Cu	Constantan Copper-Nickel Cu-Ni	Thermocouple Grade -328 to 662°F -250 to 350°C Extension Grade -76 to 212°F -60 to 100°C	-454 to 752°F -270 to 400°C	-6.528 to 20.872	greater of 1.0°C or 0.75%	greater of 0.5°C or 0.4%
E	Nickel–Chromium Ni-Cr	Constantan Copper-Nickel Cu-Ni	Thermocouple Grade -328 to 1652°F -200 to 900°C Extension Grade 32 to 392°F 0 to 200°C	-454 to 1832°F -270 to 1000°C	-9.835 to 76.373	greater of 1.7°C or 0.5%	greater of 1.0°C or 0.4%
N	Nicrosil Ni-Cr-Si	NISIL Ni-Si-Mg	Thermocouple Grade -450 to 2372°F -270 to 1300°C Extension Grade 32 to 392°F 0 to 200°C	-450 to 2372°F -270 to 1300°C	-4.345 to 47.513	greater of 2.2°C or 0.75%	greater of 1.1°C or 0.4%
R	Platinum- 13% Rhodium Pt-13% Rh	Platinum Pt	Thermocouple Grade 32 to 2642°F 0 to 1450°C Extension Grade 32 to 300°F 0 to 150°C	-58 to 3214°F -50 to 1768°C	-0.226 to 21.101	greater of 1.5°C or 0.25%	greater of 0.6°C or 0.1%
S	Platinum- 10% Rhodium Pt-10% Rh	Platinum Pt	Thermocouple Grade 32 to 2642°F 0 to 1400°C Extension Grade 32 to 300°F 0 to 150°C	-58 to 3214°F -50 to 1768°C	-0.236 to 18.693	greater of 1.5°C or 0.25%	greater of 0.6°C or 0.1%
U▼	Copper Cu	Copper-Low Nickel Cu-Ni	Extension Grade 32 to 122°F 0 to 50°C				
B	Platinum- 30% Rhodium Pt-30% Rh	Platinum 6% Rhodium Pt-6% Rh	Thermocouple Grade 32 to 3092°F 0 to 1700°C Extension Grade 32 to 212°F 0 to 100°C	32 to 3308°F 0 to 1820°C	0 to 13.820	0.5% over 800°C	Not Established
G▼ (W)	Tungsten W	Tungsten- 26% Rhenium W-26% Re	Thermocouple Grade 32 to 4208°F 0 to 2320°C Extension Grade 32 to 500°F 0 to 260°C	32 to 4208°F 0 to 2320°C	0 to 38.564	greater of 4.5°C or 1.0%	Not Established
C▼ (W5)	Tungsten- 5% Rhenium W-5% Re	Tungsten- 26% Rhenium W-26% Re	Thermocouple Grade 32 to 4208°F 0 to 2320°C Extension Grade 32 to 1600°F 0 to 870°C	32 to 4208°F 0 to 2320°C	0 to 37.066	greater of 4.5°C or 1.0%	Not Established
D▼ (W3)	Tungsten- 3% Rhenium W-3% Re	Tungsten- 25% Rhenium W-25% Re	Thermocouple Grade 32 to 4208°F 0 to 2320°C Extension Grade 32 to 500°F 0 to 260°C	32 to 4208°F 0 to 2320°C	0 to 39.506	greater of 4.5°C or 1.0%	Not Established

++Except as further restricted by temperature limits for T/C diameter and insulation tables that follow. ▼Not official symbol or standard designation.

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BM-2468

DS 12x12x24 2 bar

Color Coding		International IEC 584-3	International IEC 584-3 Intrinsically Safe	CZECH British to BS 1843	Netherlands German to DIN 43710	Japanese to JIS C 1610-1981	French to NFE-18001	Comments Environment–Bare Wire	ANSI Code
Thermocouple Grade	Extension Grade								
+ –	+ –	+ –	+ –	+ –	+ –	+ –	+ –	Reducing Vacuum, Inert. Limited Use in Oxidizing at High Temperatures. Not Recommended for Low Temperatures.	J
+ –	+ –	+ –	+ –	+ –	+ –	+ –	+ –	Clean Oxidizing and Inert. Limited use in Vacuum or Reducing. Wide Temperature Range. Most Popular Calibration.	K
None Established	None Established	+ –	+ –	+ –		+ –	+ –	Alternative to KX Type Extension Wire for Low Temperature. Not Recommended for General Use.	V▾
+ –	+ –	+ –	+ –	+ –	+ –	+ –	+ –	Mid Oxidizing, Reducing Vacuum or Insert. Good Where Moisture is Present. Low Temperature and Cryogenic Applications.	T
+ –	+ –	+ –	+ –	+ –	+ –	+ –	+ –	Oxidizing or Inert. Limited Use in Vacuum or Reducing Highest EMF Change Per Degree	E
+ –	+ –	+ –	+ –	+ –	No Standard Use American Color Code			Alternative to Type K More Stable at High Temperature	N
None Established	+ –	+ –	+ –	+ –	+ –	+ –	+ –	Oxidizing or Inert. Do Not Insert in Metal Tubes. Beware of contamination. High Temperature	R
None Established	+ –	+ –	+ –	+ –	+ –	+ –	+ –	Oxidizing or Inert. Do No Insert in Metal Tubes. Beware of Contamination. High Temperature	S
None Established	+ –	+ –	+ –	+ –	+ –	+ –	+ –	Extension Guide Connecting Wire for R and S Thermocouples Also Known as RX and SX Extension Wire	U▾
None Established	+ –			No Color Standard	+ –	+ –	No Color Standard	Oxidizing or Inert. Do Not Insert in Metal Tubes. Beware of Contamination. High Temperature. Common Use in Glass Industry.	B
None Established	+ –			No Standard Use American Color Code				Vacuum, Inert, Hydrogen. Beware of Embittlement. Not Practical Below 399°C (750°F) Not for Oxidizing Atmosphere.	G▾ (W)
None Established	+ –			No Standard Use American Color Code				Vacuum, Inert, Hydrogen. Beware of Embittlement. Not Practical Below 399°C (750°F) Not for Oxidizing Atmosphere.	C▾ (W5)
None Established	+ –			No Standard Use American Color Code				Vacuum, Inert, Hydrogen. Beware of Embitterment. Not Practical Below 399°C (750°F)–Not for Oxidizing Atmosphere.	D▾ (W3)

++Except as further restricted by temperature limits for T/C diameter and insulation tables that follow. ▾Not official symbol or standard designation.

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13.2. TC-2 Curing and Firing (for Hot Zone with Graphite)

The compound TC-2 is applied to certain types of Heat Shield assemblies used in IPSEN furnaces. The TC-2 must be initially cured and fired because of the inherent out gassing qualities. The following procedure describes the method to accomplish the curing and firing before using the furnace for processing product:

- Evacuate the chamber as low as possible with the roughing pump only
- Program the heat cycle with a ramp rate of 100° to 200°F/hour to a soak point of 50° to 100°F above the highest furnace operating temperature, for a soak duration of one (1) hour. The slower ramp rate gives the best result.
- No further out gassing of TC-2 should occur
- Depending on the size of the chamber, it may be necessary to change the roughing pump oil
- The TC-2 gives off organic binder decomposition products that have a varnish-like coating on interior cold surface
- This coating can be wiped off with MEK, acetone or a similar solvent

13.3. Temperature Uniformity Survey

13.3.1. General

This section provides the procedures to be used to determine temperature distribution within vacuum heating equipment. This procedure meets or exceeds the requirements of MIL-H6875G.

13.3.2. Procedure

Survey thermocouples must be used in conjunction with a precision instrument with total instrument accuracy of +2°F. Total instrument accuracy is the maximum error attributable to the instrument's capability.

Type K 20 Ga. thermocouples with vitreous silica fiber insulation (Ipsen part number S776-7405) shall be used for the survey. To prevent the vaporization of chromium in "K" thermocouples, 100 microns partial pressure of inert gas shall be used above 1800°F. These thermocouples shall be used only once above 2000°F. Type B thermocouples in a molybdenum sheath with BeO insulators shall be used above 2300°F. In no case shall grounded thermocouples be used. All thermocouples shall have a welded type hot junction.

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WARNING

BeO (beryllium oxide) is carcinogenic in a powder form. Dispose of the insulation carefully if a sheath is broken.

13.3.3. Calibration of Thermocouples

All test thermocouples must be calibrated against an NBS certified thermocouple. All test thermocouples and the standard must be bundled so their hot junctions are in the same vertical alignment. The bundle shall be placed in a thermocouple calibration furnace and the temperature of the test and standard thermocouples will be read after they reach thermal equilibrium at the upper, middle, and lower temperatures of the range at which they will be used. If a calibration furnace is not available, the furnace to be certified may be used. In either case the bundle will be placed as close to the furnace control thermocouple as possible.

NOTE

To determine uniformity about the actual control thermocouple temperature, it is necessary to certify the control thermocouple also. A roll of thermocouple wire may be calibrated by checking one thermocouple from the beginning and end of a roll. Provided the correction factor does not vary by more than +1°F, all thermocouples from this roll will be considered calibrated. If the correction factor is not consistent, each thermocouple must be calibrated against the standard. This is the preferred method of thermocouple calibration.

NOTE

Certified rolls of wire, calibrated at designated temperatures, are available for purchase.

13.3.4. Certification Procedure

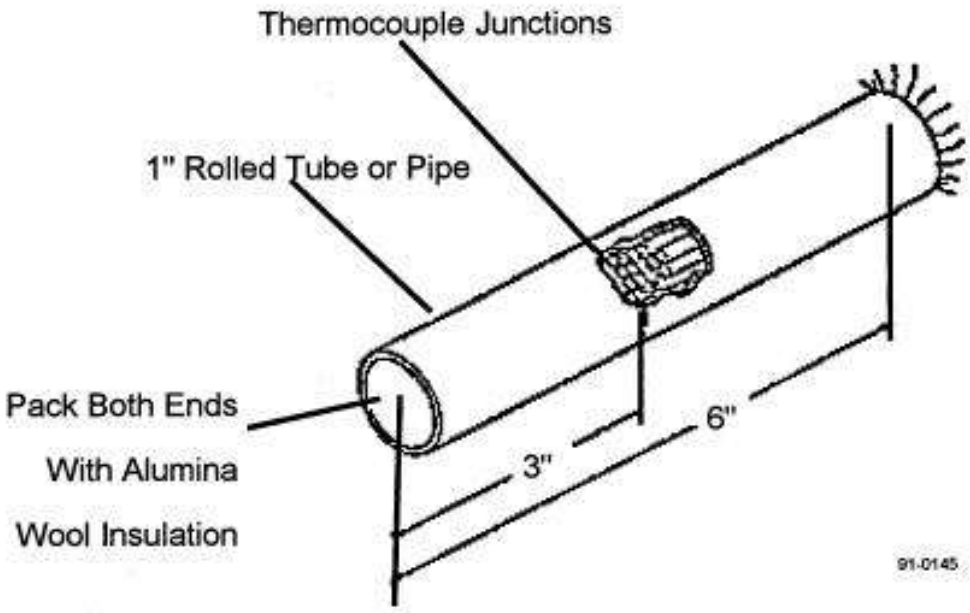
Nine thermocouples shall be distributed as shown in Figures 12-3 and 12-4. Furnaces with less than 10 cubic feet of volume will require three T/C's, located at the front, middle and back. Thermocouples more than nine shall be distributed symmetrically throughout the effective work area. The test thermocouples should be placed into 1/2" OD test slugs (1018 or equivalent) as shown in Figure 12-2. The test slugs should be attached to baskets or fixture that will locate the thermocouples on the perimeter of the effective working area. The use of thermocouple extension wire inside the furnace should be avoided. If such use is unavoidable, do not exceed the wire manufacturer's temperature specifications. Location of test slugs on the fixture will provide consistent location of thermocouples and prevent direct radiation on thermocouple hot junctions. Temperature shall be recorded every two minutes to detect any overshooting. After thermal equilibrium has been reached, temperature may be recorded at intervals up to 5 minutes.

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The correction factors determined during thermocouple calibration and/or as supplied by the thermocouple manufacturer will be applied to the average of five (5) readings taken at one (1) minute intervals at the end of thirty (30) minutes at equilibrium to determine furnace uniformity.

A temperature uniformity survey fixture is available for purchase through the IPSEN aftermarket sales.

Figure 13-1. Thermocouple Bundling Technique



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Figure 13-2. Thermocouple Hot Junction Fixture

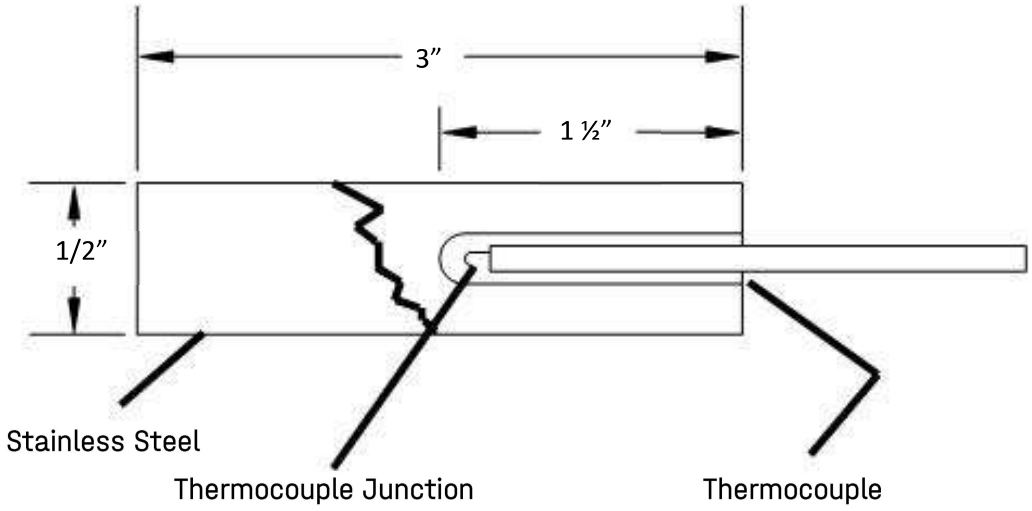
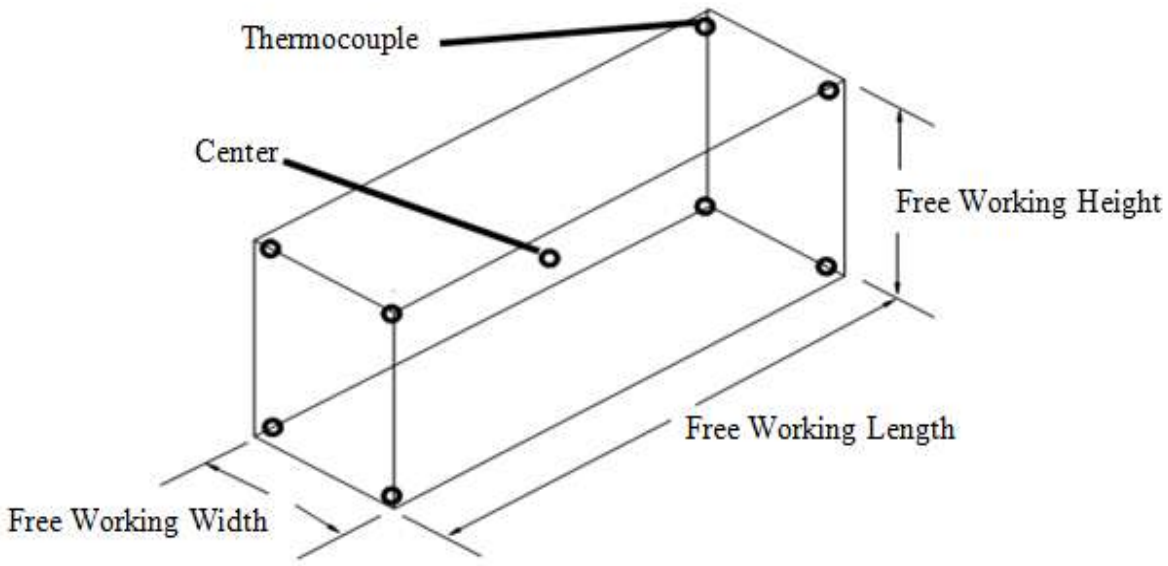
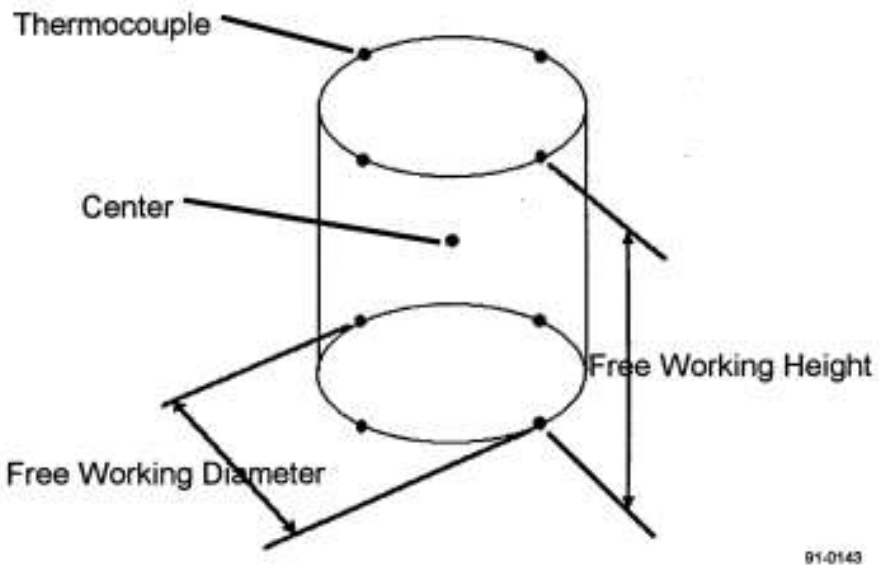


Figure 13-3. Thermocouple Location in Rectangular Hot Zone



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Figure 13-4. Thermocouple Location in Cylindrical Hot Zone



13.4. Cooling Fan Motor

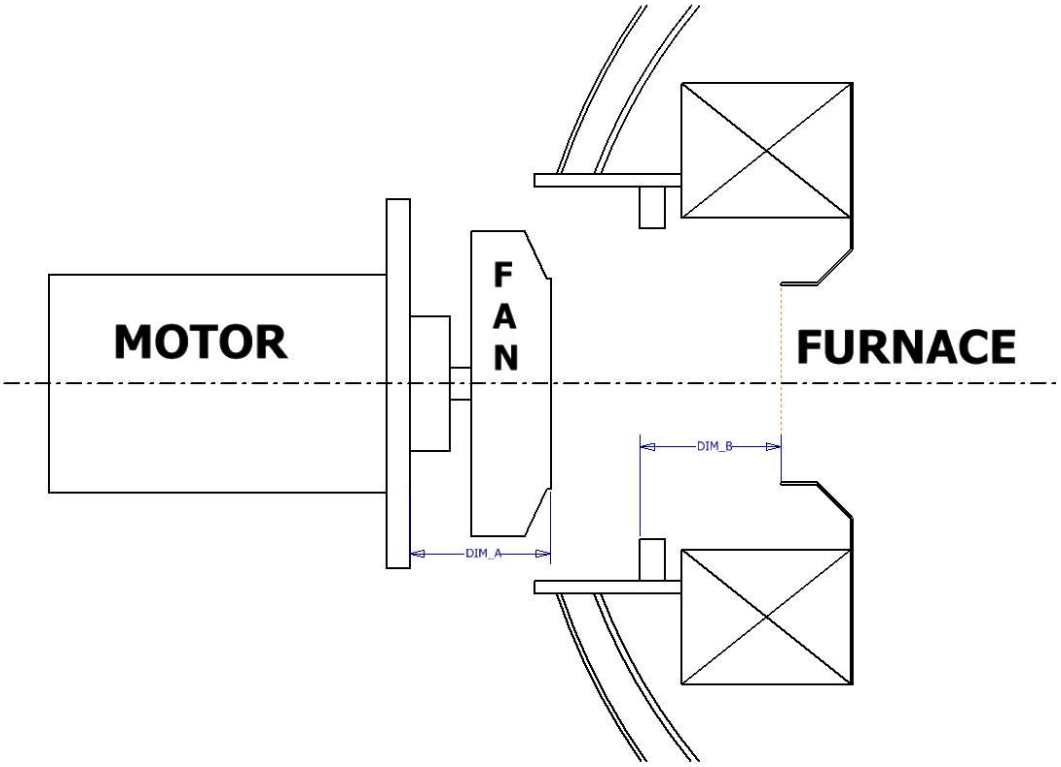
The following is intended to be a guide when assembling cooling motor and fan assemblies for horizontal Ipsen furnaces. It is important to follow this procedure to avoid costly problems:

- Check that fan and motor have been balanced
- Determine the correct positioning of the fan on the motor shaft
    - Dimensions on drawings showing fan positions on motor shafts should be verified in every case (refer to the diagram below for this procedure)
    - To find DIM_A, the correct position of the fan on the motor shaft, first measure DIM_B, then calculate DIM_A = DIM_B + ¼ inches
    - The end of the fan should overlap the baffle inside of the furnace by ¼ inches (if no overlap is made, a short circuit will occur)
- Assemble fan and motor with corresponding mounting brackets, bushings, seal and so on using the proper DIM_A (as found above)
- Tighten the set screws on the fan hub

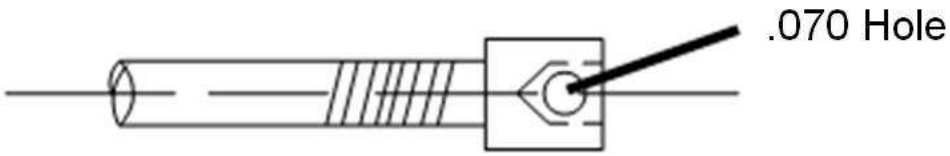
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- Tighten bolts in fan hub (the bolts in the hub must be socket head cap screws with a .070-inch diameter hole drilled, as shown below)
    - Apply anti-seize to hub bolt threads
    - Use a torque wrench to tighten bolts (unless otherwise specified, each bolt must be torqued to 30-foot pounds or 360-inch pounds)
    - Tighten bolts ½ turn maximum at a time, alternating from bolt to bolt



- Check for proper fan location on shaft after hub bolts are tight (if fan is not in correct position, loosen the hub approximately 1/16 inches, reposition fan and repeat previous steps)
- After the fan is on the motor shaft at the correct position, and after all hub bolts are properly torqued, all hub bolts are to be safely wired together using .060-inch diameter carbon steel wire (stainless may be substituted)

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13.5. Glossary of Vacuum Terms

A

Absorbent – Material which absorbs gas.

Absorption – Binding of gas in the interior of a solid or liquid.

Atmospheric Pressure – Pressure exerted by the earth's atmosphere on the surface of the earth (sea level) at 58°F equal to 14.696 lbs./sq. inch. Also equal to the pressure exerted by a column of mercury 760 mm high (or 30" high) at 58°F.

C

Conductance – A measure of a system or a component to handle a "flow" of gas at vacuum pressures. It is analogous to conductivity of an electrical circuit in that high conductance is desirable and represents low "losses" and more efficient use of the pumping system.

Cold Wall Vacuum Furnace – Furnace in which the work, insulation and heating elements are all within a water-jacketed vacuum vessel.

D

Degassing – Deliberate removal or gas from a material – usually by applying heat under vacuum.

Desorption – Process of removing absorbed gas.

Deviation Event – A programmed event used to keep the process within specified limits.

E

Evacuation – Pumping down or removing gases from a closed system vessel (or container) by means of a pumping system.

Evaporation Rate – Mass of material evaporated per unit time from a unit of surface of solid or liquid.

Event – A programmed function that will be initiated at a specific point in the process.

G

Gas – In vacuum technology, refers to the noncondensable gas and vapor within a vacuum system.

Gas Ballast – The venting of the compression chamber of a mechanical pump to the atmosphere to prevent condensation of condensable vapors within the pump.

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H

Hot Wall Vacuum Furnace – Furnace in which work is within vacuum and heat is applied through the wall of the vacuum chamber, such as a retort.

L

Leak (Actual) – In vacuum technology, a hole or porosity in the wall of a vacuum chamber capable of admitting gas from the outside of the vessel to the interior

Leak (Virtual) – The semblance of a leak in a vacuum system (with respect to pressure) caused by a slow release of gas from a substance unstable under vacuum (see out-gassing).

Leak up Rate – Rate at which the pressure rises within a static vacuum system with respect to time, expressed in microns/hour.

M

Micron of Mercury – A unit of measure equal to 1/1000 of one millimeter of mercury pressure absolute ($1x10^{-3}$ Torr).

Millimeter of Mercury – A unit of pressure corresponding to a column of mercury one millimeter high at 58°F (abbreviated: mmHg).

Multi-Point Recorder – Used with survey or work thermocouples to provide a documented record of furnace surveys and/or actual temperature of parts in process.

N

Noncondensable Gas – A gas heated above its critical temperature so that it cannot be liquefied by the increase of pressure alone.

O

Out-gassing – Spontaneous evaporation of a gas from a material in a vacuum (see leak, virtual).

Over-Temp Controller – An instrument used to set a temperature limit for the furnace.

P

Partial Pressure (Vacuum) – Pressure exerted by the quantity of gas in a vacuum vessel as measured by a vacuum gauge.

Pressure – In a vacuum, a measurement of the density of the gas in the chamber and is usually expressed in microns (of mercury) or Torr.

Process Variable Event – A programmed event that will be initiated when the process variable (temperature) is above a pre-determined level (partial pressure).

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Program – A set of instruction used to control a machine or process.

Programmable Logic Controller – (PLC) A control system with a user programmable memory, a control processor, and I/O boards.

Pump-down – The evacuation of a vacuum chamber.

Pump-down Time – Time required to pump a system from atmospheric pressure to a specified vacuum pressure.

R

Ramp Rate – A programmed rate of temperature rise within the furnace from one temperature level to another.

Roughing – The initial phase of pump-down during which the "roughing" pump evacuates the chamber from atmospheric pressure.

S

Soak Duration – A programmed time-frame that the process will remain at a soak point.

Soak Set Point – A programmed level of temperature within the furnace. Timing will begin when process reaches programmed level.

Soak Set Point (Guaranteed) – Timing will not begin until the furnace temperature is within specified limits of the programmed temperature.

Sorption – Taking up gas by absorption or adsorption, or a combination of these processes.

Survey – A procedure which monitors the temperature in the work area to determine the temperature profile (Temperature Uniformity).

T

Timed Event – A programmed event that will be turned on and off at a specified time (time based events must have an ON and OFF time).

Temperature Recorder – Used with the digital control programmer to provide documented records of the furnace temperatures.

Torr – Unit of pressure equal to 1000 microns or one mmHg.

U

Ultimate Pressure (Ultimate Vacuum) – The limiting low pressure approached after sufficient pumping time has elapsed to establish that further reductions in pressure will be negligible.

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V

Vacuum* – In vacuum technology, refers to a given space filled with gas at less than atmospheric pressure.

Vacuum Gauge – An instrument used to indicate level of vacuum. Indicates in inches of Mercury, Microns and Torr.

Vacuum Heat Treatment – Heating of material in a vacuum furnace without melting. Some of the heat treating processes include cleaning and brightening, degassing, annealing, sintering, brazing, hardening, tempering and age hardening.

Vacuum Pumping System – All vacuum pumps, manifold or pipelines, vacuum valves, cold traps, and vacuum gauges.

Vacuum Recorder – Used with the vacuum gauges to provide documented levels of vacuum.

Vacuum System – A chamber or vessel having walls capable of withstanding atmospheric pressure and having an opening through which gas can be removed to a pumping system. The pumping system may, or may not be considered a part of the vacuum system.

Vapor – Gas that is below its critical temperature so that it can be condensed to a liquid or a solid state by an increase of pressure alone.

Vapor Pressure – Pressure exerted when a solid or a liquid is in equilibrium with its own vapor. Vapor pressure of a substance is a function of the temperature to which it is exposed.

**Various terms are commonly used to define the degree of vacuum in a vessel. The degree of vacuum may be expressed in terms of the pressure inside of the vessel, or directly in terms expressing the vacuum within the vessel. It should be remembered that the lower the pressure, the higher the vacuum. Expressions such as high vacuum, hard vacuum, great vacuum, etc., indicate very low pressure within the vessel.*

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14. Vendor's Documentation

The following vendor documents are provided with this manual. They contain important information about the purchased components that comprise the furnace:

Analog Output Module

Capacitance Manometer

Current Transducer

Door Closure Maintenance

Graphite Adhesive Application

Manual Motor Starter

Motor

Operator Interface Terminal

Pirani Gauge Tube

PLC Analog Input Module

PLC CPU

PLC Input, Output Module

Power Controller

Power Supply - OIT

Power Supply - Vacuum Pump/ Control

Pressure Sensor

Pressure Switch - Chamber Overpressure

Pressure Switch - Chamber Pressure Transducer

Pressure Switch - Chamber Pressure

Pressure Switch - Water System - High Pressure

Pressure Switch - Water System - Low Pressure

Roughing Pump

Temperature Limit Controller

Transformer – Control Cabinet

Transformer – Furnace Electrical

UPS Universal Power Supply - OIT

UPS Universal Power Supply – PLC Rack

Valve Actuator

Valve

Variable Frequency Drive

Voltmeter

Water Pressure Relief Valve

These documents are not intended to supplant, conflict with, or exclude any individual manufacturer's recommendations for non-Ipsen equipment. Always read the latest manufacturer's manual online in full and follow their recommendations. Contact Ipsen Service with questions.

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15. Reference Drawings

The following reference drawings are supplied to support your Ipsen Atmosphere Furnace System:

Phase	Title	Number	Links	
100A	Hot Zone Assembly	2468	Drawings	BOM
100B	Refractory Assembly	2468	Drawings	
200	Tank Assembly	2468	Drawings	
400	Pumping System Assembly	2468	Drawings	
500	Water System Assembly	2468	Drawings	
500S	Water System Schematic	2468	Drawings	
600	Gas System Assembly	2468	Drawings	
800	Electrical Schematic and Layout	2468	Drawings	
1200A	Pneumatic System Assembly	2468	Drawings	
1200B	Backfill System Assembly	2468	Drawings	
1200C	Hydrogen Purge Panel Assembly	2468	Drawings	
3300	Equipment Arrangement	2468	Drawings	

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