NUMBER 6 | VACUUM FURNACE REFERENCE SERIES

IMPORTANT CONSIDERATIONS When Purchasing a Vacuum Furnace

SOLAR

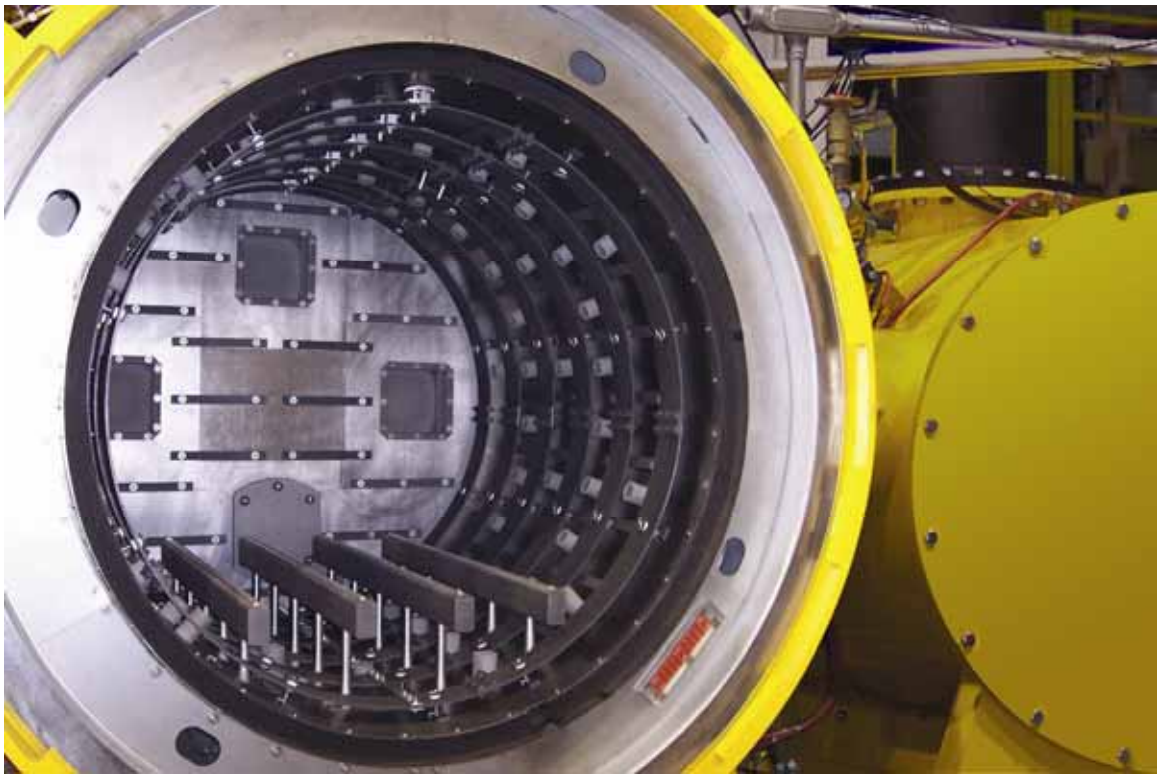
Important Considerations When Purchasing A Vacuum Furnace

There are many factors that should be considered when investing in a new vacuum furnace. Although price is obviously important, there are many detailed design and other technical considerations buyers should evaluate to ensure that they select the best equipment for their requirements.

A) HOT ZONE EFFECTIVE WORK AREA AND WEIGHT CAPACITY

1) **Effective Work Area** - The effective work area should be selected based on the maximum part or load size to be processed. Do not purchase a larger furnace than required as operating cost will escalate and result in an unacceptable situation for the economics of the investment. Also, remember that with a circular hot zone, wider or taller parts can be accommodated.

2) **Hearth Weight Capacity** - Normally, weight capacity of a furnace is specified based on maximum projected load weights that can be processed for a given work size and at a specific operating temperature. It is important that maximum load weight at a particular elevated temperature be included to assure proper furnace hearth design.



B) TEMPERATURE CONSIDERATIONS

1) **Maximum Temperature** – Most manufacturers rate their furnaces to operate up to 2400°F. Solar Manufacturing builds their furnaces with capability to operate up to 2650°F. This is important for clean-up cycles which help insure long term operation of the hot zone. Also, should a specific higher temperature requirement be necessary for a given process, the added temperature capability is available.

2) **Temperature Uniformity** – It is important to state complete operating uniformity across the furnace operating range as there could be applications for the lower ranges. Solar Manufacturing states the following for our furnaces:

    a) +/- 20°F, 300-600°F, Conforms to AMS 2750D, Class 4

    b) +/- 15°F, 600-900°F, Conforms to AMS 2750D, Class 3

    c) +/- 10°F, 900-2500°F, Conforms to AMS 2750D, Class 2

3) **Hot Zone Temperature Uniformity** – This is obviously dictated by insulation design and required openings necessary for various hot zone components and gas flow patterns. Some hot zone designs have difficulty meeting uniformity due to unacceptable gaps or openings especially on rear, baffled gas exit ports. **Also, due to the inconsistency of the heat losses from the front to the back of a hot zone, it is essential to have a minimum of three zones of heating for proper trimming and adjusting power input.**

C) HOT ZONE CONSTRUCTION

1) **Insulation Package** – Based on power loss studies for various insulation combinations, Solar Manufacturing has determined that the most acceptable insulation package consists of 0.040 Flexshield facing backed by 4 layers of ½" graphite felt all housed in a 0.090" thick 304 stainless steel support structure. **Some furnace manufacturers use carbon steel for their support structure which we have found, from many years of experience, will eventually lose its shape and become severely oxidized or rusted and cause moisture absorption within the furnace, especially during humid summer operation**.

    Note: For certain applications, especially for long cycles at elevated temperatures, we will add a fifth layer of graphite felt to further minimized hot zone losses and reduce power consumption.

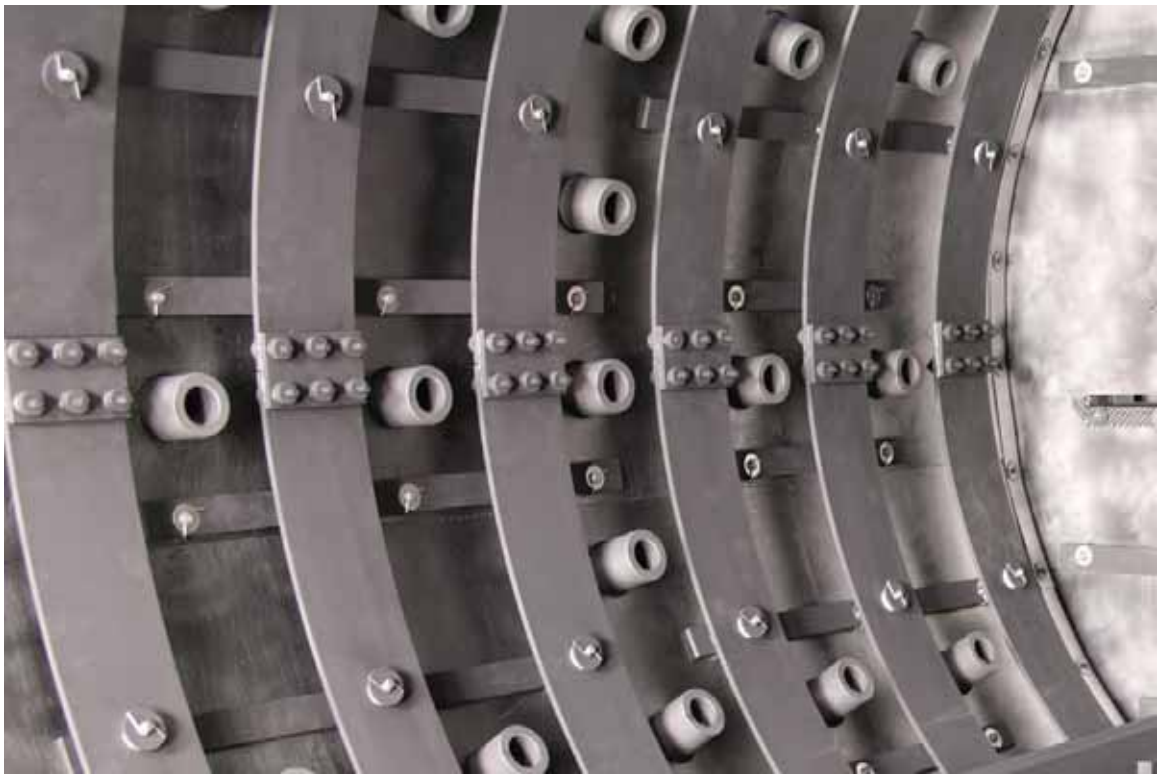
2) **Heating Elements** – Solar Manufacturing uses curved graphite type, ISO-63, resistance **balanced** and **matched** both on the original and replacement elements. It is most important that the elements be properly resistance matched to minimize potential temperature uniformity problems. **Some other designs use bar elements that have been roughly sawed from a solid graphite block resulting in non-uniform thicknesses. These often include a sharp bend or angle which could cause a stress point due to thermal expansion and contraction.**

3) **Work Support Rails** – These normally consist of heavy duty graphite rails supported by Molybdenum vertical members. The rails are top slotted to allow for Molybdenum rod inserts to minimize possibility of load contact reactions. Also, adequate clearance is provided under and between the rails for loading truck operation.

4) **Heating Element Insulators** – Solar Manufacturing uses a U.S. patented design with excellent and proven electrical isolating results. Insulators are protected from contaminating vapors. **Some other furnace manufacturers use molybdenum covers to protect the insulators. Our experience tells us that at elevated temperatures, this design will cause molybdenum vaporization resulting in serious insulation, metallization and short circuit problems.**

5) **Heating Element Indicators** – Solar Manufacturing provides front panel mounted current and volt meters for each heating zone of the hot zone. This allows for simple and easy proportional trimming when required on the furnace. **Some other furnace manufacturers do not provide these important indicators.**

6) **Ground Light Indicators** – Solar Manufacturing provides these indicators for simple service checking of elements and electrical hot zone insulators.



D) VACUUM PERFORMANCE FOR VACUUM FURNACES

The values and times stated below should be required and used for basis of establishing furnace performance:

1) **Ultimate Vacuum** – For a diffusion pumped furnace – ultimate vacuum will be in the 10-6 Torr range. For furnaces using mechanical pump/blower only combinations, ultimate vacuum will be 20 Microns Hg or better.

2) **Operating Vacuum** – With a diffusion pump, operating vacuum will be 10-5 Torr range. Without a diffusion pump, operating vacuum will be in the 50-60 Micron Hg range. **Other furnace manufacturers state higher operating ranges.**

3) **Pump-down Time To High Vacuum Cross-over** – approximately 10 minutes.

4) **Pump-down Time To 1 x 10-4 Torr** – approximately 15 Minutes. **Some other furnace manufacturers do not specify pump-down time.**

5) **Furnace Leak Rate** – less than 5 Microns per hour. It is most important that the leak rate on any furnace be specified and guaranteed for proper and clean operation.

E) VACUUM SYSTEM COMPONENTS

1) **Mechanical Pump** – Although there are several available manufacturers, Solar Manufacturing highly recommends Stokes Mechanical Pumps. This is primarily because they are designed in the U.S. and provide a much larger oil reservoir on the pump. The larger reservoir greatly improves operation during hot and humid days where water vapor is of great concern and must be removed via the mechanical pump. **Other brands of pumps will not perform as well under these conditions.**

2) **Vacuum Blower Pump** – Again, we recommend Stokes for their U.S. design and proven reliability.

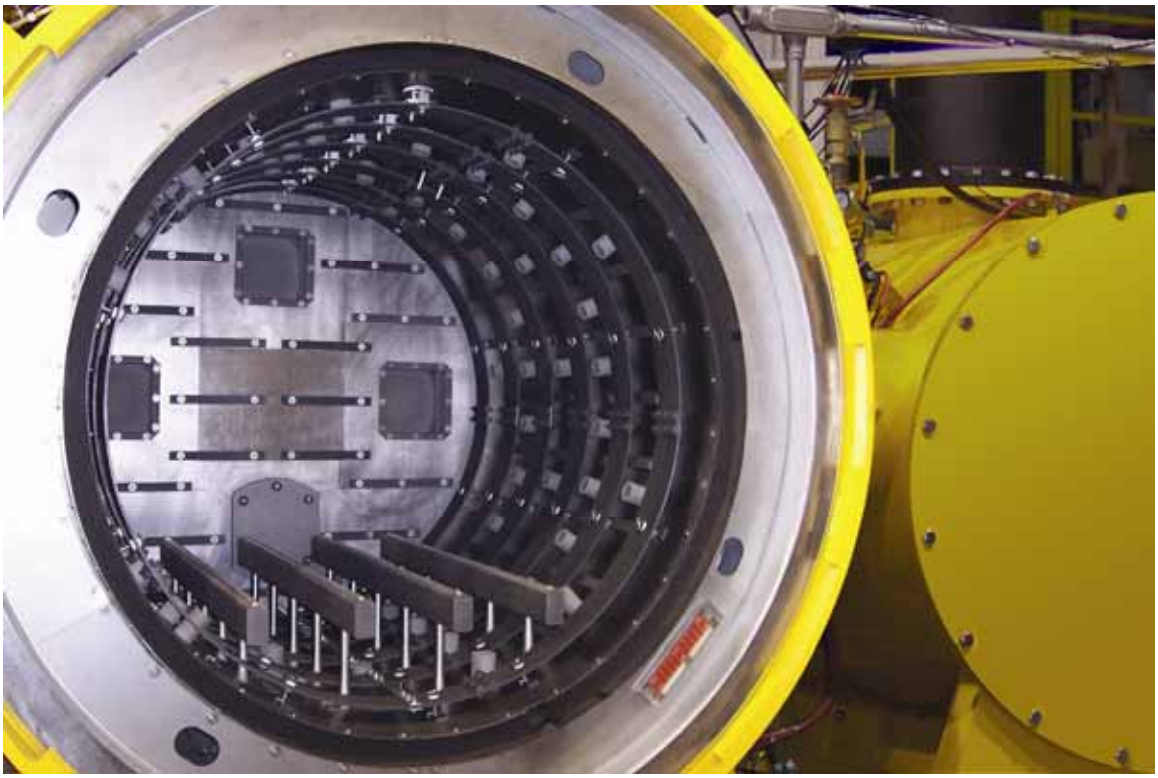
3) **Diffusion Pump** – We prefer to use diffusion pumps made in the U.S. and recommend Varian as the manufacturer. They have been in the industry for many years and are highly respected for their equipment and performance.

4) **Main Vacuum Valve** – poppet, right angle type.

5) **Vacuum Roughing Port** – Solar furnaces provide direct pumping to the chamber. Although this means an extra port on the furnace chamber, it provides direct pumping access without going through the diffusion pump high vacuum valve.

F) FURNACE CHAMBER DESIGN

1) **Basic Construction** – The chamber is manufactured using A36 Grade Steel and built to conform to ASME Code Section 8. It includes a standard double wall design allowing for proper water circulation throughout the main structure and heads.



2) **Chamber Door Design** – Solar Manufacturing uses an autoclave-type design with a rotating ring and standard Buna-N type O-rings. Protective shields are provided on the autoclave movement for personnel safety concerns. The door is operated manually and allows the operator to see what is happening as the door is closed. **Other designs incorporate a powered door which can be useful but could be a personnel safety concern. They also use a rotating door seal which could be subject to dirt collection and seal failure. This design also makes it very difficult to replace the seal.**

G) GAS COOLING SYSTEM

1) **Internal/External** – Solar Manufacturing builds both types of cooling systems. There are plusses and minuses with each design. The external cooling system provides for easier access to the heat exchanger and drive motor but does use additional floor space. Our internal gas cooling systems are all housed within the vacuum confines and eliminate the need for any drive motor shaft rotating seals. **Rotating seals are subject to leaks, early failure and are very difficult to replace. We also use a standard model drive motor.**

2) **Step-down Transformer** – We use this 460V-to-230V transformer to minimize possibility of arcing problems with a 460 Volt motor.

3) **Gas Nozzles** – Solar Manufacturing uses machined tapered graphite nozzles through-out the main section of the hot zone and the front door. These very rugged nozzles are tapered to accelerate gas flow and are easily removable if one has to be replaced. **Other designs use round Molybdenum sheet formed types which tend to lose their shape after a short time becoming brittle and nearly impossible to replace.**

H) POWER SUPPLY

1) **Power Supply Type** – Solar Manufacturing normally uses a SCR type dry power supply with power trim controls within the control cabinet. **Other equipment often includes a VRT water cooled type power supply. Although both systems perform satisfactorily for given applications, the dry system eliminates the possibility of water contamination and any resulting flow problems within the power transformer.**

I) ELECTRICALS AND CONTROLS

1) **Control Cabinet** – Solar Manufacturing prefers to house electrical controls in one standard 6’ x 6’ Standard NEMA 12 Cabinet which meets NFPA 70 Standard and includes an integrated main electrical switch interlock. **Other designs often split the controls into many, various smaller cabinets thus making it more difficult to co-ordinate operation and trouble shooting.**

2) **Controls and Instrumentation** – to simplify the operation and capabilities of our vacuum furnaces, we developed the SolarVac™ 4000/5000 systems of controls. Both incorporate “user friendly” touch screen capability to continually control and monitor furnace status and operation. Allen-Bradley PLC equipment is provided with other front panel mounted instruments including a programmable controller, an over temperature controller, a paperless graphic recorder and a vacuum gauge controller, all housed within one cabinet. **Other designs provide similar equipment, but usually use Siemans Type PLC systems which we have found to be much more difficult to program and modify. Other systems also often do not include auto tune or PID down-load features which are very desirable for broad range temperature control.**

3) **Thermocouples** – We, and most other manufacturers, have standardized on Type “S” thermocouples for control and over temperature. Usually Type ”K” thermocouples with appropriate jack panels are included for work monitoring and survey.

J) OTHER CRITICAL AREAS

1) **Gas Backfill Valve** – Solar Manufacturing uses a standard ASCO-type valve. It is important to specify this for proper gas backfill considerations and reliability.

2) **Partial Pressure Operation** – Proper control of partial pressure is most important on many process cycles. Our furnaces are designed for auto-control from 500 Microns Hg to 10 Torr. **Equipment from other manufacturers often limits control to 1 Torr. Control above 1 Torr is important on processes where it is desirable to reduce chrome and copper evaporation at process temperatures over 1800°F.**

3) **Water Cooling Requirements** – Any equipment specification should state the required rates of water flow required during heating and cooling segments of a cycle. Pressure regulators should be included on furnace and supporting piping. Also, water flow sight indicators should be provided on all critical lines.

4) **Heating and Cooling Rates** – The time to heat the empty furnace from ambient to 2000°F should be stated. We normally specify 5 minutes. In addition, an empty furnace cooling rate should be defined. We normally state a 5 minute time from 2000°F to 200°F.

5) **Short Circuit Current Rating (SCCR)** – It is important that the furnace shall be designed and rated to accept possible short-circuit current plant conditions.

Installation of electrical equipment that has a short circuit rating (SCCR) lower than the available fault current of the electrical service is both a safety hazard and a violation of National Electrical Code.

K) PRE-SHIPMENT TESTING

Every furnace must be manufactured to fully meet customer requirements and expectations. These requirements are normally written in an “Equipment Specification” document which becomes part of the overall purchase order documentation.

The specification should not only highlight the various required hardware components but also highlight the overall performance expected of the equipment.

In order to demonstrate that the furnace will perform as expected by the customer, Solar Manufacturing does a thorough and complete test of the system. These tests include:

1) **Complete electrical check-out and “debugging” of all related components and systems.**
2) **Heating of equipment to demonstrate optimum heating temperature (bake-out).**
3) **A complete Temperature Uniformity Survey (TUS) to illustrate uniformity throughout the hot zone.**
4) **A gas cooling demonstration to confirm cooling rates required of the furnace.**
5) **Other specific tests required by the specifications.**

Please note that many manufacturers are unable or reluctant to perform these tests prior to shipping the equipment.

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