INDUCTOTHERM GROUP

Vacuum Aluminum Brazing and Vacuum Deoiling Furnaces

CONSARC

VAB Process

Vacuum Aluminum Brazing (VAB) is a process in which two aluminum base metals are joined using a third filler metal with a melting point below that of the base metal. The filler metal - often referred to as the “braze alloy” - is melted in a high-vacuum environment and drawn into the space between the base metal via capillary action. The process demands tight control of temperature uniformity together with low vacuum leak rates and high repeatability. VAB produces components with very clean, high quality, and high-strength brazed joints without any residual corrosive flux.

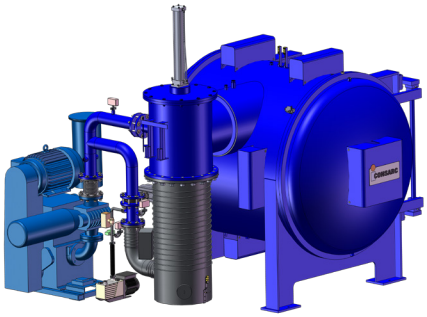
Vacuum Aluminum Brazing furnaces are designed for a range of high vacuum fluxless brazing applications such as:

- aerospace heat exchangers and fluid coolers
- automotive radiators, evaporators, condensors, and oil coolers
- electronic cold plates
- microwave components
- cryogenic heat exchangers
- petrochemical heat exchangers
- compressor oil coolers
- research and development

Consarc VABs are capable of adjusting the vertical and horizontal heat inputs to match thermal charicteristics of the work and fixture, accomplished through the use of multiple “trimmable” heat zones. Closely-spaced ribbon heating elements with edges facing the work provide optimal heating charicteristics. This design permits the work load to be located closer to the elements, resulting in more usable space in the hot zone and higher throughput.

All Consarc aerospace furnaces can conform to AMS2750 standards if necessary, with Class 1 temperature uniformity Type B instrumentation that enables uniformity surveys within +/-5°F (3°C).

VAB Furnaces



Consarc offers a wide range of standard Vacuum Aluminum Brazing furnace designs for a variety of applications, and offers the flexibility to design for bespoke and individual customer requirements. The tables below outline many common furnace configurations.

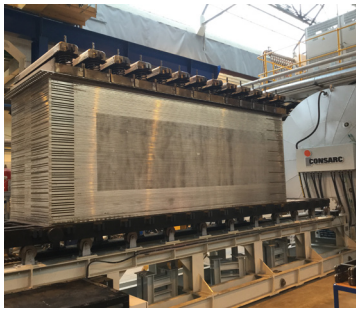
Different brazing applications may have other temperature control requirements that affect final qualified hot zone size. Contact Consarc for more information about furnace configurations and options.

STANDARD FURNACE SPECIFICATIONS

Model No.	Aerospace (Hot Zone Usable Space)		
	Height	Width	Depth
VAB 22-24-22	16” (405 mm)	18” (455 mm)	16” (405 mm)
VAB 28-34-36	22” (560 mm)	26” (660 mm)	26” (660 mm)
VAB 34-28-36	27” (685 mm)	20” (510 mm)	26” (660 mm)
VAB 36-41-60	28” (710 mm)	37” (940 mm)	54” (1370 mm)
VAB 41-36-60	33” (840 mm)	30” (760 mm)	54” (1370 mm)
VAB 53-46-60	44” (1115 mm)	40” (1015 mm)	54” (1370 mm)
VAB 48-40-100	42” (1065 mm)	36” (915 mm)	95” (2410 mm)

Model No.	Automotive (Hot Zone Usable Space)		
	Height	Width	Depth
VAB 73-2x21-144	50” (1270 mm)	2x15” (2x380 mm)	129” (3275 mm)
VAB72-2x22-99	60” (1525 mm)	2x18” (2x455 mm)	93” (2360 mm)
VAB 88-2x26-167	70” (1770 mm)	2x12” (2x290 mm)	144” (3630 mm)
VAB 88-24-157	64” (1640 mm)	17” (425 mm)	136” (3450 mm)

Model No.	Cryogenic (Hot Zone Usable Space)		
	Height	Width	Depth
VAB 75-61-264	60” (1525 mm)	48” (1220 mm)	248” (6300 mm)
VAB 109-83-341	79” (2000 mm)	71” (1800 mm)	311” (7900 mm)
VAB 98-71-305	83” (2100 mm)	59” (1500 mm)	275” (7000 mm)



Furnace Design

VACUUM PUMPING SYSTEMS

Consarc designs vacuum pumping systems to match the size of the furnaces and their corresponding charge loads. These systems are designed to achieve working vacuum in the low 10^{-5} torr (mbar) range.

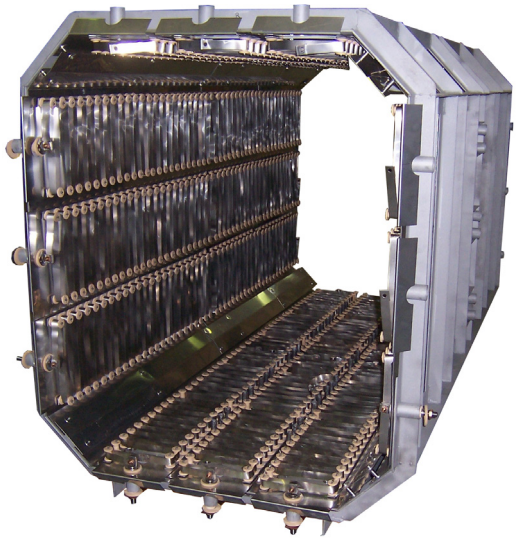
For superior vacuum performance, hot zone shields have gas passage louvers to permit easy escape of gases from the work assembly. Both the internal volume and surface areas of aluminum components must be evacuated of moisture vapor and air to ensure a high quality braze joint.

TEMPERATURE UNIFORMITY

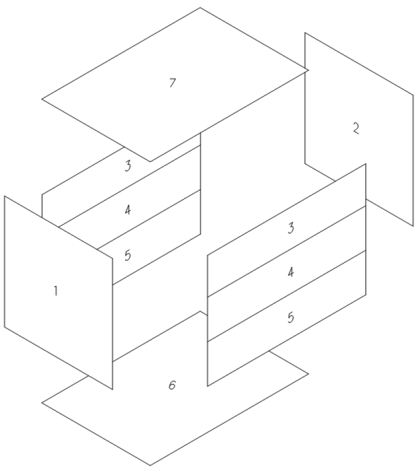
The shortest brazing cycles produce the best brazing results. It is essential that the rate of heat input in VAB furnaces is maximized while maintaining good uniformity.

Uniformity values of +/-5°F (3°C) across the work zone at brazing temperature are typical for this process. Uniformity is determined by the design of the hot zone heaters and the degree of accuracy of furnace instrumentation and controls.

To give full utilization of the hot zone space, most modern VAB furnaces are built with six sided heating element panels. Each side may also be sub-divided into multiple zones each with its own dedicated power supply and control loop. This gives the optimum design for fast and uniform heating of the workload.

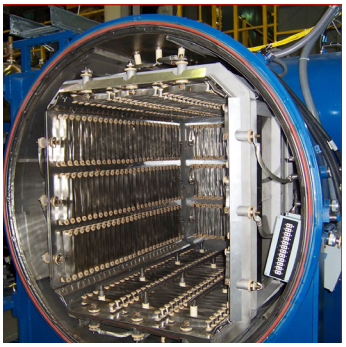


48" x 40" x 100" Hot Zone

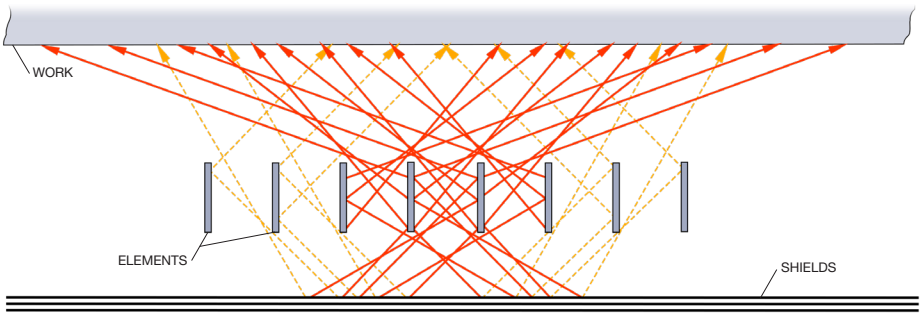


ZONE TRIMMING

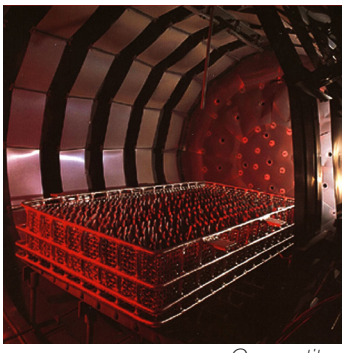
The use of multiple "trimmable" heating panels with individual power adjustments has been developed to allow for balance of heat input matching the workload and fixture thermal characteristics. Uniform heating is accomplished by adjusting the temperature profile both vertically and horizontally. Flexible hot zone control allows the heat input to be trimmed to match components/charge loads of varying height, resulting in faster heating, more uniform temperatures and uniform brazing in the work assembly.



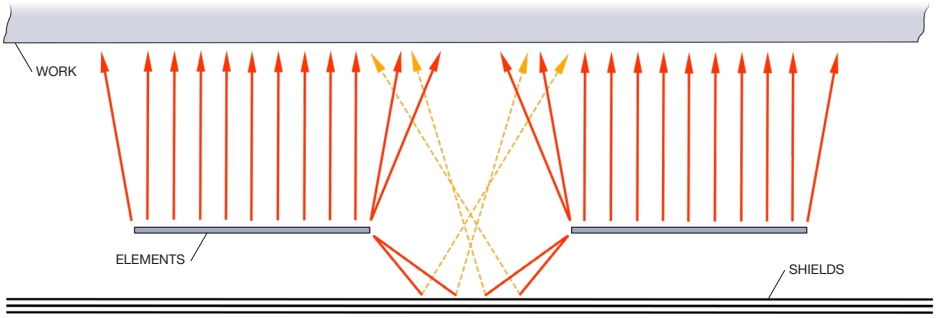
Consarc



RIBBON ELEMENT - FACING EDGE



Competitor

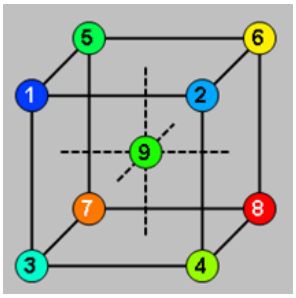


RIBBON ELEMENT - FACING FLAT

TEMPERATURE UNIFORMITY CONTROL

The Consarc heating element design (wound nickel element on edge) offers more lines of radiation to the workload - both sides of the elements radiate towards the work. Reflected energy from the heat shield can pass between the elements to the work with little obstruction.

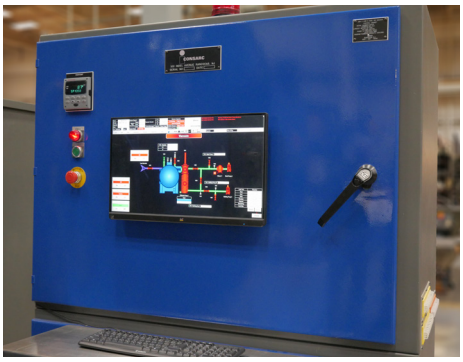
The Hot Zone is designed with individual modular heating element racks mounted in a removable frame. The element racks are arranged and powered to produce individually “trimmable” heating zones to guarantee optimum temperature uniformity.



TUS Rack HMI Display

Controls & Automation

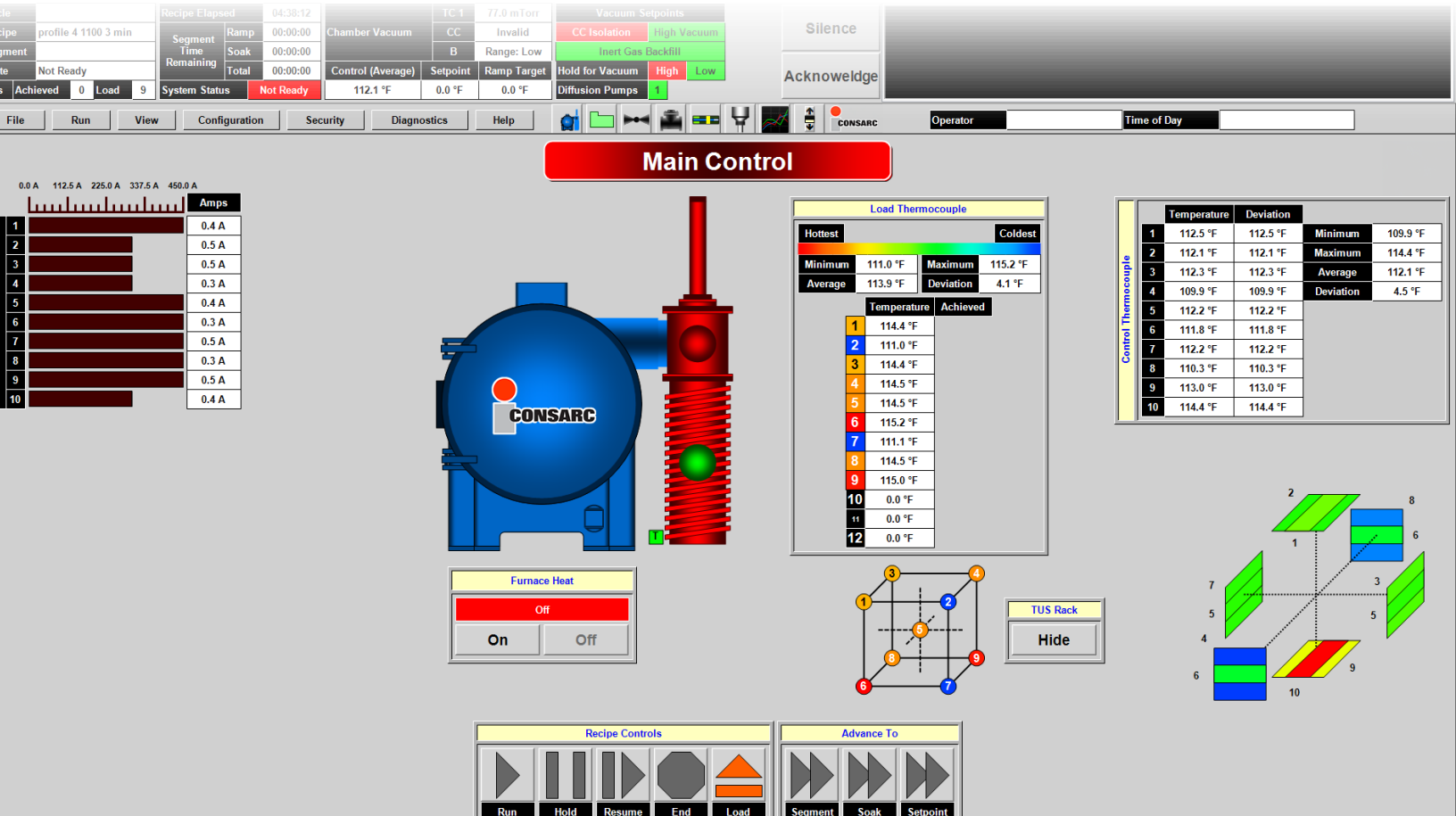
All Consarc furnace installations are supplied with a fully integrated and interlocked control system for safe and efficient operation of the furnace. Modern Vacuum Aluminum Brazing furnace controls are also fully automated. The braze cycle is carried out by recipe-driven schedules that are optimized to the individual component being brazed.



Consarc has developed and implemented the latest generation of controls into every VAB furnace. These controls incorporate a full Supervisory Control And Data Acquisition (SCADA) package which reports and records all pertinent data required by the latest pyrometry systems. All data is electronically archived on the system's hard drive. Consarc control systems can also be connected to a customer's factory network for data transfer and management.

The Human-Machine Interface (HMI) PC is a graphical touch screen or mouse-driven system which allows control of all systems and design of new braze cycles. A wide range of customization options are availabile to operators for ease-of-use. Operating alongside the HMI is a fully-integrated Programmable Logic Controller (PLC) with a full compliment of safety interlocks to prevent unintended operation of the VAB furnace. Along with sensors and switches in critical components of the furnace, this arrangement provides the end user with the most capable vacuum aluminum brazing equipment on the market today.

Below: VAB Main Control Screen



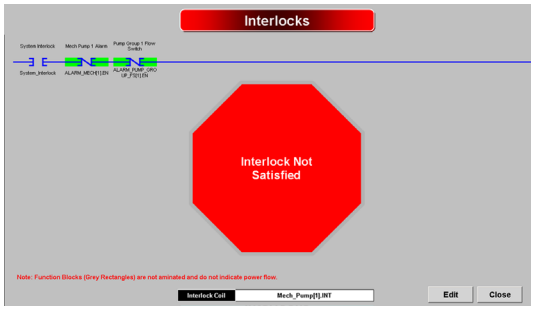
TEMPERATURE CONTROL FOR LARGE HEAVY LOADS

Large-batch VAB furnace systems, like those used for brazing large petrochemical heat exchangers, have fully-automated heat zones that utilize a continuously-calculated offset system that analyzes workpiece thermocouples on the skin and body of the core being brazed. The software calculates and defines the temperature needed for each individual heating zone panel, enabling the core to heat as rapidly as possible during each scheduled step.

The automated sequence continuously verifies that workpiece thermocouples are operating properly. In the event of a thermocouple failure, an error message is issued, and the operator is given the option to switch to another functional skin thermocouple.

FAULT DIAGNOSIS

Vacuum furnace control systems are inherently complex, and it can be difficult and time-consuming to recover from fault scenarios. Modern Consarc VAB furnaces include simple fault-finding screens on the control system HMI. These screens indicate fault locations and conditions within the system that interfere with normal operation, enabling operators to quickly identify and correct issues. Furnaces also have built-in vacuum leak detection systems.

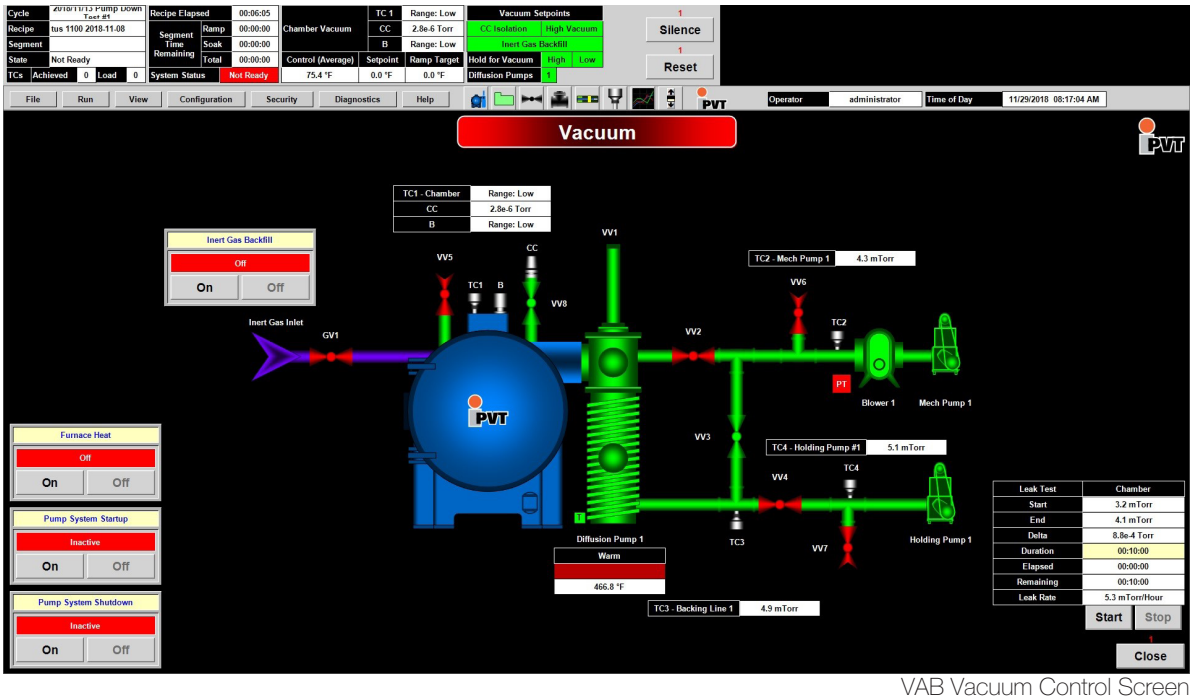


Example of fault condition indication

REMOTE SUPPORT

Real-time remote diagnostics and support is available on modern furnaces. This enables Consarc technicians to swiftly identify and address issues in real time, often eliminating the need for site visits and lengthy equipment downtime.

Remote furnace access



VAB Vacuum Control Screen

Additional Processes

COOLING SYSTEMS

To improve the cycle time of VAB or to anneal the components (T2 condition), fast cooling systems can be employed. There are several configurations available to achieve this, the most effective being a separate external cooling station with circulation fans used to pass high velocity air over the components. Components are removed from the furnace post brazing at a temperature below 950°F (500°C) and are placed into the cooling station. The heat transferred to the circulating air from the hot parts is recoverable and can be used for general building heating. Closed loop internal cooling systems with gas/water heat exchangers are also available.

Air Blast Cooling Station

TRANSFER SYSTEMS

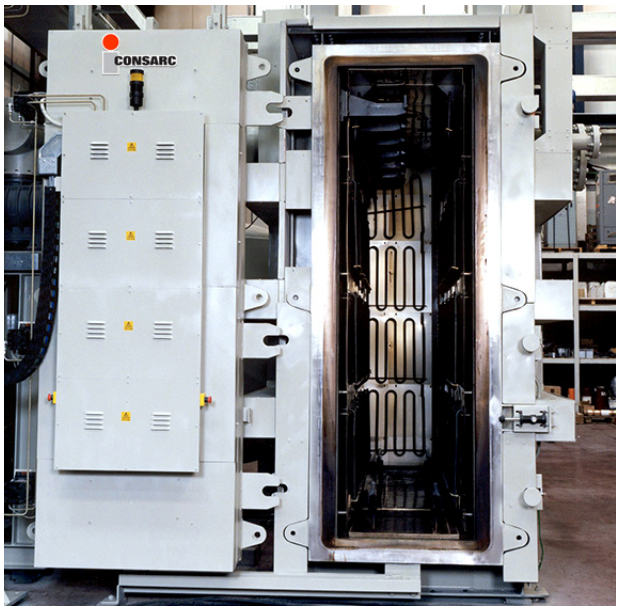
The degree of automation and complexity of the transfer system largely depends upon the size of the charge and the productivity requirements. For small, single chamber furnaces a basic, manually operated load stacker truck usually is sufficient to transfer loads in and out of the furnace. For very large and heavy loads, a transfer cart with hydraulic drive systems and rollers which align with serial rollers inside the furnace is the most practical solution.

When the charge must be moved between multiple stations and chambers, a fully automated transfer system consisting of transversing loading carriages with push/pull pusher chains and drives is required. This transfer system is controlled by its own PLC and HMI interface. This system is typically used for small to medium size components found in high productivity environments such as the automotive industry. These complex systems are typically developed by the customer or in conjunction with third-party material handling specialists.

VACUUM DEOILING

Removal of residual oils from aluminum components is an essential step prior to brazing. Traditionally, this was achieved with the use of chemical washes, such as trichloroethane and CFC-based solvents. These hazardous chemicals have since been phased out, creating a worldwide need for alternative deoiling processes.

Vacuum deoiling (VD) is an efficient alternative. The internal walls of the VD furnace are continuously heated to prevent condensation of oil vapors within the furnace. Furnaces can be fitted with specifically-engineered dry vacuum pump systems for removal of the oil, which can then be recycled. Vacuum deoiling has no requirement for waste water treatment, unlike aqueous cleaning processes.

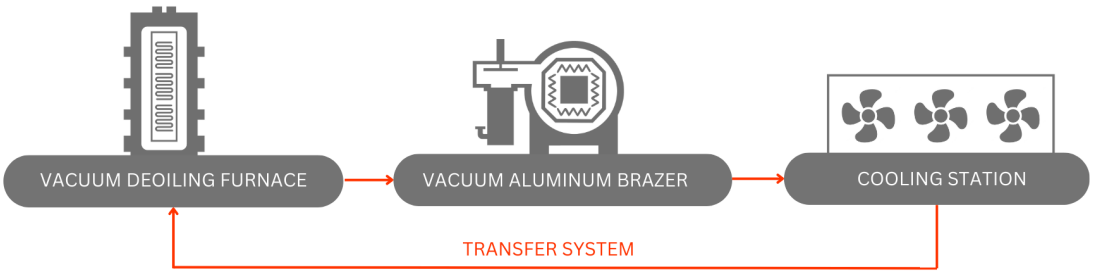


Vacuum Deoiling Furnace

Vacuum deoiling furnaces can be integrated with existing furnace installations and inline brazing systems.

HIGH-VOLUME MULTI-CHAMBER DESIGNS

In high-volume production environments such as the automotive industry, it is common for manufacturers to use two or three chamber steps for brazing aluminum parts under vacuum. The diagram below shows the product flow in a three station system, together with an automated transfer system for high volume manufacturing operation.



It is typical to have a VAB furnace in sequence with a vacuum deoiling furnace and cooling station. The vacuum deoiling furnace preheats the parts to 550°F (300°C), removing surface oil contamination. The parts are then transferred to the brazing furnace. Brazed parts are then passed through a cooling station, where forced-air blast cooling reduces the temperature of brazed parts from 550-950°F (300-500°C) to ambient temperature for unloading and finishing.

An inline three-station concept can significantly increase productivity by reducing brazing cycle time. Preheating parts at the deoiling stage also reduces energy consumption when brazing.

Solutions at every step

Primary Melting

Vacuum Induction Melting (VIM) is the first step in creating metals used in the most demanding applications. A VIM furnace incorporates an induction furnace within a vacuum chamber in order to prevent oxidation of volatile elements during the melting and refining stages. The end result of the process is a high purity metal with a homogenous chemical composition for use in secondary processing. Once molten and fully refined, the molten metal is passed through a preheated tundish for a final refinement before entering into ingots for further processing.

Masteralloy Vacuum Induction Melting Furnace (VIM)

Electrode Vacuum Induction Melting Furnace (VIM)

Secondary Processing

Remelting and casting are secondary melting processes used to further refine and improve the quality of materials produced from primary melting. During the remelting processes, a metal alloy ingot is melted in a controlled atmosphere environment to remove impurities and/or improve the macro and microstructure of the ingot or cast part, depending on the final application. The hallmark of secondary melting is not the melting but rather the controlled solidification which is what gives the final product its refined structure for use in high-temperature and high-stress applications.

Electroslag Remelting Furnace (ESR)

Vacuum Arc Remelting Furnace (VAR)

Vacuum Precision Investment Casting Furnace (VPIC)

Thermal Processing

Vacuum Aluminum Brazing (VAB) is a specialized process used to join aluminum components using a brazing alloy in a vacuum environment. Brazing is commonly used to join metal parts that are difficult or impossible to weld using traditional welding techniques. Other thermal processing options are also available from Consarc, designed to fit customers' specific process needs.

Vacuum Aluminum Brazing Furnace (VAB)

Vacuum Heat Treat Furnace (VHT)

Specialized Melting

Consarc offers a wide range of additional melting options. Inert Gas Atomization furnaces are used to produce metal powders with high purity and controlled particle size distribution. Vacuum Cap furnaces are versatile units capable of vacuum degassing and controlled-atmosphere melting operations.

Vacuum Inert Gas Atomization Furnace (VIGA)

Vacuum Cap Furnace (VCAP)

ONE SIZE DOES NOT FIT ALL

Considering a stock furnace option that doesn't meet your exact needs? Why not consider a custom designed Consarc furnace?

Our team of experts works with you to create tailored solutions that fit your unique requirements. We don't believe in a one-size-fits-all approach - every project is different, and we take the time to understand your specific needs before designing a furnace that meets them perfectly.

Our commitment to collaboration and flexibility set us apart from other furnace manufacturers. You'll have input every step of the way, ensuring that the final product is exactly what you need. Plus, our flexible approach means that we can adapt to changes and make adjustments as needed.

Experience the difference a custom Consarc furnace can make. Get in touch with us today!

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ABOUT CONSARC

For more than 60 years, Consarc Corporation (USA) and Consarc Engineering Ltd (UK) have been designing vacuum induction furnaces and engineering solutions for the world's most advanced materials. We believe in a partnership approach that is present through furnace design, testing, delivery, and comissioning, but it doesn't stop there. Consarc offers after-sales support for troubleshooting, process optimization, and spare parts.

In addition to a field engineering team, Consarc has a global technology team dedicated to advancing furnace technologies and optimizing machine performance. Our 'tech team' staff have far-reaching backgrounds in research and production of various materials, processes, and processing equipment. Many services are offered including full Technology Packages, melt profile development, process optimization, operator training, and metallurgical consulting.

In a world where everyone seems to be looking for a quick fix or an off-the-shelf solution, we believe that there's tremendous value in taking the time to do things right. Contact us today to learn more about our solutions and how they can benefit your business.

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