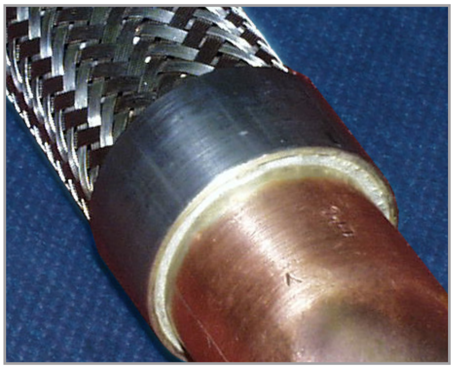
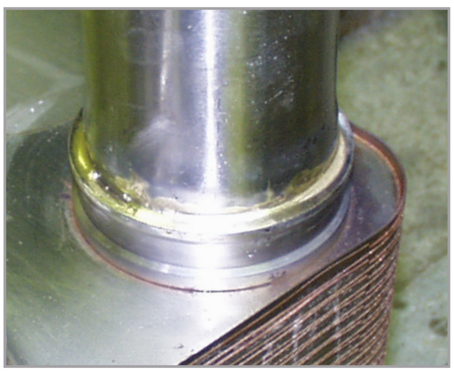
Ambrell®
INDUCTION HEATING SOLUTIONS
an inTEST Company

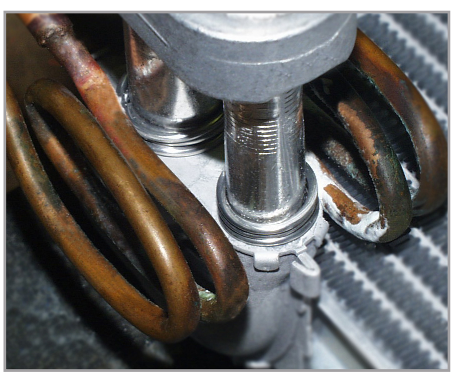
Precision Induction Brazing

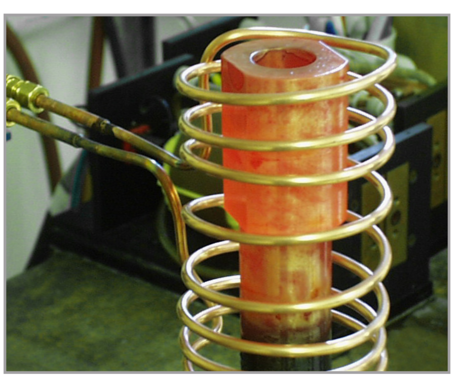
Experience the Excellence.™

Brazing is Ideal for Many Applications in Manufacturing.









What is Brazing?

Brazing is a process for joining two metals with a filler material that melts, flows and wets the metals' surfaces at a temperature that is lower than the melting temperature of the two metals. Protection from oxidation of the metal surface and filler material during the joining process is achieved using a covering gas or a flux material. Brazing and silver soldering are terms that usually refer to the joining process where the filler materials have a melt temperature above 400°C (752°F) to create a stronger joint.

Why Brazing?

The brazing process does not melt the base metals being joined yet produces strong robust joints. Brazing offers distinct advantages over other joining techniques:

- Similar and dissimilar metals can be brazed
- Brazing uses lower temperatures, resulting in less part distortion and joint stress
- Dimensional integrity of the finished product is easier to control
- Brazing produces strong low stress joints

Why Ambrell?

Induction heating is an ideal method for brazing. Ambrell has more than 18,000 systems installed in over 50 countries, and many of them are brazing application installations. It's our most common application that is used daily, worldwide, in many different industries.

We also offer exceptional customer service before and after the sale. Your specific brazing application will be analyzed and tested in the nearest Ambrell Applications Lab. There is no charge, and you will receive a system recommendation designed to deliver the best possible solution for your brazing requirements. Ambrell delivers the expertise, innovation and system quality to give your company a competitive edge.

Replacing Torch and Furnace Brazing with Induction Brazing

Torch brazing is the most common form of brazing today, but requires a skilled operator. However many manufacturers are finding it harder to find experienced brazing operators and the open flame raises regulatory and safety concerns in manufacturing plants.

Furnace brazing is another widely used technique. Manufacturing companies today are looking to improve production efficiency, reduce manufacturing costs and replace energy and space inefficient furnaces while improving product quality.

Induction addresses the issues of torch and furnace brazing by removing the requirement for a skilled operator, by reducing energy costs and by decreasing the equipment footprint while implementing a lean manufacturing process for higher quality parts.

Induction Brazing Offers Numerous Benefits

- Throughput: induction generates heat only in the portion of the part needed for brazing
- Better efficiency
- Better quality with less part distortion
- Repeatability: after the coil and heating process are defined, you can count on a precise, consistent quality braze every time
- Easy integration: into a lean manufacturing process
- Safety: no open flame or hot furnace
- Small footprint: Frees up valuable factory floor space

Induction brazing a brass mixing nozzle onto a twin feed copper tube for an oxyacetylene torch nozzle assembly. 6 kW at 380 kHz for 36 seconds to 732°C (1350°F).

Braze Filler Materials and Fluxes

The function of braze filler material is to provide a metallurgical bond to the surfaces of the materials on both sides of the joint. There are many different braze alloys that are designed to correctly melt, flow, wet out and bond materials for joining. Typical braze filler materials that are used to create the correct alloy for the joint materials are copper, silver, zinc, nickel and aluminum.

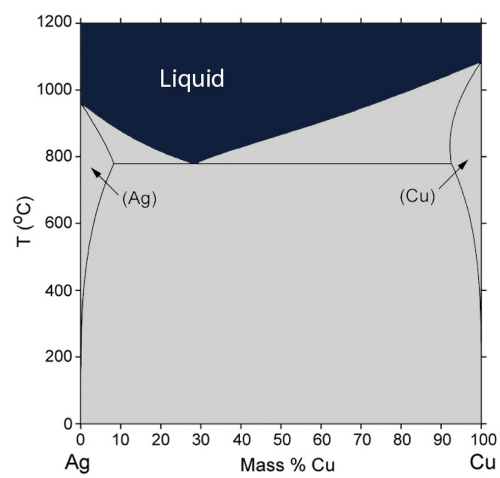
Some filler material alloys have eutectic properties that are very useful for the brazing process where the alloy melts and flows at a lower temperature than the melt temperature of either of the base materials. As shown in the diagram, the 30% copper/silver braze melts at 790°C (1454°F) compared to a melt temperature of 1180°C (1980°F) for copper and 960°C (1760°F) for silver.

The primary function of the flux is to protect the two metal surfaces being joined and the braze material from oxidation during the heating process. Some flux materials also act as a cleaning agent. A typical flux material for lower temperature brazing would be a potassium salt of boron and fluorine with a temperature range from 565°C (1050°F) to 982°C (1800°F). Other flux materials with less fluorine are available for higher braze temperatures between 870°C (1600°F) and 1100°C (2200°F).

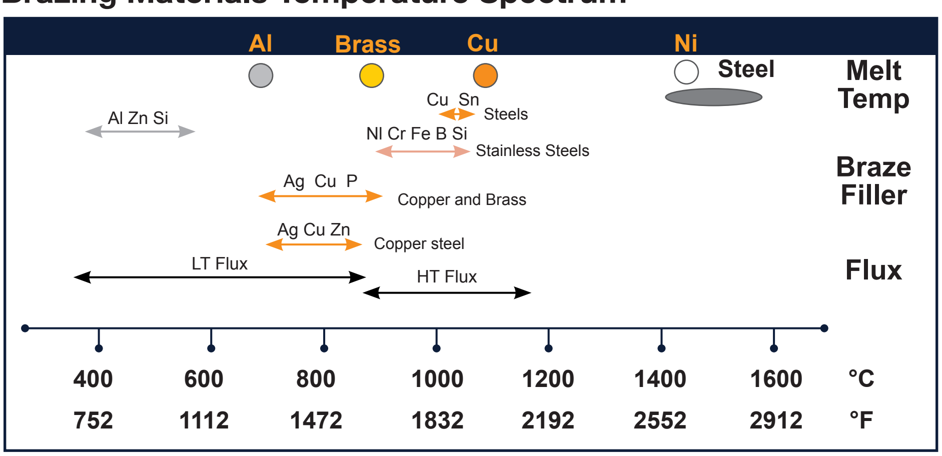
The Four Phases of a Typical Flux Material

100°C (212°F)	Water vapor boils off
315° C (600°F)	Turns white and foams slightly
425°C (800°F)	Has a milky look and flattens out
593°C (1100°F)	Flux coating becomes clear and glassy and joint is ready for braze filler to flow

Eutectic Properties



Brazing Materials Temperature Spectrum



Filler and flux operating temperature ranges for typical materials used in brazing steel, copper, brass and aluminum.

There are many suppliers providing braze fillers and flux designed for different materials and different brazing temperatures. A list of braze and flux suppliers can be found at http://braze-suppliers.ambrell.com

A Smarter Brazing Solution

Whether you're concerned with throughput, part quality or manufacturing efficiency, induction heating is the ideal brazing method for your process

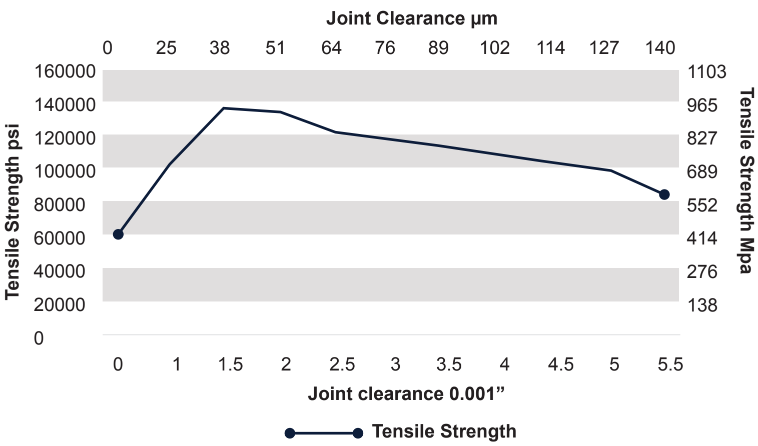
The Induction Brazing Process

Induction brazing is used in the joining of many different metals for multiple applications. Typical joints are steel-to-steel, steel-to-brass, steel- to-copper, copper-to-copper, aluminum-to-aluminum, and copper-to-aluminum.

The Six Steps to a Quality Induction Brazed Joint:

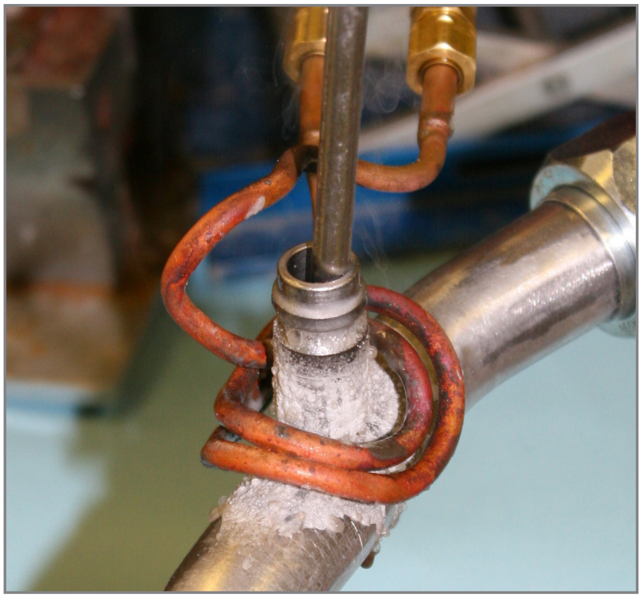
1. Design the joint correctly allowing for a 40µm (0.0015") to 125µm (0.005") clearance between the two surfaces at the braze material flow temperature – to allow for capillary action and joint wetting
2. Clean the surfaces of the joint materials
3. Apply flux to both pieces
4. Fixture the two pieces together with a braze ring or pre-form and position in the coil
5. Heat the two pieces until both pieces achieve the braze material flow temperature and stick feed the braze material if pre-forms are not being used. (Our application lab will make sure the coil is designed to correctly heat your parts.)
6. Clean the brazed joint and remove all of the flux residue

Tensile Strength with Joint Clearance



The optimum braze joint strength occurs with a part joint clearance between 25µm (0.001") and 125µm (0.005"). Data from Lucas Milhaupt.

Steel to steel brazing of part of a regulator used in the oil industry. 200 kHz at 8 kW for 9 seconds to 732°C (1350°F).



Brazing steel tube fittings used on trucks. 300 kHz at 3 kW for 45 seconds to 732°C (1350°F).

Every Brazing Application is Customized

Ambrell products are custom-designed to fit each of our customers' unique applications. Our systems are continually replacing outdated heating methods worldwide for their speed, consistency and precision.

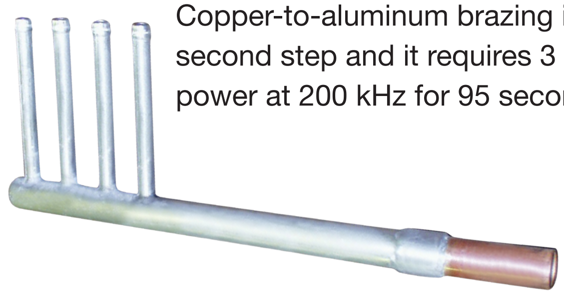
Brazing a Steel Tube Assembly

Brazing a steel tube assembly. 220 kHz at 3.5 kW for 30 seconds to 732°C (1350°F). Ambrell's customer utilized the EASYHEAT 3.5 kW power supply for brazing many different tube assemblies.

Brazing Applications

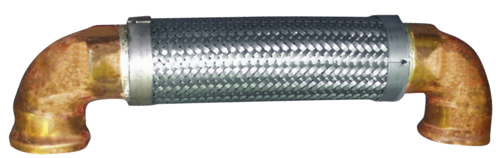
Manifold Assembly Brazing

Replacing torch brazing for assembling a manifold for an air conditioner is a two-step induction brazing process. First, the four aluminum tubes are brazed into the aluminum manifold using an elongated coil in 60 seconds with 3.5 kW at 180 kHz to 566°C (1050°F). Copper-to-aluminum brazing is the second step and it requires 3 kW of power at 200 kHz for 95 seconds.



Brazing Stainless Steel to Copper Elbows

Replacing torch brazing of copper elbows on a 4" (102mm) diameter flexible stainless steel tubing that is used to allow plumbing in large buildings to tolerate movement in the structure. 10 kW at 128 kHz for 3 minutes to 675°C (1250°F).



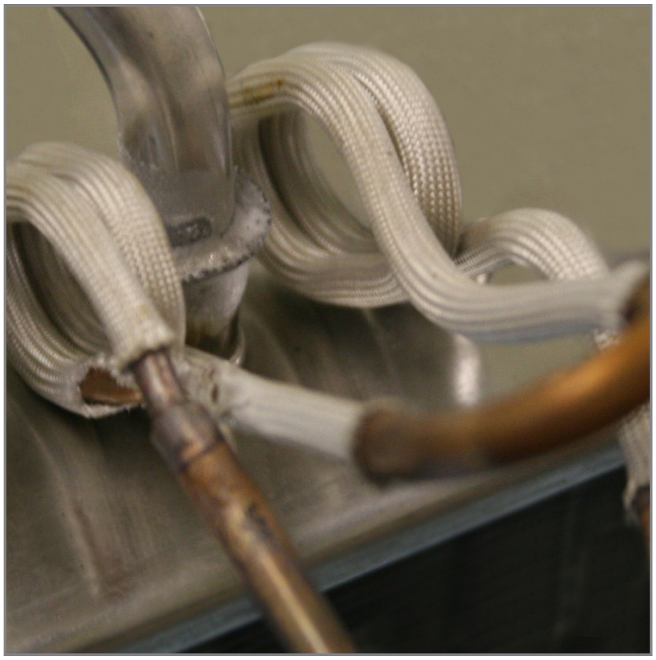
Brazing Stainless Steel to Stainless Steel

Using a saddle shaped coil the two stainless steel ends of this medical tool were brazed to the stainless steel flange in a single induction brazing process. 3 kW at 180 kHz for 20 seconds to 675°C (1250°F).

Aluminum Brazing Applications

Aluminum requires a lot of energy to heat using induction and its thermal conductivity is 60% compared to copper. Coil design and time for the heat to flow is critical in a successful induction brazing process for aluminum parts. Recent advances in lower temperature aluminum braze materials has allowed induction to effectively replace flame and furnace heating in high volume brazing of aluminum assemblies.

The low melt temperature of aluminum requires that the induction brazing process apply the energy to the part correctly to raise both part surfaces to the braze flow temperature at the same time without overheating and melting the edges of the part. Get the experience you need for precision aluminum brazing applications with Ambrell.



Replacing torch brazing of aluminum tubing to air conditioning evaporator. Using flux cored aluminum braze rings and a split helix induction coil for easy access to the joint area. 5 kW at 260 kHz for 12 seconds to 565°C (1050°F).

Brazing an aluminum cable fitting onto an aluminum tube for bicycle manufacturing. 20 kW at 10 kHz for 45 seconds to 482°C (900°F) using stick fed braze. Two parts were brazed simultaneously in a two position coil.

Steel Brazing Applications

Induction brazing is an excellent method of joining parts made of dissimilar metals. Applications with mixed metal joining include steel-to-copper, steel-to-brass and brass-to-copper. With these materials, it's all about timing.

Induction brazing is the ideal technique for joining steel parts where welding is not suitable. A well-designed induction brazed steel joint provides many benefits including part geometry integrity and lower part stress.

Carbon and stainless steel have high resistivity – they couple well to induction energy and heat easily. However, they have poor thermal conductivity so the induction brazing of steel parts should not be rushed. With steel, it is important the heat is given time to soak through to the joint surface for proper flow and wetting out of the braze material.

Copper-based alloys are often used as a low-cost braze material on carbon steels while nickel based alloys are used for stainless steels.

Ambrell's induction brazing experts have extensive conductivity knowledge needed for joining dissimilar parts. Some quick insights include:

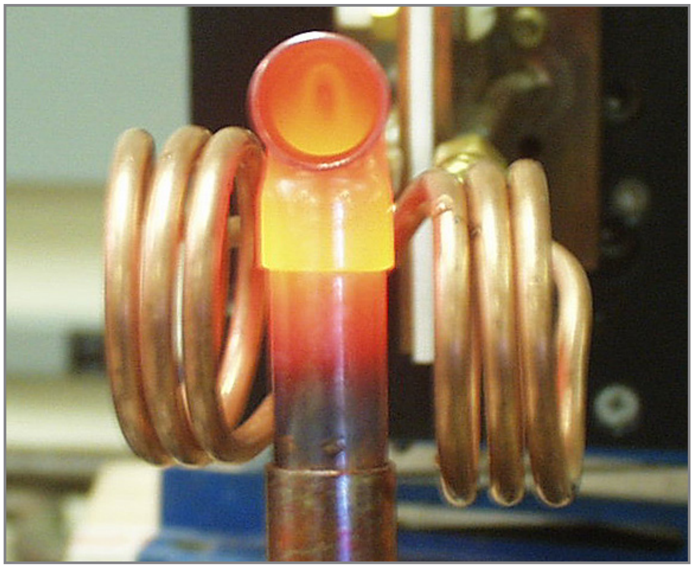
- **Steel heats well, but is a poor thermal conductor**
- **Copper takes more induction energy to heat, but is an excellent thermal conductor**
- **Brass heats better than copper, but has less thermal conductivity**
- **Silver copper alloys are popular braze materials for brass and copper parts**

Material	Thermal Conductivity k Cal/cm s °C	Electrical Resistivity ρ ohm m x10ˆ– 8	Typical Melting Temp °C	°F
Aluminum	0.60	2.65	660	1220
Brass	0.26	7.1	930	1710
Copper	0.95	1.7	1084	1983
Carbon Steel	0.11	74	1480	2700
Stainless Steel	0.05	74	1510	2750

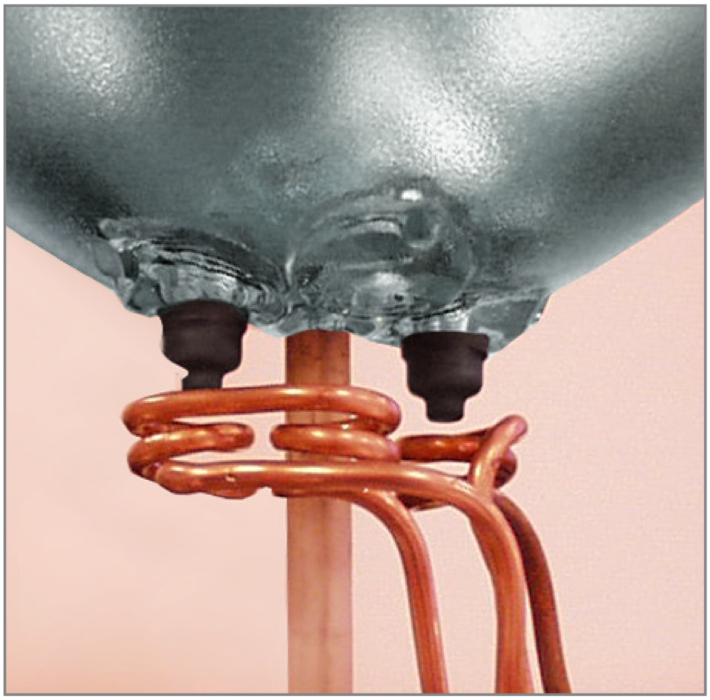
Only with Ambrell will you get the experience you need for precision brazing applications.

Steel, Copper and Brass Brazing

Induction brazing is an excellent method of joining parts made of dissimilar metals. Applications with mixed metal joining include steel-to-copper, steel-to-brass and brass-to-copper. With these materials, it's all about timing. For a successful brazed joint between different metals it is critical that both metal surfaces reach the braze flow temperature at the same time as the joint. The induction heating solution must take into account the different thermal conductivities of the materials, and the time each material takes to get to temperature.



Replacing torch brazing on a copper elbow to copper pipe using a split helix coil. 7 kW at 190 kHz for 90 seconds to 760°C (1400°F).



Replacing torch brazing with a multi-position helical coil to induction braze two or three nickel plated steel ferrules to nickel plated pins from an Automobile light bulb. 8 kW at 360 kHz for 6 seconds to 620°C (1150°F).

Replacing torch brazing for two brass joints on a faucet manifold. Each joint was induction brazed using a saddle coil. 22 kW at 90 kHz for 30 seconds to 620°C (1150°F).

Sensor assembly using a 3/8" diameter stainless steel tube brazed to the ½" diameter stainless steel sensor body. 3.5 kW at 300 kHz for 20 seconds to 732°C (1350°).

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Ambrell Induction Heating Systems at a Glance

With our EASYHEAT and EKOHEAT we offer a wide power and frequency range with our induction heating systems. Whether you're brazing large or small parts or multiple metal materials, Ambrell can help you maximize cost efficiencies and productivity.

Ambrell's systems are versatile with multiple capacitor and tap transformer configurations. They offer efficient power conversion that will minimize your energy costs. Our systems are user-friendly, offer agile frequency tuning for repeatable heating, and can be easily integrated into your existing process. With their small footprint, they free up valuable floor space in your facility.

Systems Include:

- Ease of integration into production processes with a small workhead – easily located in the work area
- Wide frequency ranges allowing brazing of different assemblies with the same power supply
- Multiple capacitor and tap transformer configurations for a more versatile brazing tool
- Agile frequency tuning for accurate, repeatable heating
- Efficient power conversion minimizes energy expenses
- Expert coil designs that maximize power delivery and save production time
- User-friendly operator interface in five languages (EN, ES, FR, DE, IT)

EASYHEAT™ 1.2 and 2.4 kW

Used for brazing small parts.

EASYHEAT™ 4.2, 6, 9, and 10 kW

Used in many brazing applications where parts are small or thin walled, or several parts are brazed at the same time.

EKOHEAT® With VPA Technology™ 10 and 15 kW

Used in many brazing applications where the parts have more mass.

EKOHEAT® With VPA Technology™ 30 and 45 and 50 kW

Used in brazing applications where faster heat up times are required and larger parts are being brazed.

APPLICATIONS LABORATORY
THE LAB
thelab.ambrell.com

Free Application Testing From THE LAB

With a Reputation for Delivering Extraordinary Results, Our Applications Laboratory is the Gold Standard in the Industry.

Our Applications Laboratory – known in the industry as THE LAB – is where we solve our customers' most challenging heating applications every day.

Dr. Girish Dahake, Sr. Vice President of Global Applications, leads a worldwide team of elite engineers who are uniquely qualified to assist you with your heating process needs. Under the guidance of Dr. Dahake, our engineers have evaluated thousands of applications in THE LAB, so it's likely we have already assessed an application similar to yours.

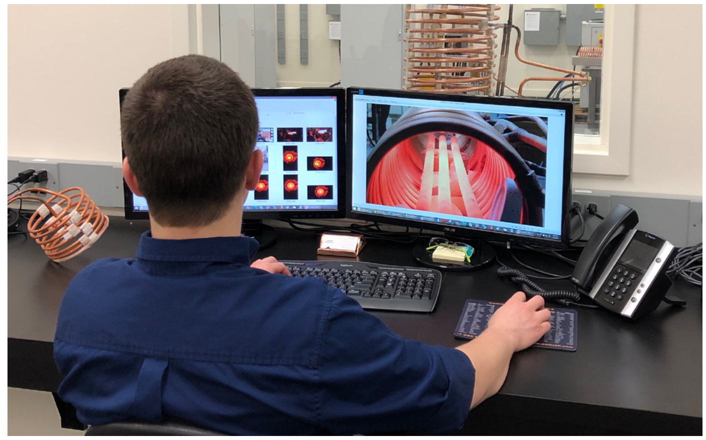
Ambrell's team of engineers is world-renowned for producing extraordinary results. Our innovative and effective induction heating solutions consistently deliver performance excellence in one application after another. It's why THE LAB is the gold standard in the industry.

Have our team of expert engineers design and test the optimal solution for your application, free of charge. All it takes are three easy steps:

1. **Send us your parts and process requirements**
2. **Our engineers will analyze your parocess and heat your parts to develop the right solution for your specific application**
3. **You will receive your parts back for inspection as well as a video of the heating process of your parts, and a laboratory report with a system recommendation**

We also invite you to visit THE LAB where you can experience our state-of-art testing facility, which is fully equipped with Ambrell induction heating systems and hundreds of proven coils. In addition, you can interface with our engineers and see first-hand how they design prototype coils and develop effective solutions to maximize the efficiency of your heating process.

For more information, contact us today at +1 585 889 9000 or visit thelab.ambrell.com



"Induction heating is a precise, repeatable and efficient method of heating. However, in order to maximize the benefits of induction, it's critical to have the correct system and coil design. Our global team of highly-skilled engineers look forward to assessing your application and making the right recommendation for your process."

Dr. Girish Dahake, Sr. Vice President, Global Applications

Our global reach includes a direct sales team along with an extensive distribution, channel partner and OEM network.

About Ambrell

Founded in 1986, Ambrell Corporation, an inTEST Company, is a global leader in the induction heating market. We are renowned for our application knowledge and engineering expertise. In addition, our exceptional product quality and outstanding service and support are at the core of our commitment to provide a superior customer experience.

We are headquartered in the United States with additional operations in Europe including the United Kingdom and the Netherlands. All Ambrell products are designed, engineered and built at our manufacturing plant in the United States, which is an ISO 9001-certified facility. Over the last three decades we have expanded our global reach through an extensive distribution, channel partner and OEM network. Today, we have more than 18,000 systems installed in over 50 countries.

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