Thermal processing

BENEFITS OF GRAPHITE AND C/C FIXTURING

COMPANY PROFILE
Thermcraft Incorporated

Technologies and Processes for the Advancement of Materials

MARCH / APRIL 2018
thermalprocessing.com



Achieving Increased Profits and Response Times with Modular Vacuum, Atmosphere Furnaces

"Initially, what appealed to us about this Ipsen equipment was its general purposefulness ... We wanted a low-cost, off-the-shelf-type solution that would allow us the flexibility we required – which is what the ATLAS and TITAN® delivered. Now after having performed some pre-training, I would say what stands out the most for both are the ease of use and control of the equipment."

– Continuous Improvement Manager

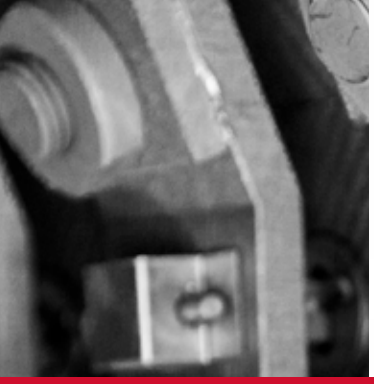
- Reduced lead times and increased flexibility by bringing the majority of heat treatment in-house
- Increased process and part versatility with the installation of both atmosphere and vacuum heat-treating systems

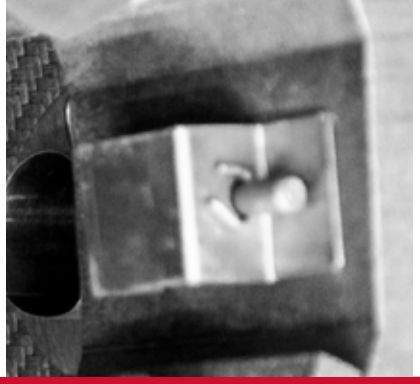
Challenge:
The customer was seeing an increase in production demands and volume of parts. While they were relocating their existing facility to a new location, they also needed to find an equipment solution that would help them keep up with the recent influx.

Action:
Expanded their production capabilities by installing a complete ATLAS atmosphere heat-treating system and a TITAN® vacuum furnace at their state-of-the-art manufacturing facility.

Discover this customer's winning outcome:
go.IpsenUSA.com/Customer-Stories

This manufacturer also relied on the ICS (Ipsen Customer Service) Team to install the TITAN vacuum furnace and the complete ATLAS atmosphere heat-treating system, including two integral quench batch furnaces and the ancillary equipment – washer, temper, endo generator, loader/unloader and a feed-in/feed-out station.





Atmosphere

The ATLAS furnace utilizes the same push-pull chain loader as the industry standard, allowing it to integrate zinto existing lines for any brand of atmosphere furnace with ease.*

- Process simulation and integrated C-Profile optimization with Carb-o-Prof® software controls
- Ease of maintenance, thanks to a cartridge-design heat fan assembly, shelf-mounted quench oil heaters and oil circulation pump and safety catwalks
- Recon® III Burners increase thermal efficiency up to 75% by utilizing the heat from the exhaust gases to preheat the combustion air
- SuperQuench® and TurboQuench® oil-quenching systems minimize distortion and improve part quality

**compatible with most single-chain, in-out-style atmosphere furnace lines*

Vacuum

The TITAN product line sets the industry standard for quality equipment at a cost-conscious value. New furnaces ship in a standard truck or shipping container with short delivery times, are easy to install and operate worldwide and handle a variety of common heat-treating processes.

- Horizontal and vertical 2-bar internal quench
- Graphite or all-metal hot zone
- Nitrogen and argon quench capabilities
- PdMetrics® software platform for predictive maintenance
- High-vacuum, debinding and sintering and low-temperature options

IpsenUSA.com/Products

FEATURES

MARCH / APRIL 2018

LEGENDARY
PERFORMANCE

WHEN JACK BEAVERS DESIGNED THE BEAVERMATIC INTERNAL QUENCH FURNACE (IQF) ALMOST 60 YEARS AGO, HE CREATED THE SIGNATURE TECHNOLOGY IN AN INDUSTRY WORKHORSE THAT STILL SETS THE STANDARDS TODAY.

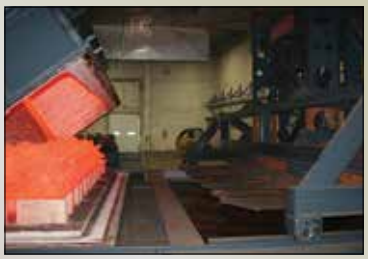
The BeaverMatic IQF's rugged design combined with a unique load transfer mechanism for high-production output is the reason for so many successful installations around the world.

- World's largest Internal Quench Furnace with 15,000 pound workload
- Users experience substantial improvement in work flow
- Simplified designs for ease of operation and maintenance
- Reliable, performance proven equipment
- Excellent and efficient processing results

Today Premier Furnace Specialists builds the BeaverMatic IQF incorporating modern process controls and materials, keeping the legend alive and reliable as ever. The legend doesn't end there, Premier Furnace Specialists offers a complete range of furnaces to suit any industrial heating process.

Call **248-596-9000**
premierfurnace.com • beavermatic.com
sales@premierfurnace.com



Premier Furnace Specialists, Inc.

BeaverMatic

DEPARTMENTS

MARCH / APRIL 2018
Volume 7 / Number 2

RESOURCES

Cover photo: SGL Group

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- ✔ *1299 model intergrates into current batch line and replaces any existing atmosphere furnace*
- ✔ *Over 1100 LPC cells installed*

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- Oil Quenching
- Hardening
- Brazing
- Sintering

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LETTER FROM THE EDITOR

Thermal Processing spring issue is here

It's hard to believe that spring is already upon us.

At least with spring, we can move on from flu bugs and stock up on allergy pills to thwart that annual hay fever.

We at *Thermal Processing* have been hard at work mentally heat-treating print and online tools that will help you find the industry information you want and need.

We are very close to debuting a new, redesigned *Thermal Processing* website. The site will offer all our archives as well as current monthly articles and columns written by experts and insiders.

We're also about to launch a *Thermal Processing* monthly newsletter and social media blast that will aid in your heat-treating know-how and keep you abreast of industry events and news.

With that in mind, it's time to bring you *Thermal Processing's* March/April issue.

We would like to proudly announce a collaboration with the Industrial Heating Equipment Association. Each issue, our friends with IHEA will share what's going on in their organization while letting you know what events and educational opportunities IHEA has to offer throughout the year.

Our March/April issue, which focuses on fixtures and thermocouples, takes an in-depth look at these often-unsung heroes of the industry.

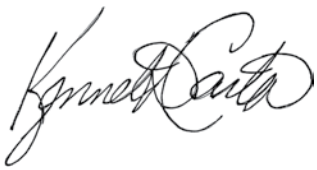
Experts from SGL Group offer their insights on the benefits of graphite and carbon composite fixtures.

TE Wire & Cable shares its knowledge on the basic steps to select the right thermocouple wire.

In our company profile, we spotlight Thermcraft and how this leading manufacturer of high quality thermal processing equipment began almost 50 years ago with … *popcorn*. Now that I've got your attention, make sure you check out the article and Thermcraft's fascinating history.

And as a reminder to our readers: We'd love to make you or your company a part of our editorial offerings. If you have an article you'd like to submit, feel free to contact me. I'm always on the lookout for informative industry expertise.

So enjoy this issue, and as always, thanks for reading!



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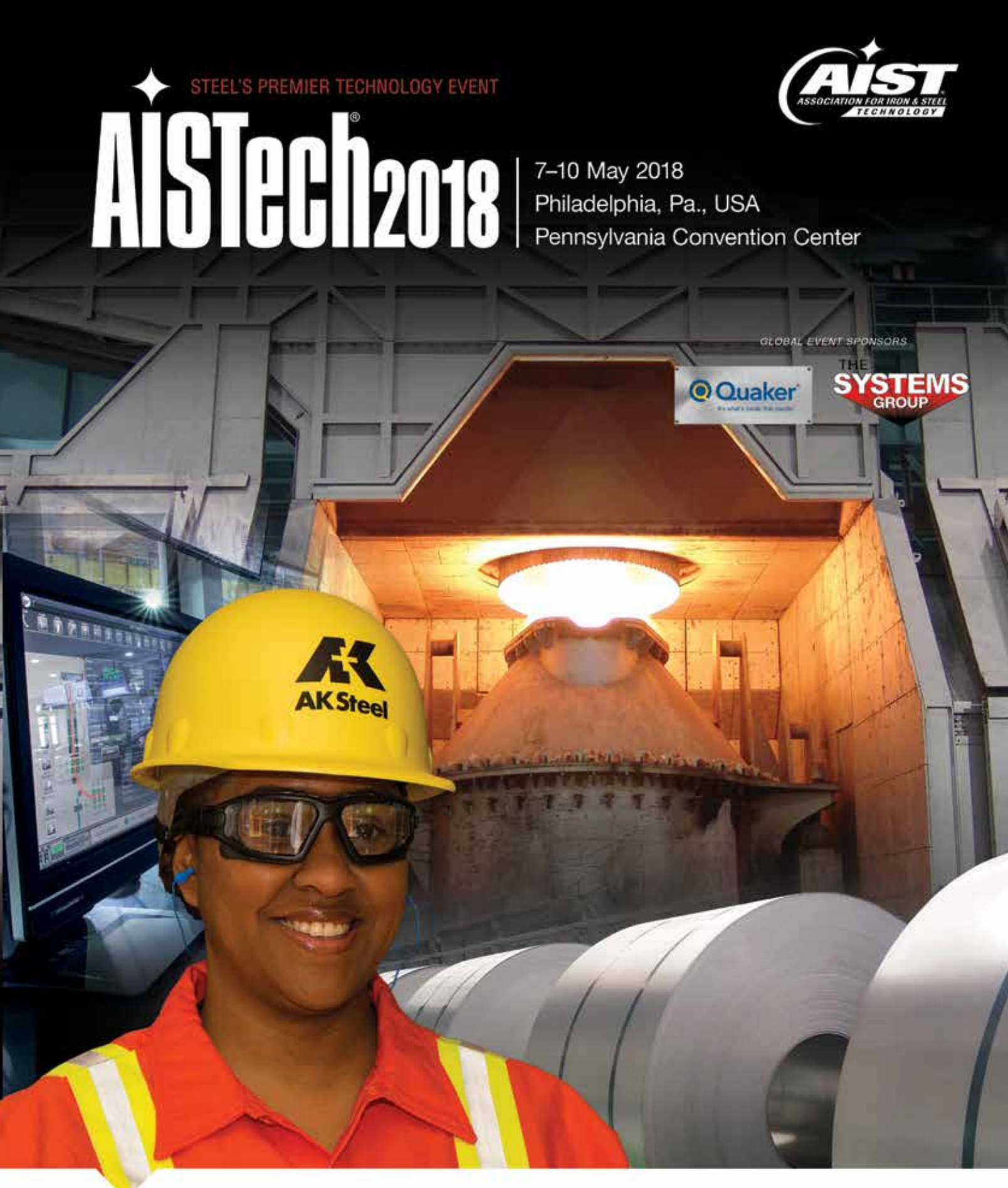

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25 Years of MVD treatment on thermowells

Thermocouple Technology in Quakertown, Pennsylvania, is celebrating 25 years of the product MVD Tungsten Carbide Treatment for thermowells, protection tubes, and other critical components.

The product is a MVD Tungsten Carbide Treatment that is used to create a stronger, longer-lasting product. The tungsten carbide is fused with the thermowell material and becomes an integral part of the mass of the well, resulting in a new, substantially harder and more durable application. The treatment is specially designed for applications in highly abrasive/erosive environments where the temperature range is ambient to 1800° F and is capable to withstand temperatures up to 2300° F.

Thermocouple Technology introduced the MVD treatment option for its products in 1992 and has experienced a huge demand since. The MVD Treatment increases the life of thermowells, protection tubes, and other critical components by two to four times the normal lifespan. The product is best used in environments such as: power plant pulverizes, pulverized coal ducts, fluidized coal bed reactors, sludge dryers, and more.

Thermocouple Technology uses this superior design upon request and is capable of treating applications for almost all customized pieces.

FOR MORE INFORMATION: www.tteconline.com

Wisconsin Oven ships quench system to aluminum supplier

Wisconsin Oven Corporation shipped two electrically heated standard horizontal quench systems to an aluminum manufacturer. The systems are designed for the solution treatment of aluminum. Each of the horizontal quench systems are designed to heat 1,000 pounds of aluminum to a 950°F operating temperature. Once the loads are heated to the operating temperature, they will soak at temperature, and then be rapidly lowered into the quench tank in less than 10 seconds from the time the door starts to open until the load is fully submerged.

The aluminum solution treating systems are each designed for a load size of 4'0" wide x 4'0" high x 4'0" long and have qualified operating temperature ranges of 775° F and 1,075° F. The customer required guaranteed temperature uniformity of ±10°F at 775° F and 1,075° F to ensure the furnace would meet AMS 2750E, Class 2 furnaces and Instrumentation Type C requirements. The systems use PLC process control with HMI operator interface.

Unique features of these horizontal quench systems include:

- Guaranteed temperature uniformity of ±10°F at set points of 775 F and 1,075 F verified by a nine-point profile test
- Meets AMS 2750E, Class 2 furnaces and Instrumentation Type C requirements
- 12-gauge, 304 stainless steel plate quench tank shell with 15° F quench tank temperature rise design, and heat input capability to maintain 140° F tank water temperature
- Electrically-operated oven/quench pusher load/unload mechanism
- One vertical lift, electrically-operated door
- Allen-Bradley CompactLogix™ PLC, 10" PanelView™ Color HMI, and programmable recipe temperature controllers with Ethernet capabilities

Wisconsin Oven's horizontal quench systems have the capacity to process loads up to 6,000 pounds with quench times as low as 7 seconds. (Courtesy: Wisconsin Oven)

"Wisconsin Oven's horizontal quench systems have the capacity to process loads up to 6,000 pounds with quench times as low as seven seconds. This makes them ideal for solution treating a range of aluminum products," said Doug Christiansen, applications engineer.

The quench systems were fully factory tested and adjusted prior to shipment from the facility. All safety interlocks are checked for proper operation and the equipment is operated at the normal and maximum operating temperatures. An extensive quality assurance checklist was completed to ensure the equipment met all Wisconsin Oven quality standards. This equipment is backed by Wisconsin Oven's Exclusive and Unprecedented 5-Year WOW™ warranty (parts only).

FOR MORE INFORMATION: www.wisoven.com

350°F electrically heated cabinet oven from Grieve

Grieve Corporation oven No. 890 is a 350°F (177°C), electrically heated cabinet oven, currently used for heating tubular aluminum parts at the customer's facility.

Workspace dimensions of this oven measure 156" wide x 18" deep x 18" high. 14.4 KW installed in Nichrome wire heating elements, while a 1000 CFM, 1-HP recirculating blower provides horizontal airflow.

This Grieve cabinet oven features 4" insulated walls, aluminized steel exterior, and Type 430 stainless steel interior. Additional features include a motor operated vertical lift door.

FOR MORE INFORMATION:
www.grievecorp.com

Grieve oven No. 890 is currently used for heating tubular aluminum parts at the customer's facility. (Courtesy: Grieve)

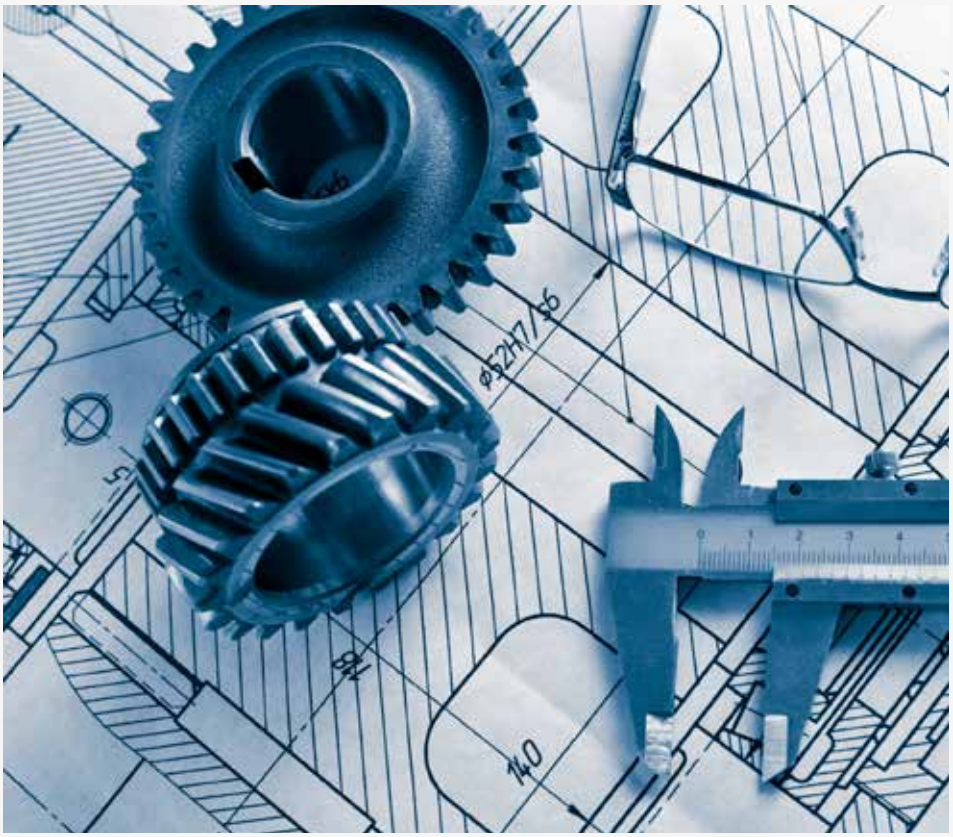
Ipsen builds custom furnace that quenches with 1,000 HP

Ipsen recently designed and built a vertical, high-pressure quenching furnace, complete with twin cooling systems and a work volume of 350 cubic feet. During the testing phase, the furnace quenched with 1,000 horsepower (0.75 megawatts) – a remarkable achievement that began as an idea just months prior.

As is typical with a custom build, the customer came to Ipsen with specific requirements: They needed a large furnace with a very aggressive cooling rate. During the design phase, Ipsen's engineering team determined that twin cooling systems to provide 1,000 horsepower quenching capability was the right solution due to the customer's process requirements and the geometry and cross-section of parts.

Ipsen engineers, alongside the customer, looked on during the testing phase. "We saw the furnace backfill and then go into quench," said Craig Moller, chief engineer. "It took us a minute to realize we were experiencing a ground-breaking design and test, with cooling curves that we've never seen for a furnace of this size."

Ipsen excels at engineering and manufacturing innovative, highly technical thermal processing systems for unique or special applications. The opportunity to create custom solutions allows Ipsen to continue advancing technology and grow its portfolio of product offerings. Whether you require custom equipment for your unique process requirement or a standard, dependable furnace with versatility, Ipsen has a solution for you.



During the design phase, Ipsen's engineering team determined the right solution for the customer's specific requirements. (Courtesy: Ipsen)

FOR MORE INFORMATION: www.ipsenusa.com

In addition to the aerospace, automotive, and energy industries, the defense industry is one of the key sectors where Seco/Warwick Group provides thermal processing innovations and solutions. (Courtesy: Seco/Warwick)

Seco/Vacuum is defense industry technology provider

Seco/Vacuum Technologies (SVT), a Seco/Warwick Group company, has secured orders for two vacuum brazing furnace systems from two separate North American defense contractors. The solutions, scheduled for delivery in the first quarter of 2018, are SVT's signature Vector® advanced front-loading vacuum furnace and a Vector® bottom loading vacuum furnace both capable of up to two bar gas quenching. Both solutions are purpose-built for a diverse range of applications including vacuum brazing.

"Not only do our Vector furnace systems meet all military aerospace specifications, they offer premium quality along with unequaled value," said Piotr Zawistowski, managing director, Seco/Vacuum Technologies. "Coupled with our exceptional professional services capabilities, Seco/Vacuum furnace systems are a key factor in delivering mission-critical components on time and under budget. We are proud to be a contributing technology partner in support of defense industry," said Zawistowski.

The two Vector vacuum brazing systems

are to be delivered to separate locations. They are manufactured to meet exacting specifications enabling each system to be fully compliant with NADCAP (National Aerospace and Defense Contractors Accreditation Program) and AMS standards. Vector's control system fulfills all pyrometric parameters, including accuracy, traceability, and reliability required by AMS 2750E. It will control all automated processes, provide all required monitoring and alert functions, manage state-of-the-art preventive maintenance routines such as monitoring heating element oxidation build-up, and is designed to operate efficiently using a built-in, power-saving mode.

FOR MORE INFORMATION: www.secowarwick.com

Solar Atmospheres of California facility expansion complete

Solar Atmospheres of California (SCA) is pleased to announce the completion of its most recent facility expansion. The new expansion allows SCA to double its current heat-treating capacity on the West coast while continually striving to meet the needs of an ever-growing customer base.

Project expansion began in July 2016 with ground breaking for a new 25,000-square-foot building. Upon completion of building construction in July 2017, and applying the lessons learned from SCA's initial facility build in 2010-11, SCA immediately began the design, fabrication, and installation of all required support systems including water and gas delivery.

In preparation for the added growth, SCA has procured an additional four vacuum furnaces from sister company Solar Manufacturing (SMI), based in Souderton, Pennsylvania.

Additional state-of-the-art vacuum heat-treating equipment includes:

SMI Model HFL-5748-10IQ-VC "High Pressure Vacuum Gas Carburizing Furnace"

- Rigid Graphite Hot Zone design measuring 36"W X 36"H X 48" Deep
- 35" varian diffusion pump for sustained high-vacuum processing
- Low pressure vacuum carburizing capability
- Operating Range: 600°F – 2200°F (maximum temperature 2750°F)
- Maximum cooling pressure: 10 Bar (135 psig) with 300HP gas blower
- Maximum loading capacity: 7,000 lbs.

SMI Model HFL-7472-10IQ-VC "High Pressure Vacuum Gas Carburizing Furnace"

- Rigid graphite hot zone design measuring 48"W X 48"H X 72" Deep
- 35" varian diffusion pump for sustained high-vacuum processing
- Low pressure vacuum carburizing capability
- Operating range: 600°F – 2200°F (maximum temperature 2750°F)
- Maximum cooling pressure: 10 Bar (135 psig) with 300HP gas blower
- Maximum loading capacity: 15,000 lbs.

SMI Model HFL-7472-2EQ "All Metal Hot Zone with Isolated Gas Quench System"

- 6-Layer all moly hot zone design measuring 48"W X 48"H X 72" Deep
- 35" varian diffusion pump with "isolated" external gas quench system for optimized sustained high-vacuum processing of sensitive materials.
- Operating range: 600°F – 2400°F (maximum temperature 2800°F)
- Maximum loading capacity: 15,000 lbs.

SMI Model HCB-120288-2EQ "120" DIA X 288" Long Horizontal Car-Bottom Furnace"

- Rigid graphite hot zone design measuring 96"W X 96"H X 288" Deep
- Multiple 35" varian diffusion pumps for sustained high-vacuum processing
- Operating range: 600°F – 2200°F (Maximum temperature 2600°F)
- Maximum loading capacity: 150,000 lbs.

All Solar Manufacturing furnaces are designed for high performance, low maintenance, and energy efficient results.

Chuck Miller, maintenance manager/facilities engineer at the Solar Atmospheres California facility, manages the building and support systems design and fabrication along with the new equipment design and installation. (Courtesy: SCA)

"We are very thankful for the opportunity to grow our facility," said Derek Dennis, president, Solar Atmospheres of California. "Every SCA employee appreciates the trust and confidence that our customers have placed in our abilities to service their vacuum heat-treating, brazing and carburizing requirements. Our focus remains on providing the highest quality product with unsurpassed customer service on-time, every-time in the safest, most efficient and environmentally friendly manner. The last 6-plus years of providing vacuum processing services in Southern California have proven to be both challenging and rewarding. We look forward to working with our current customer base along with new customers in solving their heat treat challenges. SCA understands the importance we play in our customers' supply chain, especially where delivery and quality are expected. These new facility expansions well help us meet these expectations."

FOR MORE INFORMATION: www.solaratm.com

Bodycote Swedish site earns Nadcap HIP accreditation

Bodycote, the world's largest provider of heat-treatment and specialist thermal processing services, is pleased to announce that its Surahammar, Sweden, Hot Isostatic Pressing (HIP) location has earned its Nadcap accreditation.

The Surahammar site has been producing Powdermet® Near Net Shape (NNS) and Selective Surface Net Shape (SSNS) components for many years, using its long experience of manufacturing complex, high-integrity components from powder metal to serve markets such subsea, oil and gas, marine, nuclear, tool steel, and automotive.

Bodycote HIP now has nine Nadcap-accredited sites globally positioned to serve the world's aerospace prime manufacturers and their first-tier suppliers with additional HIP capacity to meet the demands of the future growth in the new aircraft programs to come.

Bodycote HIP serves clients globally, operating in markets as diverse as medical, power generation, marine, and electronics with both HIP services and Powdermet technologies. The recently launched Powdermet technologies incorporate new, patent-pending techniques that combine 3D printing with well-established net shape and NNS techniques. This new technology dramatically reduces the manufacturing time and production cost of a part compared to producing the same part using 3D printing alone.

Bodycote operates with the world's largest network of HIP equipment and continues to invest, recognizing the growing demand for HIP technology. Having established industry expertise over decades, Bodycote has more than 50 HIP vessels of varying sizes in multiple locations. Processing capability can accommodate components which are nominally up to 2m diameter by 3.5 m high; and weighing 0.1kg to over 30,000kg. In addition to standard quality and environmental accreditations, Bodycote's HIP facilities also hold ASTM and NORSOK accreditations.

FOR MORE INFORMATION: www.bodycote.com

Seco/Warwick goes with Microsoft cloud

Seco/Warwick, a global leader in metal heat-processing solutions, goes digital with the cloud-based Microsoft Dynamics 365 for Finance and Operations system. The management chose to implement Microsoft's solution to provide the best security and efficiency for the enterprise.

In constant pursuit of improving heat-treatment technology, the company decided to change the solutions supporting management and key business processes, as investing in new technologies is crucial to stay relevant and be a trend-setting force on the market. One of the main reasons for adopting Microsoft Dynamics 365 is to maximize profits by taking advantage of the fruit of digital transformation. Other top priorities include standardizing products and going entirely paperless, in an effort to become a truly digital enterprise. In the first wave, Dynamics 365 will be implemented for almost 500 employees working in finance, cost management, supply chain management, logistics, design and production, sales, warehousing, and service management. Also covered by the project is the modernization, streamlining, and moving to the cloud of the CRM solution currently used by nearly 200 employees.

"New technologies are at the base of the fourth industrial revolution, in which we take an active part. They are vital for a company to stay in the game, provide new options for its customers, and optimize its business operations. If trends are adapted early enough, we can set the direction for the entire industry to move in," said Bartosz Klinowski, Member of the Board at Seco/Warwick S.A.

Aside from implementing Dynamics 365, Seco/Warwick intends to employ machine learning technologies to predict and prevent malfunctions in the company's systems and machines. Moreover, service technicians will be using HoloLens-based SECO/LENS augmented

reality glasses for increased work comfort and efficiency. At the same time, the Microsoft Azure IoT platform will enable for continuous tracking of the parameters of the manufacturing equipment and products installed in customers' locations.

"The industry is already realizing the benefits of using cutting-edge IT solutions. The industrial revolution pushes us toward merging ERP systems with IoT or augmented reality solutions, and early adopters will set the course of digital transformation for the entire sector," said Przemysław Szuder, member of the board at Microsoft.

FOR MORE INFORMATION: www.secowarwick.com

Continued year-over-year growth for Lindberg/MPH in 2017

Lindberg/MPH has experienced steady growth year after year, and 2017 was no exception. At the beginning of the year, Lindberg/MPH invested in the future by purchasing an Emrak Press Brake and Hydraulic Swing Beam Shear to maximize their production capabilities. These equipment investments were key resources as Lindberg/MPH experienced considerable increases in equipment sales.

Throughout the year, Lindberg/MPH shipped several integral quench furnace systems (IQ), box furnaces, pit furnaces (both nitriding and steam), along with several cyclone pit and cyclone box furnaces to a variety of industries such as automotive, foundry, marine, and mining. Not only has the heat-treat side of the business grown significantly, the non-ferrous melting side of the business has also seen impressive gains this year. Light Industrial and laboratory furnaces continue on the growth path in the R&D and education markets. 2017 was a strong year for Lindberg/MPH and the growth trend is expected to continue in 2018.

"Lindberg/MPH has shown strong increases over the past couple years in both their heat treat furnace sales and non-ferrous melting equipment sales. Their strategic planning for future growth has laid the ground work for continuing this trend in the years to come," said Dave Strand, CEO.

FOR MORE INFORMATION: www.thermalproductsolutions.com

Ipsen USA finishes fourth quarter of 2017 strong

With a strong fourth-quarter finish, Ipsen USA continues to provide heat-treating solutions to customers worldwide. Recently, 15 furnaces shipped to eight states in the United States, as well as Asia and Europe, to support customers in additive manufacturing, aerospace, commercial heat treating, medical and MIM industries.

The shipments included:

- Nine TITAN® vacuum furnaces, including three TITAN DS (debinding and sintering) units, two TITAN LT (low temperature) units and several H2- and H6-sized furnaces, all equipped with PdMetrics® predictive maintenance software.
- Three horizontal MetalMaster® vacuum furnaces, each with a work zone of 36" (910 mm) x 30" (762 mm) x 48" (1219 mm) and load capacity of 2,000 pounds (907 kg).
- Two horizontal TurboTreater® furnaces.
- One vacuum aluminum brazing furnace with a 1500-pound (680 kg) load capacity and an all-metal, radiation-shielded hot zone for the aerospace industry.

Nine TITAN® vacuum furnaces were shipped during 2017. (Courtesy: Ipsen USA)

Several of these customers also took advantage of Ipsen's support offerings such as Ipsen U training, spare parts kits, installation, and startup assistance. A few furnaces shipped to repeat customers and one customer received two furnace orders.

To best support such diverse industries and needs around the world, Ipsen's Global Support Team facilitates system installations, as well as provides expert training, startup assistance, and 360° support throughout the entire lifespan of the equipment.

FOR MORE INFORMATION: www.ipsenusa.com

New year, new services added to Solar Atmospheres

Solar Atmospheres of Western PA has expanded its wings by adding another type of mechanical testing to its repertoire: tensile testing. Tensile tests are essential in determining and understanding the ultimate strengths of materials. Currently, many aerospace specifications demand at least one tensile test to be performed on each heat lot of material and/or for every furnace load of components being heat-treated. Tensile testing is not only more prevalent today but is often the mechanical test of choice for the acceptance of properties.

Solar Atmospheres has traditionally outsourced all tensile testing. Due to shipping and transporting test specimens to these laboratories, a delay of 24-48 hours before the lab even received the specimens was normal. With an ear to customers' needs of receiving tensile results faster and more efficiently, Solar Atmospheres of Western PA has brought tensile testing in-house. In the summer, Solar took delivery of a new Tinius Olsen 300SL Universal testing machine and installed it in a temperature-controlled environment. In addition, in order to custom machine test specimens, Solar Atmospheres of Western PA purchased a new Haas Model TL-1 CNC lathe. Both units are physically located in a new 10,000-square-foot facility adjacent to its 75,000-square-foot state-of-the-art vacuum heat-treating production facility.

Solar Atmospheres of Western PA has added room-temperature tensile testing to the scope of its Nadcap accreditation. "Our customer feedback was very definitive: they wanted faster turnaround on their heat-treated components. By bringing this new destructive mechanical test in house we will be able to do just that," said Bob Hill, president.

FOR MORE INFORMATION:
www.solaratm.com

The Tinius Olsen 300SL Universal testing machine allows the company to provide tensile results faster and more efficiently. (Courtesy: Solar Atmospheres)

IHEA to share its programs and projects

IHEA committees and divisions meet several times a year.

The Industrial Heating Equipment Association (IHEA) recently welcomed Thermal Processing magazine as a new member. We'll be reporting on a variety of programs and projects for the thermprocess industry in each issue of Thermal Processing and would like to take the opportunity to introduce IHEA to Thermal Processing's readership.

WHAT IS IHEA?

Founded 89 years ago, IHEA was started by a small group of industrial furnace manufacturers. Over the years, IHEA has grown to include the Induction Division and the Infrared Equipment Division along with the original Combustion Division.

WHAT IS IHEA'S MISSION?

IHEA drives member success by providing the knowledge base and authoritative voice for industrial process heating worldwide. With our vast amount of expertise in all things related to process heating, IHEA members keep the industry informed and advancing. We believe by bringing key executives together who share our sense of responsibility, we improve our industry, and we enjoy being the catalyst for that improvement.

WHY ARE ASSOCIATIONS IMPORTANT?

Associations foster a positive environment by which we educate and train those in our industry, continuously helping members and the industry improve their manufacturing operations related to thermal processing. Involvement in your industry association gives members a network for idea exchange, a voice in the development of industry standards both in the U.S. and globally, and a chance to both educate and be educated on a wide variety of thermal-processing technologies.

WHAT IS IHEA'S STRUCTURE?

We have a corporate membership structure, meaning that the company becomes a member and everyone within the company

is entitled to membership benefits. For many years, IHEA's membership was limited to industry suppliers. We launched an "end-user" member category recently, and the great thing about this category is that everyone at a company can take advantage of member discounts on IHEA's training activities. The cost savings for sending two or three individuals from a company to IHEA seminars pays for the cost of membership! Dues vary based upon your membership category.

WHAT TYPES OF PROGRAMS DOES IHEA OFFER?

IHEA offers a variety of training seminars, on-line learning courses, and an executive level summit. Training seminars covering combustion, induction, infrared, and safety standards & codes are offered yearly. This is a big year for our Safety Standards & Codes seminar since NFPA 86 will provide a revision of the code. Our fall seminars also typically include a tabletop exhibition; however, our 2018 fall seminars will be held in conjunction with Furnaces North America in Indianapolis. This will give our seminar attendees the opportunity to visit the show and meet with exhibitors alongside our seminars.

IHEA's online training courses are offered several times each year. The Fundamentals of Industrial Process Heating is normally offered each spring and fall. The Advanced Industrial Process Heating course is currently under revision, with the goal of it being offered in the fall of 2018.

IHEA's signature event, ITPS — The International ThermProcess Summit, is a biennial event specifically designed for executives in the industrial process heating industry. We focus on hot business topics, trending technologies that affect the industry, global market reports, and more. Initially held in 2016, we'll offer our second ITPS from July 30 to August 1 at the InterContinental Hotel in the Buckhead neighborhood of Atlanta. Programming is being finalized now and will be available in early spring. This event attracts executives from around the globe.

Finally, IHEA's Annual Meeting, held each spring, gives members a chance to connect in an informal atmosphere that includes high quality presentations, social activities, IHEA committee meetings, and our annual President's Gala. This year we are co-locating our meeting with the Metal Treating Institute, which allows for additional networking with users of thermal process technologies.

WHAT ELSE DOES IHEA DO?

IHEA is also active in government relations to ensure our members are informed about government issues that affect our industry. Over the years, we've worked closely with the Department of Energy (DOE), Environmental Protection Agency (EPA), and the National Association of Manufacturers. Over the past 10 years, we have served as the ANSI US TAG Administrator to ISO TC 244. Involvement in the development of international standards that affect our members and industry is vital to ensure our member companies' voices were represented.

IHEA also maintains a close relationship with the European Committee of Industrial Furnace & Heating Equipment Associations (CECOF) and the Japan Industrial Furnace Manufacturers Association (JIFMA). Additionally, IHEA has coordinated a resource center at the previous two ThermProcess in Dusseldorf, Germany, to support members wishing to exhibit at the show.

Participation in international meetings brings a sharing of information.

IHEA 2018 CALENDAR OF EVENTS

APRIL 9–MAY 16
Fundamentals of Process Heating | On-Line Distance Learning Course

APRIL 23–25
2018 Annual Meeting in conjunction with MTI
Talking Stick Resort | Scottsdale, Arizona

JULY 30–AUGUST 1
International ThermProcess Summit
In conjunction with the International Finishing & Coatings Summit
InterContinental Hotel | Atlanta (Buckhead), Georgia

OCTOBER 8–10
IHEA Combustion Seminar
Indiana Convention Center | Indianapolis, Indiana

OCTOBER 8–10
IHEA Safety Standards & Codes Seminar
Indiana Convention Center | Indianapolis, Indiana

OCTOBER 8
IHEA Induction Seminar
Indiana Convention Center | Indianapolis, Indiana

OCTOBER 15–NOVEMBER 26
Advanced Process Heating | On-Line Distance Learning Course

For details on IHEA events, go to www.ihea.org/events

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Thorough knowledge of AMS2750E will speed implementation of new standard as it applies to Nadcap requirements

By Jason Schulze

INTRODUCTION

Pyrometry, as it relates to heat treat, Nadcap, and AMS2750E does not embody the traditional definition of 'pyrometry.' Regardless, AMS2750E has been placed as the Aerospace Industry Standard to control thermocouples, furnace testing, and related quality requirements. In this essay we will briefly explore the necessary steps to understand the requirements of AMS2750E and the separate requirements of Nadcap which are put forth in the Nadcap Pyrometry Guide.

PYROMETRY – HOW IMPORTANT?

I am a metallurgical engineer. I've worked about 50/50 R&D and production processing. This has provided me with what I believe is well-rounded experience in heat-treat and related thermal processing. As a specific example, I have seen the effects that a non-thermally uniform furnace can have on the metallurgical results in a laboratory. During development of a diffusion braze process, I had five samples distributed throughout a vacuum furnace; one in the center and one in each corner. The sample in the back-left corner had a dissimilar diffusion phase and, consequently, smaller solid solution loops in the braze joint. In the end, this makes for not only a less homogeneous microstructure between the hardware processed but presents a much higher opportunity for re-melt in service. The furnace itself should have a ±10°F tolerance — although once tested, it was found to be ±32°F with the back-left corner being -32°F from set-point.

Stating the importance of pyrometry, negating Nadcap requirements, and looking at this from a laboratory point of view is not the hard part. If AMS2750E were employed strictly from a results-based laboratory perspective, the importance of pyrometry is dependent on the sensitivity of the process itself. For example, a simple stress relieves of 4340 bar stocks in an air furnace is not nearly as sensitive as, say, a braze cycle of small circular joints. From an engineering point of view, pyrometry typically is not going to be the largest variable in most processes we work with. Braze joint size, filler material, temperature, time, ramp rates, and atmosphere are all typical examples of what engineers dwell on during development of a processes; not pyrometry.

For those of us who have Nadcap requirements flowed down to us, it is important. It's almost an entirely different aspect of quality engineering regarding any thermal process it applies to. In the end, AMS2750E, when invoked by Nadcap flow down from customers, becomes top priority for engineering and quality since it has been the largest source of Nadcap heat-treat findings.

NEW TO NADCAP & AMS2750E

Throughout my consulting career, I have been approached by many companies who had attempted to get their initial Nadcap accreditation in heat-treat on their own. Typically, these companies have experienced less than satisfactory results. I've seen multiple reasons for this, from lack of knowledge regarding heat-treat processing, incorrect interpretation of the checklists, to the most common reason — poor knowledge and execution of pyrometry requirements. Pyrometry requirements typically make up 70 percent of all Nadcap heat-treat findings in a single year. If you're new to Nadcap, then you are most likely new to pyrometry, and I would recommend retaining the services of an experienced engineer who is familiar with pyrometry.

UNDERSTANDING AMS2750E

As with any specification, it must be read carefully. It would do no good to read the specification and attempt to implement it if you do not understand the material. Put another way, on a scale of 1 to 10, with 1 indicating zero knowledge of pyrometry, someone reading AMS2750E for the first time would need to be at least a 5 in order to properly comprehend and implement the AMS2750E specification.

Most quality engineers are familiar with the term 'bubbling' as it relates to blue prints. Bubbling a print is a practice in which each requirement is assigned a sequential number. Once this is done on the print, it is then logged onto a form which contains the designated number, its associated requirements, the subsequent result, and an accept/reject notice. Typically, this is done on machined parts that may have an intermediate process (such as heat-treat) involved in their manufacture. When an intermediate process is performed, the specification is simply listed as the requirement and an accept designation is applied. The specification itself is not bubbled, but read by an engineer, and the applicable requirements flowed down.

My method is to bubble the specification itself. Take each requirement out of the specification and assign it a sequential number. Let's call them 'characteristic requirements.' Some paragraphs may

have several requirements within a single paragraph; each would be separated and assigned its own sequential number. Let's look at an example of this:

AMS2750E PG 19, PARA 3.4.5.1:

"The displayed temperature indication and/or recording of the sensor being tested as used in production, with appropriate offsets or correction factors, at any operating temperature, shall be compared with the corrected temperature indication of the test sensor on a test instrument."

It may seem that a single requirement is being put forward; but there are actually seven contained within this one paragraph.

1. The displayed temperature indication…
2. and/or recording of the sensor being tested…
3. as used in production…
4. with appropriate offsets or correction factors [*option for either*]…
5. at any operating temperature…
6. shall be compared with the corrected temperature indication of the test sensor…
7. on a test instrument.

I have performed this task on both AMS2750D and AMS2750E. Revision E ended with 513 characteristic requirements, including tables and figures. Once bubbled, each requirement must be accounted for as they apply to your operations. For example, any requirement regarding a retort furnace would be designated 'N/A' if your operation employed only vacuum furnaces. Of course, the continuing issue of comprehension arises at each step of this process. If you have a poor understanding of pyrometry, it will be difficult to bubble AMS2750E, and nearly impossible to successfully complete the process of showing conformance. Training is an important step in this process.

SUMMARY

In the end, ensure your comprehension of AMS2750E is in line with Nadcap's expectations and that your internal auditing system is sound. This will expedite your success in implementing AMS2750E as it applies to Nadcap.

ABOUT THE AUTHOR Jason Schulze is a metallurgical engineer with 20-plus years in aerospace. He assists potential and existing Nadcap Suppliers in conformance as well as metallurgical consulting. He is contracted by eQualearn to teach multiple PRI courses, including pyrometry, RCCA, and Checklists Review for heat treat.

Methodology to ensure design intent is satisfied

By Lee Rothleutner

Surface hardening heat treatments have been shown to significantly improve strength, mitigate wear, and enhance the fatigue performance of wrought, cast, and sintered ferrous components [1]. As a result, surface hardened components are often placed in challenging applications that demand additional scrutiny to confirm specific design requirements such as surface hardness, case depth, and case microstructure. Case depth is of particular interest to the product designer because it characterizes the gradient in material properties near the surface, where stresses tend to be the highest.

Case depth can be defined a variety of ways, but is routinely quantified by measuring both the total and effective case depths of the component via physical testing, chemical testing, or microstructural examination. Total case depth has a well-accepted definition, but effective case depth can be defined in several ways — and, in some instances, defining it is unnecessary. Although an assortment of surface hardening technologies is available in industry, this discussion will be limited to defining case depths resulting from the carburizing and induction hardening of wrought steel.

MEASURING CASE DEPTH

Accurately measuring the surface hardened case depth of a component is not a task that should be trivialized. Consequently, metallographic specimens are typically specified to validate a surface hardening process, with hardness testing being the most widely preferred method of characterizing the surface hardened layer. Figure 1 shows three preferred techniques for determining case depth profiles via hardness testing. All three techniques require careful sample preparation and sound hardness testing methodology to ensure data validity. Although the cross-section procedure is the primary method used due to its simplicity, the taper and step methods can be very useful in specific scenarios such as characterizing shallow case depths or very coarse microstructures that require higher loads (larger indentations) to reduce variability in the data.

Figure 2 shows an example of the use of hardness testing to measure carburized and induction hardened case depth profiles. During carburization, carbon is diffused into the surface of the steel at austenitizing temperatures, followed by quench hardening. During induction hardening, the surface of the steel is rapidly heated using a high-frequency alternating magnetic field, also followed by quench hardening. The shapes of the hardness profiles generated from the two surface hardening techniques are very different; this difference results from the method by which the case is created. Carburizing results in a relatively gradual hardness profile, dictated primarily by the carbon diffusion gradient. Induction hardening results in a more pronounced hardness profile, controlled primarily by heat conduction. Even though the profiles in Figure 2 look markedly different, both can be characterized with hardness depth references, which ultimately define the case depth.

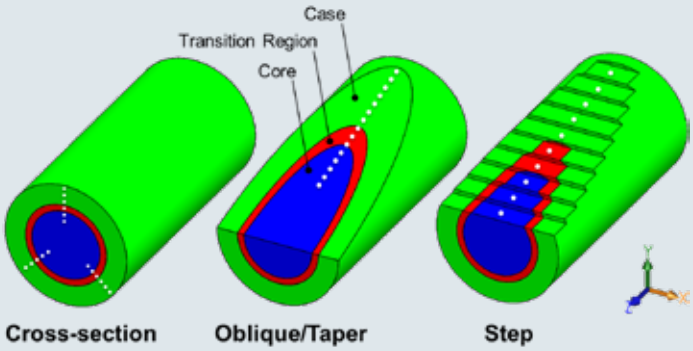


Figure 1. Three commonly used methods for quantifying case depth profiles via hardness testing. Case region is shown in green; case-core transition region is shown in red; core is shown in blue with white dots illustrating example hardness testing locations. Details regarding implementation of each method are available in SAE J423 [2] and ISO 18203 [3].

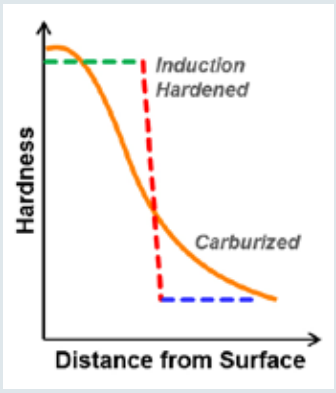


Figure 2. Schematic showing examples of carburized (solid line) and induction hardened (dashed line) case depth profiles.

DEFINING CASE DEPTH

Understanding the design intent of a component allows aspects like case depth validation to be appropriately defined. Following are some commonly specified values used to characterize surface hardened case depth profiles:

- Surface hardness: Typically specified as a range (minimum and maximum).
- Depth to minimum specified surface hardness: The beginning of the case-core transition region.
- Total case depth: Generally defined as the distance from the surface (measured perpendicularly) to a point where the differences in the chemical or physical properties of the case and core may no longer be distinguished [1–3].
- Effective case depth: Approximately 66 percent

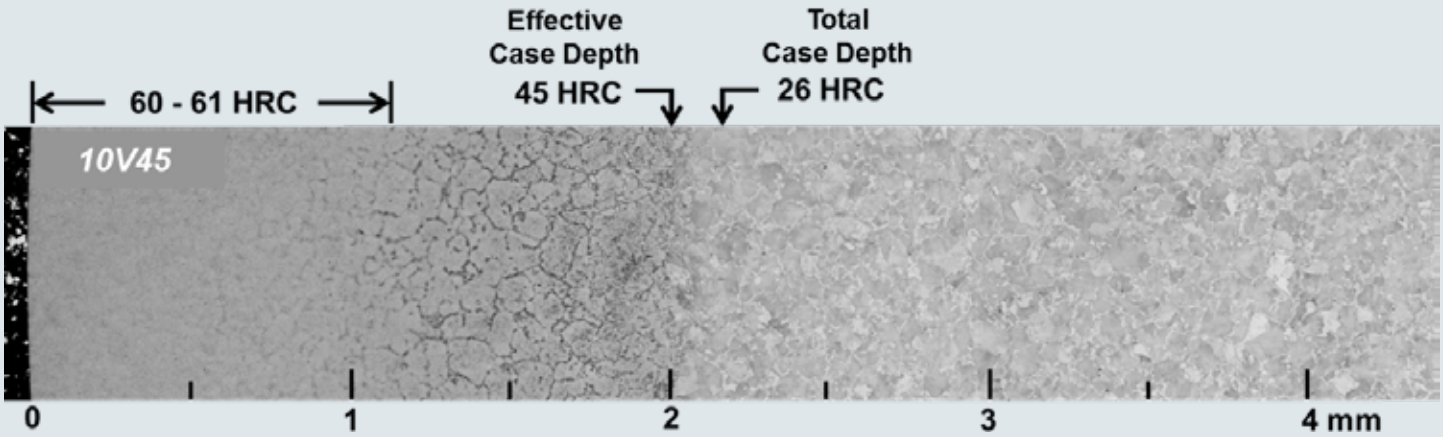


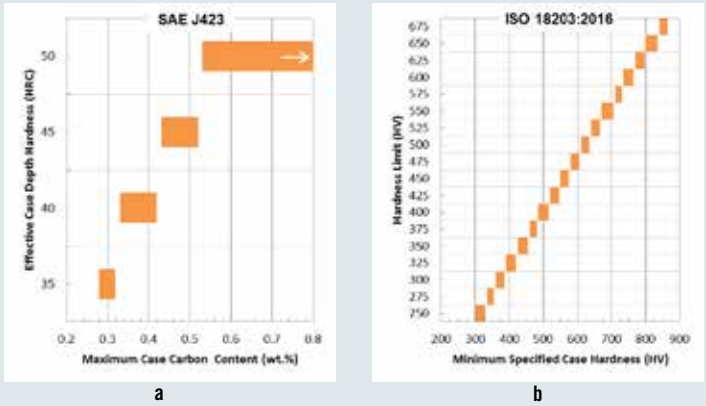
Figure 3. Optical micrographs of an induction hardened case in a 10V45 steel shaft. Hardness values and locations relative to the surface are indicated for the effective and total case depths [4].

to 75 percent of the total case depth [1], but often specified as the depth to a specific hardness.

Of the four terms used to define case depth, effective case depth is the most ambiguous. In fact, one could argue that induction hardening does not require effective case depth to be defined because of the relative abruptness of the case-core transition. Simply determining the depth to the minimum specified surface hardness and total case depth should adequately define the hardness profile of the majority of induction hardened components.

Figure 3 shows an example of this justification in an induction hardened 10V45 steel shaft in which the effective and total case depths have very little separation. However, with the carburizing technique, having the effective case depth defined verifies the curvature of the hardness profile with an additional point of reference.

Figure 4 shows two industry standards that are often referenced to define effective case depth (also known as "hardness limit" in ISO 18203) in the surface hardening of steels. The SAE standard defines the effective case depth as a function of the carbon content



a b

Figure 4. Graphical summary of values specified in (a) SAE J423 [2] and (b) ISO 18203:2016 [3] for the effective case depth hardness/hardness limit for surface hardened components.

of the case, while ISO specifies effective case depth strictly by the minimum specified hardness of the case. Literature justifying which method is more appropriate from a strength or fatigue improvement perspective is very limited, suggesting either definition is sufficient. However, a paper by Fett [5] concluded that the torsional strength of induction hardened medium-carbon steel shafts more closely correlates with effective case depth, while the fatigue performance more closely correlates to total case depth.

This observation makes sense after further examination of the profile shown in Figure 1. The total case depth of an induction hardened component is the location in the core that has the lowest strength and highest stress, assuming the stress is highest toward the surface — an assumption that is valid in nearly all loading schemes. This provides some evidence to suggest that if strength is one of the key design factors being addressed by surface hardening the component, then specifying effective case depth may be prudent.

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ABOUT THE AUTHOR Lee Rothleutner is a principal development engineer with The Timken Company. He received his Ph.D. in Metallurgical and Materials Engineering from the Colorado School of Mines. His research experience includes microstructural evolution during induction hardening, torsional fatigue, and vanadium microalloying. Rothleutner serves on the Heat Treating Society Membership Committee and is a veteran of the U.S. Coast Guard. He can be reached at lee.rothleutner@timken.com

Why heat-treating furnaces look the way they do

By Jack Titus

Decades ago, early in my heat-treating and metallurgical career, there used to be a saying that heat-treating — the institution — couldn't decide whether it was an art or a science. This philosophy was likely due to the fact that personal computers, programmable logic controllers (PLC), and cellular phones were decades away and the term 'digital' related to something to do with counting one's fingers. And the knowledge base, "the hands-on art of the process," resided in the minds of experienced men and women who grew up in the industry.

From the perspective of those skilled in the art, the science of heat-treating has made enormous strides in moving the process into the 21st century. Still, even for most people inside the manufacturing arena, heat-treating is a mysterious process where the terms 'tempering' and 'scorch and warp' are all that come to mind when they hear the term heat-treating.

It's true that when an outside-the-industry observer compares a photo of a typical batch and pusher furnace from 1945 to today's systems they'd say, "OK, I give up. What's the difference?" Why? Because the casual observer would see two sets of three rectangular steel boxes connected together with a lower box sitting in a hole, Figure 1. And looking closer at Figure 2, they'd see the pusher furnace with a refractory lining, work support, and alloy radiant tubes. In the second connected box called the 'vestibule,' they'd see an elevator and below they'd see a quench tank in the hole or pit in the ground. The second furnace system would still have three boxes (Figure 3), one still in a hole, but the one with the refractory lining is very short — almost the same size as the other two boxes. But that's where the similarity ends.

Heat-treating, specifically endothermic carburizing, can be performed continuously in pusher furnaces, the long box, where trays of parts are pushed against one another through the furnace, processing many trays through successive zones until all of the required parts in the inlet queue have been processed. Batch furnaces, the short box, process one tray at a time. In both furnaces, parts are heated in an endothermic atmosphere consisting of 20 percent CO, carbon monoxide; 40 percent H_2, hydrogen; and 40 percent N_2, nitrogen; with small amounts of CO_2, carbon dioxide; H_2O, water vapor; and CH_4, methane. After the atmosphere's carbon potential (CP) has added a specified depth of carbon to the steel parts, each tray is individually, even in the pusher furnace, quenched in oil to harden the parts. Tempering to improve toughness then follows.

Why do the pusher and batch furnaces outwardly look similar when they're 73 years removed? Because both must have refractory insulation, like the kind that lines the typical refractory fireplace to reduce heat losses and protect the home's construction. Carburizing takes place at 1,700°F (927°C) and higher so the insulation exists to eliminate heat losses and

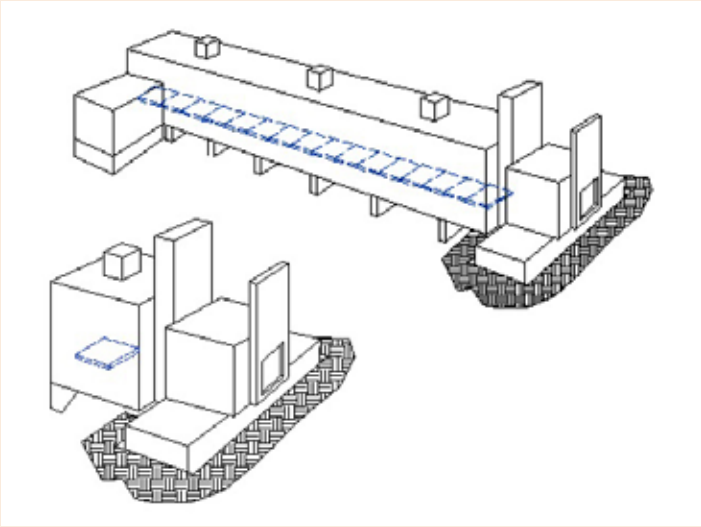

Figure 1: Left, batch furnace. Top right, one row pusher furnace. (Courtesy: AFC-Holcroft.com)

Figure 2: Complete three-row pusher layout, furnace, wash, temper and material handling. (Courtesy: AFC-Holcroft.com)

protect the furnace's steel construction. It's the same reason your home has fiberglass insulation in the walls and ceiling — to conserve energy.

Having said that, one might ask: With insulation like that used on the space shuttle, isn't there a better material than that used in fireplaces? The answer is, of course, yes. There is. We don't use it because manufactures wouldn't pay the price we'd have to charge for the furnace if we used it. Let's say a typical 36" x 48" x 36" oil quench batch furnace would sell for about $400,000 with the normal insulating fire brick. If we used state-of-the-art insulation that was not as expensive as the space shuttle but with similar efficiency, that furnace would probably cost at least three times more.

No one has come up with a better or less expensive insulation system

Figure 3: UBQ Integral quench batch furnace. (Courtesy: AFC-Holcroft.com)

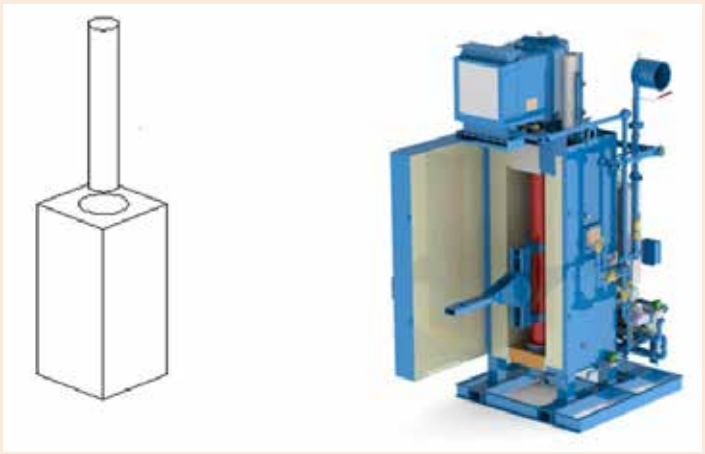

Figure 4: E-Z Series 4500 CFH endothermic generator. Left, typical old-style generator requires additional head room to remove retort for maintenance. Right: The E-Z generator's retort is removed through the door — no head room required. (Courtesy: AFC-Holcroft.com)

that manufacturers could afford and still make an acceptable margin on their product.

Carburizing furnaces, those that operate at atmospheric pressure and use endothermic gas, have their casing structure made from 3/16" mild steel plate with structural steel members such as I-beams and channels to add rigidity. Insulation usually consists of nine-inch-thick insulating fire brick on the hot face backed by four-and-one-half-inch thick low temperature insulating fiber board. Harder brick made from alumina, aluminum oxide, is used to support the tray-on-tray system in pusher furnaces. Batch furnaces, for the most part, employ heat-resisting stainless-steel alloys containing nickel, chromium, iron, cobalt, tungsten, and other critical metals to enhance the performance of today's furnaces.

Years ago, endothermic gas for atmosphere carburizing was produced in generators containing a heat-resisting iron, nickel, and chromium retort, a vertical 10" diameter pipe filled with nickel nitrite catalyst that creates endo gas from the reaction of air, and natural gas at 1,950°F (1,065°C). It's difficult to change the catalyst in the retort — maintenance personnel had to pull the retort up through the top of the generator with an overhead crane, requiring even more head room. Those days are over now that we can just open the door to the generator shown in Figure 4, disconnect the retort from the cooler, and simply pull it out with a walk-behind fork loader or forklift.

Although the technology exists to reduce heat loss and accommodate manufacturing's material handling requirement and the proven assembly construction methods still in use today, there's just no more economical solution to make the furnace box at present than that presented above.

However, because of the worldwide demand to improve quality and implement continuous improvement, the human machine interface has definitely evolved. Figure 5 is a visual description of the evolution of furnace process control for carburizing steel and other critical heat-treating processes. Early carburizing process control required very experienced human intervention to make decisions on controlling the CP. In the past, monitoring equipment was often crude, requiring constant calibration to maintain accuracy. Temperature, carbon potential, and their association with a material could not be integrated since communication between instruments and sensors did not exist.

Step-by-step, as technology improved in other industries, some of those developments found their way into heat-treating. Case in point: the microprocessor, computer, and the programmable logic controller (PLC). The injection molding industry was one of the first to embrace the PLC as a device to drastically increase production and reliability of hardwired

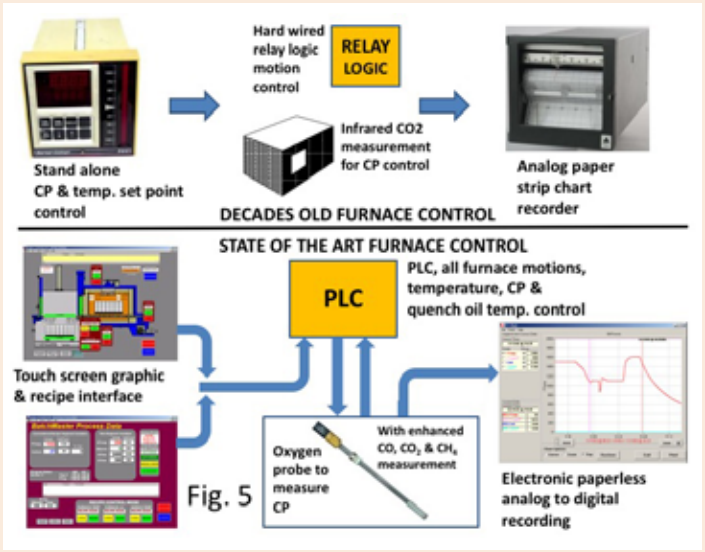

Figure 5. (Courtesy: AFC-Holcroft.com)

relay logic. Relays are mechanical switches that, when energized by single-phase 120 vac, would power items such as motors, solenoid valves, and other electrically operated devices. Although they operated fairly quickly, being mechanical they are prone to failure. PLCs operate in the software realm on what's called firmware. Firmware is basically software that's permanently programmed into plug-in chips. Software as we know it is what makes computers, cell phones, and the internet work. PLCs also accept special software that creates the same functions as hardwired relays but are orders of magnitude faster and more reliable.

Finally, industrial hardened computers have morphed into the human machine interface (HMI) and talking to the PLC via the touchscreen HMI to control temperature, CP, and all motions such as doors, elevators, valves, etc. Specialized communication protocols allow recipes to be stored in main or host computers anywhere and distributed anywhere to any heat-treat facility. Equipment can be interrogated via the internet to diagnose alarms and download new software just as is done with the mobile phones.

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Visual inspection, routine preventative maintenance of atmosphere furnaces is critical to maintaining safety, efficiency

By Ipsen USA

Looking around your immediate environment, you may notice almost everything you use on a daily basis contains a metallic object that has undergone some type of heat-treatment process. The process used may be through-hardening, case hardening, annealing, or even brazing. All of these heat treatments involve elevated furnace temperatures where oxygen can adversely affect the surface of the material being processed.

To protect the material from surface reactions while it is being processed in the furnace, the heating chamber(s) are filled with an atmosphere. This atmosphere may be either inert or reactive. When a reactive atmosphere is formulated, it allows a desired surface reaction, such as carburizing, to take place. It is important to ensure the integrity of the processing equipment chamber so that the atmosphere contained inside can produce the desired result.

In order to provide a consistent envelope, most equipment operates at a slight positive pressure. This positive pressure is what prevents air infiltration. The chamber will typically have a vent that allows the pressure to be accurately controlled by venting off the excess atmosphere. When the chamber is tight and the pressure is maintained, the atmosphere composition will also be controlled. Maintaining the integrity of the processing chamber is the key to predictable process results.

There are some signs that can help determine if your equipment is not providing an effective environment for your desired process atmosphere. The signs may include part discoloration, decarburization, and scaling. In the case of an integral quench furnace with hydrogen-based atmosphere, there may be small explosions (i.e., woofing) because of room air infiltrating and combusting in the furnace work environment.

VISUALLY INSPECTING COMMON LEAK SOURCES

One way to locate the source of a leak is to start with a detailed visual inspection of the equipment.

First, check the connection points where gaskets join larger equipment sections to smaller subassemblies. Evidence of hot spots where the paint has been discolored may indicate that gaskets have deteriorated and formed gaps.

When assembling or reassembling components, there are a couple of recommendations to ensure an air-tight seal. One suggestion is to use a double-wrapped gasket with overlapping ends to properly seal the gaskets (Figure 1). Another suggestion is to use a RTV (room temperature-vulcanizing) silicone to hold the gasket material to the frame as the two sections are mated together. However, you may notice some silicone products can char and burn out, leaving a passage for air infiltration. Even products designated for high-temperature use are only rated for temperatures below 300° F. As a best practice, use a thin layer

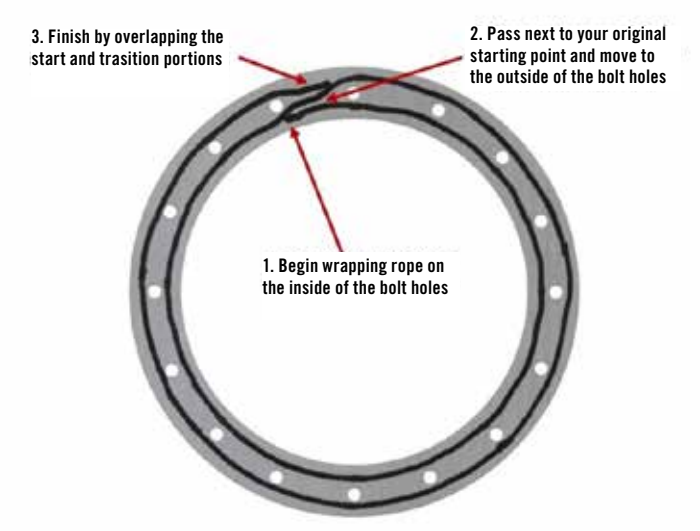


Figure 1: Best practice for wrapping a gasket for a bolt-on flange connection.

Figure 2: The photo above shows strapping material inserted in a split in a furnace casing. Missing refractory material allowed excessive heat to reach the welded seams. This led to failure of the furnace casing.

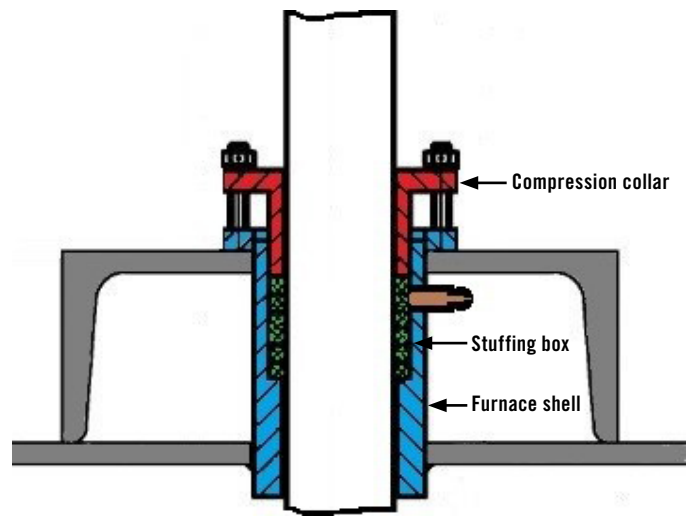


Figure 3: Packing glands around a cylinder shaft.

of high tack adhesive for holding gaskets to frames for assembly. This will prevent air gaps from forming after thicker layers of RTV adhesive burn away.

A second area of the furnace that is susceptible to leaks is the heating chamber. Over time, the refractory material within the chamber will expose the metal shell to unexpected temperatures. This causes cracks and weld separations that create leaks (Figure 2). This is why visually inspecting the furnace for discolored exterior paint can provide clues to the leak's origin.

A third area of the furnace to visually inspect, and one of the more common sources for furnace leaks, is the packing glands that surround the cylinder shafts used to raise and lower inner doors and quench elevators (Figure 3).

The shafts typically pass through a collar welded to the furnace shell. Graphite re-enforced rope, or simply ceramic rope wetted with high-temperature grease, is stuffed into a stuffing box. This creates a packing gland that seals tightly around the shaft. The packing is compressed and held in place with a compression collar. A grease fitting installed on the collar allows the stuffing material to be periodically lubricated, ensuring a tight seal to the shaft.

LEAK DETECTION METHODS

One method for detecting leaks would be using smoke generators (i.e., smoke bombs). They are very effective in finding leaks that are difficult to locate. This method is performed when the furnace is cold and after all combustibles have been purged from the furnace. Place the smoke generator inside the furnace and ignite it. The resulting smoke plume infiltrates the potential leaks and are spotted as it exits the furnace.

When using this method, remember that the furnace doors, effluent stacks, and any quench oil overflow pipes must be tightly capped off and a slight positive pressure should be introduced into the furnace. Remember that most furnaces operate with a slight positive pressure typically less than 1" water column. This integral pressure must be duplicated to force the smoke into any potential leaks. Pressures greater than the level that the furnace is designed to operate at can result in leaks occurring in places where they would not normally occur.

Another acceptable method is to spray a solution of water and liquid dish soap over suspected areas and look for bubbles that indicate there is air leaking.

Figure 4: This photo shows a protection tube that has holes that would allow air infiltration. This area would have been hidden behind the refractory and not easily viewed by inspection without removal.

OTHER POSSIBLE LEAK SOURCES

There are additional ways air can enter the furnace chamber. Units that are heated indirectly through firing tubes can push air entering into the furnace through leaking tubes and tube packing glands.

Another often overlooked area where air can enter is through thermocouple protection tubes (Figure 4). Thermocouples are checked and replaced routinely, but protection tubes are not checked as often.

PREVENTATIVE MAINTENANCE

Integral quench furnaces that operate with a combustible atmosphere should be given special attention. During the quenching process, the chamber pressure can briefly go negative. This will allow air to be sucked into the chamber where it can mix with combustibles and ignite. This is what produces the "woofing" sound. Always remember that frequent inspection coupled with proper maintenance will help ensure that accidents do not occur.

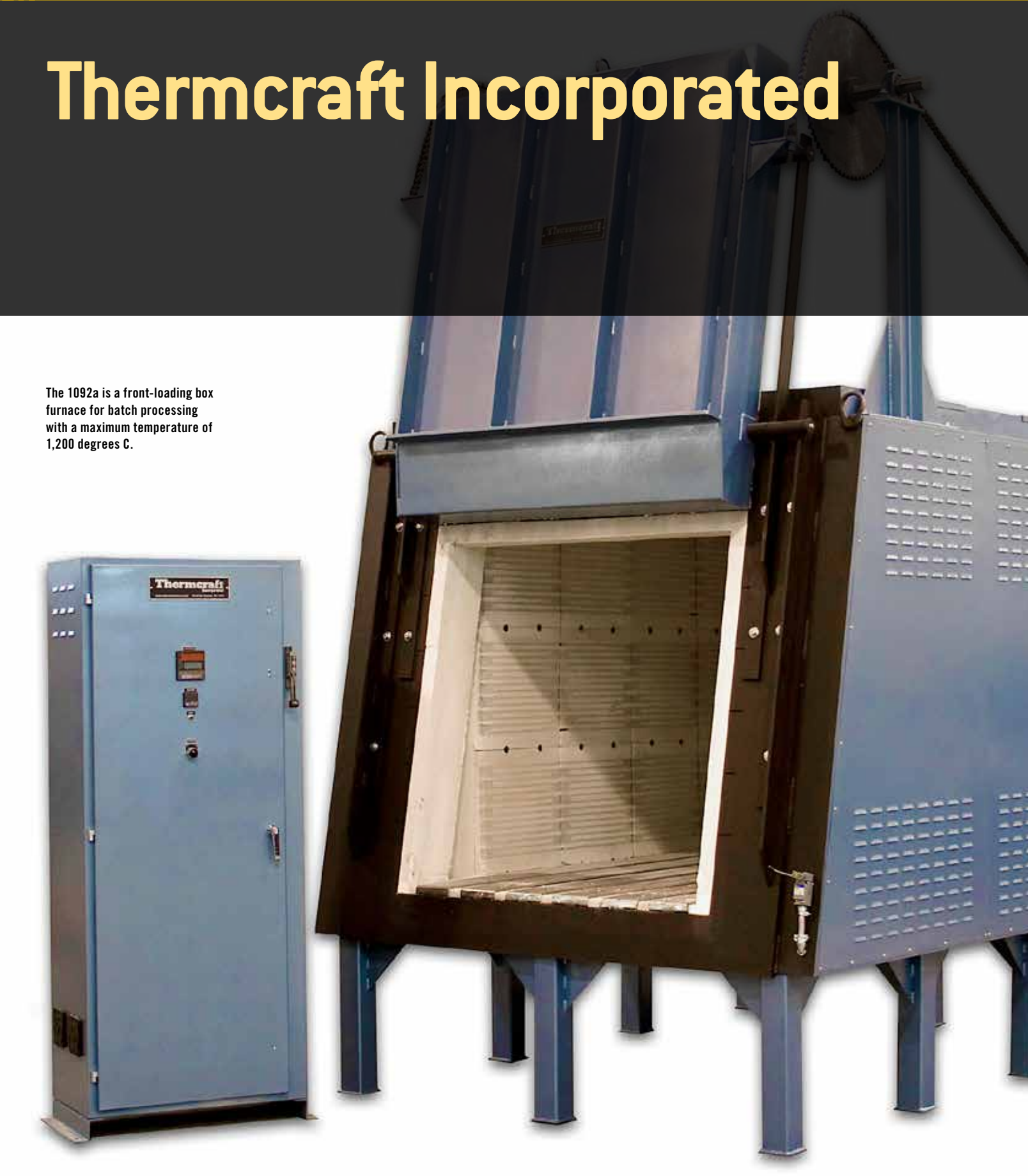
At a minimum, a thorough bi-annual inspection when the furnace is cold should be performed with an emphasis on any areas where there are penetrations into the chamber. Additional recommendations are:

- Weekly lubrication of packing glands is critical and yearly replacement is recommended.
- Daily inspection of door seals should be done and promptly repaired when leaking.
- Immediately replace missing or damaged refractory.

Overall, visually inspecting your atmosphere furnace and performing routine preventative maintenance are critical to maintaining your furnace. While some leak sources are easily identified, others may involve a more thorough leak detection method to find and repair. Taking these steps will help ensure part quality and the overall successful operation of your equipment.

Thermcraft Incorporated

The 1092a is a front-loading box furnace for batch processing with a maximum temperature of 1,200 degrees C.



With products ranging from quick-ship designs to fully customized solutions, Thermcraft Incorporated is an international leading manufacturer of high-quality thermal processing equipment.

By Kenneth Carter
Editor | Thermal Processing

For laboratory and industrial oven supplier Thermcraft, it all began with popcorn.

Yes, you read that right.

And even though it might be hard to imagine a stranger way to begin a heat-treat business, selling popcorn machines and their replacement heating elements is where it started for Thermcraft founder Morris Crafton.

But every company has to start somewhere, and Crafton eventually decided to invest in a partnership with a company that manufactured industrial and laboratory furnaces as well as replacement heating elements for industrial and laboratory furnaces. That eventually led to him owning his own company manufacturing heating elements that would evolve into what the company is today, according to Thermcraft Marketing Manager Derrick Wilson.

OFFERED EQUIPMENT

In addition to laboratory and production furnaces, Thermcraft also offers recirculating ovens, vacuum-formed ceramic fiber heaters, cast heaters, heater coils, air heaters, ovens, kilns, and diffusion heaters for application temperatures up to 1,800 degrees C (3,272 degrees F).

"We have several standard product lines as well as what's been our core product over the years of fully customized thermal product solutions," Wilson said. "We also have a product line of ceramic fiber and refractory ceramic component heating elements, as well as replacement heating elements for the semiconductor diffusion type chemical vapor deposition systems, which are basically a large replacement heating element for all the different OEMs of systems that manufacture or process semiconductor wafers through CVD-type applications. And we offer all types of high-temperature insulation."

Thermcraft also can manufacture replacement parts or heating elements for just about any OEM manufacturer's furnaces and ovens, he added.

CUSTOMER SERVICE

Thermcraft supplies its products with a high level of customer service, according to Wilson.

"One of the major contributors that sets us apart — and we get a lot of feedback from our customers — is our level of customer service, and the level of customization that we're willing to offer," he said.

Since most of Thermcraft's furnaces are air atmosphere, it doesn't compete much with the large commercial heat-treating equipment processors.

"Our primary technology for heating is electricity," Wilson said. "We do some gas-fired systems, but those are very scarce."

With potential new customers, it's important to establish a good connection, according to Wilson. And Thermcraft caters to a variety of industries, including heat-treat, aerospace, automotive, ceramics, metal-treating, pharmaceuticals, laboratory, and more.

"A lot of times, customers don't understand exactly what they need," he said. "They know what they're trying to achieve, but they don't know what system they need to achieve the results they want. We have a team of in-house sales engineers who start a dialogue, whether it be by email or a phone conversation. With a potential new customer, we find out exactly their needs and the parameters of the process, and if they have any budget constraints or technical constraints such as size and power limitations."

Once a proposed solution is reached and the customer signs off on engineering approval drawings, then Thermcraft goes forward with engineering and manufacturing, Wilson said.

OFF-THE-SHELF ADDITIONS

Although Thermcraft has decades of experience designing and creating custom furnaces for its custom-

The 0684 is a dual drawer oven, maximum temperature: 300 degrees C.

"One of the things we're trying to do now is become more competitive with standard products and offer more standard laboratory furnaces, as well as some industrial furnace offerings."

The Ash5LClosed is a 5L Laboratory Ashing Furnace, maximum temperature: 1,100 degrees C.

ers, the company wants to offer more off-the-shelf type products, according to Wilson.

"One of the things we're trying to do now is become more competitive with standard products and offer more standard laboratory furnaces, as well as some industrial furnace offerings," he said. "Thermcraft has been very strong over the years with fully customized solutions, and those have not been off-the-shelf catalog or brochure type offerings. What we're trying to do is develop more standard offerings, so we can be more competitive in that market of off-the-shelf products, especially in the laboratory products industry."

Thermcraft recently introduced the eXPRESS-LINE, a full series of standard, quick-ship furnaces, ovens, and control systems.

NEW TECH

Wilson said Thermcraft also is working with new technologies and looking at new alternative types of insulation.

"One that we brought up in conversation recently was one of the new types of mineral-based insulation for higher temperatures," he said. "It's much more health friendly to your lungs. And we're also looking into different types of coating and materials to use in furnace construction in order to increase the insulation efficiency of our systems. We're trying to reduce the footprint and the weight without reducing any of the thermal heat transfer barrier."

With more customers wanting to incorporate heat treating into their in-house manufacturing process, Wilson said he expects Thermcraft to be there to make that request a reality. Those technologies also include 3D printing of metals, ceramics, and other types of materials.

"We're trying to keep up with that and stay on the cutting edge wherever possible," he said.

Some of that cutting edge was even featured on the Science Channel series, *How It's Made*. In that 2016 episode, the company's 5L laboratory box furnace was demonstrated.

ACQUISITIONS AND LEGACY

Thermcraft, still located in Winston-Salem, North Carolina, has come a long way since its corn-popping beginnings in 1971. Over the years, several smaller companies have been acquired under the Thermcraft brand that includes Lab-Temp, TransTemp, Marshall Furnace, and Contemporary Kiln.

Thermcraft, now in its second generation of ownership with current president Thomas Crafton leading the way, above all else, is dedicated to its customers and what it can do for them, according to Wilson.

That dedication is personified by none other than Thermcraft's founder and CEO:

Crafton, now 92, still drives himself to the company he started for a few hours almost every day.

FOR MORE INFORMATION www.thermcraftinc.com

The Bridgman is a Bridgman crystal growing system with a 3 zone tube furnace and PLC control system for control of furnace temperature, ampule rotation, and furnace translation, maximum temperature: 1,300 degrees C.

The 1680 is a dual hearth elevator hearth furnace, maximum temperature: 982 degrees C.

A heat-treating furnace fixture made of unidirectional C/C, solid posts and lock nuts. (Courtesy: SGL Group)

Benefits of graphite and C/C fixturing

More heat-treating engineers are making the switch to graphite fixturing using carbon composite materials.

By Erica Hillebrand and Jim McAllister

Limited only by the designer's imagination, heat-treating fixtures constructed of graphite and carbon composite (C/C) materials can offer manufactures serious operating benefits.

Historically, successful manufacturers of precision parts have used various materials such as steel, molybdenum, or nickel-chrome alloys for the construction of their heat-treating fixtures. Over time, these alloys become distorted and embrittled from long exposure to increased temperatures. This often results in damage to the surface, creating the need to source entirely new fixtures. In comparison to alloy-based materials, C/C and graphite fixtures have many advantages including: increase in mechanical strength as the temperature increases, high stability while being resistant to thermal shock (no deformation), and lower density resulting in significant weight reduction. These factors result in a longer service life of the product, increased load capacity, and operating efficiency with a handsome return on the investment.

Graphite products that contribute to these fixtures include isostatic, extruded, and carbon composite (C/C) material grades. Isostatic and extruded materials are manufactured with a combination of graphite materials and pitch tar coke that are formed, baked, and then graphitized per the desired grade specification. These materials are used as posts or plates in fixture designs. C/C is a composite material produced through the combination of polyacrylonitrile (PAN) fiber and a converted carbon matrix. The PAN fiber is produced in either a unidirectional or multidirectional layer. These layers are infused with a high carbon content resin compound. The resulting resin infused layer, called a Pre-Preg, is combined with identical layers in a stack up configuration to create a two-dimensional sheet material to the required thickness. After the initial stack up, the sheet is compressed and heated to set or cure the resin. Consequent production steps of baking, resin

impregnation, and graphitization will result in a C/C material. All materials are capable of being easily CNC machined or water jet cut into application specific, intricate shapes for use in high temperature environments up to 3,000 degrees C.

Graphite, and thus C/C, has many properties that provide advantages over alloy materials (Figure 1).

BENEFITS

Graphite has the unique property of increasing in strength as it is heated from room temperature up to 2,000 degrees C. This property is a function of the internal stresses in the material. As process temperatures increase, the internal stresses that exist at room temperature reduce, and as a result, mechanical strength increases. An increase in mechanical strength means less fixture support structures are needed and thinner designs are possible, which equates to increased batch sizes.

C/C material also has a much lower density than alloy materials, making C/C fixtures more ergonomically attractive. Operator fatigue from moving and loading fixtures is greatly reduced by using the significantly lower weight C/C material. In many cases, operators can move C/C fixtures by hand versus using an overhead crane or forklift. The density difference between C/C and other fixture materials is seen in Figure 2, most notably the 1 to 5 comparison to cast steel. Lower density also means a higher ratio of part weight to fixture weight, which means less energy needed per part.

C/C fixtures have low thermal mass and excellent thermal conductivity, which allows for rapid heat up and cool down compared to other fixture materials. This reduces the total energy consumption and increases efficiency because the energy used is heating the parts and not the fixture, resulting in overall reduced cycle times.

Typical hot bending strength of various high-temperature materials

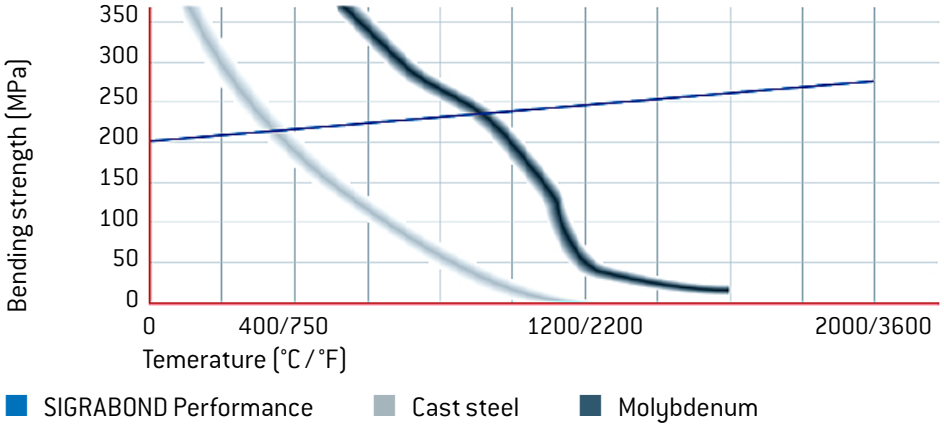


Figure 1

Density of different high-temperature materials

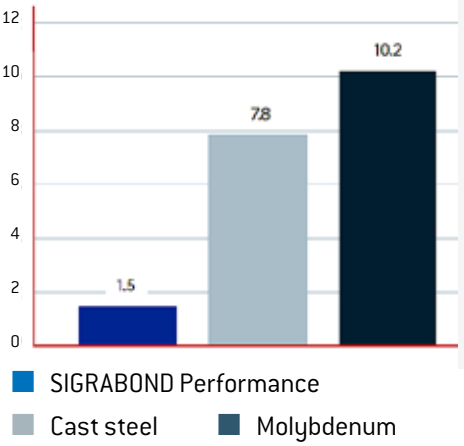


Figure 2

These properties, along with lack of embrittlement, low CTE, and no distortion or embrittlement make C/C an ideal material for improving the dimensional outcome of many different products. Graphite and C/C systems do not show any signs of material fatigue or warping — even after hundreds of furnace cycles. The tool holders can be mechanically loaded and unloaded for years without problems. Time-consuming and expensive manual adjustment work is eliminated, scrap expenses are reduced, and productivity and cost-effectiveness are increased.

In fact, the fixture becomes a critical component in the control of the final dimensions on a variety of precision components of any size. Thermal cycling of C/C has little to no effect on the physical dimensions of C/C machined components. Therefore, the physical attributes of C/C provide for an ideal material for controlling and minimizing distortion of a wide range of materials and part sizes over multiple thermal cycles. Components made of fiber composite materials do not break abruptly under stress the way ceramics materials will. They do not exhibit the plastic behavior of metals when stressed beyond the elasticity limit. This longer life equates to a lower cost of ownership.

POTENTIAL ISSUES

Although graphite and carbon composite materials have many advantages over alloy fixtures, they are not ideally suited for every process. Graphite and carbon in general is subject to failure at temperatures exceeding 930 degrees F in an open air or oxygen environment. At these temperatures, the graphite structure will start to oxidize

and will weaken over time and become structurally unsound. The ideal environment for temperatures above 930 degrees F requires the furnace to pull a vacuum or operate with a protective inert gas atmosphere. There are no oxidation issues at any temperatures in vacuum or inert atmospheres.

Depending on the process and part makeup, another possible issue with using graphite is carbon pickup or, in extreme cases, eutectic reactions. Carbon pickup is dependent on process temperatures and the heat-treated part's metallic alloy components. Every case is different, but typically, process temperatures above 1,920 degrees F and parts with high contents of nickel, chromium, and vanadium, along with some lower alloyed tool steels, are carbon captors and highly reactive. The higher the content of these alloy components, the more likely carbon diffusion and thus, carbon pickup will occur. In the most extreme cases, eutectic reactions could take place, rendering the fixture useless. Countermeasures to carbon pickup and eutectic reactions include intermediate layers or barriers made of ceramics such as alumina oxide. These can include intermediate layers of ceramic papers, plates, or even coatings. Such barriers can seal the open porosity of the material surface or separate the carbon surface from the product to be heat treated. Coatings include silicon carbide or boron nitride. Other options are hybrid racks containing both C/C parts and ceramic parts. Although temperature and part makeup can be good indicators of carbon diffusion, it is always best to test C/C in your process first. Any refutable C/C provider will be more than happy to provide samples for testing.

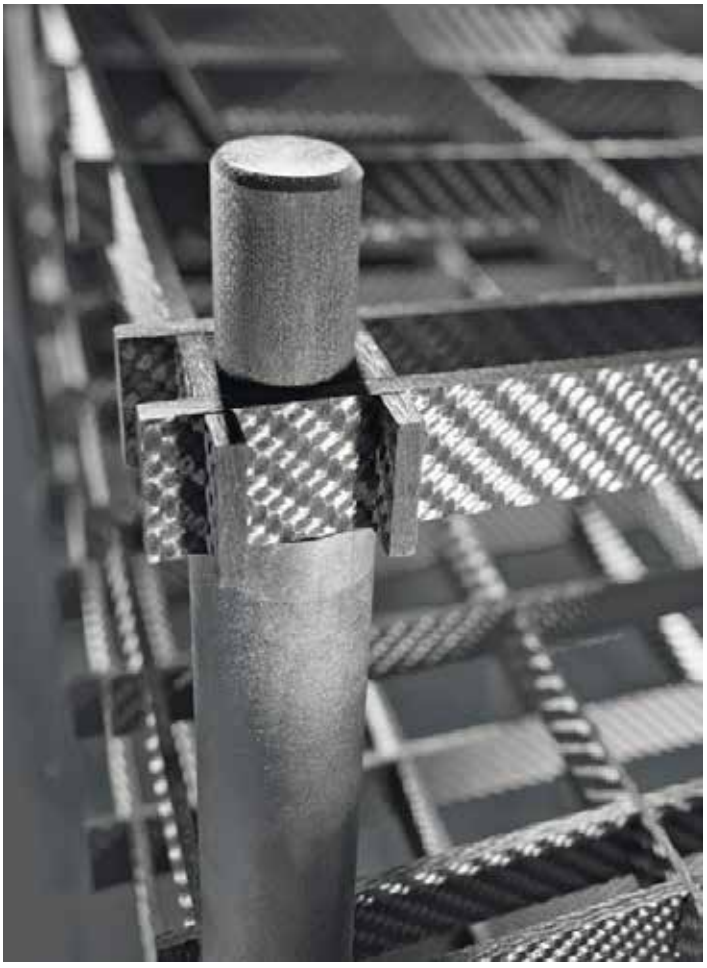
C/C FIXTURE DESIGN

C/C is commonly produced in sheet or tube form. These shapes allow for utilization in a variety of configurations such as flat plates, finger-joint structures, columns/pillars, fasteners, or multi-layer structures. Such structures can be as basic or customized as possible. Grids and plates can be designed specifically to hold a desired part and can be interchangeable over multiple part designs. Likewise, basket designs can ensure that only one fixture is required for a start-to-finish heat-treating process, and parts such as blades or stems can be hung to avoid eutectic reaction while ensuring specific tolerances are met. Designing a fixture, rack, or tooling out of C/C material requires an understanding of the needed strength of material grade to be used, along with loading conditions, total load weight, weight distribution, and the method by which the fixture will be transferred in and out of the furnace.

C/C materials require different construction techniques when building fixtures, as compared to traditional alloy materials. Typically, structures are built through the use of threaded connectors, interlocking joints, solid posts, and fasteners versus welded joints required of alloy structures. For more secure fixtures, innovative locking techniques can be employed such as interlocking finger joint designs. The final size and configuration of the furnace tooling or structure is also important to consider. As the fixtures are constructed of different variations of graphite components, if a piece would fail, it can easily and individually be replaced. This is different from alloy fixtures, which, due to the structure welds, need to be refurbished or in extreme cases completely replaced.

C/C APPLICATIONS

Graphite and C/C system components for high temperature furnaces can be used in a wide range of applications including gas carburizing to improve case depth hardening of components, vacuum brazing to join metals together creating perfect joints, sintering of green powdered metal components, and many other heat-treating processes.



A finger joint grid made of woven C/C and solid posts. (Courtesy: SGL Group)

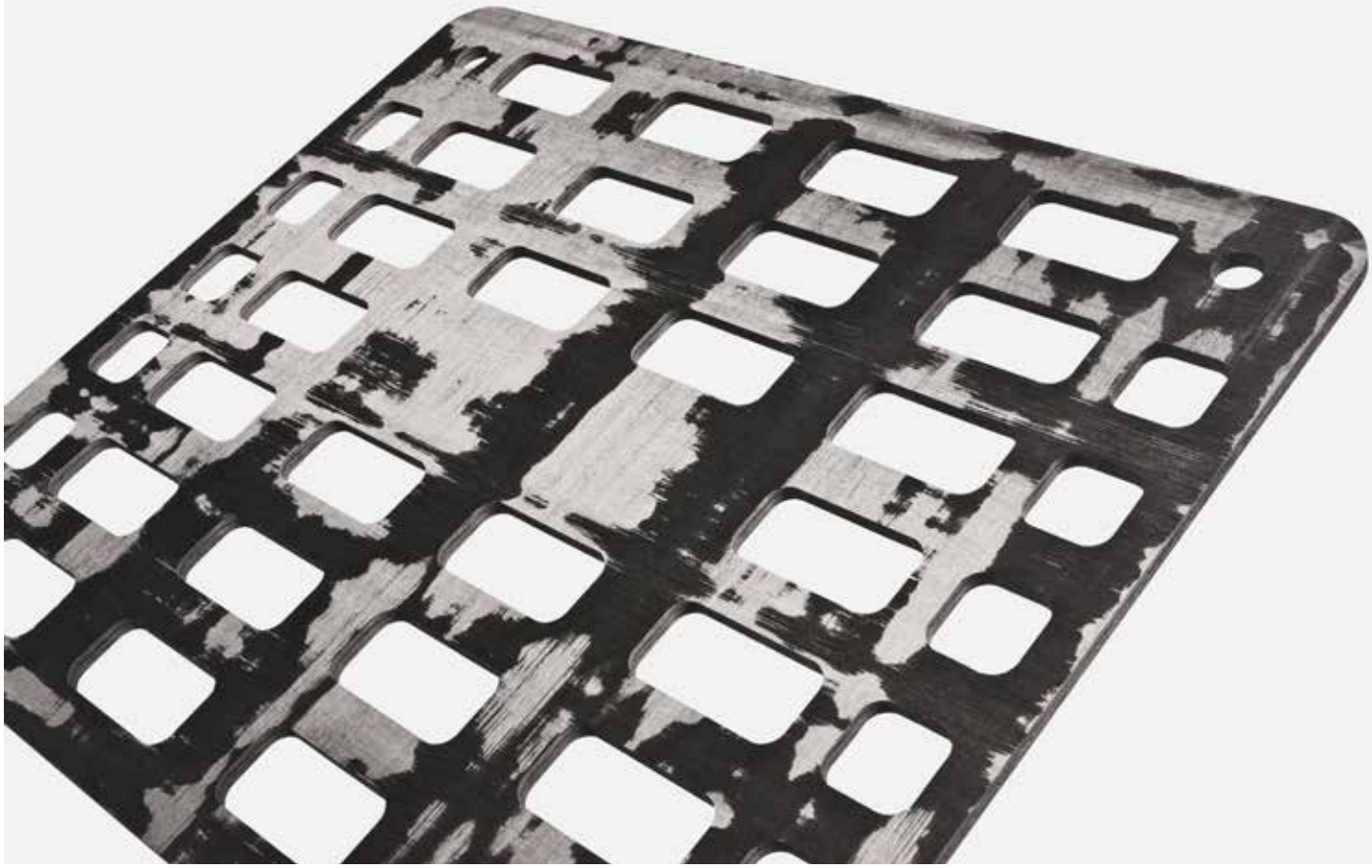
Recent material advances have allowed C/C material to become suitable for oil and liquid quenching applications. In these types of applications, open porosity of the fixture material is important, and a sealed surface area is desired. Although the woven structure is common for most C/C material, new advances with unidirectional C/C fiber structure material have provided lower open porosity, making it ideal for liquid quenching operations. Recent testing has shown that after two quenching process runs, open porosity was reduced from 11 percent to 8.2 percent, which means the oil absorption into the unidirectional material was only 3 percent. After an additional 200-plus runs, the open porosity remained at 8.2 percent with no signs of delaminating. The absorbed oil had been cracked (decomposed) into the material's carbon during the first couple of furnace runs. Outgassing during the cracking was very low due to the low absorption percentage and had been guided out of the furnace hot zone by normal furnace atmosphere exchange.

Furthermore, additional processing of the material in the form of silicon carbide impregnation can further seal the open porosity of the material surface and protect the fixture pieces from mishandling or frequent repetitive handling of the structure. This can be in the form of robotics or automation process that constantly grab/rub the same material surface, employee mishandling/ throwing of the trays, or fork truck/ loading mechanism mishaps of the fixtures.

CONCLUSION

For decades, alloy fixtures have been the norm for heat treating. In recent years, due to the numerous benefits and few

For decades, alloy fixtures have been the norm for heat treating. In recent years, due to the numerous benefits and few drawbacks, more heat-treating engineers are making the switch to graphite fixturing using C/C materials.



A heat-treating plate made of unidirectional C/C. (Courtesy: SGL Group)

drawbacks, more heat-treating engineers are making the switch to graphite fixturing using C/C materials. C/C materials offer excellent properties such as thermal shock resistance and thermal conductivity. This high thermal stability allows filigree structures to be manufactured with high mechanical strength. The flatness of the material, combined with low thermal mass, affords rapid heat-up and cool-down time, reducing cycle time and providing for longer service life. Recent advances in material structure makes C/C material useful for almost all heat-treating processes, including secondary operations such as quenching. In the years to come, graphite and C/C will continue to prove their operating cost effectiveness and high return on investment compared to the lifetime of components for heat-treating applications.

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To determine which thermocouple wire is right for your application, select one that provides a temperature rating that meets (or exceeds) the temperatures to be measured in your application. (Courtesy: TE Wire & Cable)

Temperature and accuracy

Three basic steps that can help in selecting the right thermocouple wire.

By Vlad Fedorchak

When it comes to selecting the right thermocouple wire, it's all about temperature and accuracy. It is vital to select a thermocouple wire that fits within the temperature range of your application. Why? Because a wire that doesn't fit the required temperature range will not provide accurate temperature measurement. And this could lead to system or parts damage if the elements of your application get too hot.

So how do you know if you're picking the right thermocouple wire? There are three basic elements: calibration, conductor, and insulation/jacket.

STEP 1: CALIBRATION

Consider the calibration type of the instrument connected to your thermocouple wire. The calibration type of the wire must match the calibration type of the instrument. In addition, the temperature to be measured can influence the calibration type as each type has a temperature range defined by ASTM E230-03 (Table 1).

Here are some details on specific calibration types:

- **Type T:** Ideal for cryogenic temperatures.
- **Type N:** Less affected by drift than Type K at higher temperatures.
- **Type J:** Provides a cost-effective calibration up to its upper temperature limit.

STEP 2: CONDUCTOR

Accuracy of extension grade, standard limits, or special limits. Select either a solid conductor or a stranded conductor and the desired wire gauge (AWG).

- **Stranded:** More expensive than solid; more flexible since they are made up of smaller diameter wires.
- **Solid:** Cost-effective conductor, easier to weld than stranded, not as flexible as stranded.

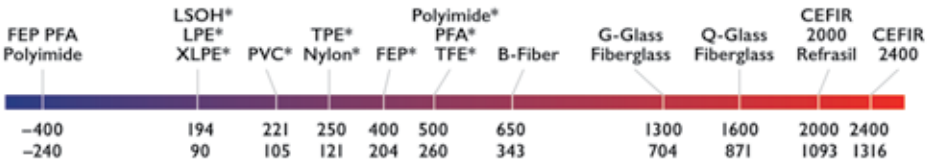
Thermocouple Type/Wire	Temperature Range °F (°C)	Grade Designation	Standard Grade Limits °F (°C) whichever is greater	Grade Designation	Special Grade Limits °F (°C) whichever is greater
T	32 (0) to 700 (370)	T	±1.8 (1) or ±0.75%	TT	±0.9 (0.5) or 0.4%
J	32 (0) to 1400 (760)	J	±4.0 (2.2) or ±0.75%	JJ	±2.0 (1.1) or 0.4%
E	32 (0) to 1600 (870)	E	±3.1 (1.7) or ±0.50%	EE	±1.8 (1) or 0.4%
K or N	32 (0) to 2300 (1260)	K or N	±4.0 (2.2) or ±0.75%	KK or NN	±2.0 (1.1) or 0.4%
T*	-328 (-200) to 32 (0)	T	±1.8 (1) or ±1.5%	TT	±0.9 (0.5) or 0.8% **
E*	-328 (-200) to 32 (0)	E	±3.1 (1.7) or ±1%	EE	±1.8 (1) or 0.5% **
K*	-328 (-200) to 32 (0)	K	±4.0 (2.2) or ±2%	KK	**
Extension Wire	**Range °F (°C)**	**Designation**	**Limits °F (°C)**	**Designation**	**Limits °F (°C)**
TX	32 (0) to 212 (100)	TX	±1.8 (1)	TTX	±0.9 (0.5)
JX	32 (0) to 400 (200)	JX	±4.0 (2.2)	JJX	±2.0 (1.1)
EX	32 (0) to 400 (200)	EX	±3.1 (1.7)	EEX	±1.8 (1.0)
KX or NX	32 (0) to 400 (200)	KX or NX	±4.0 (2.2)	KKX or NNX	±2.0 (1.1)
RX or SX	32 (0) to 400 (200)	RX or SX	±9.0 (5)		
BX	32 (0) to 212 (100)	BX ***	±7.6 (4.2)		
BX	32 (0) to 400 (200)	BX Alloy ***	±6.7 (3.7)		

* Thermcouple material is normally supplied to meet tolerances above 0°C (32°F). If material is required to meet tolerances below 0°C (32°F), this must be specified. Special material selection is required.

** Suggested initial calibration tolerance. Requirements should be discussed between purchaser and supplier.

*** Copper vs. copper can be used as an extension for Type B thermocouples if the transition is below 100°C (212°F). Above 100°C (212°F), PCLW30-6 alloy should be used as the positive extension wire.

TC Wire Insulations



* Maximum continuous temperature shown. All others show major single use temperature. CEFIR is a registered trade mark of TE Wire & Cable. Refrasil is a registered trade mark of Hitco Carbon Composites, Inc.

STEP 3: INSULATION AND JACKET

Consider the upper and lower continuous process temperatures that will affect the wire.

The highest temperature of the process also should be considered so that the insulation can withstand it.

Insulation for abrasion resistance can be especially challenging to select. For help, consult with TE Wire for a chart that shows the relative abrasion resistance of insulations.

Consider corrosive gases or liquids that the insulation must bear.

Consider the color of the conductor insulations and the jacket (if not to the ANSI standard).

DIFFERENT WIRE CALIBRATION TYPES

Can different thermocouple wire calibration types be used in the same circuit? The short answer is "no."

It is important that the entire circuit must be the same calibration type. Even if you're using calibrated wire that has been tested in a calibration laboratory, they cannot and should not be substituted one for another. The electro motive force (EMF) output of each thermocouple type is different and unique from all other types. You want to be sure that you've selected the right calibrated wire for the temperature range of your application.

For example, placing a Type J with EMF thermoelectric power of about 30μV/°F into a control circuit programmed for Type K with thermoelectric power of about 22μV/°F (or vice versa) will cause significant errors in temperature reading.

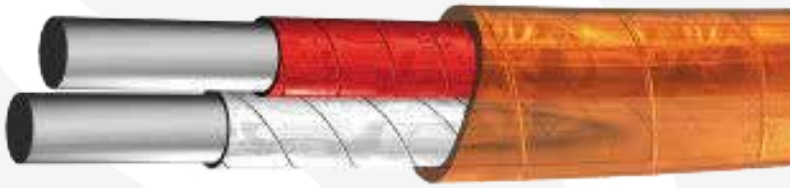
This incorrect use of thermocouple wire can result in more energy use and ruined parts that must be scrapped.

If you're unsure of the thermocouple wire you should be using, especially in high temperature heat treatment applications, consult the ABC's of thermocouple.

THE ABC'S OF THERMOCOUPLE WIRE CALIBRATION TYPES

When it comes to thermocouple wire, there's an alphabet of calibration types available: K type thermocouple, J type, T type, and so on. The most frequently asked question is: What do these designations mean and which type is right for a specific application?

First, you need to understand what is meant by the phrase "calibration type." This refers to the designation name (or type) that defines the unique chemical composition of the dissimilar metals of the positive and negative thermo element bare conductors used in the thermocouple wire. Commercially available calibrations are grouped into two groups according to the conductor's material characteristics.



To determine which thermocouple wire is right for your application, select one that provides a temperature rating that meets (or exceeds) the temperatures to be measured in your application.

There are five base-metal thermocouple types and three noble-metal thermocouple types defined and accepted by governing bodies such as ANSI (American National Standards Institute) and IEC (International Electrotechnical Commission). The base-metal types, J, K, N, E, and T are nickel-metal based. The noble-metal types R, S, and B are platinum-metal based.

Type J: Widely used because of its versatility and low-metal cost. The positive thermoelement is 99Fe. The negative thermoelement is 44Ni/55Cu alloy. Type J is also known as Iron-Constantan. Type J bare conductors have an accepted upper temperature limit of approximately 1,300 degrees F (700 degrees C).

Type K: Also known as Chromel-Alumel, Type K is widely used for its higher temperature range. The positive thermoelement is 90Ni/9Cr. The negative thermoelement is 94Ni with alloying constituents of Si,Mn,Al, Fe, and Co. Type K bare conductors have an accepted upper temperature limit approximately 2,350 degrees F (1,285 degrees C).

Type N: Also known as Nicrosil-Nisil. It provides EMF stability superior to that of Type K at elevated temperatures. The positive thermoelement is 84Ni/14Cr/1.4Si. The negative thermoelement is 95Ni/4.4Si. Type N bare conductors have an accepted upper temperature limit of approximately 2,350 degrees F (1,285 degrees C).

Type E: Also known as Chromel-Constantan. Type E provides the largest EMF output of any base metal thermocouple. The positive thermoelement is 90Ni/9Cr. The negative thermoelement is 44Ni/55Cu. Type E bare conductors have an accepted upper temperature limit of approximately 1,600 degrees F (870 degrees C).

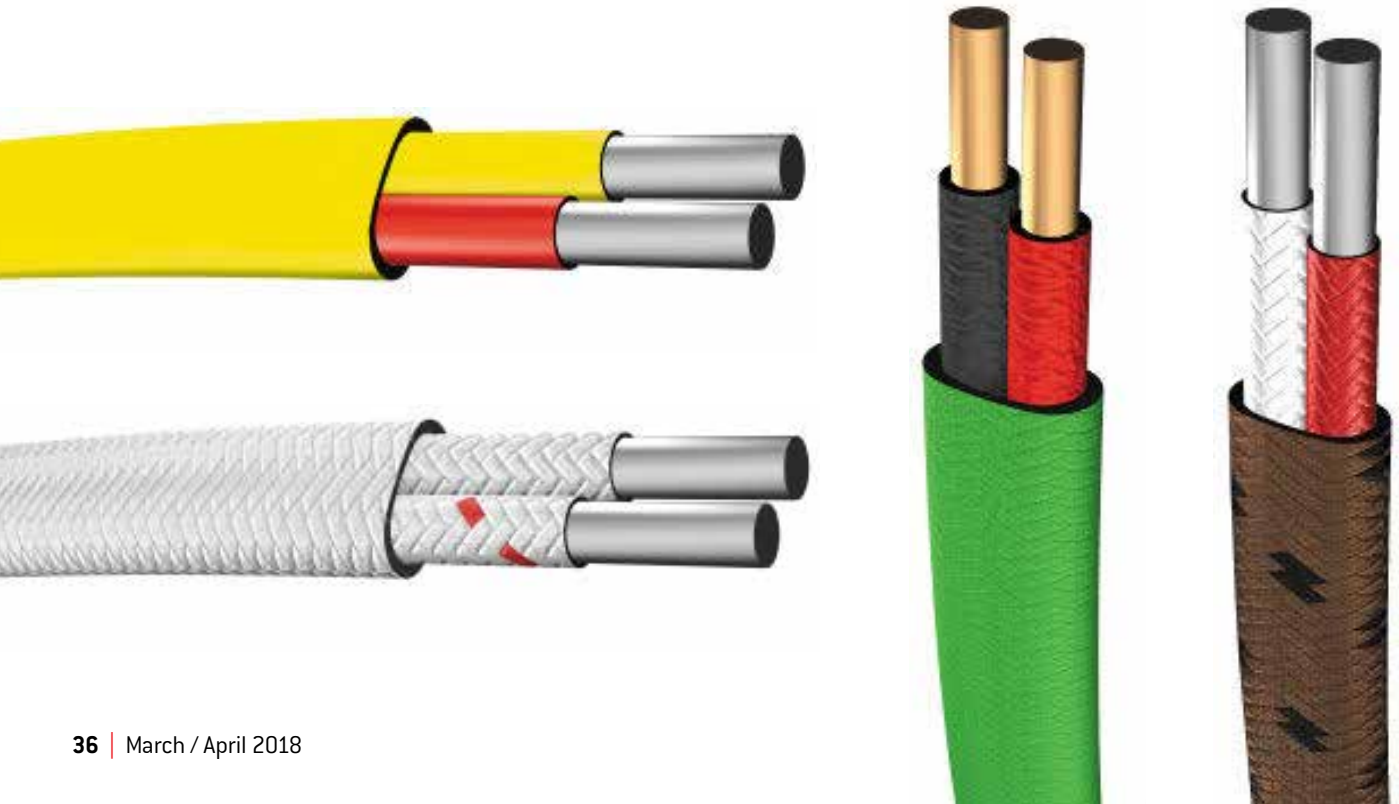
Type T: Preferred for sub-zero cryogenic temperatures and up to 700 degrees F (370 degrees C). The positive thermoelement is oxygen-free copper OFHC CU. The negative element is 44Ni/55Cu. Type T is also known as Copper-Constantan. Type T bare conductors are accepted temperature limits of cryogenic up to 700 degrees F (370 degrees C).

The following three types are also called Nobel metal thermocouples and consist of differing amounts of platinum and rhodium. All three are relatively expensive and susceptible to contamination at high temperatures.

- **Type R and Type S:** Used for high temperatures up to 2,700 degrees F (1,480 degrees C).
- **Type B:** Used for high temperatures up to 3,100 degrees F (1,700 degrees C).

To determine which thermocouple wire is right for your application, select one that provides a temperature rating that meets (or exceeds) the temperatures to be measured in your application.

ABOUT THE AUTHOR Vlad Fedorchak is business unit manager — Aerospace Composites for TE Wire & Cable and has more than 12 years of sales and marketing experience ranging from high volume telemarketing, international sales, focus group research, and digital marketing. Fedorchak joined TE Wire & Cable in 2006 and has been instrumental in the growth and development of international sales. Prior to joining TE Wire, he worked for Q10 Marketing, specializing in focus group research in the consumer space. He holds a MBA in Finance Strategy from Rutgers Business School and a Bachelor's degree in Finance from Rutgers University.



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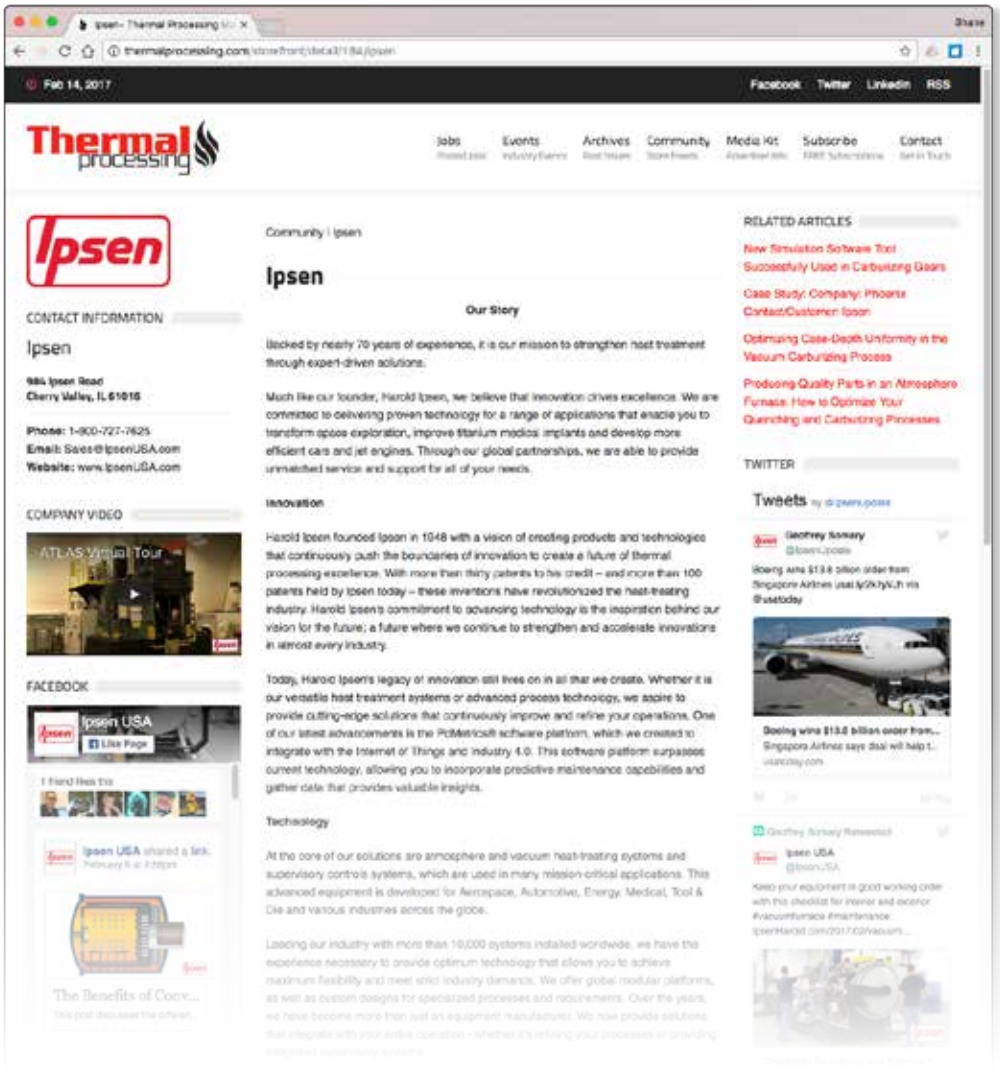

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Thermal processing

When considering cables for applications, engineers have to make sure they specify make sense, not only in mechanical performance but also in signal or electrical properties performance. (Courtesy: TE Wire & Cable)

Noise in instrumentation circuits

How to control and understand "noise," as well as installation considerations.

By Vlad Fedorchak

It can be a real challenge to select the right thermocouple wire for accurate temperature measurement. You not only have to determine the type of thermocouple elements to use, but also the temperature range, calibration accuracy, and insulation type for your application. With thousands of different configurations, it's still far less complicated than thermocouple and instrumentation cable circuits. Regardless, it is important to know how to control noise in instrumentation circuits.

When considering cables for applications, engineers have to make sure the cables they specify make sense, not only in mechanical performance but also in signal or electrical properties performance. The type of signal transmitted by the sensor is related to its sensitivity to noise: The lower the voltage level and the higher the impedance of a circuit, the greater the circuit's sensitivity to noise of all types.

FOUR COMMON SOURCES OF NOISE

There are four types of major noise that must be understood and some commonly accepted solutions for each noise type.

Common Mode

Problem: Different ground potential at each location in a process plant causes common mode noise to be a problem. Two different grounds in an instrument circuit mean a current will flow between them, causing noise to be added to the signal being transmitted.

Solution: Using a receiver that has a high common mode rejection ratio will control this type of common mode interference.

Problem: A second type of common mode interference will occur even when a high-quality receiver is being used and is a particular problem in thermocouple

extension cable circuits. Most thermocouples used are the "grounded" type. That is, the couple is connected physically and electrically to the well in which it is installed. When a thermocouple circuit shield (or any nearby metallic object, such as conduit, tray, building frame, etc.) is at different potential than the couple, charging currents flow in the extension wire, causing interference to be superimposed on the thermocouple signal.

Solution: Grounding the shielded circuit at the couple and only at the couple will eliminate noise problems from common mode. Multi-pair cables used with thermocouples must be individually shielded, isolated pair shield type so that the shield circuit may be maintained at the individual couple ground potential all the way back to the control room.

Cross Talk

Problem: Cross talk occurs with AC instrument signals, especially pulse-type signals, where more than one circuit are carried in the same cable. It is the tendency for a signal to be coupled from one pair to another within the cable, resulting in noise being superimposed on a circuit.

Solution: Cross talk noise may be eliminated by the use of cables with individually shielded, isolated pair shields. The pair shield protects against noise picked up from adjacent pairs, as well as reducing noise by the pair it surrounds.

Static

Problem: Static interference is caused by the electric field radiated by a voltage source being coupled capacitively into the instrument circuit.

Solution: The best way of fighting static noise is to place the circuit inside a total coverage shield, which isolated the pair of wires from the outside influence. The grounded shield intercepts static interference and carries it off to ground. The shield must be grounded in order to reduce static noise; an ungrounded shield will not reduce noise.

Magnetic

Problem: Magnetic noise is produced by currents flowing through conductors and pieces of electrical equipment such as motors, generators, etc. As the current flows through equipment, a magnetic field is radiated around the conductor. As this field passes through the space between the conductors in a circuit, a current is set up in the circuit to oppose the magnetic field (transformer action). This current causes a noise to be superimposed on the signal in the instrument circuit.

Solution: The best way of compensating for this type of noise is to twist the wires in the instrument circuit. Twisting causes the noise to be cancelled in adjacent sections of the wire. This is the least expensive, most effective way of combatting magnetic noise.

INSTALLATION CONSIDERATIONS

Table 1 classifies several environmental areas as having low, medium, or high noise levels. This is intended to give a relative indication of how much noise is expected in a particular installation and how far to go in protecting against noise for the particular instrumentation circuits involved. As always, results may vary.

Environment vs. Relative Noise Levels

Environment	Relative Noise Level
Wiring located far from power lines, motors; motors less than 5 hp; no induction heating, arcs, control or power relays nearby *(Examples: Tank farms, material storage areas, light process plants and blending operations)*	Low
Instrument wire run near medium-sized motors, control relays *(Example: Most processing plants)*	Medium
Electrolytic processes, large motors, generators, transformers, induction heating, relay controls, power lines or control wire nearby *(Examples: Heavy industry, metals and utilities)*	High

PLANT INSTALLATION

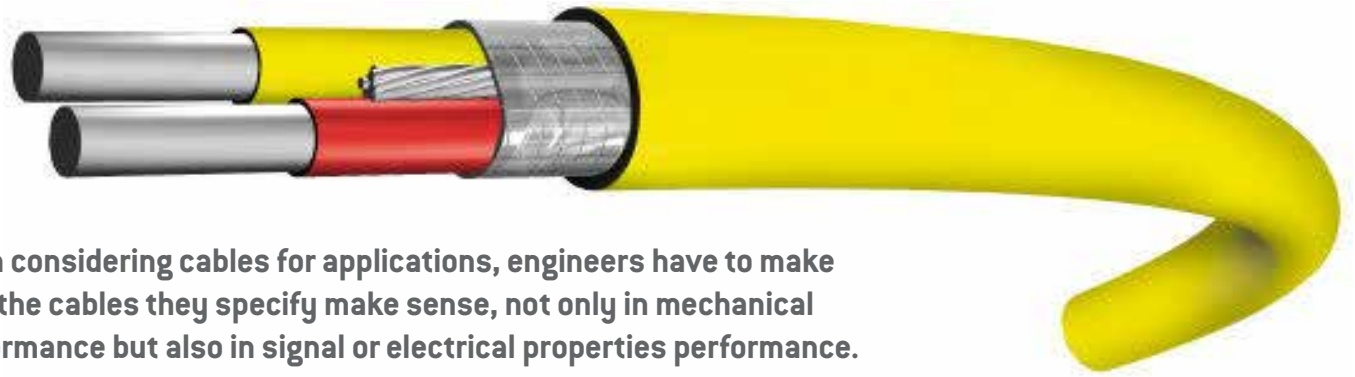
Besides the electrical problems that must be considered in choosing the proper wire and cable, you should also consider what a particular wire or cable installation must withstand from a mechanical standpoint. Here are a few to keep in mind:

- If a cable is being installed in an open tray — or ungrounded — armored or ER rated cable should be provided to protect against damage from crushing or the impact of falling objects.
- If the cable is to be pulled a great distance, suspended from two points, or buried where shifting ground will cause tensile forces on the cable, an armor that acts as a strength member should be considered.
- Armoring should be used where crush and impact resistance are required.
- Where tensile strength is important, served wire armor will provide this protection, as well as crush and impact resistance.

NECESSARY PRECAUTIONS

Precautions taken during design, engineering, and installation also can reduce the effects of noise considerably. For example:

- Routing of instrument cables away from noise sources such as power cables, motors, generators, and any arc-producing equipment will greatly reduce the chances of noise pickup.
- Putting signals of the same relative strength into the same cable and excluding any higher level signals will reduce the chances of cross talk.
- Shielding of data transmission circuits will reduce pickup by nearby instrument circuits.
- Twisting of control and power cables will reduce the magnetic noise pickup in nearby instrument circuits.
- Separation of instrument circuits from noise sources will reduce the noise problem



When considering cables for applications, engineers have to make sure the cables they specify make sense, not only in mechanical performance but also in signal or electrical properties performance.

considerably, as both static and magnetic fields fall off fairly rapidly as distances from the source is increased.

GROUND RULES FOR SHIELDS

Where shields are employed in both the single pair wires and in multi-pair cables for noise protection, there are some important ground rules to follow:

1. To protect against common mode noise pickup within the wire and cable, a shield circuit should be grounded at the point where the instrument circuit is grounded and isolated from all other grounds (i.e., with a grounded couple, ground the shield on the extension wire at the couple).
2. As the shield circuit is carried back to the control room through a junction box and a multi-pair cable, be sure to connect the pair shield in the cable to the single pair which leads to the couple without grounding the shield in the junction box or connecting it to any other shield (on other pairs).
3. The shield should not be grounded in the control room.
4. Ground all shields. An ungrounded shield will not provide noise protection.
5. Ground a shield at one point only.

ABOUT THE AUTHOR Vlad Fedorchak is business unit manager — Aerospace Composites for TE Wire & Cable and has more than 12 years of sales and marketing experience ranging from high volume telemarketing, international sales, focus group research, and digital marketing. Fedorchak joined TE Wire & Cable in 2006 and has been instrumental in the growth and development of international sales. Prior to joining TE Wire, he worked for Q10 Marketing, specializing in focus group research in the consumer space. He holds a MBA in Finance Strategy from Rutgers Business School and a Bachelor's degree in Finance from Rutgers University.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AD INDEX

JOE UGALDE
BUSINESS MARKETING ANALYST WITH TE WIRE & CABLE, LLC

"Many of the company's proudest moments have occurred in times of great innovation and collaborative partnerships. We work with and sell to the best in the industry, which makes it very exciting to work at TE Wire."

WHAT PRODUCTS AND SERVICES DOES TE WIRE & CABLE OFFER?

TE Wire is known as a master of temperature sensing and specialty wire and cable since it was first founded in 1941 during WWII. We participate in three main areas of wire and cable: aerospace/composite, OEM, and metallurgy. TE Wire & Cable maintains an in-house laboratory directly certified by the National Institute of Standards and Technology (NIST) allowing it to calibrate its own wire, which, in turn provides a higher quality product with lower cost and improved efficiency. TE Wire is a Marmon Wire & Cable/Berkshire Hathaway company.

Calibration temperature capabilities include cryogenic -320 degrees F (-196 degrees C) and at any point in a range from a low temperature of -110 degrees F (-79 degrees C) through an upper temperature of 2,400 degrees F (1,316 degrees C). TE Wire & Cable's Calibration Laboratory is ISO9001-2008 certified and ISO/IEC 17025:2005 accredited. It conforms to MIL STD 45662A, ANSI/NCSL-Z540, AMS2750, ASTM E220, ISO/IEC Guide 25, ASTM E207, and others. Products can be supplied to meet BAC5621, ANSI MC 96.1, and other customer unique accuracy requirements.

WHAT IS TE WIRE & CABLE DOING TO ADVANCE THE HEAT-TREATING INDUSTRY?

We're very proud to announce our latest partnership with Cambridge Enterprises, CCPI-Ltd, and ISOMIL to develop and manufacture a low drift dual wall mineral insulated cable that reduces drift by over 80 percent. This dual wall, low-drift type K and type N mineral insulated (MI) thermocouple cable design was developed to improve temperature measurement accuracy, extend thermocouple life, and significantly enhance drift characteristics.

The new low-drift thermocouple cable design was developed for high temperature thermocouple applications and thermocouple installations that require longer use at higher temperatures. The technology will be of particular interest to those involved in aerospace/aircraft manufacturing for measuring jet engine temperatures and for metallurgy applications like heat treatment.

WHAT ARE SOME OF TE WIRE & CABLE'S PROUDEST MOMENTS?

Many of the company's proudest moments have occurred in times of great innovation and collaborative partnerships. We work with and sell to the best in the industry, which makes it very exciting to work at TE Wire.

One great example is our patented, AccuClave® thermocouple assemblies for composites manufacturing operations using large autoclaves. Designed to reduce or completely eliminate the numerous problems associated with hand-made TC cables (i.e., vacuum leaks, reversed polarity, loose connections, and the need for stripping insulation at the vacuum seal, to name a few) this innovative product line is used around the world by many aviation/aerospace manufacturers to monitor composite curing and composite repair. The product family includes extension cables, multiple-circuit cables, and a flat thermocouple for composites repairs with minimal mark-off. All AccuClave products include our easy-to-use TRAC thermocouple traceability, which is a tremendous help in simplifying NADCAP audits.

I'm confident in saying the AccuClave products are the best pre-made thermocouples in the aerospace industry. We're proud to say that every 787 flying today had our product touch it.

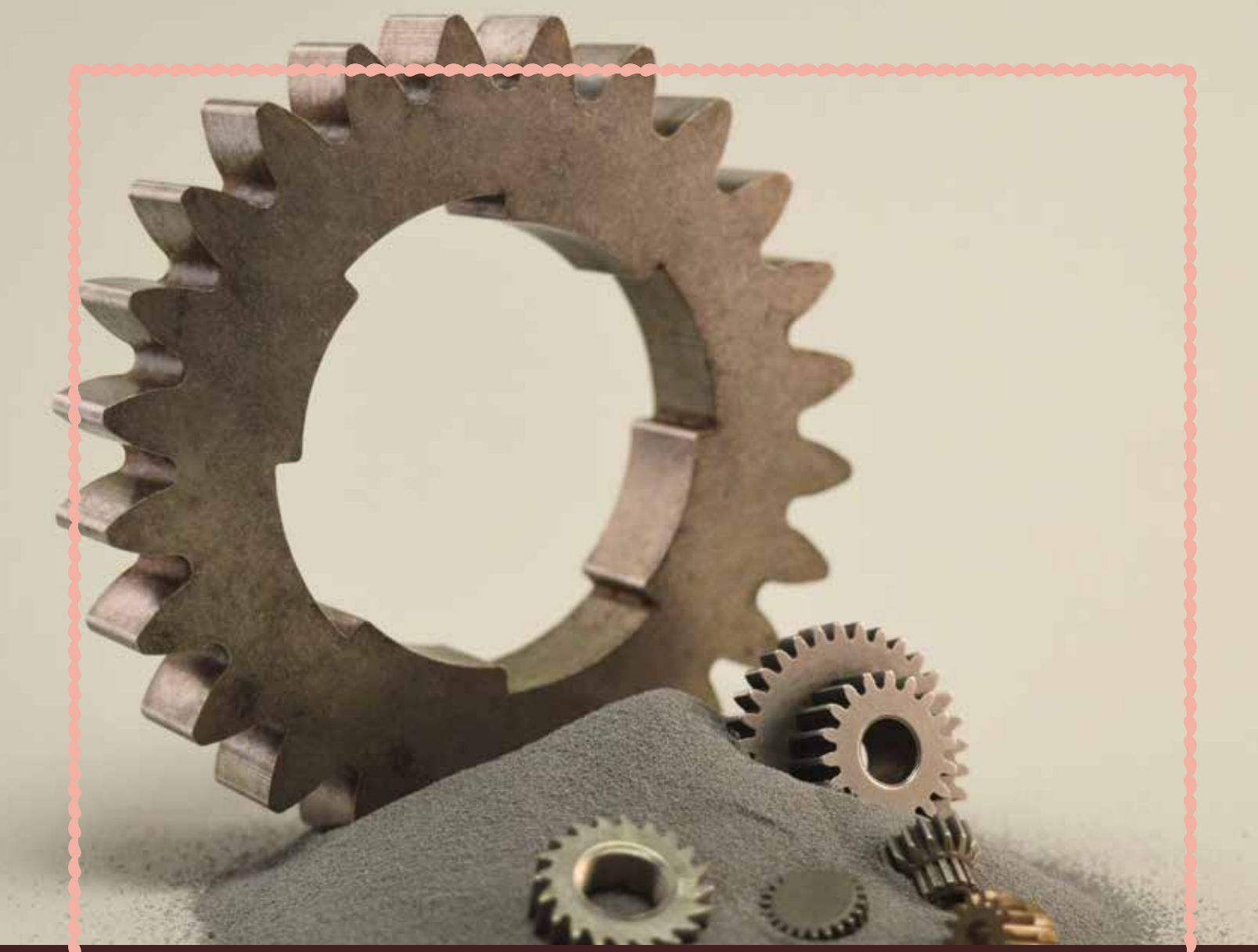
WHAT SETS TE WIRE & CABLE APART WHEN IT COMES TO WHAT YOU CAN OFFER A CUSTOMER?

We provide our customers with the highest quality products in temperature measurement available today at a competitive price. Beyond that, we go the extra mile to help provide customers with the assurance that they're selecting the right thermocouple solution for their specific applications. Collectively, the TE Wire team has an incredible knowledgebase regarding thermocouple applications that is truly hard to match in our industry. Some of our people have been with us for over 30 to 40 years, helping customers solve their most unique heat-treatment and temperature-measurement challenge.

WHERE DO YOU SEE TE WIRE & CABLE IN 10 YEARS? IN 20?

I believe that TE Wire will become a much more dominant player in the temperature sensing market and sensing in general. There will be additions to our current product lines as well as new and innovative products to be developed for the Internet of Things (IoT) and Industry 4.0 spaces in the years to come. TE Wire recognizes the importance of the budding IoT industry and that there is a future for itself with this kind of innovation.

FOR MORE INFORMATION www.tewire.com



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