November 2024

THE UTILITY SOURCE

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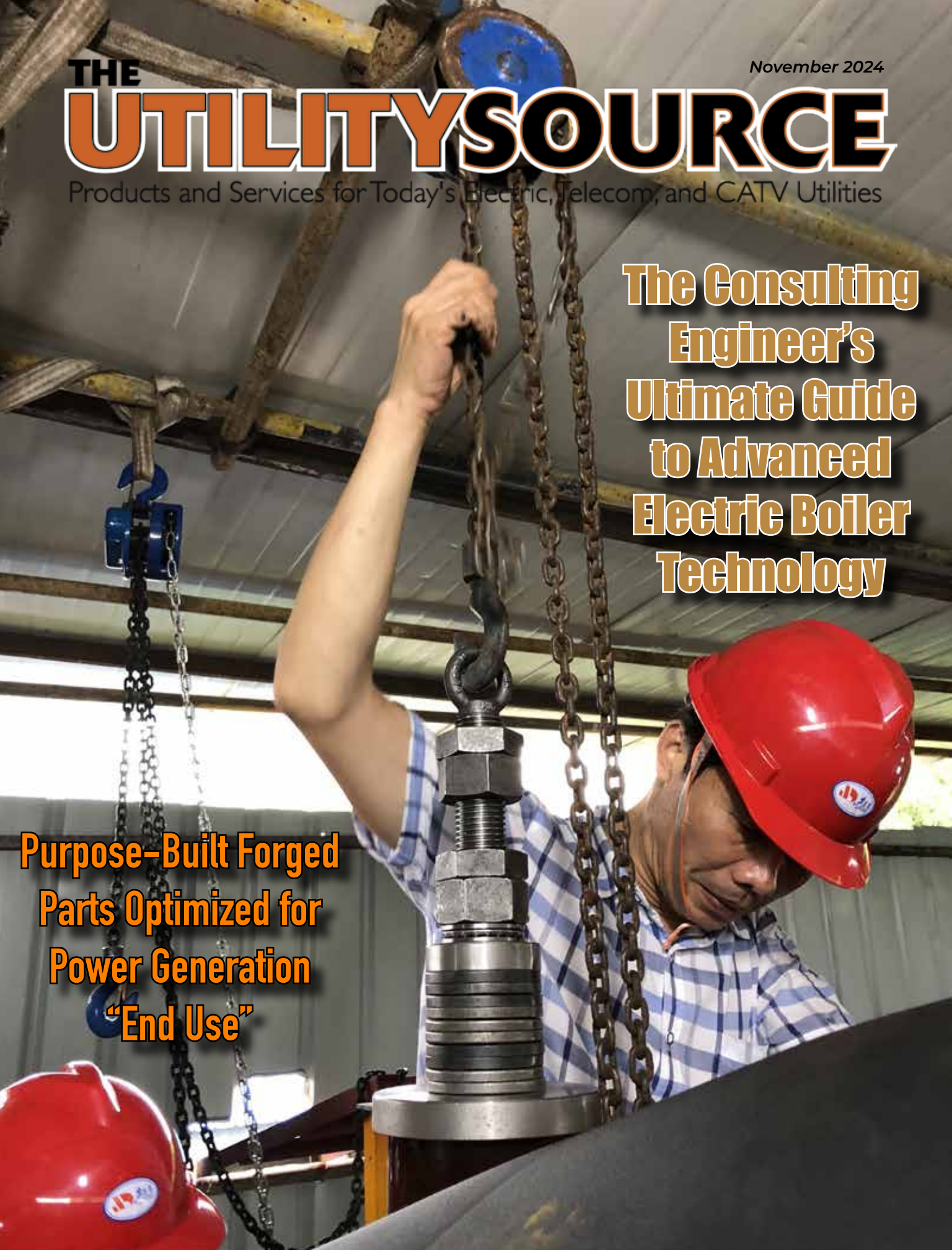
The Consulting Engineer's Ultimate Guide to Advanced Electric Boiler Technology

Purpose-Built Forged Parts Optimized for Power Generation "End Use"



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Purpose-Built Forged Parts Optimized for Power Generation "End Use"

By Royce Lowe

Working with an experienced supplier of open die forgings, seamless and contoured rolled rings, and complex forged parts that prioritizes the "end use" of the part form in the early stages of the process helps ensure quality, performance, safety, and compliance in critical applications.

When forging seamless rolled rings for the power and energy industries, it is crucial to tailor components for their specific applications, or "end use." In the realm of metal parts, this term commonly denotes the ultimate form and state of the final machined part, along with a comprehension of the operating conditions it will face during service.

"By understanding the final application or purpose – the end use – for which these parts are designed and manufactured, forged parts suppliers can determine the appropriate materials, manufacturing processes, and quality standards necessary to ensure that the metal parts perform effectively and reliably in their intended applications," says Jeff Klein, Director of Sales for All Metals & Forge Group. The ISO 9001:2015 and AS9100D-certified manufacturer produces open die forgings, seamless and contoured rolled rings, and complex forged parts to industry standard specifications in 8-10 weeks.

According to Klein, open die and forgings and seamless rolled rings play a crucial role as components in the power and energy sector for a wide variety of end uses. In this industry, forged shapes and seamless rolled rings are crucial for turbines and other power generation machinery as well as hydraulic applications including gears, shafts, hubs, and flanges. As such, these items must exhibit exceptional

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attributes such as strength, durability, precision, and resistance to fatigue, deformation, and harsh environments in saltwater or downhole uses to meet precise performance standards when deployed in the field.

In some cases, failing to consider the end use can even introduce serious risk, including catastrophic failure of a part while in operation, resulting in safety hazards as well as very costly production downtime when essential replacement parts are not readily available.

Consider End Use, from the Start

The consideration and planning to meet end use requirements should begin with the service requirements outlined during the engineering phase of design and conclude when the part is in its operating position, performing as intended.

“It is vital that the manufacturer specify the end use of each part and ensure it is communicated throughout the production chain, from the design engineer, through purchasing, the forging operation, heat treating, finish machining, and final assembly of the end use, including the mechanical property requirements and the heat or corrosive conditions in which the forged part will perform,” says Klein.

According to Klein, the power and energy industries have unique specifications and standards that metal parts must meet. The specific function of the part will dictate its design, dimensions, material selection, forging, heat treating and finishing processes. In all cases, the part must be manufactured to industry standard specifications such as ASTM or AISI unless the OEM has developed their own requirements by modifying one of those standards. In short, the finished product must comply with all quality, durability, chemistry, and mechanical properties within the selected standard.

Seamless rolled rings can be produced in a variety of alloys, sizes, and shapes specific to fit end use requirements. However, by collaborating closely with the forging supplier, engineers, buyers, and machinery builders can ensure the ideal selection of chemistry, mechanical properties, heat treatment, machining, and testing ultimately required for each part's end use.

The process often begins with the selection of the alloy grade used in for open die forging or seamless rolled ring production, which can apply to many specific uses. These range from low and medium carbon steels, through high-carbon steels, aluminum alloys, alloy steels, stainless steels, nickel alloys, tool steels and titanium alloys. The precise alloy for the intended end use should always be specified and stated in the purchasing process according to final mechanical property requirements and service conditions.

Material properties can also be altered for specific end uses by hot working as well as by using various chemistries, temperatures, heat treatment times, and cooling methods. This facilitates the production of seamless rolled rings or forged parts with optimized mechanical properties and structural integrity before the part moves on to finish machining.

Each metal possesses unique alloy chemical compositions formed during the steel mill process, along with diverse production procedures for generating ingots or billets of different grades and purities tailored for industry specifications. Consequently, the quality of steel mill output is critical.

In the case of All Metals & Forge Group, end use is emphasized from the very beginning in the request for quote (RFQ) process. The company works with its steel mills to purchase the correct starting stock to achieve the specified properties and operating reliability required of every part.

In addition, rough machined parts are tested at least three times to prove chemistry, mechanical properties, and soundness before shipping.

According to Klein, there are groups of alloys within each metal material that lend themselves to specific end uses.

High-nickel alloys (I625, I718, I825), for example, are used at high temperatures in such applications as nuclear power generation, where high oxidation resistance is required.

The Inconel 600 and 700 series were developed for specific end uses. Inconel 600 resists chloride-ion stress corrosion cracking. Inconel 690 resists sulfur-bearing gases. Inconel 718 is a precipitation-hardening alloy designed to give very high yield, ultimate tensile strengths, and resistance to creep rupture at temperatures up to 1300°F (705°C).

End use is equally important with stainless steels, where the various groups of martensitic (hardenable), ferritic, and austenitic cover a very wide range of properties and applications when resistance to corrosion and heat are critical.

Basic type 410 martensitic grade stainless, with around 13% chromium, is sufficient for mild corrosive conditions, whereas the ferritic type 430, with 17% chromium shows resistance to more severe environments. The performance of the austenitic stainless steels, based on the 18% chromium/10% nickel in type 304 is selected for certain end uses when correctly heat treated and not subject to carbide precipitation. The various additions to the base 304, such as molybdenum, improve resistance to pitting corrosion. The resultant molybdenum-containing grades are types 316 and 317, normally supplied in the low-carbon versions, 316L and 317L.

The range of stainless steels continues through types 329 and 2205 duplex alloys – austenite and ferrite – that provide good resistance to pitting and stress corrosion cracking, to precipitation hardening grades such as 13-8Mo, 15-5PH, 15-7Mo and 17-4PH. These latter grades reach high yield and ultimate tensile strengths from a single, low-temperature heat treatment following a solution anneal. This makes these types of stainless steels suitable for challenging applications such as nuclear reactor parts.

With so many options available, a thorough grasp of the end use is vital for establishing the correct material, dimensions, and properties needed during forging to guarantee peak performance in the eventual application.

By collaborating with an experienced seamless rolled ring manufacturer that can tailor the forging process to the specific end use, power sector OEMs can ensure their final product meets all the necessary requirements and industry standards for their specific application.

For more information, contact All Metals & Forge Group, LLC at 75 Lane Road, NJ 07004; (973) 276-5000; Canada 416-363-2244, toll-free (800) 600-9290; fax (973) 276-5050 or visit ***www.steelforge.com*** •

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The Consulting Engineer's Ultimate Guide to Advanced Electric Boiler Technology

By Del Williams

An international boiler expert helps industry professionals take advantage of high voltage electrode boilers' virtually 100% efficient, zero-emission capabilities, providing guidance on selection and installation

For consulting engineers tasked with planning, designing, and supervising construction projects for a wide range of industries, advanced electric boilers – particularly high voltage electrode boilers – offer numerous advantages over traditional fossil fuel burning boilers. Due to advances in technology, these boilers can match the capacity (up to 65 MW) and output (270,000 pounds of steam per hour) of traditional gas or oil-fired boilers in a much smaller footprint while converting almost all the energy to heat.

These zero-emission, high voltage electrode boilers are used in diverse environments for applications such as centralized heating, power plants, nuclear stations, swing-load balancing, solar/wind energy consumption, and fuel boiler replacement.

Today, there is growing interest in utilizing a new generation of these boilers as an environmentally friendly decarbonization solution. Companies across the globe are considering using electric boilers to become carbon neutral in alignment with COP26 UN Climate Change Conference targets. The transition to electric boilers also aligns with U.S. goals to achieve a carbon pollution-free power sector by 2035 and net zero emissions economy by 2050.

Electric boilers are emerging as more environmentally friendly solutions than traditional gas-fired units that emit not only the notorious greenhouse gasses carbon dioxide (CO_2) and methane (CH_4), but also dangerous nitrogen oxides (NOx), carbon monoxide (CO), and nitrous oxide (N_2O), as well as volatile organic compounds (VOCs), sulfur dioxide (SO_2), and particulate matter (PM).

"Communities and businesses appreciate the eco-friendly nature of ultra-efficient, electric boilers. Without combustion, these boilers are safe, clean, and emission free. The design eliminates many environmental issues associated with fuel burning boilers, such as fuel fumes, fly ash, and large obtrusive exhaust stacks," says Robert Presser, Vice President of Acme Engineering, a manufacturer of industrial and commercial boilers.

However, the challenge for consulting engineers is that many have experience with gas-fired boilers but are less familiar with the selection and implementation of advanced electric boilers, especially the high voltage, high-capacity alternatives available today.

To bridge the knowledge gap, boiler technology expert Robert Presser explains what consulting engineers most need to understand about electric boiler technology, including its selection, implementation, and benefits. Acme, which has operations in the U.S., Canada, and Europe, provides state-of-the-art boilers and accessories for some of the world's most renowned companies including Siemens, Toshiba, Bechel, PG&E, Power & Mine, and Hydro Quebec.

Types of Electric Boilers

The first factor to consider in selecting an electric boiler is how much capacity will be required by the user, business, or community.

According to Presser, lower voltage (480 KV) electric resistance heating element boilers are economical, compact, reliable sources to produce steam or hot water for industrial use. The units are well suited to supply these resources at lower capacities, from 9 to 3,600 kW.

However, there are design limitations when heating element boilers exceed 4 MW in capacity, as numerous flanges, elements, contactors, and fuses are typically necessary to function properly. The considerable amperage involved also requires expensive bars for distribution, step-down transformers, and large switch gear.

To avoid these complications at capacities of 4 MW or higher, high voltage jet type and immersed electrode boilers were developed.

High Voltage Electrode Boilers
In the high voltage category, electrode boilers consist of two basic types: immersion and water jet.

In resistance element type boilers, current flows through a resistance wire, which generates heat. The heat is transferred through the element's sheaf and into the water by conduction to produce hot water or steam.

"With the immersed electrode design, electric current is passed through the water from the electrodes to the counter electrodes [grounded via the vessel's shell]. The more direct the exposure between counter electrode shield and the electrode, the greater the current draw [amperage] and the more power is produced in hot water or steam," explains Presser.

Modern jet type electrode boilers utilize the conductive and resistive properties of water to carry electric current and generate steam. An AC current from the grounded central column to a minimum of one electrode box per phase, using the water as a conductor. Since the water has electrical resistance, the current flow generates heat directly in the water itself.

"The more current [amps] that flows, the more heat [BTUs] is generated, and the more steam is produced," says Presser.

High voltage jet or immersed electrode boilers directly connect to high voltage supply lines from 4.16 KV - 25 KV. Hot water boilers are filled with treated water to create a closed loop system.

According to Presser, the maximum capacity of the boiler can be adjusted by varying the conductivity, which is determined by the temperature and boiler capacity. Typically, a conductivity monitor is installed in the piping and any adjustments are automatically made with chemical treatment.

When it comes to installation, con-

sulting engineers need to consider whether there is sufficient high voltage power, and if a new transformer will be required.

"For these high voltage electrode boilers, the incoming voltage typically required by code is a 4-Wire, three-phase wye wiring configuration, and the phases must be balanced," says Presser.

In addition, it is necessary to ensure that there is sufficient available space to bring in and install the electrode boilers. This includes determining that there is adequate access into buildings and elevators as well as enough clearance through hallways and doors. When space is limited, Acme's Slim Series resistance boilers units are designed to produce ample hot water while easing conversion and installation with an ability to "squeeze through" narrow passageways and fit into smaller spaces without costly demolition.

The Benefits of Electric Boilers

For consulting engineers considering the use of electric boilers, there are numerous advantages over gas fired units. These include very high energy efficiency and output control, along with increased safety and other benefits.

Energy Efficiency

Although traditional gas fired boilers are familiar, the design is inherently less efficient than modern electric units. Within this category, the energy efficiency of electrode boiler technology offers extraordinarily efficient power-to-heat generation capability.

"With an electrode boiler, you get out of it what you put into it. Basically, you don't have a decline in efficiency," says Presser.

With electrode boilers, almost all the electrical energy is converted into heat with no stack or heat transfer losses. This level of efficiency is not achievable in fuel-fired steam boilers even when using an economizer.

In the case of Acme's CEJS, which has a boiler capacity from 6MW to 68MW, the electrode boiler operates at distribution voltages from 4.16 to 25 KV. The unit is up to 99.9% efficient at converting energy into heat. The boiler can produce steam in capacities up to 270,000 pounds per hour, with pressure ratings from 75 PSIG to 500 PSIG.

Output Control

High voltage electric boilers also offer superior control of energy output. The control system automatically monitors factors such as water level, steam pressure, conductivity, and electrical imbalances so energy input and adjustment is precise, and virtually immediate.

"In contrast, increasing or decreasing the temperature in a gas fired boiler is a slower process because it takes time for the heat in the boiler to rise or dissipate before

reaching the targeted output," says Presser.

As an example, advanced high voltage electrode steam boilers like Acme's CEJS can control the capacity progressively from 0%-100% and have a 100% turndown ratio (the ratio between a boiler's maximum and minimum output). Most gas boilers have a ratio of 10:1 or 5:1, which means the units require a much higher minimum output level to function and take a significant time to reach full capacity.

"With a 100% turndown ratio [in a high voltage jet-type electrode unit], you can leave the boiler in standby at low pressure and bring it to full capacity in about 90 seconds as needed, which no other boiler type can achieve today," says Presser.

High voltage immersion steam boilers like Acme's CEJWS can control the capacity progressively from 10%-100%.

"From hot stand-by, both the CEJS and the CEJWS steam boilers reach 100% capacity in one minute," says Presser. He adds that stand-by insulation losses never exceed 10KW even for large boilers.

Increased Safety

High voltage electric boilers are inherently much safer to use than traditional, combustion-fueled boilers, which can emit harmful vapors, leak gas, and even cause explosions and fires.

"With gas burning boilers, any gas leak can increase the risk of an explosion wherever there are fuel lines, fumes, flames, or storage tanks. So, gas units must be continually monitored or periodically inspected," says Presser.

In gas-fired boilers, explosions can result in the ignition and instantaneous combustion of highly flammable gas, vapor, or dust that has accumulated in a boiler. The force of the explosion is often much greater than the boiler combustion chamber can withstand. Minor explosions, known as flarebacks or blowbacks, can also suddenly blow flames many feet from firing doors and observation ports, seriously burning anyone in the path of a flame.

Natural gas-fired boiler emissions also pose potential hazards in the form of emissions. In addition, fossil fuel burning boilers can face potentially dangerous operational issues stemming from excessive heat accumulation.

Modern electric boilers eliminate many of these risks, so can dramatically improve both operator and environmental safety.

"With the jet type electrode boilers, there are no combustion hazards because there are no flames, fumes, fuel lines or storage tanks, which minimizes the risk of explosions and fires," says Presser. In case of an electrical short, the breaker that protects the high voltage circuit trips in a matter of milliseconds, protecting the boiler and the electrical network. There is no chance of electrical mishap or fire from the boiler.

"Electric boilers, and specifically the electrode units, are inherently the safest boiler design today. These units do not need an operator because if anything goes wrong, the breaker trips, preventing further escalation of the issue," says Presser.

Since the design does not rely on combustion, it does not create emissions that would endanger the operator or environment. In addition, the design eliminates common environmental problems associated with fossil fuel burning boilers such as fuel fumes, fly ash, and large obtrusive exhaust stacks.

Although consulting engineers are experts in their designated fields of expertise, keeping up to date with the latest developments in advanced electric boiler technology can provide significant advan-

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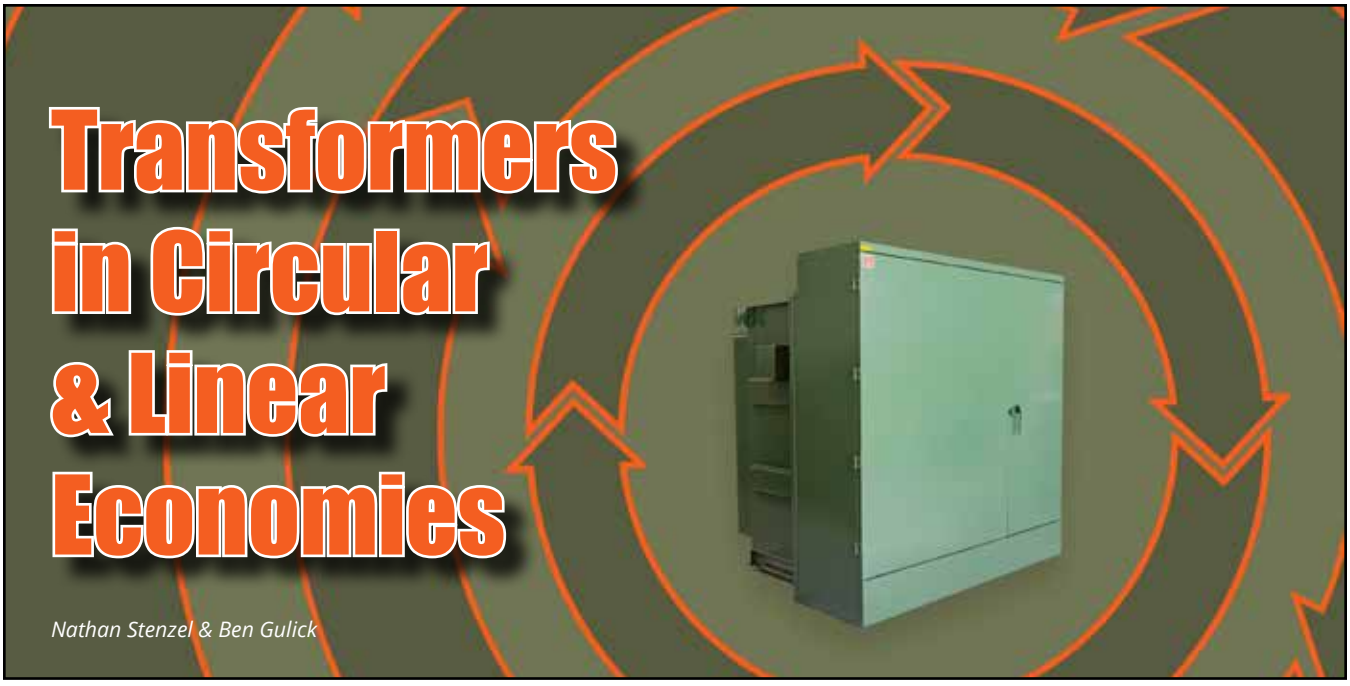
tages in providing hot water and steam for a variety of industrial purposes.

Understanding how to select, specify, and install electric boilers for the specific situation will conserve substantial energy, space, and resources compared to fuel-fired options. In addition, it will not only facilitate project success but also a safer environment that helps combat global warming.

For more info, contact Robert Presser at Acme Engineering via e-mail: rpresser@acmeprod.com; phone: (514) 342-5656; or web: ***www.acmeprod.com/hv-electrode-boilers*** •



Let's look at typical examples of how these two systems play out in the transformer world.

Typical Linear Economy

It is common to remove transformers from service for reasons other than failure. In some cases, the primary voltage may change. Utilities update sections of their distribution network from time to time. In other cases, building expansions need a bigger utility service. This requires a larger transformer. In both situations, the end of the transformer's service life has nothing to do with its condition. Such units are often discarded with the majority of their lifespan intact.

Sometimes a component inside a transformer fails. Examples include bushings, tap changers, or switches. Component failures require repairs which take the unit out of service. In some cases, the entire unit is discarded or set aside. Rather than repair the faulty component, the transformer is replaced with a new unit.

A linear path discards a transformer when it no longer serves its original design. Regardless of how much life is left. For some products, this is understandable. It makes less sense for goods with a low level of obsolescence (like transformers).

Typical Circular Economy

In a circular economy, the same scenarios hold true. Utilities may make voltage changes at the grid. Larger transformers end up replacing smaller ones. Transformer components sometimes fail. The difference is how the transformer is treated after it comes out of service. Rather than going to the scrap yard, the unit gets repurposed elsewhere.

If the transformer taken out of service is of no further use to the end user, it goes to someone who can

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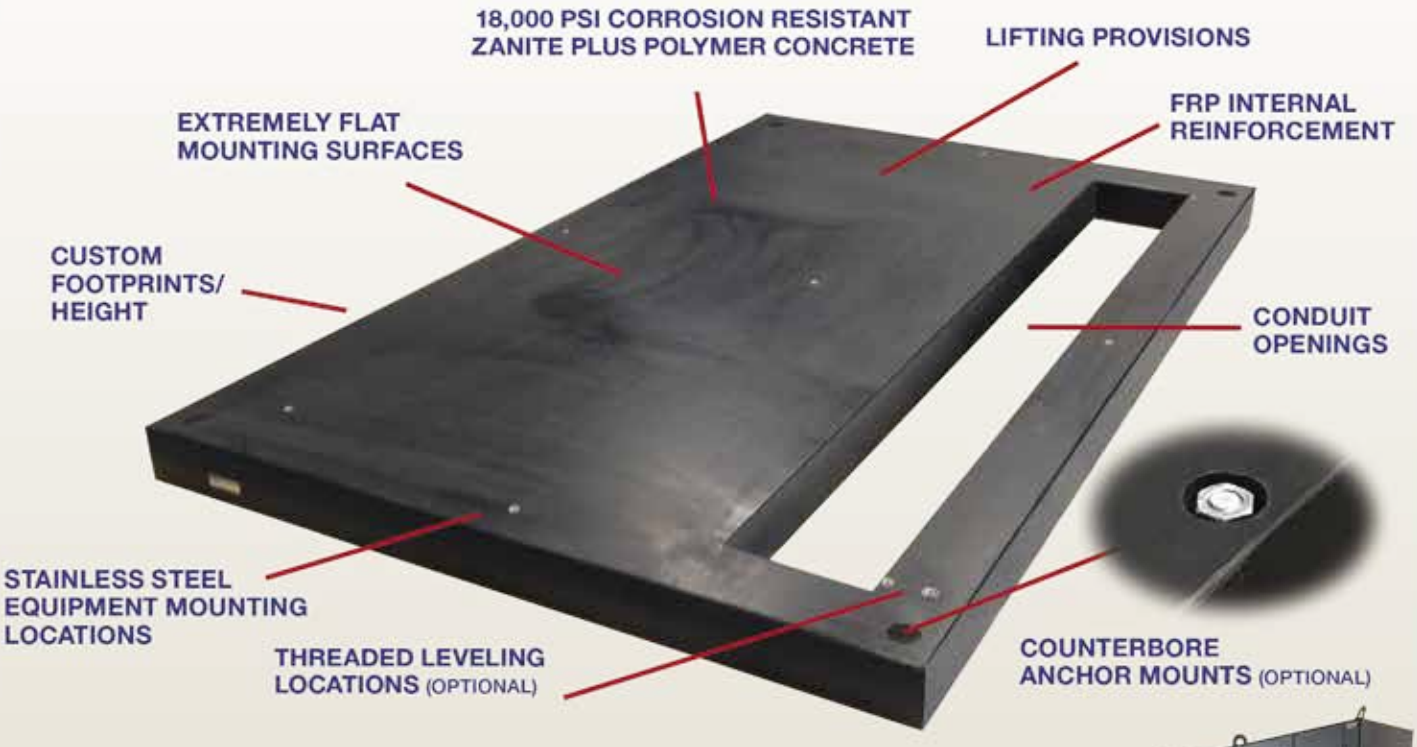

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use it. Users don't want the hassle of selling or repurposing surplus units. The task of repairing, testing, and shipping adds cost and time. But companies like Maddox make this easy. Maddox buys these surplus units and outfits them for new projects.

Maddox and the Circular Economy
At Maddox, we recondition used transformers to get them back into service. A used transformer sitting in a warehouse or field is no good to anyone. Not when it could be back in service supplying power to a new project. Using existing transformers provides relief to the already-slow supply chain. It also makes efficient use of our nation's scarce raw materials. Both support the circular economy.

Let's look at the two main ways Maddox does this.

Transformer Reconditioning
Reconditioning transformers allows Maddox to increase its stock of deployable units. This reduces pressure on new manufacturing. It also promotes the most efficient use of materials, allowing them to reach their true end of life.

Many people choose to recycle, instead of recondition, their old or unused transformers. Recycling costs time, energy, and money. Like building new transformers. Recycling increases the availability of recycled materials for new products. But, it also increases the demand for the same product just taken out of service. At Maddox, we buy units headed for recycling for 5x their scrap value. We then recondition these units and redeploy them on the grid.

Reconditioning processes are easier on the environment too. Transformer reconditioning consumes less energy and emits less greenhouse gasses than new manufacturing.

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With shops located from coast to coast, Maddox makes repair convenient and easy. From basic external welding fixes to complete core and coil replacement—we do it all. The more transformers we repair, the more units reach their full service potential.

We also have field service teams equipped to travel to your location. They handle minor repairs and testing on site. Saving you the logistical cost of transformer removal and shipment.

Conclusion

At Maddox, we promote a circular economy. We work to ensure transformers reach their full potential out in the field. Before scrapping your old transformer, call Maddox. And if you're looking for a transformer for your next project, we've got you covered.

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Ronk Electrical	9	www.ronkelectrical.com
Sellick	2	www.sellickequipment.com
Skyhook	BC	www.skyhookmfr.com
Sunbelt Solomon	17	www.sunbeltsolomon.com
Underground Devices	15	www.udevices.com
Voltec	6	www.voltec.com
Working Concepts	24	www.safeworker.com

Step 1: Remove Damaged Conduit

Step 2: Cut Split Duct Conduit to Fit

Step 3: Snap in Place

Step 4: Attach Adapters

Step 5: Finish Job in Record Time

REPAIR CONDUIT IN A SNAP!

- **No Tape**
- **No Plastic Straps,**
- **No Metallic Straps**

NO KIDDING!

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