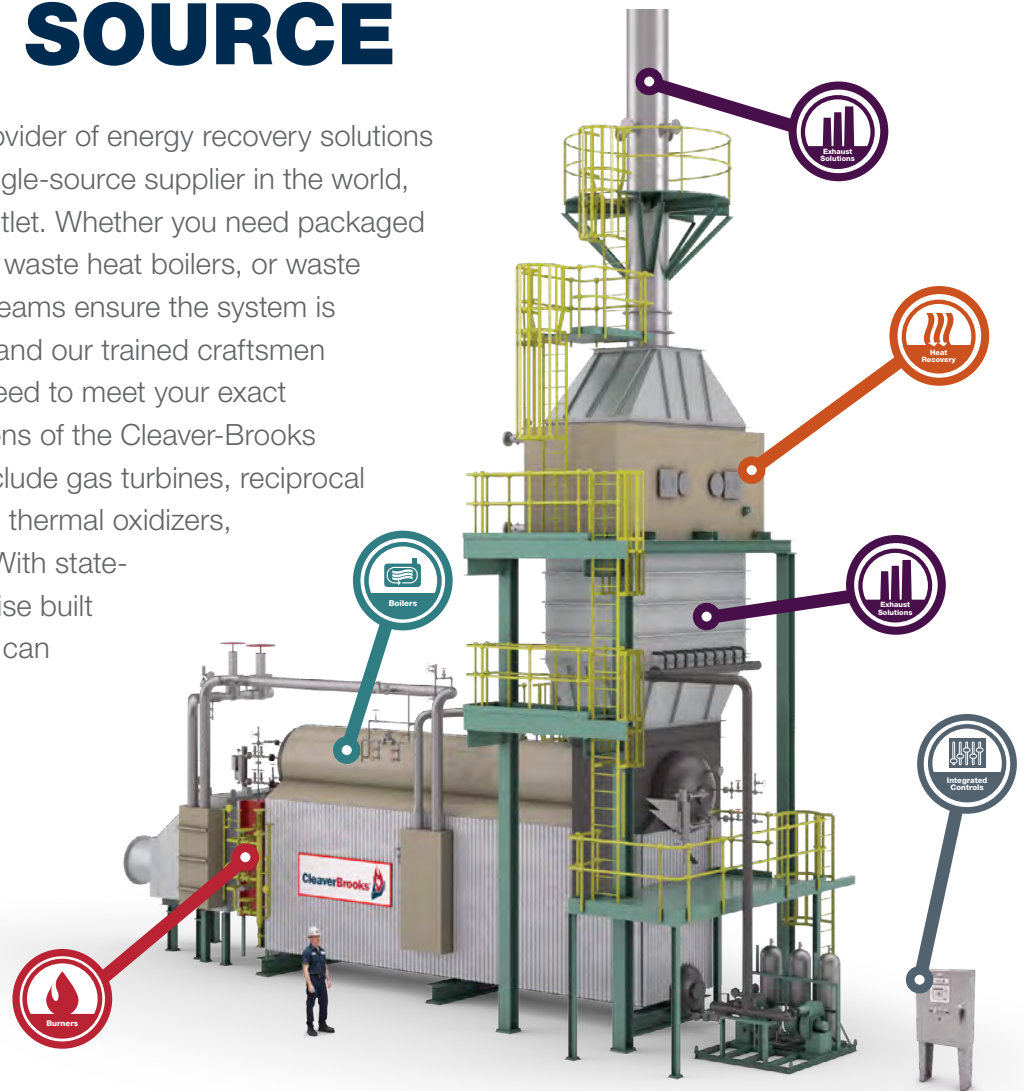


HEAT RECOVERY STEAM GENERATOR

When Reliability Matters

TOTAL INTEGRATION FROM A SINGLE SOURCE

Cleaver-Brooks is the leading provider of energy recovery solutions and the only totally integrated single-source supplier in the world, from the fuel inlet to the stack outlet. Whether you need packaged heat recovery steam generators, waste heat boilers, or waste heat recovery units, our project teams ensure the system is designed to your specifications, and our trained craftsmen produce boilers that are guaranteed to meet your exact standards. Typical implementations of the Cleaver-Brooks Energy Recovery product line include gas turbines, reciprocal engines, FCC, FGC, incinerators, thermal oxidizers, economizers, and fluid heaters. With state-of-the-art technology and expertise built over 80 years in the industry, we can meet practically any need.

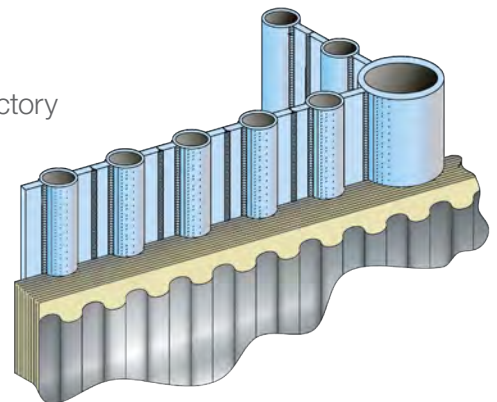


Markets Served

Power Generation, Universities, Hospitals, Pulp & Paper, Chemical, Petroleum Refining, Military

Membrane Wall Construction

Our Energy Recovery line features innovative designs to help eliminate refractory wherever possible. Water-cooled membrane walls allow the boiler to safely withstand firing or flue gas temperatures up to 2,800°F. They also minimize high-maintenance refractory, provide a positive inner gas seal, add structural strength, eliminate flue gas entrapment, and help maintain thermal efficiency. The adjacent fins of each outboard tube are seal-welded together, forming a robust gas-tight and water-cooled enclosure.



Heat Recovery Steam Generators

HRSG Solutions to meet today's CHP applications

We lead the industry with our packaged heat recovery steam generators, which have natural circulation designs with design pressures up to 2,300 psig and steam temperatures up to 1,050°F. For supplemental and/or fresh-air fired applications, our heat recovery steam generator is integrated with a NATCOM duct burner and our in-house controls systems for the highest efficiency and lowest emissions possible.

Slant HRSG Series

Single Pass Energy Recovery in a compact design

The Slant series of natural circulation heat recovery steam generators features the traditional Slant model and the VC (Vertical Drum Cross Flow) model, both tailored for applications with gas side inlet temperatures less than 1,700°F. This series is capable of steam flows from 10,000 – 150,000 lb/hr at steam pressures up to 2,300 psig, and superheated steam is available up to 1050°F. The Slant Series is ideal for gas flows from 50,000 – 400,000 lb/hr at near atmospheric pressure with gas flow perpendicular to the steam and water drums (cross flow).

The traditional Slant model incorporates a steam and water (mud) drum positioned diagonally, which maximizes the amount of heating surface for a given shipping profile. This yields a compact and efficient method of heat recovery.

The VC model is a drum-over-drum design well suited for higher-pressure steam applications, integral CO / SCR systems, and horizontal exhaust flow arrangements. It can be customized with a stainless steel inner liner, refractory lining, or watercooled membrane wall construction, depending on your process requirements.

Both models are single-pass designs. The absence of gas baffles eliminates flue gas bypass and associated baffle maintenance. Convection access doors on both sides of the tube bank provide easy inspection, maintenance, and replacement of gas side heating surface and other components. Full-length steam and water drums with manways on each end allow access for inspection and maintenance of internal waterside surfaces. Unheated downcomers, completely external to the boiler casing, ensure maximum natural circulation.

Steam
10,000 to 150,000+ lb/hr
Pressure
Up to 2,300 psig
Gas Flow
Up to 400,000+ lb/hr
Steam Temperature
Up to 1,050°F

Integrated Components
Flue Gas Bypass Systems; Superheaters; NATCOM duct burners; Fresh Air Firing, CO / SCR Systems and Cleaver-Brooks Integrated Control Systems



Slant Model



Features

- Highly suited for gas turbine heat recovery or waste heat with low particulate loading heat recovery applications
- Multiple gas flow options conform to space restrictions and minimize cost
- “Cold” casing design with stainless steel floating inner liners

VC Model



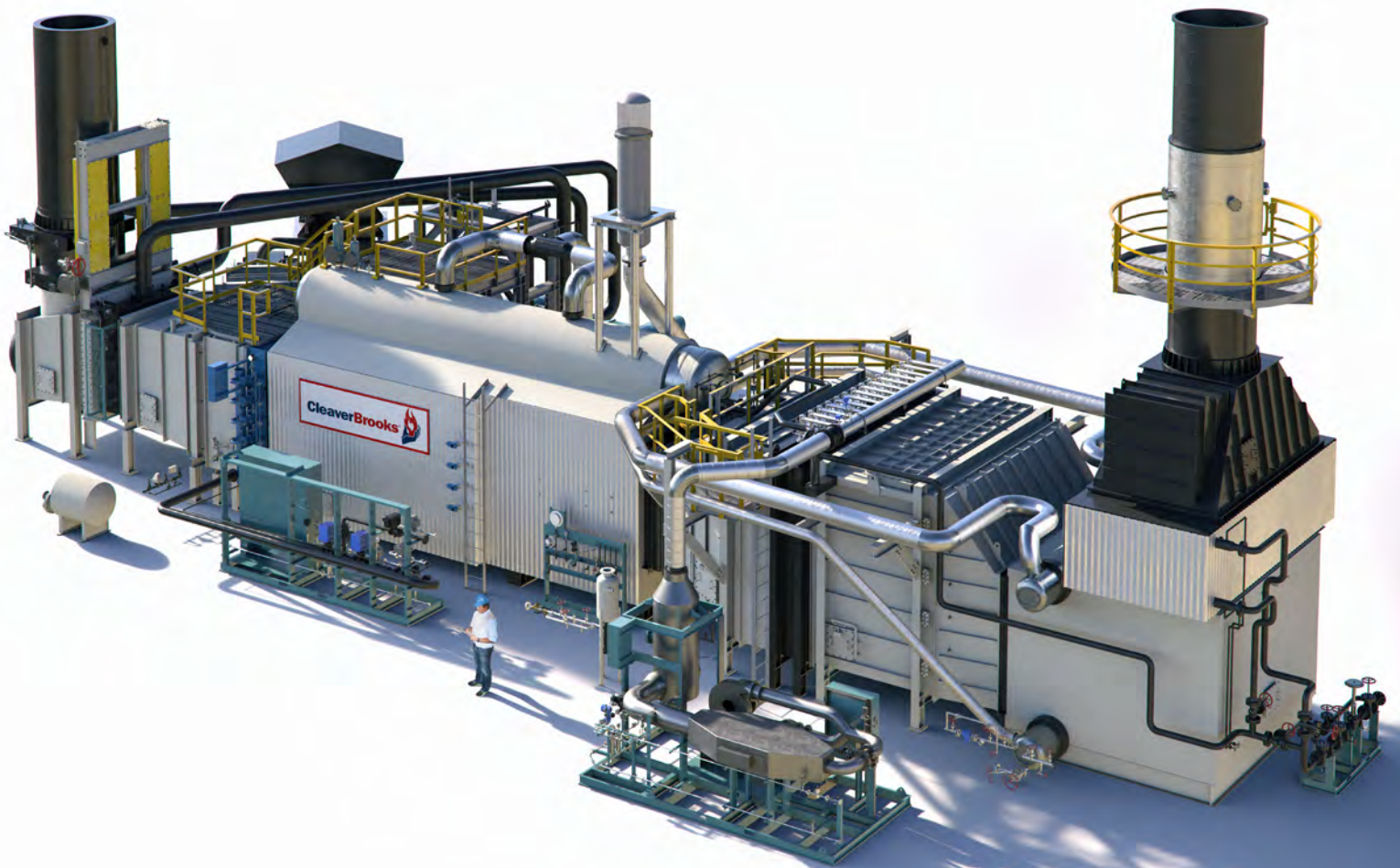
Features

- Cross drum gas flow design is suitable for horizontal gas flow applications
- Optional in-line tube arrangement promotes effective soot blowing and ash removal
- Multiple casing options including membrane wall construction.

MAX-FIRE® HRSG Series

Cleaver-Brooks innovations are built in to every unit

The Max-Fire® series incorporates an integral furnace in a single, shop-assembled packaged HRSG. This series is capable of steam flows up to 500,000 lb/hr at steam pressures up to 2,300 psig. Superheated steam is available up to 1,050°F. The Max-Fire® is well-suited for gas flows up to 1,000,000 lb/hr at near atmospheric pressure.



The MF (O-style) and MFA (A-style) models combine a waterwall combustion chamber formed from membrane wall construction with an evaporator section in a single shop-assembled boiler. The integral watercooled furnace allows for supplemental firing temperatures up to 2,800°F. The evaporator section is a combination of bare tubes and various degrees of finned tubes in a staggered or in-line arrangement for optimized heat transfer and pressure drop.

Features

- Watercooled membrane wall construction extends throughout the boiler and eliminates high inner casing temperatures
- Vertical (top) or horizontal gas outlet helps meet tight space restrictions
- Combination of bare and finned tube sections provide efficient heat recovery
- Downcomers on both ends of the boiler

Steam
10,000 to 500,000+ lb/hr
Pressure
Up to 2,300 psig
Gas Flow
Up to 1,000,000+ lb/hr
Steam Temperature
Up to 1,050°F

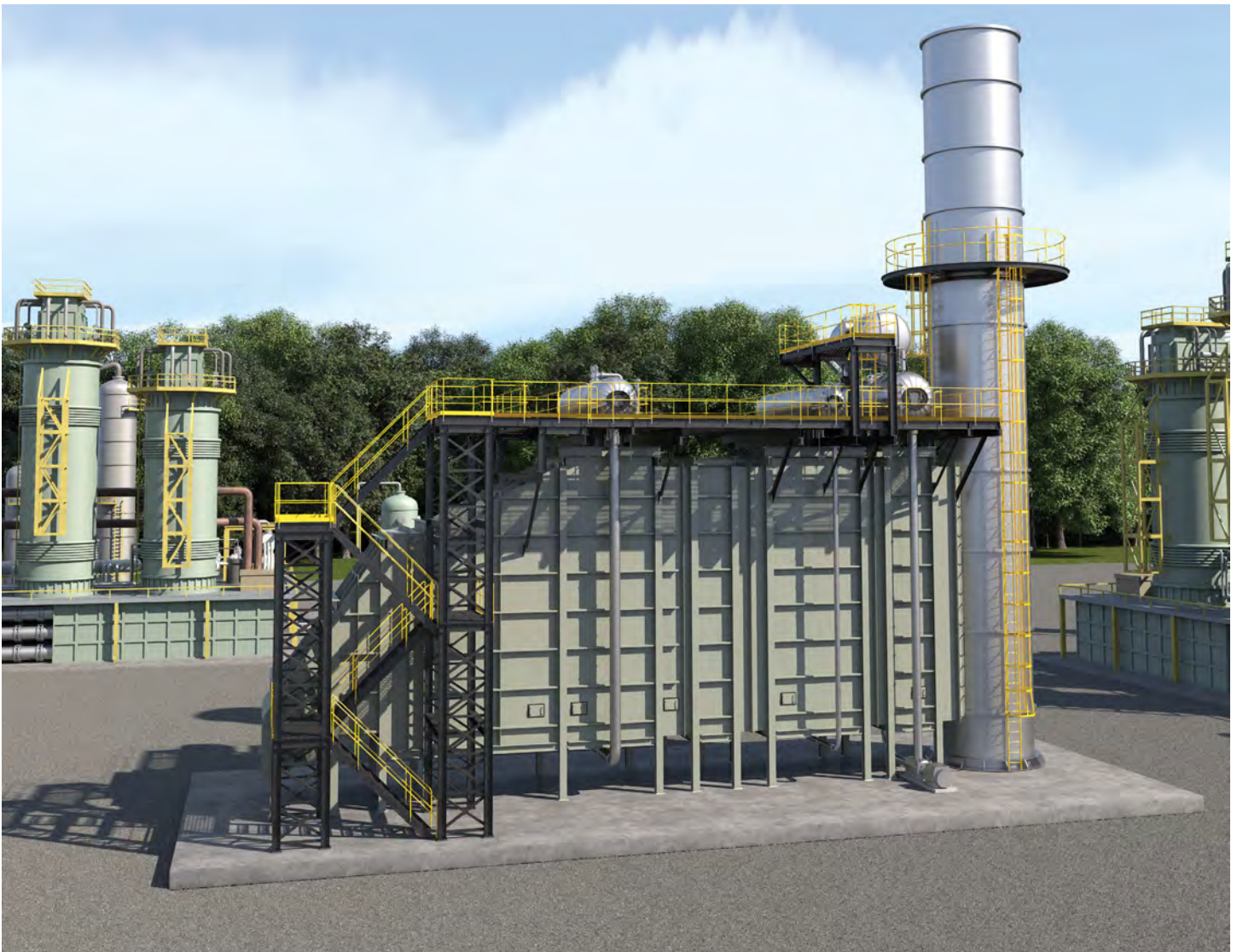


Integrated Components	Flue Gas Bypass Systems; Integral, External, or Combination Superheaters; NATCOM duct burners; Fresh Air Firing, CO / SCR systems; Cleaver-Brooks Integrated Control Systems
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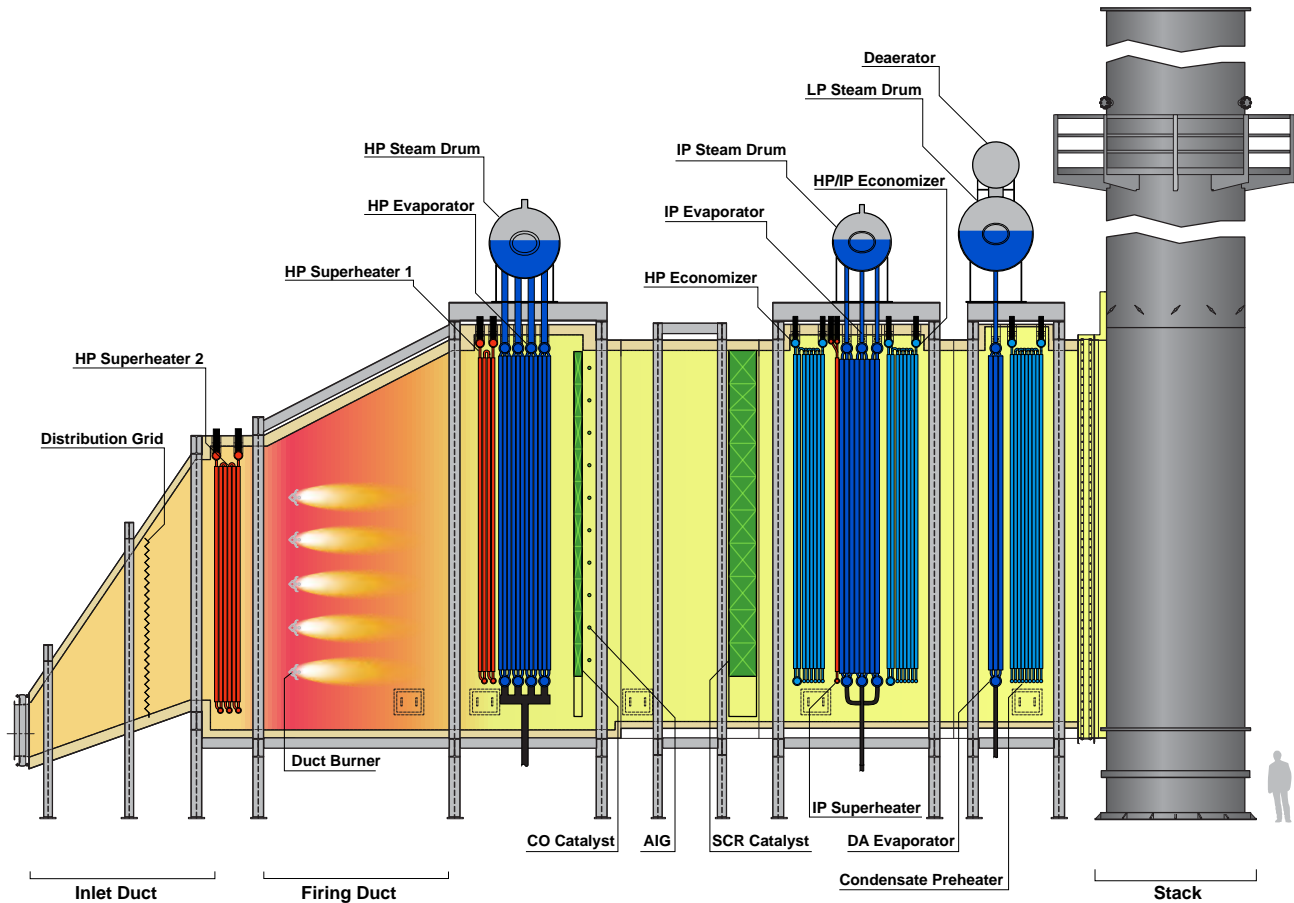
Modular HRSG Series

Maximum shop assembly, minimum field labor

Cleaver-Brooks strives to provide the maximum amount of shop assembly in our Modular HRSG system. Modules are shipped with casing as single pieces and require minimal field work to assemble multiple sections. We offer natural circulation designs for minimal parasitic power consumption and reduced maintenance of rotating equipment. Our Modular HRSG is available in single or multiple pressure levels to optimize cycle efficiency. Our expert engineering teams review every aspect of the design including, but not limited to, thermal performance, mechanical fatigue evaluation, circulation studies and pipe stress analysis. Each HRSG is custom designed per our customer's unique requirements. This robust design benefits from more than 80 years of experience in the industry and incorporates design features proven across all product lines.



Modular HRSG Diagram



Features

- Multistage high pressure and high temperature superheaters
- Vertical tube natural circulation evaporators
- Top supported coils for unrestricted downward expansion
- Tube bundles pre-installed in a shop-assembled casing to minimize field erection costs
- Large remote steam drums
 - High efficiency separators meet the most stringent steam purity requirements
 - Large water holding capacity is ideal for load swings
- Unheated downcomers, completely external to the boiler casing, provide desired natural circulation
- Convection access doors at each bundle allow for ease of inspection, maintenance, and replacement

Steam Production

500,000+ lb/hr

Steam Pressure

Up to 2,300 psig

Steam Temperature

Up to 1,050°F

Exhaust Gas Flow

1,000,000+ lb/hr

Integrated Components

Flue Gas Bypass Systems; Evaporators; Economizers; NATCOM duct burners; Fresh Air Firing, CO / SCR Systems; Cleaver-Brooks Integrated Control Systems



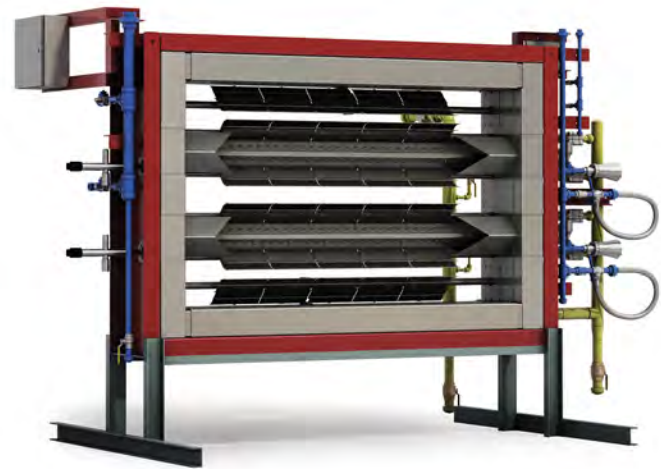
Duct Burner

Boost the efficiency of your HRSG

NATCOM Duct Burners supplement the gas turbine in heat recovery steam generator (HRSG) applications with an innovative flame stabilizer system. Ideal for use in Combined Heat and Power applications when additional steam is required for heat or process needs. For every BTU via the duct burner, the HRSG will have an additional BTU of heat output. Duct burners can fire a variety of gaseous fuels, including natural gas, LFG, digester gas, refinery gas and H₂, as well as fuel oil. Our in-house simulation experience allows accurate and complete modeling of the turbine exhaust flow, distribution grid, combustion, heat recovery system, and selective catalytic reduction (SCR) for every HRSG we build. We can offer a complete control system for the HRSG, duct burner, and SCR, or a stand-alone BMS for the duct burner.

Features:

- Self-supporting, high-temperature stainless assembly with diamond shape eliminates common “element sagging” issues
- An exclusive Retro™ fuel injection system enhances turbine exhaust gas (TEG) and fuel mixing for optimal flame control
- Complete Computational Fluid Dynamics (CFD) analysis, design, and fabrication of TEG flow correction devices, including distribution grids, turning vanes, and anti-swirl systems



Custom Controls

Integrated industrial controls

Cleaver-Brooks manufactures control systems for any combustion application. Regardless of the level of complexity of your system, we will provide state-of-the-art hardware and programming for safe, reliable, and efficient operation with a user-friendly interface.

Features:

- Custom control systems save energy
- Completely custom PLC controls
- Color touch-screen controls
- Factory Acceptance Test (FAT) and Site Acceptance Test (SAT)





Integrated Exhaust Solutions

Lower emissions from heat recovery and steam generation

Whether you're in need of installation-ready or freestanding stacks, Cleaver-Brooks manufactures an exhaust solution for virtually every application with the latest engineering and technology in combustion gas venting. We engineer and produce our exhaust systems to exacting standards quickly and efficiently.

SCR & CO Catalyst for HRSG

Reduce NOx to single digit ppm levels

Cleaver-Brooks designs and incorporates Selective Catalytic Reduction (SCR) into our energy recovery systems to meet the most stringent emission requirements. Computational Fluid Dynamics (CFD) analysis along with years of field experience, allows us to accurately predict the flue gas distribution through the entire HRSG and optimize the duct burner design in conjunction with the SCR design.

Features

- Integration of a Cleaver-Brooks Burner, Control System, and SCR ensures fast response & minimal Ammonia Slip for increased operation flexibility & lowest emissions for any application
- Designed with CFD and validated through field results
- Optimum temperature window for maximum NOx & CO reduction



Freestanding and Installation-ready Stacks

Exhaust Solutions for any application

Cleaver-Brooks engineers and manufactures freestanding stacks according to project specific requirements and constraints. In addition, we offer installation-ready stacks that feature our exclusive Male-to-Female Jointing System, which allows the parts of all models to fit into one another, thus decreasing installation time by up to 40%. Our highly qualified engineering department has diversified experience and knowledge in exhausting and venting stacks and can provide a customized solution for any size project.

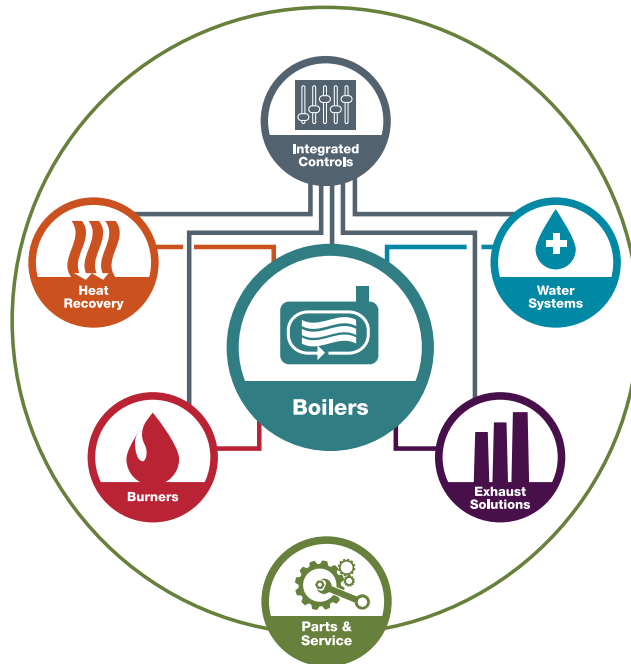
Features

- Factory laser-welded joints
- Available in carbon steel, COR-TEN® steel and stainless steel
- Integral stack dampers and/or silencers

Custom solutions across the entire energy recovery line

Cleaver-Brooks can meet virtually any need, based on expertise developed over more than 80 years in business. We have the capability and expertise to provide custom HRSG, WHB, or WHRU designs focused on maximizing the amount of shop assembly while minimizing the costly field labor often associated with other heat recovery steam generators. Our commitment to total integration is built into our custom solutions, as every one still incorporates genuine Cleaver-Brooks components designed and engineered to function together at peak efficiency. Regardless of your application or need, we can help you design a solution that meets your unique needs and lasts for years to come.





Total Integration goes far beyond energy recovery.

Cleaver-Brooks is one of only a few boiler room solution providers in the world to operate a dedicated research and development facility. Having pioneered several industry-leading technologies, we remain just as committed today to introducing technology and products that enable a more energy-efficient and environmentally friendly generation of steam and hot water.

We distribute our products through the Cleaver-Brooks Representatives Association, or CBRA, an alliance of independently owned and operated companies that provide boiler room products and service. CBRA companies can be counted on to provide Cleaver-Brooks products and parts, engineering support, customer training, technical service and system maintenance. To find a CBRA representative near you, please visit cleaverbrooks.com/rep.boiler system. To learn more, please call or visit us online at cleaverbrooks.com.



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