CleaverBrooks®

PACKAGED AND MODULAR STEAM BOILERS

For Heavy Oil and Petrochemical Applications

Cleaver-Brooks Engineered Boiler Systems
Manufacturer of Nebraska Boilers,
NATCOM Burners, and ERI
Heat Recovery Steam Generators

Cost-Effective Steam

Every Cleaver-Brooks Engineered Boiler System Features:

- 100% water-cooled furnace with no refractory seals
- Zero refractory burner throats
- Fully integrated boiler + burner + controls from a single source
- Optimized furnace and heat transfer sections for low heat flux to work with evaporator-produced water quality
- 100% mechanically cleanable circuits
  - less than 2% blowdown
  - greater than 99.5% steam purity
  - greater than 86% thermal efficiency high heat value (HHV) basis

FC-OSSG

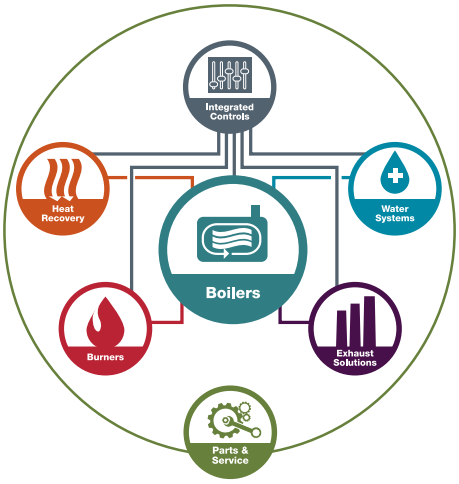
MaxFire® - HRSG

Boilers designed specifically for
Heavy Oil and Petrochemical Applications

FC-OSSG	Forced Circulation Oil Sands Steam Generators up to 227 T/H steam
MODULAR	Modular Drum Boilers up to 454 T/H steam
PACKAGED	Fully packaged D / O / A type boilers up to 113 T/H steam
HRSG	MaxFire® HRSGs up to 454 T/H steam

Complete Integration for Proven Performance for Heavy Oil Applications

Engineered to work together from burner to stack



As the heavy oil industry continues to grow and expand, Cleaver-Brooks is setting the standard for boilers specifically designed for Steam-Assisted Gravity Drainage (SAGD), Cyclic Steam Stimulation (CSS), Power Generation, Mining and other applications. We can custom design and manufacture a system built to your specs that will endure any substantial change in water quality, heat flux, and flow.

Only Cleaver-Brooks can offer watertube boilers, state-of-the-art burners, and combustion controls that are 100% designed, engineered, manufactured, and integrated by one company. This approach allows us to offer the most cost-effective and efficient systems to install, operate, and maintain. Other boiler manufacturers rely on equipment from any number of other manufacturers, simply bolted on, jeopardizing compatibility and performance.

The seamless integration of the optimized burner, boiler, combustion control system, and burner management system (BMS), in addition to the water systems, exhaust system, and heat recovery, allows the equipment to function at maximum efficiency and minimum emissions, all while maintaining the highest safety standards. And of course, our parts and service and global network of ground support from Cleaver-Brooks Representatives complete our commitment to total integration.

NATCOM Burners

NATCOM burners meet the most stringent NOx, CO, VOC, and particulate emissions requirements for any furnace configuration.

- On-line adjustability and possible removal of each individual gas injector
- Mulitiple fuels applications
- Unmatched flame stability with Center-Core technology
- Unbreakable 100% reliable pilot
- NOx levels from 9 to 30 ppm
- Ultra-low excess air / high efficiency
- High turndown ratio: 40:1 on gas / 15:1 on oil

Available for retrofitting any boiler/heater application, resulting in reduced emissions and increased reliability.

Forced-Circulation Oil Sands Steam Generator

Cleaver-Brooks FC-OSSG features an integrated boiler/burner/control package with a NATCOM ultra-low-NOx burner.

- Large capacity up to 227 T/H (500,000 lb/h) of steam
- Steam pressures up to 15,850 kPag (2,300 psig)
- 10:1 turndown
- 100% mechanically cleanable by pigging
- Smaller footprint for reduced total cost (equipment and installation) and space savings
- Shipped modular packages for ease of installation
- Highly efficient steam solutions capable of meeting strict emissions requirements

Increase Reliability and Efficiency

The FC-OSSG is specifically designed with significant margins to avoid metal temperature excursions and tube failures. A two-layer defense addresses fluctuations in water quality, increasing reliability compared to traditional OTSGs. The unit is designed to operate with 1% to 2% blowdown compared to 20% blowdown required for a traditional OTSG. The net result is you save considerable energy and increase efficiency.

Experience with Heavy Oil Applications

- Multiple FC-OSSG units with over 1.5 million lb/h total steam capacity under construction.
- Over 5 million lb/h total steam capacity projects experience with heavy oil applications.
- Proven design, equipment supply, installation support, and mechanical installation experience.

FC-OSSG

Capacities
Up to 227 T/H
Operating Pressures
Up to 15,850 kPag
Fuels
Natural Gas
Produced Gas
Heavy Oil
Emissions
Natural Gas – 15 ppm or higher. Integrated SCR solutions available for lower emissions.
Turndown
10:1 Typical

Reliable, Cost-Effective Steam

For Heavy Oil Applications

One of the biggest challenges for heavy oil development is to acquire the most reliable and cost-effective steam generators for bitumen extraction. The Cleaver-Brooks Forced-Circulation Oil Sands Steam Generator (FC-OSSG) combines the benefits of a traditional drum-type watertube boiler with high steam purity, minimal blowdown, and the cleaning ease of the Once-Through Steam Generators (OTSG). This large-capacity steam generator is uniquely suited for the needs of the Heavy Oil Industry and is ideal for high-pressure steam use in SAGD and CSS applications.

The FC-OSSG is the most cost-effective and efficient system to install, operate, and maintain.

FC-OSSG (Patent Pending)

Modular Packaged Boiler Systems

Cleaver-Brooks incorporates the proven design features of our standard products into a modularized system that maximizes shop assembly and minimizes costly field labor. Each module is shop-assembled, insulated, and lagged at the factory to save time and money in the field.

- Large capacities up to 454 T/H (1,000,000 lb/h) of steam
- Steam pressures up to 15,850 kPag (2,300 psig)
- 10:1 turndown typical
- Features for 100% mechanical cleaning
- Shipped modular for ease of installation
- Waste heat scavenging systems for improved thermal efficiency > 86% HHV basis
- Highly efficient steam solutions capable of meeting stringent emissions requirements

Increase Efficiency and Reduce Project Costs

Modular Elevated Drum Steam Generators are specifically designed for maximum thermal efficiency and minimum field installation and operation costs. The units are designed to operate with 1% to 2% blowdown and to generate 99.5% purity steam. You save considerable costs in fuel, installation, and operations with Cleaver-Brooks.

Experience with Heavy Oil Applications

- Multiple units with over 2.5 million lb/h steam capacity in operation.
- Over 5 million lb/h total steam capacity projects experience.
- Proven design, equipment supply, installation support, and mechanical installation experience.

Modular Elevated Drum

Capacities
Up to 454 T/H
Operating Pressures
Up to 15,850 kPag
Fuels
Natural Gas
Produced Gas
Heavy Oil
Emissions
Natural Gas – 15 ppm or higher. Integrated SCR solutions available for lower emissions.
Turndown
10:1 Typical

Cost-Effective, Large Capacity Steam Generation

For Commercial SAGD Plants, Mine Projects, Power and Process Steam

Another major challenge for heavy oil applications is to cost-effectively meet large steam demands. The Cleaver-Brooks Modular Elevated Drum Steam Generator answers the call with large steam capacities and minimal field work. These shop-assembled drum boilers offer the benefits of a traditional watertube boiler, with high steam purity and minimal blowdown. This large-capacity steam generator meets the large steam needs for commercial scale projects utilizing either ASME quality or Evaporator-produced water quality.

Packaged Drum-Type Boilers

Cleaver-Brooks line of Packaged Boilers are also available in the traditional D, A, and O Style configurations. These shop-assembled boilers are selected to operate with low blowdown, low furnace heat flux, low emissions, and high efficiency. The boilers, the burners, and the controls are designed and manufactured by the same company. This approach ensures the system is properly engineered to work seamlessly together and last for years to come. We draw on over 80 years of field experience to design and manufacture steam solutions that offer maximum value to our customers.

- Capacities up to 113 T/H (250,000 lb/h) of steam
- Steam pressures up to 15,850 kPag (2,300 psig)
- 10:1 turndown
- Features for 100% mechanical cleaning
- Shipped modular for ease of installation
- Waste heat scavenging systems for improved thermal efficiency > 86% HHV basis
- Highly efficient steam solutions capable of meeting stringent emissions requirements

Reduce Project Cycle Time and Cost

Cleaver-Brooks burner and trim-mounted, shop-assembled boilers are specifically designed for minimum field installation cost. The units are designed to operate with 1% to 2% blowdown and to generate 99.5% purity steam. You save considerable installation costs and time with the Cleaver-Brooks boilers.

Experience with Heavy Oil Applications

- Multiple units with over a million lb/h steam capacity in operation.
- Over 5 million lb/h total steam capacity projects experience.
- Proven design, equipment supply, installation support, and mechanical installation experience.

Packaged

Capacities
Up to 113 T/H
Operating Pressures
Up to 15,850 kPag
Fuels
Natural Gas
Produced Gas
Heavy Oil
Emissions
Natural Gas – 15 ppm or higher. Integrated SCR solutions available for lower emissions.
Turndown
10:1 Typical

Easy-to-Install Packaged Steam Generation Systems

For Pilot Scale SAGD Plants, Power and Process Steam

Getting your steam system up and running in the shortest time possible from the day you place your order can often be the biggest challenge for heavy oil applications. Cleaver-Brooks 100% packaged boilers provide the cost-effective solution with its line of heavy oil solutions.

These Drum boilers offer the benefits of a traditional watertube boiler, with high steam purity and minimal blowdown. They are fully packaged with burner and boiler trim mounted at the shop and delivered by conventional transportation (Rail/Truck). A large range of steam generation capacities is available to meet the unique needs of heavy oil applications utilizing either ASME quality or Evaporator-produced water quality.

Heat Recovery Steam Generators

The Cleaver-Brooks MaxFire® HRSG features an integrated boiler/burner/control package with a NATCOM ultra-low-NOx duct burner which ensures the system is properly engineered to work together – all under the same manufacturer.

- Capacities up to 453 T/H (1,000,000 lb/h) of steam
- Steam pressures up to 15,850 kPag (2,300 psig)
- 10:1 turndown
- Features for 100% mechanical cleaning
- Shipped modular for ease of installation
- Waste heat scavenging systems for improved CHP efficiency > 86% HHV basis
- Highly efficient steam solutions capable of meeting stringent emissions requirements
- SCR integrated with the HRSG available for single digit NOx and CO

Reduce Fuel Cost

Cleaver-Brooks HRSGs are equipped with state-of-the-art NATCOM duct burners designed to fire down to 3% O_2 in a 100% water-cooled furnace. The system is optimized by CFD modeling for industry-leading emissions and combustion performance, and delivers nearly 100% thermal efficiency (LHV basis) with supplementary firing. The units are designed to operate with 1% to 2% blowdown and generate 99.5% purity steam. The Cleaver-Brooks HRSG saves you considerable fuel costs.

HRSG

Capacities
Up to 453 T/H
Operating Pressures
Up to 15,850 kPag
Fuels
Natural Gas
Produced Gas

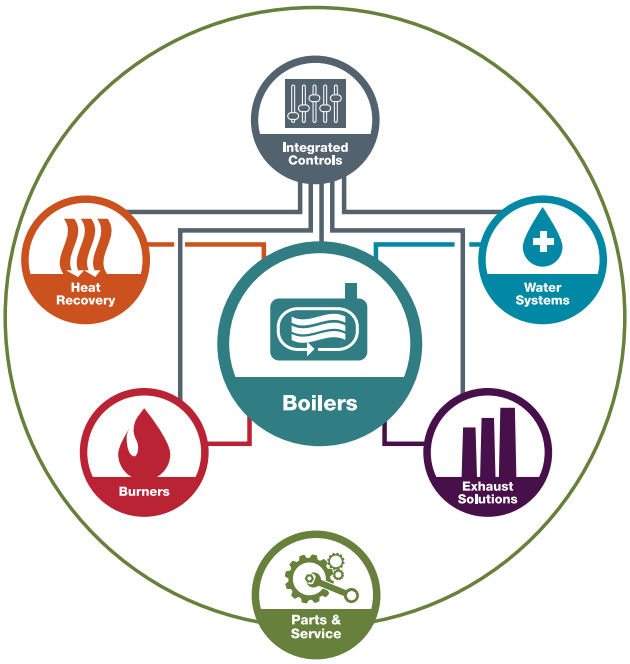
Lowest Fuel Cost Steam Generation Systems

For Large Steam Demands for SAGD, Power and Process Applications

Cogeneration and Combined Heat and Power installations are common solutions for heavy oil applicaitons to meet on-site power and steam needs. Cleaver-Brooks offers premium Heat Recovery Steam Generators (HRSG) for unfired, fired, and waste heat recovery applications.

We have customized our MaxFire® series to deliver up to three times the steam from conventional HRSGs with near 100% thermal efficiency (LHV basis) on supplementary firing. MaxFire® series HRSGs offer the benefits of a traditional watertube boiler, with high steam purity and minimal blowdown. Customized with low heat flux to work with ASME quality or Evaporator-produced water for a wide range of Gas Turbines from 2 to 60 MW output.

The Cleaver-Brooks MaxFire® HRSG is the most efficient and lowest fuel cost alternative solution to direct-fired steam generators in the market.



The Power of Total Integration.

Only Cleaver-Brooks can offer complete boiler systems, from fuel inlet to stack outlet, that are completely designed, engineered, manufactured, and integrated by one company. Other boiler manufacturers rely on equipment from a variety of manufacturers, simply bolted on, jeopardizing compatibility and performance. If you're looking for the best-quality boiler systems with the lowest emissions and highest efficiencies, you're looking for Cleaver-Brooks.

CleaverBrooks®

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