28 YEAR ANNIVERSARY

Rentech Boiler Systems, Inc.

Boiler Presentation to:

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"Boilers for people who know and care"®

Rentech Boiler Systems, Inc.

1 Introduction

"Boilers for people who know and care"®

Systems Approach

Engineering

We Deliver Custom Engineered Boiler Systems

We Provide Project Solutions for Boiler Systems

Manufacturing

Design & Manufacture Steam Generators, Hot Water Boilers and Fluid Heaters

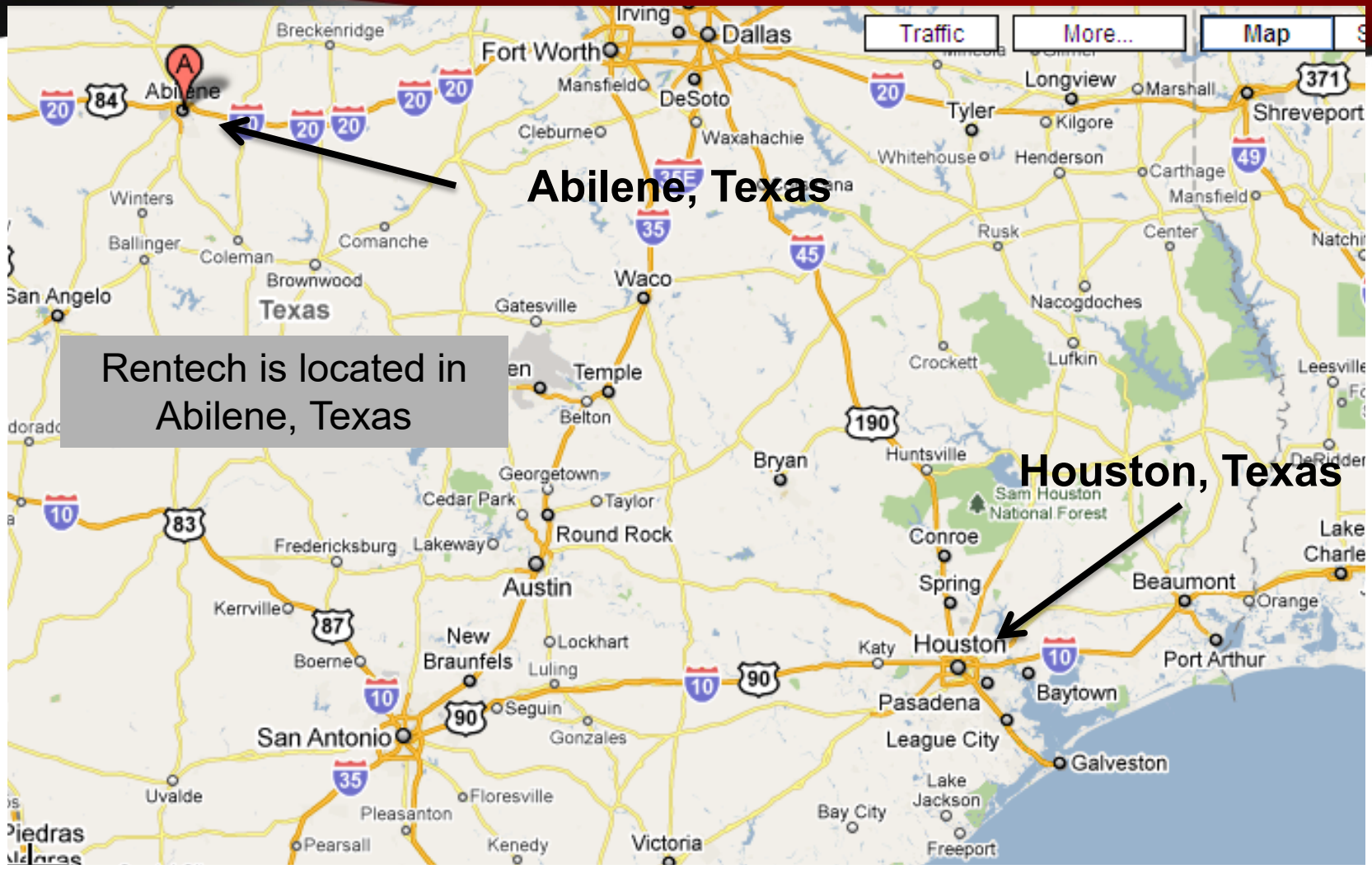
Service

We Service, Repair & Upgrade New & Existing Equipment

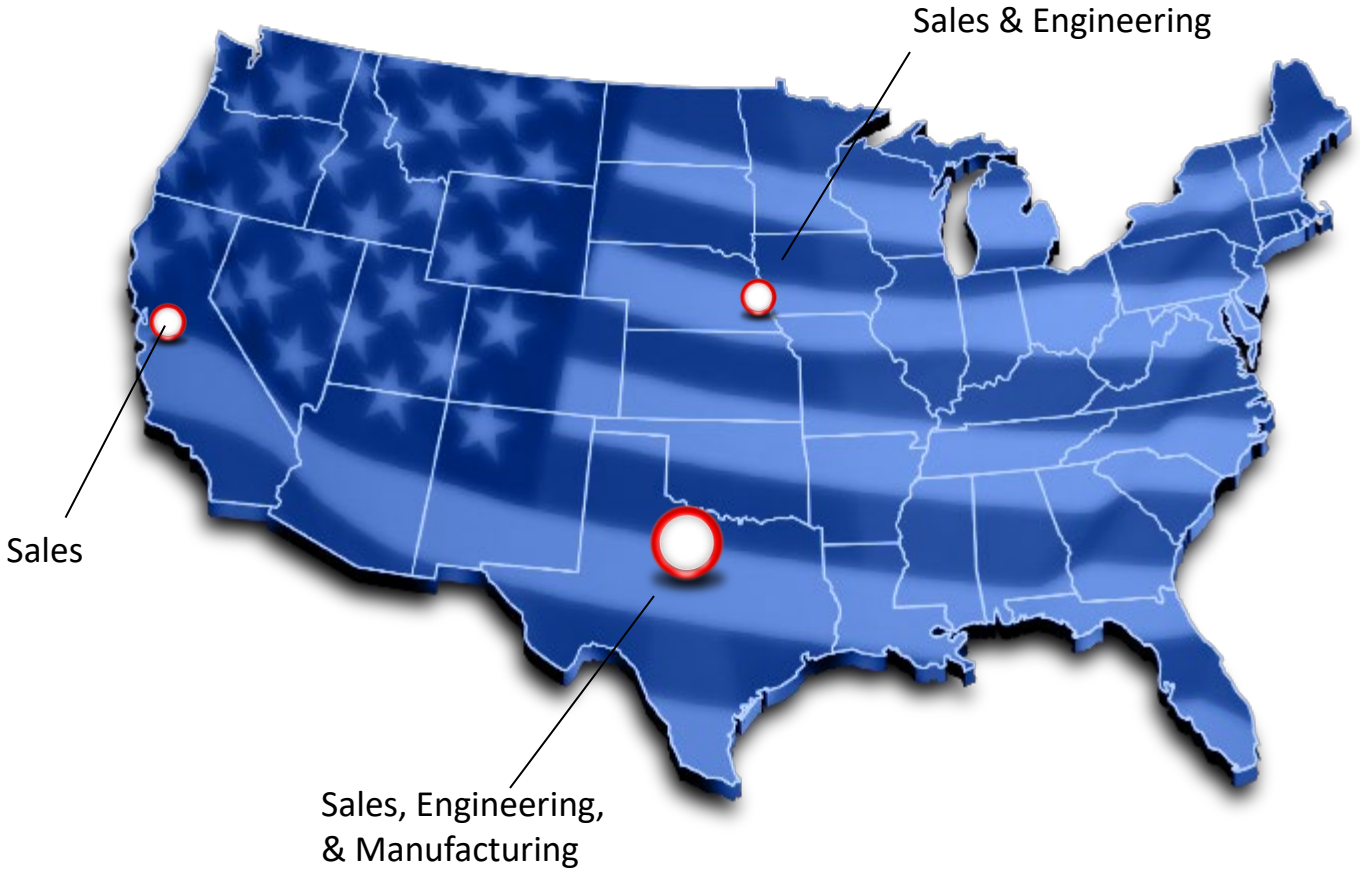
Rentech Boiler Systems Inc.

- Located in Abilene, Texas USA
- Established in 1996
  - Staff has long history in the boiler industry
- Privately held "C" corporation

Rentech Boiler Systems - Location



Other Locations



Rentech Boiler Systems Inc.
Product Offering

- Large Drum Boilers 150 to 600 KPPH (70 to 270 ton/hr.)
  - "A", "D", & "O" Style
  - Modular Configurations
- Small Drum Boilers 40 to 150 KPPH (20 to 70 ton/hr.)
- HRSG (Heat Recovery Steam Generators) 2 to 40 MW
- Waste Heat Water Tube and Fire Tube Boilers
- Emissions Control Equipment (As low as 2ppm NOx SCRs)

Product Distribution

Rentech Boiler Systems, Inc.

Our Customers – Partial List

- 3 Shops 179,000 sq. ft. under cover (16,630 sq. m)
- 2 Bays – 100 tons lift (Note additional lift capacity available with mobile cranes
- 2 Bays – 50 tons lift
- 72 acres (29 hectares)

Drum, Panel Tube, and Pipe Fabrication Facility (Shop #3)

Rentech Boiler Systems
Engineering and Design

- PROPRIETARY THERMAL DESIGN
- PROPIETARY BOILER CIRCULATION ANALYSIS
- MRP/ERP
- Solid Works® - Solid Modeling
- STAAD ® – Structural Design
- CAESAR ® – Pipe Stress Analysis
- ASME S, U, R,
- ABSA , CWB , CSA
- CE/PED

RENTECH CAPABILITIES

- Custom Design.
- Package Boilers up to 600 KPPH / 270 T/H
- HRSGs (40 MW and below CTs)
- Waste Heat Recovery Boilers (MSW, Incinerators, Sulfur Recovery)
- Emissions Control Equipment : Selective Catalytic Reduction Systems (SCRs) for NOx control
- Single source of responsibility
- Seamless integration with equipment sub-vendors
- Engineering staff with average 25 years of experience boiler OEM.
- In house field erection supervision and start up support

Rentech Boiler Systems, Inc.

2 Design

"Boilers for people who know and care"®

WATERTUBE BOILER

"Boilers for people who know and care"®

Construction Challenges

- Combustion Chamber Exit Temperatures. Compare Package Boilers and HRSGs (Duct Burner firing temperatures are also important)
- Thermal Expansion. Metals will grow when heated. Differential expansion is something that needs addressing every time.
- Mechanical reinforcing of boiler envelope.
- Available methods to enclose a boiler :
  - Refractory + Hard Casing. Good for very high temperatures, high maintenance due to refractory cracking.
  - Soft Insulation + Floating Liners. Low Maintenance and least expensive, Limited temperature (1600F). Most common in HRSGs.
  - Water cooled walls. Best possible since it can integrate furnace with boiler and it is the lowest maintenance. Most Expensive due to welding labor.

WATERTUBE BOILER (Refractory + Hard Casing)

"Boilers for people who know and care"®

WATERTUBE BOILER (Fully Watercooled)

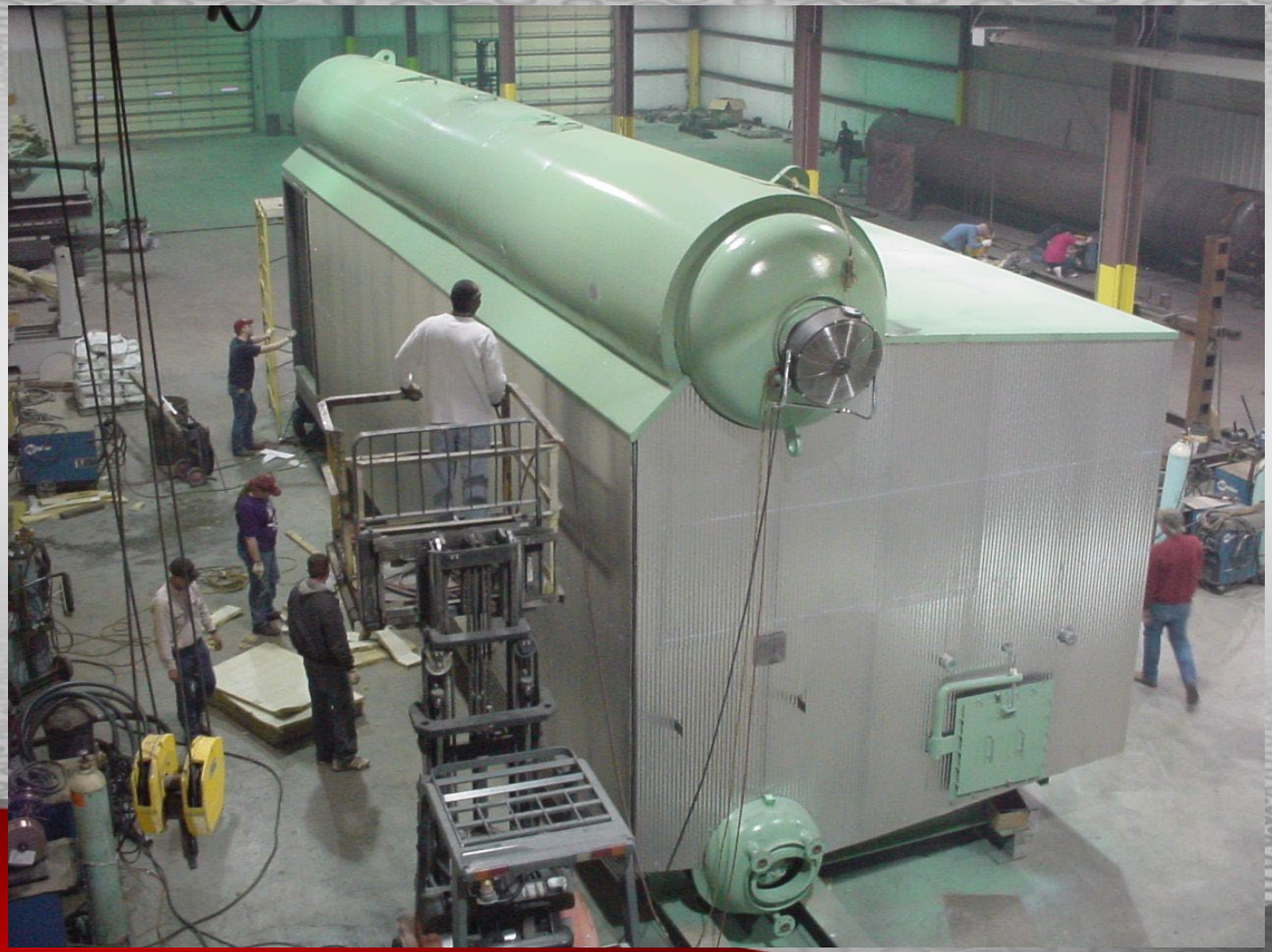
"Boilers for people who know and care"®

REAR WALL MEMBRANE CONSTRUCTION


AHERN
LINCOLN ELECTRIC
61148
snorkel
54930

INSULATION

OUTER LAGGING



Rentech Boiler Systems, Inc.

3 Hydrogen Firing

"Boilers for people who know and care"®

DEFINITIONS & TERMINOLOGY

- Green (or Clean) Hydrogen: “Climate Neutral” H2 production, with energy for salt water electrolysis from renewable sources (wind, solar). Then H2 used for combustion, synfuels production, ammonia production, etc.
- Blue Hydrogen: From steam reforming or gasification of a hydrocarbon (methane, coal) combined with carbon capture
- Gray Hydrogen: Same as Blue, except methane feed and no carbon capture
- Turquoise Hydrogen: Hydrogen from methane pyrolysis
- Pink, Yellow, Black, & Brown Hydrogen—variations on the themes above

DEFINITIONS & TERMINOLOGY

"Vintage" Hydrogen: Byproduct from chlor-alkali process, in use since the 19th century using electrolysis to produce chlorine and sodium hydroxide from salt water.

Produced at low pressure, compressed with blowers for combustion. All H2, saturated with 0% to 5% water vapor. Has been burned in package boilers and fired GTE HRSG's for decades.

Refinery also gas ranges from 20% to 80% H2, extensive experience with these fuels.

DESIGN CONSIDERATIONS

Flame detection: Not a problem with modern “tunable” scanners—Fireye Signature, Honeywell “Iris” models, Coen iScan, Zeeco ProFlame. Lots of UV in flame.

Burner material selections: High flame speed and flame temperature dictates high alloys like 310 SS, Inco alloys for burner tips.

Emissions: No CO, no VOC, UHC. NOx easily controlled in boiler with FGR or steam injection.

NOx Generation: 3X natural gas, but easily controlled with FGR. 1.5X in duct firing in GTE.

FGR (or steam injection) for NOx Control (can use a lot due to wide limits of flammability)

Boiler & HRSG Design: Nothing special; “standard” industrial designs for furnace, convective superheater.

MORE DESIGN CONSIDERATIONS

Higher cold and water vapor condensation in flue gas: Water vapor 32% for H2 vs 18% for NG.

Area classification may need upgrade to Class 1 Div. 2 Group B.

Can be blended directly at burner manifold, in the supply line, or in separate burner nozzles.

Gas line sizes comparable to natural gas if H2 supply pressure is comparable. Can be lower but line size is larger and turndown is limited.

SSO's need to be close to burner to minimize flashback in fuel line.

Also considerations for vent lines. Some suggest application of toroidal ring to vent stack to prevent flashback (NASA solution)

Normal fuel metering (orifice plate) works well, Wobbe meter also fine. BUT, be careful of water content in cell H2. 5% H2O vapor causes significant measurement error. Make sure fuel is very dry.

COMBUSTION COMPARATIVE DATA

FUEL	FLAMABILITY LIMITS IN AIR	FLAME SPEED, FPS	FLAME TEMP degF	HHV/LHV BTU/SCF	STOICH AIR, LB AIR/MBTU (HHV)	WATER IN FLUE GAS	NOx, no FGR
NG	4-16%	1.3	3,520	1050	860	17.7	60 (typ)
H2	4-77%	5.6	3,960	325	672	31.4	180 (3X)

FUEL PERFORMANCE COMPARISON - 300,000 PPH; 400 PSIG; 625 DEGF SH, 15% EXCESS AIR

FUEL/ FGR	EFFICIENCY LHV/HHV %	AIR FLOW, PPH	STACK TEMP F	HEAT INPUT MMBTUH HHV	FURNACE DUTY MMBTUH HHV	FURNACE EXIT TEMP F	SH GAS TEMP IN/OUT	SH DUTY MMBTUH HHV	DSH SPRAY PPH
NG/10	92.79 / 83.82	339,655	299	408.30	96.7	2,348	(consult designer)	(consult designer)	(consult designer)
H2/15	93.56 / 79.14	278,657	289	432.44	121.2	2,297	(consult designer)	(consult designer)	(consult designer)

Hydrogen in Supplementary HRSG's in GT Exhaust

- Also has been done for decades
- Dedicated burner runners alternated with natural gas runners for dual fuel
- NOx is 3X natural gas
- Flame very short, "clear" but easy to scan
- Flame holders need high alloy material and designed to avoid overheating
- No significant HRSG design changes normally needed

Rentech Package Boiler Experience

- Chemical Plant in TX: 4 units, each 250 KPPH, 1300 psig, 950 F SH. Designed for NG, Cracker Off Gas, Cell H2. Multiple separate nozzles. In successful service since 2017. One unit is dedicated to Cell H2.
- Chemical Plant in LA: 4 units, each 198 KPPH, 220 psig sat. Designed for 100% H2, 100% NG, or any combination mixed at burner entrance and burned in same tips. Fuel piping & controls are separate up to mix point at burner entry. In operation since 2020.
- In Excess of 30 units burning refinery gas with high H2 content.

Questions


Thank You.
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