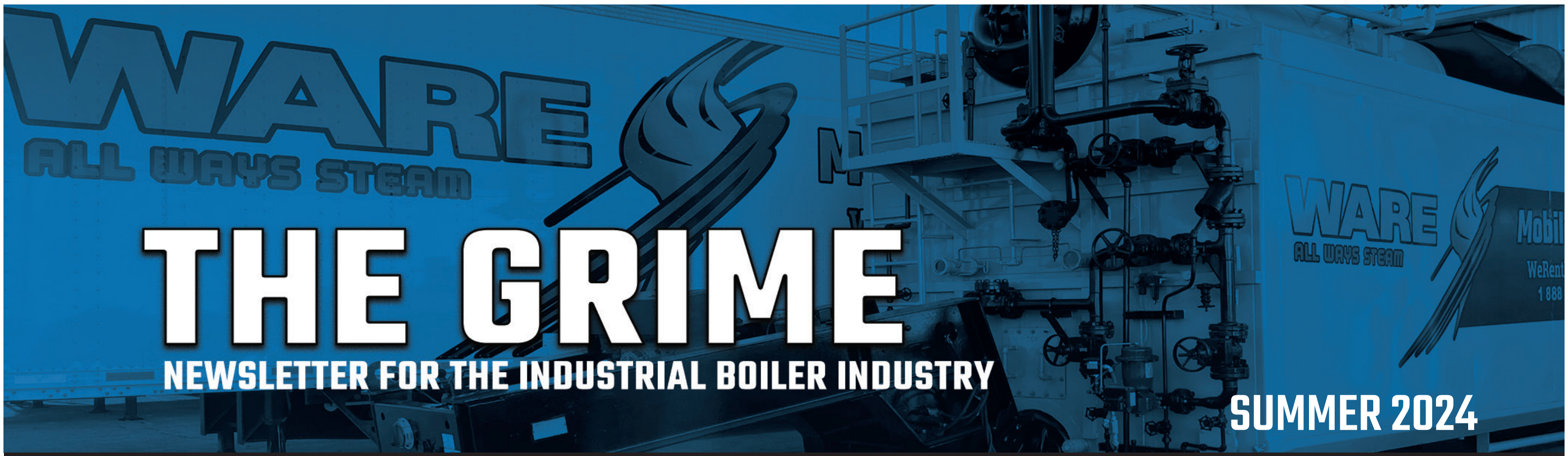


# THE GRIME

NEWSLETTER FOR THE INDUSTRIAL BOILER INDUSTRY

SUMMER 2024

## WARM IT UP

by Steve Taylor

Your boiler is a big, heavy, solid metal thing. It weighs tons. Of course it can take whatever you can dish out, right? Wrong. Despite its massive size, a boiler is a precision instrument that's been carefully designed to squeeze every last bit of usable energy out of the fuel it burns, so it can supply your work processes in the most efficient way. You have to treat it with care, especially during startup, or else you're going to drastically shorten its useful life and ruin your efficiency in the process.

### LADIES AND GENTLEMEN, START YOUR BOILERS

Starting up a boiler, a process known as "steam startup", is a carefully choreographed symphony of processes and procedures that work together to bring your boiler from a cold stop to full steam production. The key principle involved here is a simple one: "don't rush it."

If you know anything about car engines, you know that you don't just turn the key and floor it. Your engine needs time to reach operating temperature before you put it under any serious load. A boiler is the same way. Since it operates at high temperatures and pressures, the heat and pressure need to be introduced gradually because each one affects the other. The higher the heat, the higher the pressure, and the more stress and

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## FIRETUBE BOILERS

by Jude Wolf

There are two main types of boilers out there, firetube and watertube. In a firetube boiler, hot combustion gases from the boiler's fireside are directed through a series of pipes (also called tubes) that are surrounded by water. As the gases flow through the furnace and tubes, the heat is transferred from the gases to the water, which eventually absorbs enough heat to change from a liquid to a gas and, voila, steam is created. If you've ever wondered how firetube boilers are made, you're in luck, because you're about to learn.

### START WITH A SHELL

Firetube boilers are typically made in several steps, but everything starts with the basic formation of the pressure vessel walls. The pressure vessel will eventually take the form of a sealed, watertight cylinder, but when work first starts on it, it's open on both ends, and is known as a "shell". Creating a finished pressure vessel isn't as easy as just welding a tube sheet on each end and calling it a day, though. Remember, firetube boilers

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operate under a lot of heat and pressure, which means they have to be extremely resistant to expansion or implosion. That's why the first step involves reinforcing the ends of the pressure vessel with anchor points.

Remember those tubes we talked about a moment ago through which the combustion gases flow? They do more than transfer heat. They also help provide some longitudinal rigidity, serving as anchor points to brace the flat ends of the pressure vessel to keep them from flexing inward and outward. They're welded in place to what's known as the tube sheet, which is a round steel plate on each end of the shell with holes in it through which the tubes can pass.

Since the tubes are tightly welded to the tube sheet at either end of the pressure vessel, they serve as reinforcement to keep the end caps from flexing. But those tubes don't pass through every square inch of the tube sheet, which means there are areas that aren't reinforced by the welded tubes in the tube sheets. Those areas without tubes still have to be reinforced, though, which is done through the use of stay rods.

Stay rods are rigid metal rods welded to the inside of each boiler end cap that extend the entire length of the boiler. They brace the tube sheet on one end against the tube sheet on the other end, preventing them from flexing inward or outward as pressure increases and decreases.

The connections between the shell and the tube sheets are absolutely crucial to boiler operation. That's why they are carefully welded by experts, and inspected multiple times to make sure there are no gaps or uneven areas. The welds must be even because if they aren't, they'll undergo uneven expansion as the boiler heats up and cools, which will lead to metal fatigue and cracking down the line. Once the tube sheets are welded into the shell, it's time to start adding the tubes that will do the heat transfer.

## THE MORRISON TUBE AND FRIENDS

The largest tube, the furnace, in a fire tube boiler is known as the Morrison Tube, which is the first pass through which the gases will flow from the burner. Since it's the largest, it is the tube that is welded into place first. Welding the Morrison Tube first also helps align all the tube sheets properly so that the smaller tubes can be pulled through and welded into place.

So, why all the tubes in the first place? It has to do with efficiency. Since the Morrison Tube is the largest, it's going to transfer a lot of heat to the water flowing around it. However, there will still be some useable heat left in the gases that isn't touching a tube wall after it's passed through the Morrison Tube to the other end of the pressure vessel. One way to look at it is like this: If you drive a car through a large storm drain, only the outer surface of the car gets scratched, because that's the only part that's touching the walls.

To capture the heat that's still in the combustion gases after passing through the Morrison Tube, those gases are directed back on a return trip, or "pass", through the water again, this time through smaller tubes, to transfer more of their stored heat so it can be turned into steam. In some boilers, the combustion gases will take multiple passes back and forth through the tubes before venting the now-cooled combustion gases out through the stack.

Why do the gases have to go back through smaller tubes? To make sure as much of that heat gets transferred as possible. Smaller tubes offer a greater surface area per linear foot than larger tubes, and surface area is what heat transfer is all about.

# TUBE BE OR NOT TUBE BE

by Brian Grinestaff

There are two predominant types of industrial boilers out there, water tube and fire tube. The difference between them lies in the way the heat is transferred to the water. In a water tube boiler, the water flows through tubes surrounded by hot combustion gases and absorbs heat as it passes through. In a fire tube boiler, however, the opposite happens. The tubes themselves are surrounded by water, and as the hot combustion gases flow through them, they heat up the water around them. But there is a lot more to tubes than you might realize.

## TUBE CENTRAL

If you've ever seen inside the WARE warehouse, you've seen a lot of tubes hanging out in neat stacks. There is a wide range of sizes and lengths available, because WARE services boilers of all makes and models. And they are all made to very exacting standards. When boiler tubes are manufactured, the materials used to make them are chosen carefully, because there has to be consistency in the metal used to roll the tubes. Any variance in the composition of the metal means that the metal will transfer and dissipate heat inconsistently. It also means the metal will not act uniformly in terms of expansion. Both of those mean trouble. Inconsistent expansion means the tube may warp or bend under heat, which strains the welds or rolls that hold the boiler together. That can lead to cracks. Inconsistent heat transfer, on the other hand, will cause hot spots that can also lead to warping and cracking.

## SIZING IT UP

Boiler tubes not only differ in length, they also have a fair amount of variance in the thickness of the tube walls. Manufacturers do tremendous amounts of research and testing to find the optimal combination of tube material and thickness to promote optimal heat transfer under the boiler's specified operating parameters.

Therefore, replacing a tube has to take into account the recommended thickness of the tube wall, because if you end up with a tube that's too thick or too thin, you'll end up with uneven heat transfer. A mismatched tube is a total wrench in the works, because it can throw off the whole heat equilibrium of your boiler. A mismatched tube can also cause water stratification, which is a pronounced difference in heat levels at different depths in the pressure vessel that leads to uneven heat dissipation, metal fatigue, and metal strain.

The good news is, an exact match is not always required. Many manufacturers build in a slight amount of variance in their operating specs that can allow for a marginally thicker or thinner tube wall without massive consequences. Of course, tube replacement should never be made without professional help, because qualified boiler technicians and properly certified inspectors know what can and can't be done. It's not a DIY project, in other words.

## HOW IT COMES TOGETHER

When it comes to installing a boiler tube, you'll find that no ordinary connection will do. It's not as simple as just mounting the tube and welding around the edge where it meets the tube sheet. Remember, one of the key factors in safe, efficient boiler operation is even heat transfer. That applies to the tubes, the pressure vessel, and all the welds that hold it all together. When a tube is mounted into the tube sheet, therefore, it's not just welded. And sometimes, it's not welded at all. it's put through a process called "rolling".

When the tube is first slid into place in the tube sheet, it's not a flush fit. There's always going to be a little extra tube protruding beyond the tube sheet. That excess tube is then "rolled" backwards to create a rounded edge. That edge can be rolled tight enough to require no welding. But in some boilers, that roll is used as a foundation for the weld that will be put into place to hold the tube to the tube sheet. In those instances, rolling the edge and then welding into the roll creates greater surface contact, and a greater ability to transfer heat evenly between the tube, the weld, and the sheet. Fun fact, the weld that holds the tube to the tube sheet isn't even designed for structural support. It's welded the way it is because that's the best way to get even heat transfer. Even heat transfer makes the weld last longer, and, subsequently, extends the life of the boiler tube.

Whatever kind of boiler you're running, you need to have a pro involved. There's no such thing as safe DIY boiler tube repair or replacement. Any modifications to, or replacement of, a tube must be done with careful attention to material composition, heat transfer, material integrity, and alignment. With the high temperatures and pressures involved in steam production, even a little bit of uneven heat transfer can lead to metal fatigue and premature failure.

If you'd like to learn more about tubes or other parts of a boiler, consider taking a few in-person or online classes at WARE's Boiler University. You'll learn from seasoned experts who have decades of experience working with boilers. If you need help with a tube, let our expert technicians handle it for you. If you're in the market for a new or rental boiler, WARE is here to help with that, as well. Whatever you need, just let us know.

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BOILER TUBES 101

strain your boiler's components will have to endure.

Before we go kicking any tires and lighting any fires, though, you have to make sure your boiler is properly configured and prepped for operation. That means inspecting the water levels and the incoming fuel pressure to make sure you have enough of both. It also means double-checking that all valves are in the right position for startup, and it means checking for leaks carefully on and around the boiler.


**"operators have to be particularly vigilant about monitoring temperature and pressure levels to make sure neither is rising too quickly"**

Next, it's time to actually light off the burner. Since we're introducing heat gradually, the initial firing is done at the lowest level. This is done to prevent thermal shock, which occurs when excess stress is placed on the boiler's components due to temperature differential.

If you've ever poured room-temperature soda into a glass of ice and heard the ice cubes pop, that's thermal stress in action. At the molecular level, the crystalline structure of the ice cube is suddenly expanding in some parts but not in others, causing it to push and pull against itself. When enough tension is created, the ice cube cracks and splits.

That's what can happen at the molecular level in your boiler, too. Which is why everything is warmed to the same level over time. To make sure it all heats up evenly, operators have to be particularly vigilant about monitoring temperature and pressure levels to make sure neither is rising too quickly. As temperature and pressure continue to rise, the boiler can begin to fire at a higher and higher rate, which will gradually increase the temperature and pressure in the vessel without shocking it. This will also allow all the other components of the boiler to expand evenly, maintaining the integrity of the watertight seals between the pipes, valves, sensors, pressure vessel, and other boiler components.

**OUT WITH THE OLD**

Before your boiler was started, it wasn't just sitting there empty. Nature hates a vacuum, remember? Your boiler was full of air, and air is full of oxygen. While oxygen is necessary for combustion, you don't want excess oxygen hanging out in your pressure vessel or steam manifold. Not only will it displace your valuable steam, it will actually contribute to corrosion in your boiler components over time. That's why the next step of boiler startup involves purging all that excess air so it can be displaced by the steam that does all the work.

Purging the air has to happen slowly, though. If the air is purged from the system and replaced by steam too quickly, you run the risk of getting a scary-sounding phenomenon known as water hammer. That's what happens when steam or water slams against the inner surfaces of pipes and valves too rapidly as the air is vented, causing damage to the boiler's components.



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As the pressure in the boiler continues to build up and the air is displaced, you're going to start developing a good head of steam in the boiler. Pretty soon, you'll be ready to start supplying your work processes. However, as with everything boiler-related, you have to introduce the steam slowly and gradually. Otherwise, you'll end up doing the same kind of damage to your pipes and processes as you're trying to prevent in your boiler.

**THERE'S A VALVE FOR THAT**

To help introduce steam into the system gradually and evenly, you could just open the valve a little. Sounds logical, right? The only problem is, it's hard to be extremely precise when you're opening a great big steam valve. Even if you're the most precise and careful valve-opener in the world, though, there's still a chance that the valve could be opened too far and let too much steam in. That's why there's a special valve out there known as a steam warmup valve.

A steam warmup valve is essentially a small steam bypass pathway that is connected to the upstream and downstream side of the main steam supply pipe. Since it's a much smaller pipe, it can be safely controlled with a much smaller, more precise valve. Because of that, it can be opened gradually to introduce steam into the system without having to open the main steam cutoff valve.

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Warm it up page 5

Think of it this way. If a main road is closed, you can get around the closure by taking a smaller street up and around the blockage. Likewise, with a steam warmup valve, the operator can allow a small amount of steam to bypass the main valve before it's opened. Since the valve on the steam warmup valve is smaller, it's going to permit greater precision in valve modulation. That, in turn, will allow the steam to be introduced as gradually as possible to ensure steady, even increases in pressure and temperature.

Another cool function of the steam warmup valve is that it can also act as a sort of safety valve during the crucial startup period. Remember, the main steam valve is under a lot of pressure. By allowing the steam warmup valve to gradually bleed steam into the lines, you can not only prevent a sudden rush of pressure from the main valve opening, it will actually make the main valve easier to open because there will be less of a pressure differential between the opposite sides of the valve. Even if it's accidentally turned too far, it will still only allow a small amount of steam to enter the pipes and processes, avoiding the dreaded thermal shock and water hammer.

**GETTING IT TUNED IN**

As the temperature and pressure continue to increase, and more steam is introduced to the system, operators need to pay careful attention to the gauges and sensors in their boiler. By keeping an eye on everything, operators can make sure that the boiler stays as safe and efficient as possible. Once all the parameters are within the manufacturer's recommended guidelines for full rate, the boiler can be brought online and taken to its optimal operating pressure. Again, careful monitoring is the key to determining that the boiler is operating as designed, and that there are no faults, leaks, or other issues occurring.

If your boiler doesn't start up like it should, or if it's taking too long to get up to rate, it's best to have a professional check it out. WARE's technicians are the best in the business, and they're always here to help. If you'd like to take a deeper dive into how boilers work to better understand everything that's happening during startup, consider taking an online or in-person class from WARE's Boiler University. If there's anything else we can do to help, or if you need a new or rental boiler, just let us know.

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UNDERSTANDING STEAM WARM UP IN STEAM SYSTEMS

Firetube page 2

**WELDING IN THE TUBES**

Once the tube sheets, stay rods, and Morrison Tube are welded in place, it's time to start installing the tubes themselves, through a process known as "tube pulling". These tubes are attached a little differently than the Morrison Tube, though. As each tube is installed through the tube sheets individually, it ends up being longer than the distance between the tube sheets on the ends. This is done to allow them to be secured with a process known as "tube rolling".

When a tube is "rolled", two things happen to it. First, it is stretched



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and expanded inside the tube sheet to make sure it makes solid, even contact with the circular cutout in the tube sheet. The second thing that happens is that the protruding edges of the tube that stick out past the tube sheet are bent backwards to form a flange shape. This flange gives the welder a solid surface to apply the fillet weld bead as the tube is welded to the tube sheet. This ends up creating a round, even weld that promotes efficient heat transfer, while making the connection more solid and resistant to heat deformation over time. Contrary to what you might think, this weld isn't there for structural integrity. It's all about the heat transfer.

## GET GROOVY

The most reputable boiler manufacturers actually add another step in the process to ensure a strong, crack- and leak-resistant connection between the tubes and tube sheets. That involves cutting a small circular groove around the inside diameter of every hole that goes through the tube sheet where a tube will eventually be mounted. When each tube is rolled into place, it is essentially "crimped" into that circular groove, making it over 40% stronger and more resistant to thermal cycling
.

If you look inside many modern boiler tubes, you'll notice something interesting. The inner surfaces are rifled. This doesn't do anything to make the gases more accurate at 50 yards. That rifling is in place to create turbulence, mixing and stirring the hot combustion gases so as much heat as possible is always touching the tube's metal surface to be transferred to the water.

Some boilers use straight tubes, and there's nothing wrong with that. We've just found in our experience that rifled tubes are the real deal, and do actually increase efficiency by around 3%. While it doesn't sound like a lot, it really adds up over time for a boiler that's running every day.

## IT ALL ENDS WELL

Once the ends are in place, it's time to add the piping, valves and components that will supply feedwater, allow blowdowns, and provide a column to be used for the level controls, sight glass, and other pressure instrumentation. The steam outlet piping is also installed so the steam can be directed to its final destination.

Once all these weld and piping connections are made the boiler is "hydroed." That's short for "hydrostatically tested", which involves pumping the boiler full of water to 150% of its maximum rated pressure. This not only gives the manufacturer a chance to test for leaks, it also allows them to measure the expansion over the boiler's surfaces, to see if the metal or pipes give or flex too much.

## REFRACT A MOMENT

After the tubes (Morrison and other) are in place, the boiler's ends are fitted with insulated doors or covers. Their refractory, which as you may know is a combination of heat shield and super-insulator that keeps the heat inside the boiler, is important so the outer surface doesn't become dangerously hot from wasted heat. Refractory can be made from several different materials such as brick, tile, or stone. However, many modern boiler manufacturers actually pour in a proprietary mix of minerals and compounds that form into a perfect custom-fit, heat resistant cement structure to act as the refractory.

Refractory is especially important in the smoke boxes and furnace doors of dryback boilers, because there's no water to absorb the searing heat. If the raw plate of the pressure vessel is subjected to those kind of extreme temperatures, often as high as 2000°F, it can experience significant stress over time.

Once steel and the refractory are installed on the front of the boiler the burner will be mounted. The rear insulation is installed on the other end to protect the door from constant heat of combustion gases. Once the stack transition is installed, the main boiler structure is complete.

From there, it's simply a matter of installing the control systems, sensors, and electrical wiring that will allow boiler operators to monitor the performance of their boiler to keep it running safely and efficiently for a very long time.

## SOLID CONSTRUCTION

The temperatures and pressures involved with steam production in a fire tube boiler can be pretty extreme. Steam can get three to four hundred degrees or so, furnace temperatures can reach 2000°F, and the pressure vessel and piping has to deal with pressure as well. Because of the diameter of the main shell being large, compared to a comparable water tube boiler, they are generally design limited to around 300 psi. As you can imagine, then, a fire tube boiler has to be able to withstand these pressures, and do so over a long service life. Which means it has to be built well, with careful attention to detail to make sure there are no cracks, gaps, or weak points anywhere, especially in the tubes. Every boiler that WARE sells or rents is made to the highest standards of quality, with the most rigorous quality control processes in place. That's why you'll get dependable, reliable steam production no matter what your needs. If you'd like to know more about our new boiler inventory, or if you'd like to get a quote on a rental boiler, we're here to help.

If you have a fire tube boiler that needs service or maintenance, remember, we're here to help with that, too. Just let us know.

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# EQUIPMENT IN STOCK

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| Unit | HP/PPH | Year | Manf. | Fuel | Type | PSI | Ctrl. |
|---|---|---|---|---|---|---|---|
| 796 | 82,500 | 2016 | Victory Energy / Faber | (Low NOx) G/#2 | Steam | 350 | IRI |
| 797 | 82,500 | 2016 | Victory Energy / Faber | (Low NOx) G/#2 | Steam | 350 | IRI |
| 767 | 75,000 | 2011 | Victory Energy | (Low NOx) G/#2 | Steam/SH | 750/750 | IRI |
| 747 | 75,000 | 2000 | B&W | (Low NOx) G/#2 | Steam/SH | 750/750 | IRI |
| 791 | 75,000 | 2016 | Victory Energy | (Low NOx) G/#2 | Steam/SH | 750/750 | IRI |
| 709 | 60,000 | 1979 | Zurn | (Low NOx) G/#2 | Steam | 500 | IRI |
| 741 | 60,000 | 1979 | Zurn | G/#2 | Steam | 550 | IRI |
| SWVB4 | 2500 | 2021 | Victory Energy | (Low Nox) G/#2 | Steam | 250 | UL/CSD-1 |
| SWVB5 | 1500 | 2024 | Victory Energy | (Low Nox) G/#2 | Steam | 250 | UL/CSD-1 |
| SSB-77 | 1200 | 2024 | Victory Energy | (Low NOx) G/#2 | Steam | 250 | UL/CSD-1 |
| 634 | 800 | 1972 | York-Shipley | G/#2 | Steam | 150 | IRI |
| 620 | 800 | 1975 | York-Shipley | G/#2 | Steam | 250 | IRI |
| SSB-72 | 800 XID | 2023 | Victory Energy | (Low NOx) G/#2 | Steam | 250 | UL/CSD-1 |
| SSB-76 | 800 | 2024 | Victory Energy | (Low NOx) G/#2 | Steam | 250 | UL/CSD-1 |
| SSB-73 | 800 | 2024 | Victory Energy | (Low NOx) G/#2 | Steam | 250 | UL/CSD-1 |
| SSB-67 | 600 XID | 2023 | Victory Energy | (Low NOx) G/#2 | Steam | 250 | UL/CSD-1 |
| SSB -75 | 600 | 2024 | Victory Energy | Low NOx) G/#2 | Steam | 250 | UL/CSD-1 |
| SSB-82 | 600 | 2024 | Victory Energy | Low NOx) G/#2 | Steam | 250 | UL/CSD-1 |
| SB-139 | 500 | 2001 | Cleaver Brooks | G/#2 | Steam | 150 | |
| SB-277 | 400 | 2023 | Victory Energy | (Low NOx) G/#2 | Steam | 150 | UL/CSD-11 |
| SSB-74 | 400 | 2024 | Victory Energy | (Low NOx) G/#2 | Steam | 150 | UL/CSD-1 |
| SSB-80 | 400 | 2024 | Victory Energy | (Low NOx) G/#2 | Steam | 150 | UL/CSD-1 |
| SB-138 | 350 | 1994 | Cleaver Brooks | G/#2 | Steam | 150 | |
| SSB-73 | 300 XID | 2024 | Victory Energy | (Low NOx) G/#2 | Steam | 150 | UL/CSD-1 |
| SSB-79 | 300 | 2024 | Victory Energy | (Low NOx) G/#2 | Steam | 150 | UL/CSD-1 |
| SSB-84 | 300 | 2024 | Victory Energy | (Low NOx) G/#2 | Steam | 150 | UL/CSD-1 |

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|---|---|---|---|---|---|---|---|
| SSB-70 | 250 | 2023 | Victory Energy | (Low Nox) G/#2 | Steam | 150 | UL/CSD-1 |
| SSB-78 | 250 | 2024 | Victory Energy | (Low Nox) G/#2 | Steam | 150 | UL/CSD-1 |
| SSB-81 | 250 | 2024 | Victory Energy | (Low Nox) G/#2 | Steam | 150 | UL/CSD-1 |
| SB-148 | 200 | 1995 | Kewanee | Gas | Steam | 325 | IRI |
| SB-285 | 200 | 2024 | Victory Energy | G/#2 | Steam | 150 | UL/CSD-1 |
| SB-286 | 200 | 2024 | Victory Energy | G/#2 | Steam | 150 | UL/CSD-1 |
| SB-146 | 200 | 1995 | Kewanee | Gas | Steam | 325 | IRI |
| SB-287 | 200 | 2024 | Victory Energy | Gas/#2 | Steam | 150 | UL/CSD-1 |
| SB-267 | 175 | 2022 | Victory Energy | G/#2 | Steam | 150 | UL/CSD-1 |
| SSB-53 | 175 XID | 2020 | Victory Energy | (Low Nox) G/#2 | Steam | 150 | UL/CSD-1 |
| SB-280 | 150 | 2023 | Victory Energy | G/#2 | Steam | 150 | UL/CSD-1 |
| SSB-66 | 150 | 2023 | Victory Energy | (Low Nox) G/#2 | Steam | 150 | UL/CSD-1 |
| SB-279 | 150 | 2018 | Victory Energy | G/#2 | Steam | 150 | UL/CSD-1 |
| SB-281 | 150 | 2024 | Victory Energy | G/#2 | Steam | 150 | UL/CSD-1 |
| SB-282 | 150 | 2024 | Victory Energy | G/#2 | Steam | 150 | UL/CSD-1 |
| SB-274 | 100 | 2022 | Victory Energy | G/#2 | Steam | 150 | UL/CSD-1 |
| SB-275 | 100 | 2022 | Victory Energy | G/#2 | Steam | 150 | UL/CSD-1 |
| SB-276 | 100 | 2022 | Victory Energy | G/#2 | Steam | 150 | UL/CSD-1 |
| SSB-60 | 100 | 2022 | Victory Energy | (Low Nox) G/#2 | Steam | 150 | UL/CSD-1 |
| SB-271 | 70 | 2022 | Victory Energy | G/#2 | Steam | 150 | UL/CSD-1 |
| SB-272 | 70 | 2016 | Victory Energy | (Low Nox) G/#2 | Steam | 150 | UL/CSD-1 |
| SSB-64 | 70 | 2022 | Victory Energy | (Low Nox) G/#2 | Steam | 150 | UL/CSD-1 |
| SB-283 | 50 | 2024 | Victory Energy | G/#2 | Steam | 150 | UL/CSD-1 |
| SSB-68 | 50 | 2023 | Victory Energy | (Low Nox) G/#2 | Steam | 150 | UL/CSD-1 |
| SB-263 | 50 | 2022 | Victory Energy | (Low Nox) G/#2 | Steam | 150 | UL/CSD-1 |
| SB-268 | 10 | 2017 | Lattner | Gas | Steam | 150 | UL/CSD-1 |

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