Whitepaper

SAFER BY DESIGN

Understanding Miura Boiler's "Safer by Design" Engineering Achievement.

While there are still places in the world where boiler laws are weak, or non-existent, wherever industrialization has existed for a prolonged period of time, people start putting safety measures in place to better protect lives and well-being when working with steam. Miura understands the importance of absolute safety as well as anyone, and have designed and engineered their boilers around achieving this goal, while maximizing reliability and efficiency. With more than 140,000 units in operation world-wide, Miura's "Safer by Design" boilers have experienced zero catastrophic vessel failures resulting in casualty. That's the best safety record in the industry.

To understand how the company was able to accomplish this incredible record, we need to take a number of factors into consideration. In his book, "Boiler Operator's Workbook," a well-accepted reference tool, the author R. Dean Wilson writes "Why is an explosion generally less disastrous in a watertube boiler than in a firetube boiler? "In a watertube boiler, the large volume of water is distributed into many small tubes, and the volume of water in the drum is comparatively small. If one water tube bursts, the pressure in the entire pressure vessel is bled off slowly, and the tendency of the large body of water to flash into steam is minimized..."

"In a firetube boiler, a sudden crack in the shell or a flue pulled loose at the end causes the entire body of water to be subjected to a sudden and substantial drop in pressure. The huge volume of flash steam that results can cause an explosion of tremendous force."

There is a commonly accepted belief in the boiler industry that watertube boilers are intrinsically safer than firetube boilers due to their design. Miura's industrial watertube boilers not only provide this intrinsic safety advantage, but also incorporate industry leading safety enhancements & controls (i.e. tube temperature sensor, scale monitor, etc.) standard on every model. While Miura boilers have all the benefits of traditional watertube boilers (safety, fast start up, compact size, and ability to respond quickly to load swings) their available horsepower and cost are more comparable to the typical firetube boiler.

In a recent interview, a food and beverage processing consultant with 20+ years of experience revealed that he recommends boilers based on functionality first, maintenance and sanitation second, form third, and safety always.

"The thing that's huge for us is everybody's concerned about boilers exploding," he stated. "I think Miura's low water content feature means that this never has to be a consideration. There's no fear of impending doom that the boiler's going to explode and fly 800 feet into a residential area."

Miura's revolutionary technology, combined with their unique boiler geometry, means that catastrophic vessel failure is practically impossible. Plus, Miura has engineered numerous safeguards beyond primary vessel safety and industry standard features to ensure safe operations. These include additional high pressure cut-offs, water tube over heat cut-off, and flue gas over heat cut-off. Preventive controls include scale over heat monitor, water pump capacity monitor, and flame sensor self-check. Fully automated operations include automatic surface blow down, automatic bottom blow down (optional) and automatic water shut-off valve (optional), with only one button required to turn the boiler on and off.

In addition to ASME / UL safety designs and installation codes, purge requirement, ventilation requirement and ASME / UL safeties, Miura's unique pressure vessel design allows the waterside failure to be contained within the boiler. The fireside is explosion proof. Miura's perfect safety record is due in part to the company's low water content design and furnace volume. It's all a matter of physics.

Miura's Low Water Content Design Maximizes Safety.

A pound of water takes up a very different volume than a pound of steam. The ratio is about 1:1600! That is, a pound of steam takes up 1600 times the volume of a pound of water. That's a big difference and under certain circumstance, the sudden transition from water to steam can cause a very hazardous situation. It is also important to understand the effects of pressure and temperature on the physical state of water. At just 15 psig,, water won't boil until it reaches approximately 250 F and the saturated water (water at 250 F) will be at a much higher energy level than water at 212 F.

Notably, this also works in the opposite direction with pressure, which brings us to the subject of flash steam. Should pressurized water at saturation conditions of 250 F and 15 psig suddenly have pressure drop to 0 psig, or atmospheric pressure, the excess energy present in 250F water will cause a portion of that water to immediately flash to steam. Imagine if you will, an entire gallon of water instantly flashing to steam, and suddenly trying to occupy the equivalent volume of 1600 gallons of water.

Another important thing to know about flash steam is that the proportion of pressurized water volume that will flash instantly to steam increases as the pressure differential from atmospheric conditions increases. For instance, in order to flash off an entire gallon of 250 F pressurized water by reducing pressure from 15 psig to 0 psig, there would need to be 25 gallons present, since the percentage of flash steam resulting from that pressure drop is approximately 4%. Should saturation conditions corresponding to 60 psig be present, that percentage jumps to approximately 10%. At saturation conditions corresponding to 250 psig, the percentage of flash steam would be approximately 20% of available pressurized water volume.

To bring some perspective to the situation, consider that a small 200 HP Scotch-Marine type firetube boiler capable of operating up to 150 psig contains a little over 1,000 gallons of water during operation. That's over 7 million BTU's of stored energy in the form of latent heat. Now imagine a pressure vessel breach, and 162 gallons (16.2% of 1,000) of that water suddenly trying to occupy 1600 times that volume, the equivalent of 259,200 gallons of water.

That's roughly 40% of the volume of an Olympic sized swimming pool! To put it another way, if 162 gallons occupies approximately 22 cu.ft of volume, then when that same volume flashes to steam, it would be trying to take up 35,200 cu.ft, and most likely, that is much more volume than is contained within the boiler room. That is quite an explosive force.

So as you can see, there is inherent danger present when water exists in saturated conditions at pressures well above atmospheric pressure. The amount of danger is directly related to two things: 1) the volume of saturated water present, and 2) the pressurization of that volume above atmospheric pressure, but practically speaking, only one of these two factors, that of water volume, can be addressed without completely negating the value of high pressure steam in the first place.

Miura's best-in-industry safety record was achieved using a low content boiler design, which is all the more impressive when you recognize that reducing water volume in a steam boiler poses a few large challenges.

That's because the water volume in a steam boiler serves dual purposes. First, and most obviously, steam cannot be generated without boiling the water present. So there must be enough water present in the pressure vessel to produce the required capacity of steam, at the required temperature and pressure. Secondly, and just as importantly, the furnace side of the boiler, where the flame and hot flue gases are generated, is very hot. Flame temperatures typically exceed 3,500 F at the burner. The materials the pressure vessel is constructed from, typically welded carbon steel, cannot maintain their structural integrity at temperatures of even less than half that.

So, the water content of the boiler also serves to cool the pressure vessel. The trick then, is to design a boiler that can contain the minimum amount of water required to produce a given capacity of steam, while still having enough cooling capacity to maintain the integrity of the vessel in substantial excess of the steam pressure desired.

That is just what Miura accomplished a few decades ago when they developed the technology to create a better water-tube boiler based on their primary goal of maximum safety. Until then, the technology to reliably operate a low water content, on-demand boiler didn't exist. Today, it is well advanced and a key reason why Miura boilers, which can generate full steam in less than 5 minutes from a cold start, are safer by design and provide maximum efficiency and reliable operation.

Just how safe are Miura's on-demand boiler designs? Let's take the example of a 200HP boiler operating at 150 psig saturated steam conditions. While the firetube we discussed held over 1,000 gallons of water while operating, a Miura low water content, on-demand boiler of the same exact output capacity maintains only up to 75 gallons of water, less than 7.5% of volume of the firetube. That is less operational water content, by more than half (46%) of the volume (162 gal) we estimated would flash off, were a breach to the firetube's pressure vessel to occur!

In a commonly cited worst case scenario, where all controls and safeties fail, with water level dropping below the LWCO and where the burner remains firing, by the time there isn't enough water remaining to cool the tubes, and a rupture occurs, the volume of water flashing to steam could be contained within the furnace volume of the boiler, and safely vented up the exhaust stack, without an explosion and loss of life.

Miura's "better" on-demand watertube boilers are available in two product lines.

Miura Boilers Maximize Safety, Reliability and Efficiency.

Miura's LX Gas/Low NOx Series, Low and High Pressure Steam Boiler (available in boilers from 50 -300HP) use natural gas or propane and are available in a range of steam options (300 MAWP, 170 MAWP or 15 MAWP). Their compact size allows most models to fit through an industrial 7-foot doorway, while their naturally low NOx (nitrogen oxides) ratings are as low as 9ppm depending on model. This meets or exceeds current and proposed regulations for nitrogen oxide emissions levels.

Miura's EX Gas/Oil Series High Pressure Steam Boilers (available in 100HP, and in 50 HP increments up to 300HP models) are very versatile due to their dual fuel capabilities. They can burn natural gas, propane, and/or #2 fuel oil.

Both the LX and EX designs minimize carryover and produce 99+% dry saturated steam in less than 5 minutes from a cold start. Faster start-up means less fuel used, greater savings, and more responsible use of precious natural resources.

The LX-Series design consists of vertical water tubes in a rectangular array, while the EX-Series utilizes vertical water tubes in a circular array. Both headers of each series are encased in a castable refractory with only the tubes exposed to flame and/or combustion gases. The upper header is attached to the lower header only by the tubes. As the tubes expand and contract, the headers float up and down accordingly.

The 'floating header' concept allows for even thermal expansion of the tubes, therefore reducing stress points within the boiler." The 'leaky tube' problems associated with firetube and bent watertube designs have been eliminated.

Each pressure vessel model undergoes extensive analytical design and empirical testing to ensure maximum heat transfer while maintaining a robust design. Fined watertubes are used near the rear of the pressure vessel to increase the heated surface area. Computational simulations are utilized to design and analyze the design of the pressure vessel geometry (quantity of tubes, placement of tubes, and size of the fins, etc). Finally, each design is put to the test through vigorous empirical testing to fine-tune the exact design. Over 100 thermocouples and other types of sensors are utilized during the testing phase to ensures that each boiler design will provide maximum heat transfer without the risk of overheating, cracking, or thermal stress. All this while maintaining high steam quality (99%+ dry saturated steam).

Of course, Miura's low water content design further improves the intrinsic safety factor, and with safety becoming a greater and greater concern, Miura boilers are being chosen by more and more buyers.

History, and 140,000 units that have been installed worldwide, is an enormous amount of evidence that proves Miura's safer by design engineering has achieved the goals of absolute safety set decades ago.