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Award-winning bridge

Bridges influence the quality of life for an entire region by providing a way across rivers, ravines, and other obstacles. Duplex stainless steels in bridge design help avoid road closures for both replacement and maintenance. A new bridge spanning one of the world's largest rivers uses both 2205 and 2507 duplex stainless steel for strength, longevity, and corrosion resistance.

The I-74 bridge, officially known as the Iowa-Illinois Memorial Bridge, lies in the cold and snowy midwestern US, about an hour east of Chicago on the Mississippi River. It's often called the "Twin Bridges" because route I-74 runs across a pair of arch bridges, one inbound to Iowa and one into Illinois. For the people who depend on bridges for transportation, these structures signal either a sense of security or one of neglect. Fortunately, the bridges' recent replacement involves some of the best materials available, carefully selected to last a century with minimal maintenance.

More molybdenum please

384 prestressed anchor rods made from 2507 duplex stainless steel secure the bridges' eight arch ends to the massive reinforced concrete abutments supporting route I-74. Each bridge is designed to carry 100,000 vehicles per day. Anchor rod systems in bridges need very careful design and detailing as they are highly loaded and often exposed to very concentrated chloride salts. High concentrations of extremely corrosive deicing salts, such as the magnesium and calcium chlorides used on the I-74, combined with the cyclic loading of the highly stressed anchor rods from bridge traffic, pose a risk to structural integrity. Salt slurry can enter the crevices between the concrete slabs and bolted bar ends. Safe design must assume that the sealant in this area will fail. Extreme tensile (pulling) stress on the bar's relatively small surface area, combined with salt exposure, can create a catastrophic combination: crevice corrosion and chloride stress corrosion cracking (CSCC) failure. Therefore, designers chose 2507 over an alloy with less molybdenum. The higher addition of molybdenum (4%) reduces the likelihood of CSCC failure by inhibiting the formation of corrosion pits.

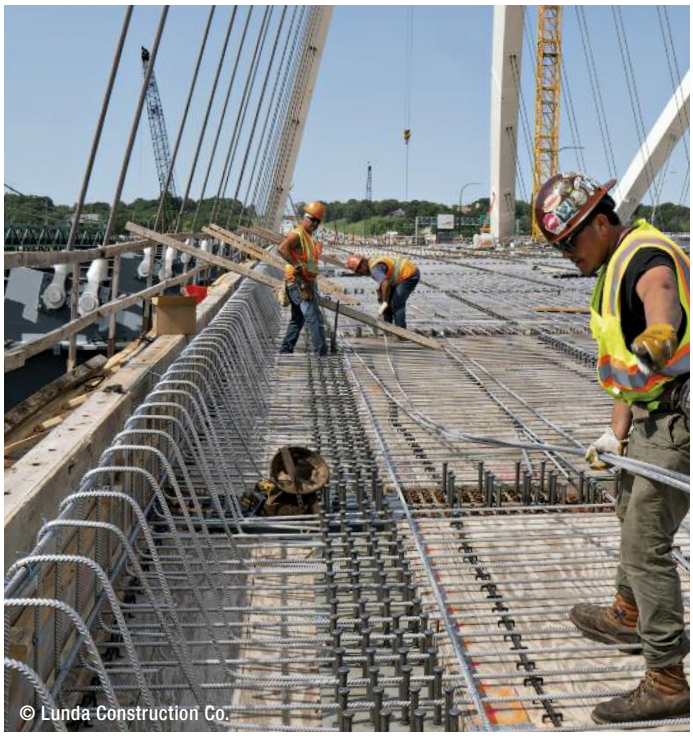
In addition to superior corrosion resistance, Simpson, Gumpertz & Heger (SGH) structural researchers also chose 2507 duplex stainless steel for its increased strength, toughness in low temperatures, and performance under strain. With greater strength, designers were able to use fewer anchor rods with greater spacing, resulting in no cost increase to the overall project. The strength of super duplex stainless steel was just as important to the design team's choice as its resistance to deicing salt.

View of the new white I-74 bridge shortly after opening to the public. The old green bridge was demolished soon after.

© Lunda Construction Co.

Note on deicing salt

Until recently, sodium chloride (NaCl), or "rock salt" was the only deicing salt available. Sodium chloride is effective at temperatures down to -21°C. When it gets colder, or when pretreatment for ice prevention is needed, calcium chloride ($CaCl_2$) and magnesium chloride ($MgCl_2$) are used, either individually or as a mixture. These harsher salts are applied seasonally on the I-74 bridge. Cold temperatures can suppress corrosion reactions – sodium chloride does not damage surfaces unless the temperature reaches 10°C with 76% humidity. But magnesium and calcium chloride are more corrosive; they cause damage at 0°C with 45–50% humidity. Many bridges worldwide were constructed well before deicing became widespread in the 1960s and did not consider the effects of sodium chloride, let alone more corrosive compounds. Learn more about road salt and structural degradation in *Deicing Salt – Recognizing the Corrosion Threat* on IMOA's website: https://bit.ly/deicing_salt



Tying the 2205 duplex rebar to the arch deck.

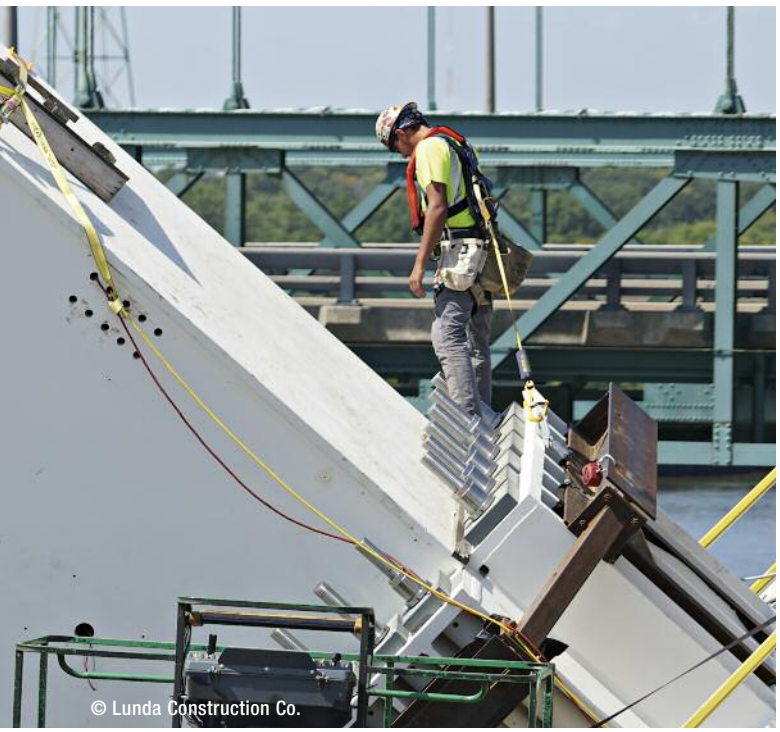
Decked out with duplex

Super duplex isn't the only stainless steel used here. The twin bridges also contain significant amounts of 2205 duplex stainless steel as rebar in the concrete abutments, bridge deck, and impact barriers. 2205 duplex stainless steel, with its 3% molybdenum, provides substantially more corrosion resistance than the carbon steel rebar used in the original bridge. Molybdenum's ability to suppress corrosion thereby helps achieve the required 100-year service life.

The I-74 bridge also convinced the jurors of the 2022 Major Span Prize Bridge Award. Organized by the American Institute of Steel Construction (AISC) and the National Steel Bridge Alliance (NSBA), this prestigious award recognizes the bridge as the winner for its creativity and innovation in design.

The difference between the old and new bridges speaks for itself. At night, lavender LED lights on the new arch bridges welcome passengers over their widened thoroughfares. The bridge is also now much safer for pedestrians, who are provided with floor windows that offer views of the river below. The old bridges, narrow and peeling, were too difficult to maintain in the river with its high winds, fluctuating water levels, and frigid winters. With the mechanical properties of duplex stainless steels, a far superior piece of infrastructure now sees commuters across one of the US's most critical arteries. (KW)

Torquing the 2507 super duplex anchor rods.



Molybdenum in biogas plants

Biogas plants make a valuable contribution to green energy generation: they provide electricity, heat, gas and vehicle fuel, thereby significantly reducing greenhouse gas emissions. Additionally, these plants contribute to the reduction of organic waste. Due to their exceptional corrosion resistance and strength, molybdenum-containing stainless steels have been proven to be an excellent choice for various biogas production applications.

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Biogas production has huge potential across the globe, as a wide variety of organic materials can be used to produce green energy. The range of feedstock is diverse and includes biomass-containing residual waste such as sewage sludge, biowaste from households and production processes, and food waste. Liquid manure and dung derived from livestock farming, as well as previously unused plants or plant parts, can also be effectively utilized, avoiding the waste of valuable resources. In some countries, specifically cultivated energy crops like corn are grown as renewable raw materials for biogas production.

Biogas production

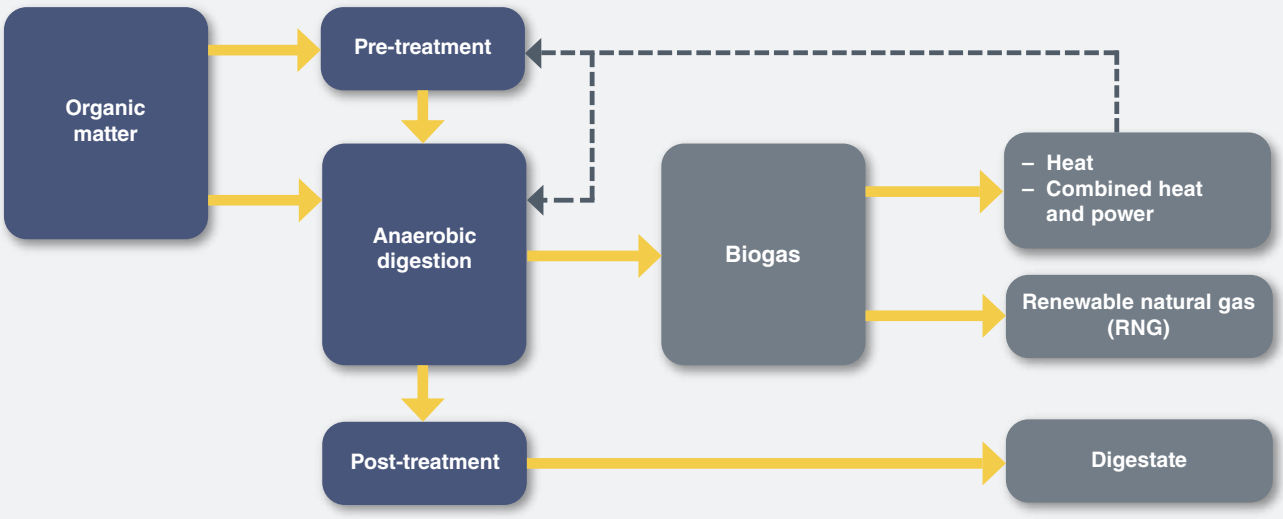
The anaerobic digester or fermenter is the core of the biogas plant. In its oxygen-free environment, various micro-organisms, primarily bacteria, break down the organic material in multiple stages resulting in the production of biogas. Most forms of feedstock must be pretreated to enhance digestibility. Some are shredded or ground into smaller parts, depending on the material. The pH value of the biomass, usually between 6.5 to 8, also affects gas production. The system can be self-heated by the exothermic digestion process, though usually additional heat is provided by burning some of the biogas. Most systems have an operating temperature between 25° and 45°C. Higher temperatures between 50° and 60°C are possible to produce gas more quickly.

Biogas comprises about 60% methane and 35% carbon dioxide, as well as small amounts of other gases. Methane and carbon dioxide are both greenhouse gases that contribute to environmental damage. However, the process of anerobic digestion captures these gases that would otherwise be emitted directly into the atmosphere from the decomposition of organic matter. Since the greenhouse gas potential of methane is many times higher than that of carbon dioxide, capturing methane and burning it to produce carbon dioxide is much better for the environment.

The biogas generated in the digester is collected through a network of pipes and transferred to a gas storage system, where it remains until it is ready for use or further processing. Biogas serves various purposes: it can be directly used as heating or cooking fuel or channeled into a combined heat and power (CHP) generator to produce heat and electricity. This flexibility makes biogas a valuable local energy source, suitable for households, farms, communities, and industries. Biogas or generated electricity can also be fed into the grid to contribute to the broader energy supply. Additionally, biogas can be further processed, resulting in a higher-quality fuel suitable for converted road vehicles. This upgraded biogas, known as renewable natural gas (RNG) or biomethane, has a similar quality as fossil-based natural gas, typically containing 90% or more methane.

The material left over after digestion, called digestate, accounts for around 50% of the input mass. Digestate is a valuable fertilizer that significantly reduces greenhouse gas and odor emissions compared to unprocessed manure fertilizer. Rich in nutrients, digestate can be applied as a liquid or a solid, thus diminishing reliance on costly and potentially harmful chemical fertilizers.

Processing steps and products of biogas plants



Two rows of bolts join the prefabricated stainless steel segments vertically. Once an enormous ring is completed, jacks lift it so that the next ring can be assembled at the bottom of the tank. The rings are horizontally connected with special profiles that enhance the stability of the tank wall. All vertical and horizontal joints are sealed.

Better than concrete

Concrete, and to a lesser extent, carbon steel are currently the most common digester tank materials, mainly because of their lower initial cost. However, concrete tank construction must be relatively large scale to be cost effective, requires heavy machinery, is labor intensive and takes a long time to cure. Regular maintenance is crucial to prevent leakages in a digester. Leaking gas, water and odor can cause serious problems for the plant and its surrounding areas. Nevertheless, corrosion is difficult to avoid in concrete and carbon steel digester tanks, even when a special coating system is utilized.

Stainless steel tanks, on the other hand, can be quickly installed without the need for heavy machinery, scaffolding or cranage. Typically circular in shape, with diameters up to 35 m, these tanks are assembled on-site by bolting segments of stainless steel sheet together. The tanks are built up ring by ring, starting with the top ring. The partially built tank is then lifted with simple jacks to make space for assembly of the next ring, until the desired height is reached. Prefabrication and construction allow for a precise fit and individual design of the tanks. Due to the segmental design of the tanks, vertical extensions can easily be added at a later stage. Even after years of use, the tanks can be dismantled and reconstructed at a different location. At the end of its long life, stainless steel can be sold as valuable scrap which is 100% recyclable.

Avoiding corrosion

Corrosive compounds, such as organic acids, hydrogen sulfide or chlorides are unavoidable byproducts of the biogas production process. The type and concentration of these byproducts depend on the composition of the feedstock and the operating conditions inside the digester. Unprocessed plant-based feedstock generally results in the least corrosive byproducts. However, if the feedstock contains residues from meat or fish processing, higher levels of sulfur compounds may be produced. Similarly, if the feedstock includes convenience food or food scraps, sodium chlorides may be present, contributing to the corrosivity. The desulfurization of biogas, which is necessary before feeding it into a CHP generator, can also produce highly corrosive byproducts.

Agitators inside the digester help to mix different feedstock components, homogenize the temperature of the biomass and reduce crust formation. The internal heating system ensures constant temperature of the biomass. Flexible, corrugated stainless steel tubes with up to 50% more surface area allow for continuous optimal heat transfer.

Japan is the most earthquake-prone country on earth. While it remains heavily dependent on fossil fuels, renewable energy already accounts for one-fifth of total energy production. Stainless steel biogas tanks are resilient and can easily be customized to meet earthquake-resistance requirements as well as local wind load specifications. This new plant in Saitama near Tokyo converts 12,000 tonnes of organic waste, including cattle manure from a nearby farm, into energy each year. Three stainless steel tanks for upstream feedstock storage, digestion and digestate storage ensure an efficient and durable production process of the biogas plant.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Managing the corrosive compounds in biogas production is crucial to prevent damage to the equipment. Repairing and restarting a digester is a complex and time-consuming process, so using materials that resist corrosion in the first place is key. Fortunately, there is a wide range of stainless steel grades available that allows for cost-effective material choices. By selecting an appropriate corrosion-resistant grade, it is possible to mitigate the negative effects of corrosive compounds. This ensures trouble-free operation throughout the lifespan of digestion and storage tanks, as well as other components like pumps, valves, agitators, pipes, fittings, and purification equipment.

A digester tank for example, can be divided into two zones, the lower part which is filled with liquid and solid biomass and the gaseous zone above. The splash or tidal zone at the interface is particularly susceptible to corrosion, as corrosive substances can concentrate on the tank walls during wetting and drying cycles. To address this, it is common to use a more highly alloyed grade such as 2205 duplex stainless steel, for the upper part. For the permanently submerged bottom part a lower alloyed stainless steel can be used, such as 2101 duplex. These molybdenum-containing stainless steels provide sufficient corrosion resistance and durability for each particular environment. Using duplex stainless steels instead of standard austenitic grades, like Type 304 or 316 stainless steel, offers another advantage. In some cases, the high strength of duplex stainless steels will enable the wall of the tank to be reduced, resulting in weight savings, which makes them a cost-effective alternative.


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Near Belfast, Northern Ireland, a food logistics company implemented an innovative approach to fuel its trucking fleet with food waste from the grocery stores it serves. A total of 17,500 tonnes of organic material sourced from over 40 supermarkets is converted to RNG on an annual basis. The food leftovers undergo a process of pasteurization, shredding and homogenization, followed by anaerobic digestion in two stainless steel digesters with a capacity of 2,625 cubic meters each. To use it as a truck fuel, 450 cubic meters of biogas are upgraded into RNG every hour. The company's fleet of trucks, which run on this biofuel, emit an impressive 93% fewer carbon emissions compared to traditional diesel trucks.

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The coastal region around Turku in southwestern Finland is characterized by its livestock farms. In this area, a 250 kW biogas plant makes use of around 40,000 tonnes of pig manure every year as its sole feedstock. The generated heat powers the 4,903 cubic meter stainless steel digester and also provides heat to nearby hog fattening houses. The entire operation of the biogas plant is fully automated, finishing with the separation of the digestate. Compression of the digestate makes it easier to transport, allowing excess fertilizer to be moved to regions where it is needed. Most importantly, by processing the manure, the plant actively combats the accumulation of nutrients in the already vulnerable local waterways and the Baltic Sea.

The big picture

Biogas plants easily adapt to shifts in power demand. As the share of renewable energy sources continues to grow, the flexibility of biogas in covering peak demands and balancing the intermittent periods of other renewables such as wind and solar power becomes increasingly important. Every part of the world has the potential to produce biogas or biomethane. With the development of local collection logistics and supply chains, the availability of sustainable feedstocks for these purposes is set to grow by 40% by 2040, according to the International Energy Agency (IEA) report, “The Outlook for Biogas and Biomethane” (2020).

Most of the biomethane resources examined in the IEA report are currently more expensive to produce than the prevailing natural gas prices in their region, but the cost gap is projected to narrow over time. Recognizing the value of avoiding carbon dioxide and methane emissions goes a long way towards improving the cost-competitiveness of biomethane. Overall, biogas production costs are projected to decrease slightly while natural gas prices tend to rise. The invasion of Ukraine tends to put upward pressure on the price of natural gas. Coupled with the potential environmental benefits of biogas production in reducing emissions from organic waste, there is a stronger incentive than ever to increase biogas production. (MH)

The Könnern industrial park near Magdeburg, Germany hosts one of the world’s largest biogas refineries, which began operating in 2009. This impressive plant processes about 120,000 tonnes of raw materials and liquid manure each year, supplied by around 30 local farmers. According to the operator WELTEC BIOPOWER, the plant annually produces 15 million cubic meters of biomethane, enough to power around 10,000 households or provide 9,000 cars with an annual mileage of 30,000 kilometers. The plant contains over 1,500 tonnes of stainless steel in its storage tanks, pumps, and other systems.

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Sterile stainless steel serves cleanrooms

When studying viruses, making computer chips, or bottling medicines, particles 100 times smaller than a grain of sand can spell disaster. Ultra-sensitive procedures like these take place in cleanrooms, the most meticulously controlled spaces on earth. Type 316 stainless steel is widely used in this sector.

How can researchers study diseases and other dangerous substances without jeopardizing public health? Where are many medicines and most computer chips made? The answer is found in a cleanroom, an enclosed, strictly monitored area with a specified maximum number of particles per cubic meter. There are many kinds of cleanrooms that serve a variety of purposes and industries, though the majority are used to manufacture sensitive products like pacemakers. While some cleanroom spaces are just a few square meters in size, some span the entirety of factory floors. The interiors of these important spaces depend on stainless steel furniture. Some cleanrooms are even constructed with stainless steel wall panels. Why? Because stainless steel, especially the molybdenum-containing Type 316, resists repeated chemical cleanings without deterioration. The latest ISO standards require higher concentrations of chlorine and more hydrogen peroxide than previous additions, making them more aggressive, likely leading to wider use of Type 316 stainless steel in certain cleanroom settings.

A condemnation of contamination

All cleanrooms adhere to the International Standards Organization (ISO) 14644 standard, which stipulates the

The inside of a cleanroom for medical device manufacturing features a variety of stainless steel furniture and equipment.

level and size of particles allowed. Temperature and humidity are also strictly regulated. There are nine levels or “classes” of cleanroom. With each class, the number of particles allowed decreases by a factor of 10. The specific classification required depends on the sensitivity of the goings on within the cleanroom. Generally, class 5 is considered the cut off for extreme levels of cleanliness. Particles smaller than bacteria pose a risk to operations below that threshold. Biotechnology is one such industry that requires operation at class 5 or lower.

Even entering a cleanroom is a complicated affair. Workers generally put on gowns and other protective gear in a separate changing room. They must move meticulously and slowly, so as not to contaminate the outside of the gown with skin particles while dressing. After that they may pass through an air shower, depending on the application. This scrupulous protocol is because humans working inside a cleanroom are its single largest source of contamination. The average person sheds 10 grams of skin a day, in addition to hair and other particulate. Wearing a specialty gown helps, but it isn’t enough. Behemoth HVAC systems cycle air and filter out particles that inevitably enter the environment. Of course, everything must be scrubbed clean at regular intervals. Damage to equipment or furniture from cleaning, even minor, can halt an entire operation.

Type 316 stainless steel contains 2% molybdenum, which provides additional corrosion protection for frequent exposure to cleaning chemicals like hydrogen peroxide. Without molybdenum’s added pitting resistance,

This perforated mobile step ladder is an example of furniture requiring rigorous cleaning because people repeatedly step on it.


© Terra Universal


© Terra Universal

This stainless steel cleanroom features an integrated air shower and pass-through chamber to minimize the inflow of contaminants.

lower-alloyed grades of stainless steel can develop crevices and pits from repeated cleaning, which become excellent hiding spots for bacteria.

Specifying the surface

Every surface in a cleanroom is an opportunity for a problem. Stainless steel is key because it’s the only common construction material that can be polished to have an extremely smooth surface. A smooth finish reduces variance between microscopic peaks and valleys where corrosive cleaning chemicals can remain left behind. If not thoroughly removed after cleaning, residual amounts of chemicals can cause corrosion over time. Surface roughness also influences how an object interacts with its environment. Smoother finishes are less abrasive, reducing friction when in contact with other surfaces, such as gloved hands. Abrasion causes particles to release into the atmosphere and therefore poses a risk to hygiene.

Cleanrooms represent a growing market where Type 316 stainless steel’s hygienic properties shine. Demand for cleanroom operations is likely to rise over the next decade, largely driven by rapid growth of the healthcare sector in India, China, Nigeria, and other countries with large populations and growing middle classes. Expanding regulatory framework worldwide also supports demand for more cleanrooms, more sophisticated equipment within them, and stricter cleaning regimens. Molybdenum-containing stainless steels are an ideal, low maintenance material to serve this critical and expanding sector. (KW)

Cost-saving super duplex

The quantifiable benefits of stainless steel are often future-oriented, namely reducing maintenance throughout service life and reducing life cycle costs. But stainless steel, especially the strong duplex grades, sometimes emerges as the most affordable option from the initial investment! The following case study discusses how a 2507 super duplex stainless steel exhaust stack replacement option was less expensive than a weathering steel alternative.

In 2017, the exhaust stack of a sintering plant suffered a partial collapse during severe weather. The facility agglomerates iron ore fines, which provide feed for an adjacent blast furnace operation. The enormous stack, approximately 60 m high with a 3.7 m diameter, was constructed with a double wall design. The design consists of a 6 mm thick inner wall made of weathering steel, a layer of thermal insulation, and an outer layer of galvanized steel sheet. This design relies on the insulation layer to keep the temperature inside the stack above the dew point to avoid corrosive condensate on the inner surfaces. However, the insulation layer began to deteriorate in the harsh service conditions of the seaside industrial plant. Indeed, inspections before the collapse revealed severe loss of wall thickness on the weathering steel at locations where the insulation layer had deteriorated.

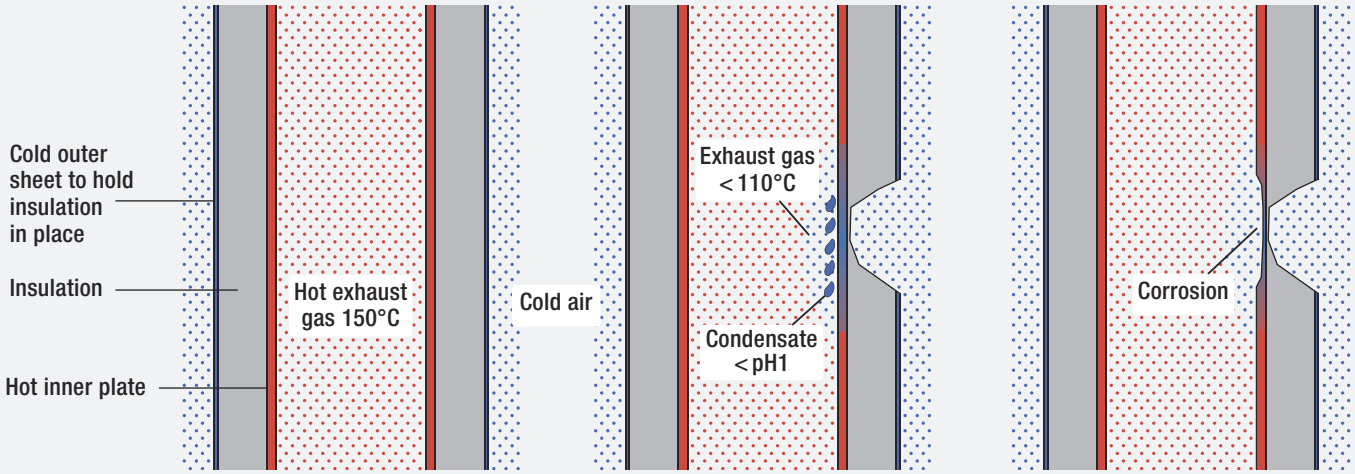
Stacking up the competition

With its exhaust stack snapped in half, the plant needed a quick and effective replacement solution with significantly improved corrosion resistance. Industeel assisted in corrosion testing and provided technical support in exploring potential replacement options, considering several key service and environmental parameters. The plant's location is in an industrial environment near the sea with considerable annual temperature variation and strong winds.

The plant runs around the clock, with an average fume temperature of 150 °C. The fumes have an acid dew point of 110 °C with an extremely acidic pH of 1, meaning that when the temperature falls beneath 110˚C, highly corrosive condensate can form in the stack. This phenomenon is made even worse by sea salt in the air. An analysis of particles in the stack found chloride contents far higher than weathering steel can tolerate.

A nearly 60 m high exhaust stack is difficult to inspect and maintain, to say the least. Its triple layered design is a double edged sword: though the layers protect each other, it's difficult to access and repair the inner layer once damaged. Even measuring the thickness of the inner most material is challenging, compromising the integrity of inspection. Because the stack's service life fell short of its anticipated 20 years, various replacement designs with improved corrosion resistance were evaluated. All options offer increased resistance to corrosive attack over the original design, but they each have pros and cons. For instance, three of the designs require the construction of a new foundation due to increased wall thickness and weight, which is not only costly but also extends construction time. On the other hand, the other two options require more expensive construction materials based on cost per kilo, but they avoid the cost of an insulation layer and can be constructed on the existing foundation. Both single wall designs using either 2507 super duplex or 904L stainless steel can resist the service environment.

Corrosion mechanism in insulated exhaust stacks



Well performing stack

If outer sheet comes off, insulation deteriorates and cold air cools down exhaust gas below dew point

Aggressive condensate leads to thinning of weathering steel stack

	Option 1	Option 2	Option 3	Option 4	Option 5
Material and design	Double wall weathering steel shell with inner protective liner	Single wall self-supporting 2507 super duplex stainless steel	Single wall self-supporting 904L austenitic stainless steel	Double wall Type 316 Ti shell with inner protective liner	Reinforced concrete structural shell/ refractory brick inner liner
Thermal insulation	yes	no	no	yes	no
Corrosion protection	Thicker shell (↑corrosion allowance) plus liner	not needed	not needed	Thicker shell (↑corrosion allowance) plus liner	not needed
Foundation	new	existing	existing	new	new
Lead time	9 months	7 months	7 months	9 months	12 months on site
Expected life	20 years	30 years	30 years	20 years	50 years
Cost of stack and foundations	**Reference = 100**	**88**	**100**	**100**	**128**

The two stainless steel solutions (option 2 and 3) which are able to withstand condensate corrosion provide the best combination of simplicity, speed of replacement and service life. Super duplex emerges as the lowest cost solution due to its higher strength and lower alloy cost.

But both increased corrosion resistance and strength of the 2507 duplex stainless steel allows for a reduced wall thickness. Saving material with thinner, stronger walls often leads to a significant cost reduction, as it did in this case. A summary of the relative costs, construction times, and relevant design factors are listed in the table above.

Less material and longer service life

Based on the cost, timing, and expected performance of the candidate designs, the stack was replaced with option two, a single wall model using 2507 super duplex

› Work on the 2507 super duplex stainless steel stack sections in the fabrication shop.

The stack was shipped in segments that were bolted together on site. Ladders and platforms are directly attached to the self-supporting wall. This is much simpler than anchoring them through the outer skin and the thick insulation to the structural inner wall in a double wall system.

stainless steel. This duplex stainless steel is alloyed with approximately 3.5% molybdenum. The grade also has a nitrogen addition of approximately 0.25%, and the combination of chromium, molybdenum, and nitrogen provides outstanding resistance to localized chloride attack.

Because this design option does not involve thermal insulation, the costs associated with maintaining insulation are avoided. There is also the potential to increase the intervals between inspections. Moreover, a single wall design is easier to inspect for loss of wall thickness than double wall designs. Although this investigation found that the 2507 duplex stainless steel replacement option had the lowest capital costs, if total life cycle costs were included in the evaluation, it would have even greater savings over other designs.

The stack was replaced using 6 mm to 10 mm thick plates that were cold formed and seam welded into massive rings. These were joined at the fabricator to create stack lengths that could be shipped to the job site for erection. Like a giant ring tower, each round section of welded plate was placed atop the next using a gargantuan crane. The replacement stack was completed and put into service in the summer of 2019.

Since installation, the stack is issue-free and should continue to provide low maintenance service for the next 30 years and beyond. This case study exemplifies how the advanced strength and corrosion resistance of duplex stainless steels often enable not only weight savings but immediate cost savings. Stainless steel is also one of the most highly recycled materials on earth – therefore, at least a portion of the initial investment can be recouped at the end of service life as scrap value. Given full consideration for its service life and maintenance needs, what seems like a luxury material sometimes proves to be the most affordable option. (JF)

Reddish-brown deposits of iron ore dust from the processing plant have accumulated over the years on the stack surfaces, but thanks to the excellent corrosion resistance of super duplex stainless steel, they will not cause any deterioration of the stack.

It sounds better with moly!

Some uses of molybdenum are less obvious than others, like helping to produce sound and music. Molybdenum is found in acoustic devices ranging from the utilitarian whistle to a 2.5 tonne fire-breathing organ. When it comes to emitting and propagating sound, molybdenum-containing stainless steels offer resistance to wear and tear.

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Unlike pianos, no wind instrument is delivered “factory-tuned” to produce the right sound. This is particularly true for trumpets, where the formation of sound depends on the architecture of the entire instrument: a perfect synchronization between the modulation of breath, the work of the lips, and the labial muscles. If the user does not sound the right note on their lips, even if they press the right piston valves, they generate a “mis-pitching” . The different materials used to make instruments have distinct properties, and these properties are just as integral to producing and controlling sound. Molybdenum can lend hardness or corrosion resistance needed for certain applications, for example, a foghorn blasting in salted mist.

Mouthpieces for brass wind instruments

Over the years, trumpet mouthpieces have become little jewels of technology, machined on digital milling machines in one or more pieces to the nearest hundredth of a millimeter. Traditionally made with brass, sometimes plated with silver, mouthpieces made instead with Type 316 stainless steel have become more popular in recent decades. Brass is a very flexible material, which absorbs vibrations. This acoustic absorption results in a sound that is often soft and more difficult to project into the instrument, which muffles the nuances. Hard stainless steel, on the other hand, projects the slightest vibrations and modulations into the instrument more faithfully and with less effort, giving the musician greater control. Though the softened warm tone of brass is often desirable, stainless steel produces crisper sounds that suit different kinds of music.

Precision Type 316 stainless steel mouthpieces offer the hardest and densest surface available. CNC (computer numerically controlled) machined cup and edge profiles can be adapted to the musician’s lip and even dental morphology. This level of customization allows for increased comfort and possibilities for experimentation with playing styles. Some players also suffer from allergic reactions to brass. Stainless steel offers an alternative and is relatively inert.

Equally interesting are saxophone mouthpieces. Often made of wood, ebonite (a hard rubber) or plastic, these pieces also benefit from the properties of stainless steel. The 2% molybdenum in Type 316 stainless steel helps resist corrosion, which prevents deterioration and changes in playing characteristics. Stainless steel’s hardness also allows for an ultra-fast response time needed to realize the full richness of the saxophone’s overtones. Mouthpieces made with stainless steel also eliminate the need for surface plating, an important benefit for those who are sensitive to nickel plating.

A strong warning with just a small whistle!

Less melodious than the music of the brass instruments, whistles resound in much more particular conditions. For example, sports meetings where the referee’s whistle overtakes the clamors of a fevered stadium! Decibels, a measure of volume, are also crucial when signaling an emergency or distress situation outdoors. A signal must reach 120 decibels to be heard several kilometers away, such as from a boat or the middle of the wilderness.

Sports referees use whistles that resound between 100–120 decibels, louder than chainsaw!

In the more peaceful context of training animals like dogs or birds, the ability to modulate pitch is key. Unlike regular whistles, often made of plastic or light metal, training whistles have specialized shapes that allow for a powerful sound easily controlled by the user. This power and modulation allows a hunter or farmer to recall their animal from kilometers away. Some professional dog-training whistles have the capacity to produce sounds at frequencies too high for humans to hear, blowing a seemingly silent whisper that can be heard by a dog or cat a field away! These training whistles often require a material that resists severe conditions of use, for example, prolonged exposure to water or humidity. Such models use Type 316, or more commonly, Type 440 stainless steel containing up to 0.75% of molybdenum. Type 440 is a martensitic grade whose hardness favors a good projection of sound, guarantees the solidity of the whistle, and protects against mild corrosion.

Other important auditory signals come from marine and truck horns, which are made of Type 316 stainless steel. This material resists salty or highly polluted atmospheres associated with road salt and dense traffic – and delivers the powerful blast of a less-than harmonious sound!

Bells to protect and be protected

The range of metallic tinkling also finds an echo in the bells that hang on the collars of domestic animals. Unfortunately for would-be predator pets, small animals are warned by the jingling of the bells triggered by the slightest movement. This also scares bears away from bell-clad human hikers. Worn whatever the weather, be it polluted, wet, or salted fog, bells made of Type 316 stainless steel will likely outlive the outdoors enthusiast to which they are attached. Resisting corrosion and wear for decades, these bells are essential for many hikers and outdoors professionals.

Finally, leather-clad bikers also equip their motorcycles with lucky bells, which protect against evil spirits said to line the roads. Hanging as close to the ground as possible, under their steel mount, in the smoke of the exhaust pipes, these Type 316 stainless steel "punishers" are neither afraid of pollution nor evil "gremlins"!

The ringing of a "gremlin bell" is said to irritate and dispel evil spirits lurking on the roads.

Fire Organ: The thermal chant of stainless steel

A true sound sculpture, the "Fire Organ" is a dramatic reimagining of an experimental 19th century instrument. And the result is nothing less than spectacular! A unique work created by a French artist, the massive fire-breathing instrument on the island of Réunion faces a corrosive coastal environment combined with the heat of many gas burners. This "beast" of fire and sound is played preferably in semi-darkness to better ignite the senses and the imagination. The principle is simple: flows of hot air jets ignited by keystrokes rush into the tubes, which then vibrate, creating a real supernatural concert of sounds that range from animal-like cries to the dull rumbles of volcanoes.

The fire-shooting organ or "pyrophone" dates to 1873 when composer and musician Frederic Kastner first patented an "exploding" organ that used hydrogen and glass tubes. However, the inventor acknowledged a "degree of danger" in operating his invention and struggled to popularize it before an untimely death at age 30. Almost 140 years later, the new Fire Organ uses 70 Type 316 stainless steel tubes, ranging from 2 m to 9 m in length! Were it not for the miraculous corrosion mitigating properties of the 2% molybdenum found in Type 316 stainless steel, this beautiful instrument and its seaside concerts would not be possible.

These sonic devices embody molybdenum's humble contributions to the arts. In particular, the hardness of stainless steel allows for unique, crisp, precise sounds. Beyond precision, the anti-corrosive properties of molybdenum-containing stainless steel help maintain safety. These steels can be trusted to pierce through salty sea fog to guide ships to shore, to provide warnings on early morning trucking routes, and to recall (or repel) animals over large distances. (TP)

Artist Michel Moglia performs with the fire organ and a flamethrower.

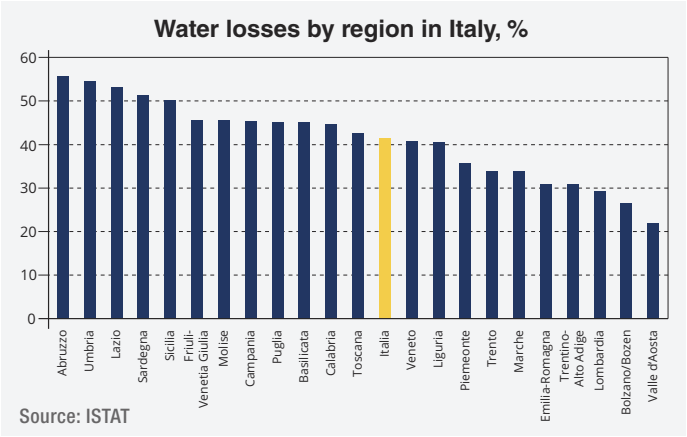
IMOA news

Stainless steel service line trials in Italy

The worst drought in 70 years and unusually high temperatures have highlighted the frailty of Italy's water infrastructure. Several regions experienced water conversation mandates in 2022 as the government issued a state of emergency.

The city of Taipei once faced a similar, though more severe, problem. In 2002, an intense drought led to 60 days of water supply disruption. To prevent this failure from recurring, the Taipei Water Department deemed it essential to maximize existing resources. The system was leaking over a quarter of its treated water and 95% of the leakage cases occurred in the last few meters of distribution, in the service lines running from the water mains in the street to individual homes, businesses, and public buildings. By the end of 2021, 15 years into a massive 20-year leakage control project replacing, among other measures, old service lines with stainless steel partially corrugated tube (SPCT), the utility had reduced its leakage over 50%. In fact, Taipei's water authority now sells surplus water to the neighboring utility. Several Italian utilities hope to achieve similar results.

Italy's aging water distribution systems have some of the highest leakage rates in Europe. Many utilities lose half of their treated water, with some leaking over 70%.



Three areas are considering SPCT as a solution: Elba, Fabriano, and Beluno. Following small trial installations, proof of concept trials with 100 to 500 connections are being discussed with these utilities. All installations will use molybdenum-containing Type 316 stainless steel tubing. A fourth utility is interested in a larger installation of 1000 to 1500 lines for a very important mission: repopulating an area devastated by a 2016 earthquake.

Worldwide, leakage rates are around 30%, with some areas losing well over half of their water supply. But it is not "only" water that is wasted. Approximately 4% of the world's electricity is used to distribute water each year – a third of which is lost to leaks. Locally, the amount of power wasted can be even more drastic. The US state of California, also plagued by severe droughts, uses nearly a third of all its natural gas on drinking water distribution, mainly on pumping. Although leakage rates in California are significantly lower, the wastage of electricity exceeds the global average. These massive losses cannot continue to be tolerated.

Molybdenum Mark pilot gathers momentum

In 2021, IMOA began collaborating with Copper Mark to develop a molybdenum-specific option to demonstrate responsible production practices. This resulted in the development of the Molybdenum Mark, an assurance framework for molybdenum within the Copper Mark Criteria for Responsible Production. It is designed to assist producers meet increasing market demands and growing regulatory requirements relating to responsible sourcing.

Two primary molybdenum mines have been awarded the Molybdenum Mark and 11 by-product mines have been awarded the Molybdenum Mark extension. Since its launch in November 2022, five molybdenum roasters and FeMo converters have confirmed participation in the Molybdenum Mark pilot. A further three copper mines with molybdenum as a by-product are awaiting the Molybdenum Mark extension. For further information visit, the Copper Mark website.

IMOA is delighted to welcome two new members:

Euro-Rijn Global Logistics BV, Netherlands
Newcrest Mining Limited, Australia

The new members will now enjoy the benefits that IMOA membership offers, including access to market updates and research results, HSE guidance and regulatory liaison, the opportunity to influence global market development programs, and also networking at member events.

Get ready for the 2023 IMOA AGM

Santiago, Chile is the venue for this year's AGM in September, kindly hosted by Sierra Gorda S.C.M. As well as an exciting speaker line-up, on topics ranging from carbon footprinting, to end uses and the market outlook of molybdenum, Markus Moll will moderate a topical panel discussion. There will be plenty of opportunities for members to network during the event, at the Sierra Gorda and IMOA hosted dinners, and at an additional reception hosted by Molymet. Members can find further information and register in the member-only area of the IMOA website.

AIA architectural and structural stainless steel webinar series

IMOA has been hosting several webinars as a continuing education provider for the American Institute of Architects (AIA), influential not only in the Americas but also worldwide. Recordings of the events, co-sponsored by the Nickel Institute, are available on IMOA's YouTube channel.

Undergraduate presentation at Carnergie Mellon University (CMU)

IMOA's Technical Director Dr. Nicole Kinsman presented on sustainable uses of stainless steel to an enthusiastic group of undergraduates at CMU in Pittsburgh, US, in March 2023. Over 150 students from a variety of disciplines ranging from environmental policy to mechanical to computer engineering joined the seminar. Nicole, an alumna of CMU herself, discussed the environmental benefits of stainless steel, notably maintenance, replacement, and weight reductions. The well-received event exemplifies IMOA's commitment to educating professionals, students, and the public alike.

IMOA member discounts

IMOA members receive a 10% discount off the delegate fee to this year's Ryan's Notes Ferroalloys conference, held on the 15-17 October 2023 in Orlando, USA. To find out more and register visit https://bit.ly/3Yc7jH8.

IMOA members also receive a 10% discount off the delegate fee for the Stainless Steel World Conference and Expo in Maastricht, The Netherlands, held September 26–28, 2023. To find out more and register please visit https://stainless-steel-world-event.com/

Members can contact the IMOA office by emailing info@imoa.info to receive the discount codes.

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Construction of the I-74 bridge which spans the Mississippi river. © **Lunda Construction Co.**

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