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MolyReview 1/2018

www.imoa.info

Innovative bridge uses stainless steel

Iconic bridges that combine cutting edge technology and aesthetic beauty are increasingly used to create visual focal points in city centers, but very few are constructed on modest budgets and ahead of schedule.

When a 100-year old Ft. Worth vehicular bridge was beyond rehabilitation, the engineers at the Texas Department of Transportation (TxDOT) designed a very special replacement – the world's first precast concrete network arch bridge. The 12 nearly 50 meter long and 7 meter high arches, each weighing 284 tonnes, are believed to be the world's largest precast concrete arches transported to a bridge location. The structural molybdenum-containing stainless steel hanger bars within them are also believed to be a first.

The 299-meter-long, multi-award winning, four-lane West 7th Street bridge was completed in 2013. This vehicular bridge also provides a walkable gateway between the downtown area and museums designed by some of the world's most famous modern architects. It offers spectacular views of the river, downtown and the museum district. Lights within its graceful arches highlight the gleaming angled stainless steel bars. The sidewalk's position, right next to the arches, encourages pedestrian interaction with them, so this sculptural bridge appears frequently on social media. The bridge was opened a month ahead of schedule, and its US $25.9-million cost was under budget and well below the typical cost per square meter for a high-profile bridge.

The key feature of a network arch bridge is its angled hangers. These hanger bars connect the 'tie', which holds the arch ends at the bottom of the arch together, to the top of the arch. The combination of the tie and hanger system creates a truss-like behavior where the hangers transmit loads from the deck through the tie and into the arch. In contrast to a traditional vertical hanger system, the angled bars reduce bending in the arch when vehicles and people pass over the bridge. This system is structurally highly efficient. Most network arches use steel box arches, whereas the West 7th Street Bridge uses precast, prestressed concrete arches.

In total, nearly 100 tonnes of stainless steel were used for the very visible ›

On-site placement of a bridge arch.
© Liam Frederick Photography

Publisher:
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The West 7th Street Bridge in Ft. Worth, Texas USA uses angled 2205 duplex stainless hanger bars in its structurally innovative precast concrete network arch design. © Liam Frederick Photography

Light gleaming off the 2205 duplex stainless steel hanger bars adds the sculptural look of this beautiful bridge. © Liam Frederick Photography

inclined hanger system at the center of the 12 arches. These large, 44.5 millimeter diameter bars are made of 2205 duplex stainless steel, containing 3% molybdenum, and are up to 8.2 meters in length. The link plate, pin and hanger tube components were manufactured from 2205 duplex stainless steel plate, and the cast clevises were CF8M stainless steel (cast Type 316). This molybdenum-containing stainless steel alloy combination was selected for its corrosion resistance and structural performance during TxDOT mock-up testing.

Traditional bridge replacement can take two to three years, causing significant traffic and business disruption, but this innovative design used arches which were cast off-site and required the bridge to be closed for less than five months. The construction and its unique challenges were documented in the award-winning US public television documentary, the ‘Arc of Innovation’.

Charles Walker, P.E., Senior Associate, Walter P. Moore and Associates (formerly of the TxDOT) played a key role in the structural design of the stainless steel elements of this special bridge. When asked about stainless steel selection, he said that, “the combination of stainless steel and concrete in compression takes us towards infinite durability of the network arch elements because stainless steel does not require the coatings and maintenance that would have been necessary for carbon steel hangers.” “Infinite durability” is a big phrase for any bridge engineer to use, but with the proven longevity of molybdenum-containing stainless steel, he may be right. (CH)

While the angled 2205 duplex stainless bars stabilize the bridge, their location beside the sidewalk makes them a lovely place to pose for photos. © TxDOT

Tank containers shrink the world

It is no exaggeration to say that the tank container has revolutionized freight transport. From its humble origins, the ISO tank container industry now numbers more than half a million units across the globe. Tank production is growing at nearly twice the rate of the world economy and they are almost always made of molybdenum-containing stainless steel. Such is their popularity that these containers now represent a significant end-use application for molybdenum.

The first International Organization for Standardization (ISO) tank containers were manufactured in the late 1960s, with the ISOTANK name being registered by Andrews of Aintree Ltd, Liverpool, UK in 1969. These were also the first tanks to gain design approvals for international transport by Lloyds Register and the UK Department of Transport.

Today, tank containers are used to transport a wide range of cargoes including gases, powders, liquids and other hazardous and non-hazardous loads, as well as a wide range of perishable and non-perishable food and food-grade products including orange juice, wine and even liquid chocolate. They can be cooled or heated using thermal jackets, either to protect perishable goods or to turn viscous commodities like heavy fuel oil into a more liquid state for unloading.

The majority of tank containers are constructed from stainless steel and are manufactured by a handful of global companies. One such company is Welfit Oddy, based in South Africa. In 2016, they manufactured 6,300 containers, some 14% of the global total. Approximately 80% of the stainless steel used to manufacture the containers is Type 316 – containing 2% molybdenum – although other grades including 304 and lean duplex 2001 are also used. Stainless steel accounts for more than 60% of the weight of the container – 2.5 tonnes of the total empty weight of 4 tonnes. At least one manufacturer has started to produce the tank barrel from higher-strength 2205 duplex stainless steel to make lighter packages with even better corrosion resistance.

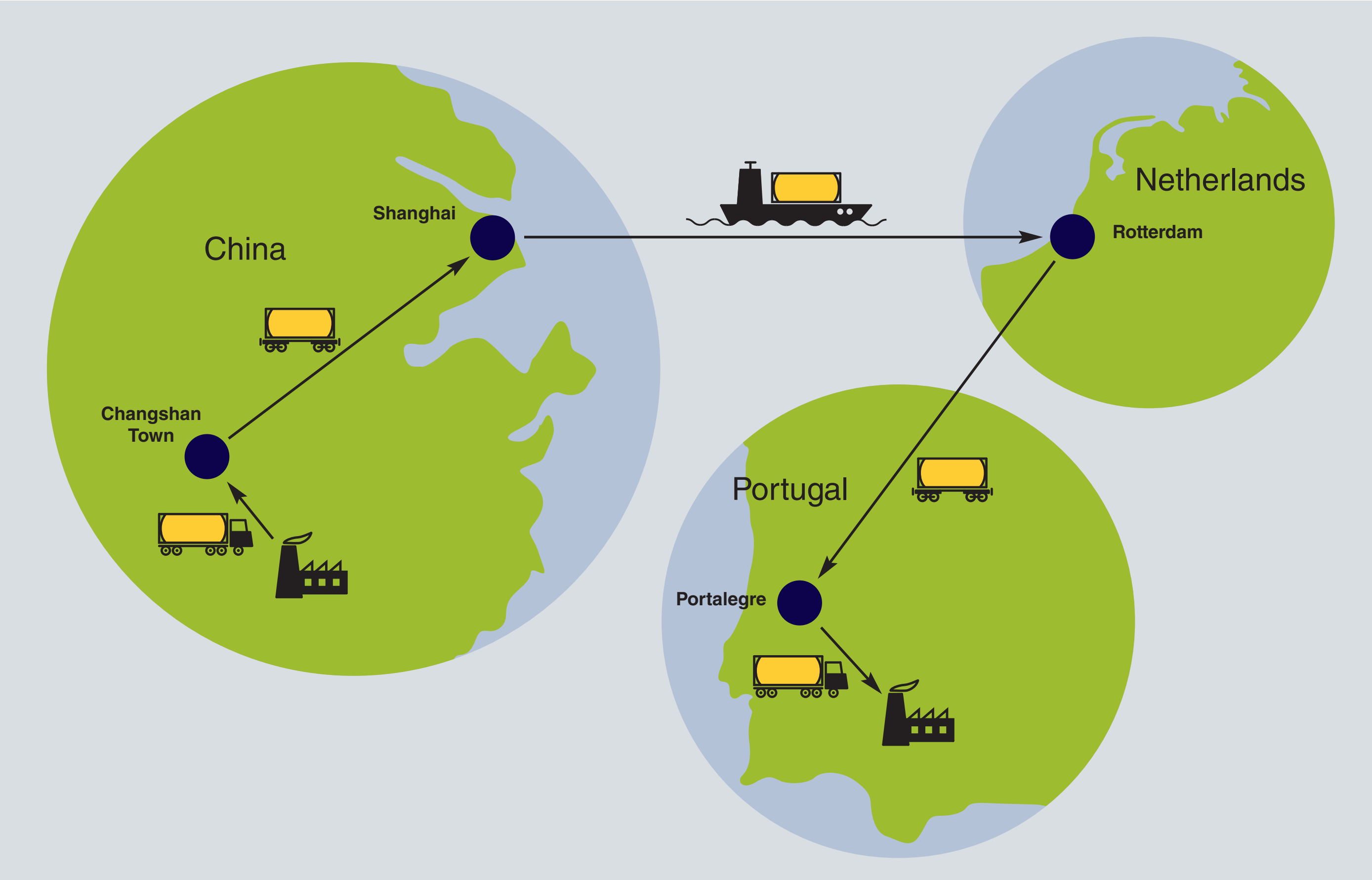
Tank containers use stainless steel for a variety of applications besides the main tank, including walkways, hatches and valves. © IMOA/Nicole Kinsman

A typical container has a capacity of 25,000 liters and a maximum gross weight of 34 tonnes. The tank is usually surrounded by a protective insulating layer of polyurethane and aluminium and is secured inside a rectangular steel frame made to ISO specifications, nearly 20 feet (6 meters) long, nearly 8 feet (2.5 meters) wide, and approximately 8 feet (2.5 meters) high. The ISO accreditation is important as it guarantees that the tank unit will seamlessly connect with an entire transport infrastructure by road, rail and sea, just as regular ISO containers do.

Global product flows

It is this intermodal capability which has proved such a catalyst for the growth of the container industry, as the goods remain in the same container throughout their journey, whatever the mode of transport.

Roger Gloor is Technical Manager for Bertschi AG, a global logistics service provider. Sharing his insights ❯



The product stays in the same intermodal container from storage at the original production facility all the way to storage at the receiving facility. The example shows a tank which is moved from the factory in China via road truck, freight train, container ship, another freight train and road truck to the destination facility in Portugal.

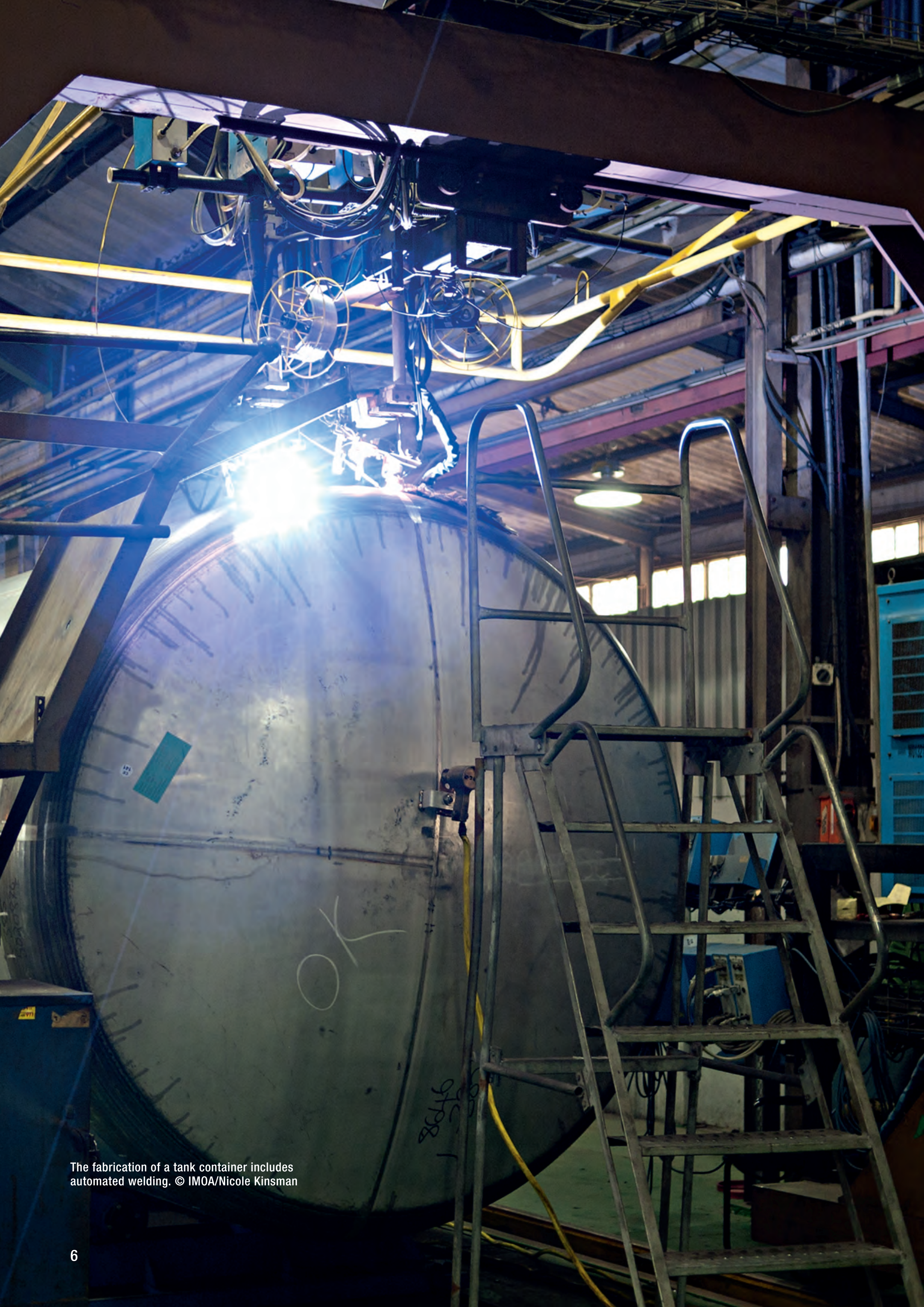
of tank container transport and its growing impact on cargo movements, he said: "What we have seen in the past decade is a globalization of product flow. Products are increasingly sourced not just regionally or on the same continent, but globally, and containerization makes this easier, allowing us to ship cargo 'door to door', using the most appropriate method. This means we can plan better, reduce lead times, and fix costs much more competitively."

Container transport is as flexible as the infrastructure allows, and because of this, it is usually also the most sustainable, saving energy and resources.

Moly makes the grade

So why use molybdenum-containing Type 316 stainless steel? "Type 316 has several advantages," said Roger. "It is easy to clean, provides excellent ❯

The tank containers can be stacked just as regular 20-foot ISO containers. © Bertschi



The fabrication of a tank container includes automated welding. © IMOA/Nicole Kinsman

Installation of thermal insulation, covering the entire stainless steel tank. © IMOA/Nicole Kinsman

resistance against chemical corrosion and has good tensile strength. Because of its global availability, it's also easy to source and repair anywhere in the world, and given its durability, it is competitively priced. Chemicals are increasingly complex and present new corrosion challenges, but providing that the tanks are thoroughly cleaned and loaded correctly, there is no reason why containers shouldn't give many years of reliable service."

Once the product has been delivered, the tank is cleaned according to the nature of its contents and is ready to be used again. There are many different cleaning processes depending on the cargo, and each process has a different application time, ranging from a few minutes to several days. These processes are an important factor in ensuring the quality and safety of transportation, and are regularly checked in accordance with international regulations.

The ease of cleaning stainless steel and its durability over repeated cycles is also an important logistical consideration. Historically, many commodities were transported in bulk by sea or in drums, which can be difficult to clean and are often disposed of after a single journey. In comparison, tank containers are rarely unused for any stage of a journey – including when they are initially delivered to their logistics customers. New containers built in South Africa typically leave laden with the country's largest export – wine – in an elegantly efficient matching of one-way supply and demand.

A growing global industry

Products are transported to and from every continent, with the flexibility of intermodal container transport helping to make previously unviable journeys possible. New rail routes have recently been opened up between China and Europe, taking advantage of the shorter distances and transit times over land compared to the sea route. Convoys of tank containers complete the 8,000 kilometer rail journey in just 18 days.

The efficiency – and ultimately, sustainability – of tank containers are fuelling a boom in this sector which shows no sign of abating. In 2016 another 44,450 tanks were manufactured around the world, using more than 110,000 tonnes of stainless steel and nearly 1,800 tonnes of molybdenum, making tank containers a significant end-use application for molybdenum.

At the end of 2016, there were some 508,000 containers in existence around the world, an increase of 8.5% over the previous year. This popularity is due in part to the durability of the containers and their resistance to corrosion. Despite a variety of corrosive cargo, endless movement and vigorous cleaning, the containers are used over and over again, thanks to molybdenum-containing stainless steel. (AH)

Tank containers are loaded on a freight train. © Bertschi

Safer seas with stainless steel

Chemical tankers are specialized ships carrying liquid cargoes that may be environmentally hazardous, flammable or highly reactive. They are designed and operated under special rules, and increasingly have built-in molybdenum-containing stainless steel tanks. Sailing around the world, they transport liquid goods safely over long distances. They represent a significant market for duplex stainless steels and molybdenum.

The term ‘tanker’ often brings to mind an image of the great supertankers plying the seas, carrying bulk and refined oil. These behemoths can have capacities exceeding 400,000 deadweight tonnes (dwt). Chemical tankers are smaller, typically 5,000–40,000 dwt, but are no less important to the world economy. Because chemical cargoes can be extremely corrosive, many of these ships are built with molybdenum-containing stainless steel tanks for longevity, safety, and flexibility. Duplex stainless steels, in particular, are more and more specified for the demanding conditions that the vessels must withstand.

Rules and classification of chemical tankers

All ships are subject to numerous stringent regulations regarding safe navigation, air pollution, and the discharge of liquids and solids. Ships that travel in international waters are subject to the International Maritime Organization (IMO) regulation known as the ‘International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk’, or IBC Code. This code establishes design standards based on the hazards presented by ships’ cargoes.

Because chemical cargoes present many kinds of safety and pollution risks, construction and operation requirements for chemical tankers are much more stringent than those for oil tankers and commodity carriers. Tank design and fabrication are complex. The IBC Code includes provisions for cargo pumping and monitoring; tank coating, cleaning and venting; vapor detection and fire protection. It also promulgates specific requirements for tank heating, cross-compatibility, corrosion control, and cargo density. Chemical tankers are arguably the most technically sophisticated of all large cargo ships.

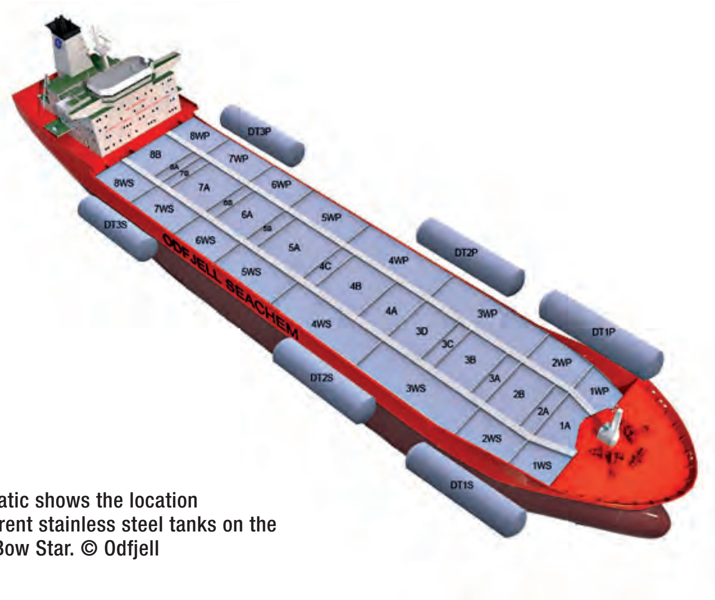
Chemical tankers can be categorized according to size, products carried, and markets served. **Parcel tankers** are relatively large vessels with multiple separate tanks carrying high-grade chemicals, often in stainless steel tanks; **product tankers** are also large, but they carry less difficult cargoes, frequently in coated-steel tanks; and **specialized tankers** are small to medium size, carry a limited number of chemicals in a dedicated trade and use either coated-steel or stainless steel tanks, depending on their cargoes.

The ship

Chemical tankers may be distinguished by an array of pipes that run above the ship’s deck. Liquid chemicals are pumped via these pipes and their associated valves to load and unload the various tanks. For example, the large chemical tanker, the Odfjell SE Bow Star, built in 2004 at Poland’s Szczecin New Shipyard, has thirty-four square and rectangular 2205 duplex stainless steel cargo tanks below deck and six cylindrical tanks mounted on the deck. The vessel is 183 meters long with a beam of about 32 meters and a capacity of 39,832 dwt. The construction of the tanks required 3,000 tonnes of duplex stainless steel (some 90 tonnes of molybdenum) and they provide 52,106 cubic meters of storage volume.

The cargo tank

Design and construction – Inboard tanks contain hatches, ladders, heating systems, piping and drains. Tank walls are typically 20–25 millimeters thick and are corrugated to increase tank stiffness. This enhances the ship’s structural rigidity and saves weight compared to ❯



The schematic shows the location of the different stainless steel tanks on the Odfjell SE Bow Star. © Odfjell

Interior of a stainless steel tank on a chemical tank ship. © Stolt Tankers

straight-walled tanks. The corrugations are about 1 meter wide and 1 meter deep. Tank fabricators must employ precision welding techniques to ensure weld integrity, and careful post-fabrication cleaning to ensure the quality and corrosion resistance of the stainless-steel surface. A typical size vessel requires about 1,500 tonnes of stainless steel.

Materials – Early chemical tankers used Type 304L stainless steel, but today a grade with 2.0–3.5% molybdenum is standard. Type 316 austenitic stainless steel and its variants are sometimes specified, but the duplex stainless steel grade 2205 is now the most widely used tank material.

This grade is popular because it is stronger and more corrosion-resistant than Type 316 stainless steel. The alloy's higher strength requires less steel and therefore reduces the ship's weight. Its superior corrosion resistance, due in large part to the addition of 3% molybdenum, allows it to carry a wider variety of aggressive liquids. The coefficient of thermal expansion of 2205 is closer to that of carbon steel than Type 304 or 316, making it more thermally compatible with surrounding carbon steel structures.

Cleaning – Tank cleaning is an essential part of chemical tanker operation, directly affecting both product quality and operating cost. Many owners consider it the most important operating cost because it is the one over which they have the most control. Stringent design codes and operating regulations tend to equalize capital and most operating costs for all operators across a given tanker size, so efficient cleaning practices can provide a competitive edge.

The tank material and its coating, if present, control the particular cleaning practice. Stainless steels do not absorb liquids like epoxy coatings on carbon steel tanks, and they are not porous like zinc silicate coatings. Because they are corrosion resistant, they are compatible with a great variety of cleaning methods and products, thereby offering owners a significant operating-cost advantage.

Chemical tanker ship market

The average life of a chemical tanker is 23 years. A 2012 study of 138 major chemical tanker operators showed some 1,800 ships to be operating at that time, of which about 400 had stainless steel ❯

The chemical tanker Bow Sagami is docking for loading or unloading. © Odfjell

The topside of a chemical tank ship is busy with a myriad of pipes and valves. © Nordic Tankers

tanks. These numbers suggest a demand of 75–80 ships per year, 15–20 of which would contain stainless steel tanks. However, more recent statistics published by IHS Markit showed that 144 stainless steel-tanked ships were either under construction or on order in 2016–2017.

The market for new chemical tankers has historically grown at 1.3–1.7 times the rate of the global GDP. Increasing demand for chemicals and their world-wide production and trade favor a continued expansion of chemical tanker fleets, especially those using stainless steel tanks. Furthermore, ships are becoming larger and more complex. Ship replacement, market growth, and a continuing shift in alloy choice for tanks combine to produce a substantial market of tens of thousands of tonnes of duplex stainless steel every year. These factors imply that the demand for molybdenum in chemical tank ships will remain strong for the foreseeable future. (CK)

MoRe® unique implants

Molybdenum-based alloys containing rhenium have been used primarily for high-temperature applications. However, the traditional "Mo-50 Re" alloy has now been clinically evaluated for a cardiovascular stent and is certified for this application. Furthermore, an ASTM standard covering its use in implants has been published recently. The alloy's high strength, excellent toughness, ductility and biocompatibility make MoRe® an excellent alternative to traditional implant materials.

People in the refractory metals field typically associate Mo-Re alloys with applications such as infra-red halogen lamp filaments, heating elements for chemical vapor deposition furnaces, thermocouple sheathing, heat shields, and space-vehicle thrusters, all of which operate at extremely high temperatures. Recently however, the traditional "Mo-50 Re" alloy, actually a 52.5% molybdenum - 47.5% rhenium alloy, has found new applications at body temperature that exploit its mechanical and biological properties. MiRus, a medical device manufacturer in Atlanta, Georgia, is at the forefront of this exciting work.

The cardiovascular connection: a Mo-Re stent

Most cardiovascular stents are made from a solid tube by micro-machining or laser cutting intricate patterns to create a tubular mesh. This mesh, or stent, is used to expand an occluded artery to restore its blood flow. To place a stent, a surgeon makes a small incision in an artery located in the arm or groin, inserts a catheter containing one or more stents into the artery, maneuvers it to the affected vessel, and expands the stent using a balloon. Traditionally, stents have been made from small-diameter stainless steel, titanium, cobalt-base, or nickel-titanium (Nitinol) alloy seamless ❯

tubing. Outside diameters are typically less than 2 millimeters for use in small arteries and 2–5 millimeters for large arteries.

Stent-placement is monitored using real-time radiography, allowing the surgeon to see the stent on a screen and direct it to the required location. Since radiation absorption is proportional to a material's density, Mo-Re, with a density of 13.5 grams per cubic centimeter, is superior to traditional materials with densities ranging from 4.5 (titanium) to 8.8 grams per cubic centimeter (cobalt-chromium). With Mo-Re stents absorbing much more radiation than traditional alloys, these stents are much easier to see during implantation. Surgeons can therefore manipulate and place them more safely and precisely than traditional stents.

In the last decade, a Mo-Re stent design was successfully developed by Icon Interventional, a predecessor of MiRus, and is now available for clinical use in Europe. The high strength of the alloy

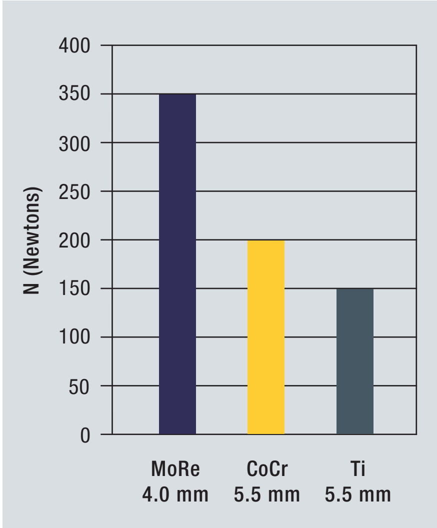
The Nuloy® coronary stent using Mo-Re alloy. © MiRus

has allowed production of a stent with a 0.06 millimeter wall, the thinnest on record. This success led MiRus to confer with a number of orthopedic specialists about other potential applications for the alloy. The ensuing discussions identified a number of unique opportunities to develop new surgical implants for spinal and craniomaxillofacial (head, face, and jaw) applications. Device designers, design engineers, and orthopedic surgeons are now focusing on applications in these areas.

Mo-Re material properties

Mechanical properties – Cold working increases the strength of Mo-Re alloy, as it does for metals generally. However, when cold worked, much of the deformation in Mo-Re is accommodated by an unusual process called twinning-induced plasticity (TWIP). TWIP simultaneously imparts high strength and high ductility, and MoRe® implants benefit from this unique phenomenon. The newly issued ASTM standard, *F3273-17 Standard Specification for Wrought Molybdenum-47.5 Rhenium Alloy for Surgical Implants (UNS R03700)*, defines several different strength levels of Mo-Re alloy based on the amount of cold working done. The strongest has minimum yield and ultimate tensile strengths in excess of 1300 MPa with double-digit percentage ductility. Higher strength allows designers to create smaller and lighter implants that disturb less of the bone structure into which they are placed. They also protrude less, blending better with the bone's natural shape.

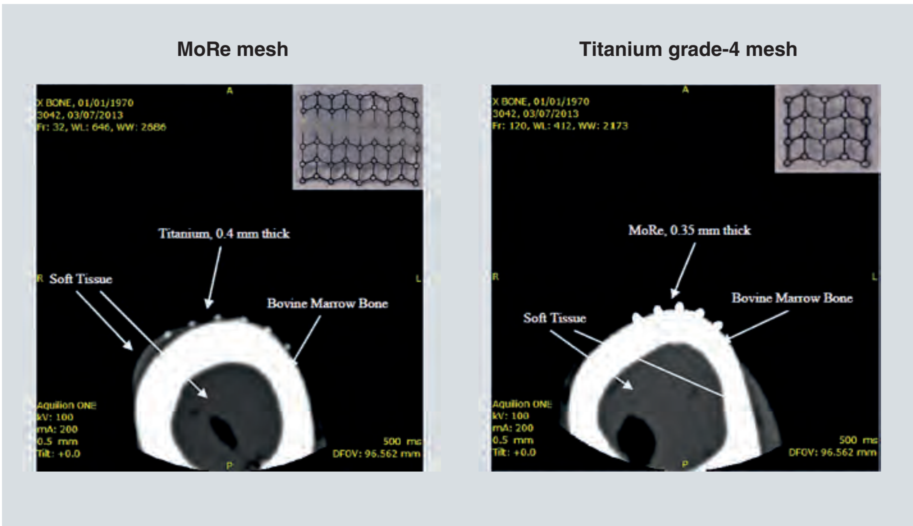
Surgical implants are often subjected to cyclic loading. Therefore, a large proportion of implant breakage occurs as a result of fatigue failure, so fatigue resistance is an important property for implant alloys. Fatigue tests comparing



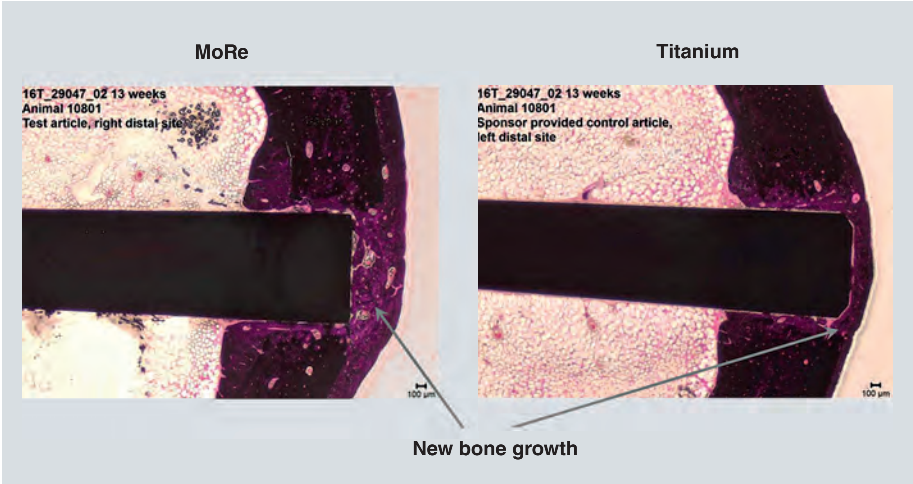
Fatigue runout load (N) of bent spine rods @ 2.5M cycles. Source: MiRus

Mo-Re, Co-Cr, and Ti-6Al-4V bent spine rods showed a great advantage for Mo-Re alloy even though its rod's cross-sectional area was only 53% of the other rods'. Improved fatigue strength offers better implant reliability, lower probability of implant failure, and less product liability exposure.

Magnetic properties – Magnetic resonance imaging (MRI) procedures present special challenges to implant designers. The extremely high magnetic ❯



Reduced MRI artifact for MoRe® mesh implant compared to titanium. © MiRus fields present in MRI equipment exert enormous stresses on magnetic materials. Implant alloys must be nonmagnetic to eliminate torque, displacement, or heating during MRI procedures. MoRe is completely nonmagnetic, so it presents no problems in this regard. Another potential problem is artifact, or 'starburst' patterns in MRI images, a function of the implant's magnetic susceptibility. Artifact can interfere with diagnostic interpretation. Unalloyed titanium implants exhibit the least MRI artifact of the traditional metallic-implant alloys. Due to its lower magnetic susceptibility, Mo-Re reduces MRI artifact below that of pure titanium, a major clinical advantage.



Bone growth after 13 weeks showing continuous bone maturation at the implant-hard tissue interface. © MiRus

Density and elastic modulus – The higher density of Mo-Re alloy is not so important for small and medium-sized surgical implants because the additional implant weight is minimal. However, a high modulus of elasticity is normally undesirable for orthopedic applications because the stiff implant reduces the load on the bone, a phenomenon called stress shielding. It can result in a reduction in bone growth because the body has less load to support. The effect becomes more important as implant size increases, so designers must work to keep implant dimensions at a minimum. This means high-modulus alloys must also have high strength to allow thinner cross-sections, a plus for Mo-Re.

A lowprofile MoRe® craniomaxillofacial (CMF) plate (right) demonstrates its size advantage over a titanium alloy plate (left). © MiRus

Design freedom

The high strength and high ductility of Mo-Re alloy implants allow designers to significantly reduce implant dimensions compared to current materials, enabling thinner implants that are less prominent and provide greater aesthetic appeal. This is especially important when skin coverage is minimal, as in the skull. Implants with smaller cross-sectional area also reduce the amount of disturbed bone, leading to more robust structures.

Small and medium-sized trauma plates used for cranial, midface, mandible, wrist, finger, pelvic, and ankle fractures may have anatomically designed shapes, but surgeons often must contour these implants to fit a specific patient's bone structure. For example, spine rods are bent to establish correct alignment for patients with scoliosis. The high ductility of Mo-Re alloy permits this deformation without forming superficial cracks, a problem that may occur during intraoperative contouring of other high-strength orthopedic alloys. Eliminating cracks maximizes implant fatigue life.

Bone friendly

Mo-Re alloy implants do not present the biocompatibility problems or allergic reactions sometimes seen in implants containing nickel, cobalt or chromium. A number of biocompatibility tests have been performed comparing Mo-Re and Ti-6Al-4V alloy; summary results are included in ASTM F3273-17. Osteoconduction (the process of bone growth on the implant surface) is another important property because it is observed mainly on highly biocompatible implant materials. In a bone implantation study where test pins were implanted in animal femurs, osteoconduction was similar for both MoRe and Ti-6Al-4V pins after 4, 13, and 26 weeks' implantation.

This new application of Mo-Re alloys in implants is an exciting field that is only in its infancy. It has the potential to provide better solutions to the problems seen by orthopedists every day. (JS)

IMOA gratefully acknowledges the assistance of Mr. John Disegi, Principal, Advanced Bio-material Consulting, in ensuring the technical accuracy of this article. Mr. Noah Roth, COO, MiRus Spine & Orthopedics is acknowledged for the development of the MoRe material for biomedical applications and directing the research work presented in this article.

Lighter and safer offshore platforms

Offshore oil and gas platforms see some of the most demanding environmental conditions for construction materials anywhere. Exposed to extreme weather, wind and waves, these structures must operate safely for decades. The most challenging sites are located in or near the Arctic oceans, where frequent storms intensify the extremely corrosive exposure to seawater. Molybdenum-containing alloys, especially duplex and super duplex stainless steels, last longer than almost all other materials in these difficult situations. One small but critical example is super duplex bolts.

Offshore platforms produce and process oil and gas from a well in the seabed. They are basically chemical plants placed in the middle of the ocean. They often contain all the equipment necessary to make them self-sufficient, including power generation, water desalination and crew accommodations. All of this is squeezed into the smallest amount of space possible. Platforms should also be as light as possible, to minimize the size of support and anchor structures. The pumping and processing of oil and gas requires many miles of pipes in addition to the processing equipment itself. The pipes are typically flanged together, using hundreds of thousands of bolts. Traditionally, these bolts have been made of hot dip galvanized (HDG) steel.

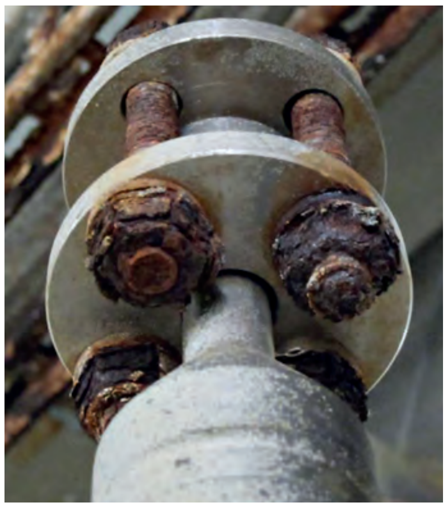
The Johan Sverdrup riser platform jacket being installed. © Jan Arne Wold/Statoil

Material selection for oil platforms

The Norwegian oil company Statoil is currently developing the Johan Sverdrup oil field on the Norwegian Continental Shelf. It is one of the region's largest oil field discoveries in recent times and will become by far the North Sea's largest producing oil field when both phases are operational from 2022 on. The oil field has a life expectancy of 50 years. This long expected life and the need to keep the platforms as compact and light as possible, drive the material selection for the project's structures, equipment and piping.

The company's experience with other oil fields in the North Sea showed that traditional bolting, in particular, suffered from corrosion problems and the lifetime of these HDG steel fasteners turned out to be limited. The protective zinc coating typically lasts about 8 to 10 years, after which the steel fasteners themselves begin to corrode. The total lifetime of this type of fastener, when exposed to marine environment, is therefore only about 15 years, but properly working fasteners are crucial for safe, reliable, and environmentally secure operation of the complex piping systems.

Because of this, and because the expected useful life of older platforms has been extended thanks to improvements in technology and oil recovery, thousands and thousands of fasteners have to be replaced, as they come to their end of life. ›



Hot dip galvanized bolts suffer from corrosion when exposed to the severe marine environment on a platform. © Statoil

The Johan Svertrub oil platform is scheduled to start production in 2019. © Statoil

Super duplex bolts and nuts of different sizes. © Bumax

This is a huge undertaking, extremely expensive and disruptive for the operation of the platform. To avoid similar work in the future, Statoil is replacing the HDG bolts on the older platforms with super duplex stainless steel bolts.

For the Johan Sverdrup project, with its 50-year life expectancy, duplex stainless steels were specified from the beginning. Lean duplex stainless steel is used for a variety of structural elements such as cable trays, pipe supports and other secondary structures which are not exposed to high temperatures. Its benefits include longevity, low maintenance and weight reduction. Weight management is the most cost-critical issue when building platforms. Higher weight on the topside of the platform requires the use of crane ships with higher lifting capacity, which increases the cost significantly. Conversely, a lighter topside also allows for a smaller, lighter, and therefore lower-cost support structure underneath.

Standard 2205 duplex stainless steel is used for piping that carries condensate, oil and gas; super duplex alloys, meanwhile, have been selected for pipes carrying seawater as well as for caissons and umbilical tubing. The duplex stainless-steel piping in this enormous project spans diameters from 50 to 500 millimeters. The super duplex fasteners which connect the flanged joints range from 12 to 36 millimeters in diameter.

Super duplex stainless steel

Super duplex alloys provide high strength and very good resistance to several different forms of corrosion. The latter can be largely attributed to the 3.5% molybdenum typically contained in these grades. As a result, super duplex stainless steels are found in seawater environments, fluids with high chloride contents, and acidic chemical processes. They are increasingly used in oil and gas, desalination, power generation, marine industries and other corrosive applications.

Duplex and super duplex stainless steels have twice the yield strength of solution annealed austenitic stainless steels such as Type 304 or 316 and are stronger than the work hardened versions of these grades, which are typically used in offshore applications. They also have good ductility and toughness down to temperatures as low as -80 °C, an important consideration in the Arctic or far North.

Beyond the oil field and into the future

Super duplex fasteners have recently also found application in energy projects beyond oil and gas, in the emerging field of offshore wind turbines. At the Greater Gabbard Wind Farm, located in the North Sea, 23 kilometers off the coast of England, 140 offshore wind turbines have UNS S32760 super duplex fasteners. The Humber Gateway Wind Farm, also located in the North Sea, uses over 50,000 of these bolts to fasten turbine components. These operations encounter many of the same problems facing offshore oil: a corrosive marine environment and the need for high-strength alloys to reduce weight, maximize efficiency, and guard against environmental disasters.

Offshore technology is evolving to supply the world's energy needs with greater efficiency, safety, and environmental protection. At the same time, the different types of duplex stainless steels have become an ever more important factor in the design decision. They have excellent resistance to multiple kinds of corrosion, high strength, and good ductility and toughness. They therefore last throughout the life of a project with minimal maintenance and enable lighter, more cost-efficient designs, more than recouping their higher initial cost. In these technologies, molybdenum shows its merit by helping to create the unique properties that makes these sophisticated materials so desirable. (NB, JS)

Super duplex bolts are also used on offshore wind turbines. © West Special Fasteners

IMOA news

AGM 2017

Boston, one of the oldest cities in the United States, provided the venue for IMOA's 29th Annual General Meeting in September 2017, kindly hosted by H.C. Starck. Outgoing President Carlos Letelier welcomed more than 120 delegates to the Massachusetts capital for the two day meeting. Here a number of experts gave unique insights into a range of subjects, alongside the formal business of the AGM.

Francois Dary from H.C. Starck gave a presentation on the rationale for the use of molybdenum metal in a range of historic and emerging applications. Richard Oppelt from Accenture talked about the outlook for the U.S. steel industry, including an assessment of the prospects for global steel to 2035 which modeled the potential impacts of disruptors. Jim Lennon from Red Door Research returned to the AGM to give his predictions on the medium-term prospects in the molybdenum market, while Markus Moll from SMR entertained us with his very animated review of the end uses of molybdenum and an outlook for the molybdenum market in the longer term.

Graham Gedge from Arup presented an industry view of the value of the technical support provided by organizations like IMOA, while Hardy Mohrbacher from Niobelcon gave an overview of the technology and market prospects for press-hardening steel when combined with hot stamping. Volker Friedrich from GBP International presented a unique view of the risks and opportunities if the economies of Asia become dominant in the future, and Aziz Asphahani from Questek gave delegates an update on how computational material engineering disciplines are being utilized in the design of molybdenum-containing steels and alloys.

Finally, Nicole Kinsman presented highlights of IMOA's market development program in the last twelve months and Sandra Carey updated delegates with IMOA's proactive and reactive work in response to global HSE and regulatory challenges. New for this year was a panel discussion held on the second day, moderated by Markus Moll, with five industry experts giving their views on drivers and disruptors in the molybdenum market, providing a fascinating conclusion to the proceedings.

IMOA hosted a dinner in the JFK Library, an impressive venue dedicated to the memory of the thirty-fifth U.S. President, now managed by the U.S. National Archives and Records Administration. Our hosts H.C. Starck very kindly reciprocated on the next evening, with a dinner at the Seaport Hotel and World Trade Center.

Outgoing President Carlos Letelier of Molymet and Benjamin Zhao of THH Molyprocessing raise a glass to another successful AGM.

Metals conferences in London

London plays host to two international metals conferences this Spring, both of which are supported by IMOA. Argus Metals Week (formerly NiCoMo) returns to London on 27 February (until 2 March 2018), promising more molybdenum-dedicated sessions. IMOA members receive a discount of 10% on the standard delegate rate. Those wishing to take advantage of this offer should book through www.tinyurl.com/amw2018 using the discount code IMOA10.

Later that month, CRU hosts 'Metals in the Future' in London on 19-20 March, exploring the long-term impact of green technology on metals supply and demand. IMOA members receive 15% off the standard delegate rate using IMOA15 at www.tinyurl.com/crumetals18.