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Molybdenum preserving Venice

For centuries Venice has been fighting nature to keep itself from drowning. It is under attack from rising water, sinking ground, high tides, wind, salt water and, more recently, erosion caused by the wake of hundreds of motorboats. In the last ten to fifteen years the maintenance team of the city has used moly-grade stainless steels extensively to strengthen its defense. In this battle, stainless steel often works behind the scenes, embedded in stone or brick. But in some cases it is in plain sight and blends in beautifully with the old building materials.

Venice is one of the most beautiful cities in the world. With its maze of canals, cobweb of bridges, grand palazzos and scenic squares, it brings to mind romantic notions: wealthy citizens leading a noble life, visiting each other by gondola, or strolling along a canal in the fog – a time before cars were ubiquitous. Its fragile position exposed to water from all sides adds to the wonderment. Venice comprises over one hundred islands. It is located in the Venetian Lagoon, a body of salt water at the North end of the Adriatic Sea.

The city of Venice was founded by refugees from surrounding Roman mainland cities like Padua and Aquileia around the fourth and fifth century AD. The people were forced to retreat to the marshy lands by several waves of invaders from the North seeking to destroy the Roman Empire. After losing the mainland cities in the North, Rome moved the main administrative and religious entities of the region to Venice before the fall of the empire.

Due to its strategic location, Venice became a flourishing trading center between Western Europe and the rest of the world. By the 15th century, huge convoys of ships full of goods left the lagoon several times a year. The stunning palaces on the Grand Canal still reflect the wealth of one of the most powerful and prosperous nations in history.

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Catalyst research for a better energy future

Under a program which aims to sponsor development of new applications involving molybdenum, IMOA and CoMoTech have given a grant for work on a new type of molybdenum-based catalyst to the University of Michigan. Molybdenum nitride and molybdenum carbide compounds would act as catalyst support, and as catalyst, improving the effectiveness of the process.

In our everyday world we think of a catalyst as something or somebody that energizes things, or people. A catalyst makes things happen, for example, the new coach for a now successful soccer team. In the world of chemistry a catalyst is a material (chemical, molecule, atom) that helps a chemical reaction to take place. It is unique because it does not get consumed in the reaction, just as the coach does not play on the field. Chemical catalysts play an important role in our everyday lives because they are essential to many commercial chemical and energy production processes. They make the process practical and economical. An example is the use of a catalytic converter in our car. Catalytic converters utilize platinum metal as a catalyst. Objectionable gases in the exhaust react chemically to form harmless gases through the aid of the catalyst.

Molybdenum as a catalyst

A unique characteristic of molybdenum is that it can function as a catalyst for many chemical reactions. It is widely used in petroleum refining (for example in the removal of sulfur from gasoline) and other industries within a total catalyst market of about 12 billion USD annually. The importance of catalysts cannot be overestimated when one considers that 200-1,000 USD of finished goods are produced for every one dollar of catalyst consumed.

The catalyst market is also important to the molybdenum industry. About 6% of the total molybdenum production, roughly 12,500 metric tons, were used for catalysts in 2008. Catalyst usage grows with the growth of emerging nations and the world economy. It will also grow because catalysts improve the efficiency of chemical processes and chemical companies continually seek to improve their efficiencies and reduce their environmental impact.

Origin of the catalyst research project

Seeking to increase molybdenum usage, IMOA and CoMoTech agreed that research in promising growth areas would be helpful. They asked CIMAT to organize a worldwide search for a worthwhile project. CIMAT mailed a call for submission of a research proposal to 2,750 researchers in 50 countries all over the world. Nearly 100 proposals poured in from 21 countries. The subjects ranged far and wide and most were very good. CIMAT organized a committee of outstanding academic experts to critically evaluate the proposals and recommend the best project. Likewise, CoMoTech and IMOA organized review committees that were focusing on the market potential. All three committees unanimously chose a project on molybdenum catalysts because of its originality and probability of success. The winning proposal was submitted by ➔

Content

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Cobalt/molybdenum catalysts such as the pre-sulfided KF-757 pictured, are key components of refinery operations. They are instrumental in the processing of ultra-low sulfur diesel. Photo: Albemarle Corporation.

CIMAT (Center for Advanced Interdisciplinary Research in Materials Sciences) is an interdisciplinary institute belonging to the University of Chile in Santiago. Its mission is scientific research and graduate student training in the field of materials. www.cimat.cl/english/index.php

CoMoTech is a shareholder-owned corporation operating in partnership with Molymet (Molibdenos y Metales SA), the University of Chile, and Copper Technology Investments Inc., a Codelco subsidiary. Its mission is to increase molybdenum demand through technological innovation.
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Professor Levi Thompson is a professor of Chemical Engineering at the University of Michigan. He earned his BChE from the University of Delaware, and MSE degrees in Chemical Engineering and Nuclear Engineering and a PhD in Chemical Engineering from the University of Michigan. His research focuses on catalytic and adsorbent materials, and on hydrogen production systems and fuel cells. Honors and awards include the National Science Foundation Presidential Young Investigator Award and the Michiganian of the Year Award (2007).
www.engin.umich.edu/dept/che/research/thompson/research.

Collaborators: Susanne M. Opalka (United Technologies Research Center), Thomas Vanderspurt (United Technologies Research Center)

Professor Levi Thompson of the University of Michigan. Professor Thompson is an expert in the field of catalysis with over 200 publications and presentations and 10 patents to his credit.

What will the project accomplish?

The project proposes to develop new catalyst systems utilizing two compounds of molybdenum. They are molybdenum carbide and molybdenum nitride. The project is unique because these compounds will be used not only for their own catalytic properties, but also as a base to physically support other metal catalysts. These carbides and nitrides can be formulated to have the necessary large surface area required for catalyst supports. They are resistant to the heat required for many chemical reactions so they can function very well in such a dual-purpose role. These catalysts are likely to promote a faster chemical reaction, be more resistant to contaminants and require less of the expensive metal catalyst. A superior dual effect catalyst could result from the project.

Of further great importance is that the catalytic effect will be studied with chemical reactions that are the basis for two well-known and well-established industrial processes. They are the Fischer-Tropsch Synthesis (FTS) and “water gas shift” (WGS) processes. These processes are routinely used to produce hydrogen, hydrocarbons and other products; thus a successfully developed new catalyst could be quickly commercially utilized.

Benefits

The commercial potential is considerable. The research of Professor Thompson’s team may help expand markets for Mo-based catalysts. The catalysts would be used in new alternative fuels and hydrogen production in addition to applications in traditional markets. Professor Thompson expects that, given the available infrastructure and the usual catalyst replacement cycles, this expansion could occur within five years.

Our best wishes to Professor Thompson and his team as they search for ways to more fully use molybdenum while making a better future.

Molybdenum catalyst is frequently used in petroleum refining.

Molybdenum enlarges your viewing pleasure

The popularity of large flat-panel displays for televisions and computer screens cannot be denied. Molybdenum plays an important role in the manufacture of the liquid crystal display (LCD), the most popular form of the large flat panel. Molybdenum applied in a very thin film has ideal electrical and chemical properties for this application.

When we turn on our televisions we don't think about how they make those marvelous life-like full-color images. We don't pay attention to the details of how the devices are made or what materials are used to make them. We are interested in whether the picture quality meets our expectations, that the set is reliable, and whether it is affordable. We may yearn for an even larger flat-panel screen that gives us the feel of being in a theater. We also think about what else our screens can do for us. Can I hook up my computer to the set? Can I use my digital gaming console? Will I be able to receive high-definition digital TV signals? Electronics companies employ many people and devote enormous amounts of energy and technology to address these questions. Molybdenum is an essential part of their technological "bag of tricks" that enables them to deliver flat panels for televisions, computers, and many other display devices so sought after by consumers.

Molybdenum has been important to the electronics industry since the days of vacuum tubes and traditional televisions. It remains important even though solid-state silicon devices have replaced vacuum tubes. Molybdenum is nearly ideal for use in manufacturing solid-state electronics. It expands little upon heating, matching well the expansion rate of silicon and glass. It resists chemical attack so it can protect other less-resistant components during corrosive manufacturing processes. It strongly bonds to glass and it conducts electricity and heat efficiently thus improving device performance. These properties make it ideal for components used in thin film transistor liquid crystal displays (TFT LCDs). This is the most popular type of display used in flat-panel televisions and computers sold today.

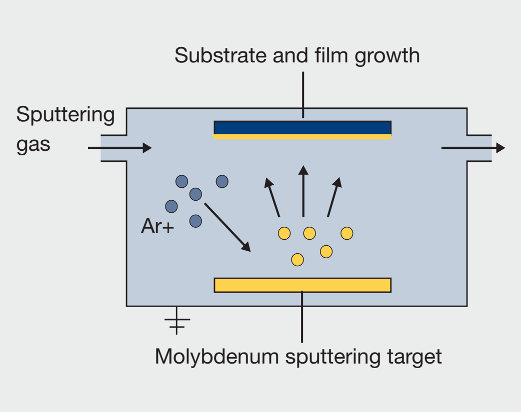
LCD computer and TV screens have a very thin layer of molybdenum on the glass as a base on which transistors and circuit wires are laid.

Operation of a liquid crystal display

Televisions work using a screen that lights up millions of picture elements (pixels) in such a way that the array of pixels creates a color image. Traditional televisions use an electron beam cathode ray tube for this purpose. The new flat-panel display eliminates the old style electron beam with its need for complicated and cumbersome accessories. Instead, it uses a fluorescent lamp behind the panel to illuminate all the pixels simultaneously. Then it employs a liquid crystal "shutter" to allow the desired light to shine on each subpixel. (Every pixel is divided into three subpixels that produce the primary colors necessary for color rendition.) Thin film transistors control liquid crystal shutters that "throttle" the light falling on each subpixel. This type of display dramatically improves image quality, provides large increases in energy efficiency and reduces sensitivity to handling and shock.

Manufacturing a liquid crystal display

A liquid crystal display consists of millions of transistors and connecting wires laid down on a glass substrate. This is where molybdenum finds its place because of its favorable properties relative to glass. Molybdenum serves as a base layer, bonded to glass, on which the transistors and circuit wires are laid. The molybdenum base layer is applied using a process called "sputtering" wherein vaporized molybdenum is removed from a target (the molybdenum source) and deposited onto the glass. The target traditionally has been a flat molybdenum plate. The transistors and wires are then laid over the molybdenum in many layers by a cyclic process of



The sputtering process showing molybdenum atoms being vaporized from the target and deposited on the substrate. Illustration: en.wikopedia.org/wiki/sputter_deposition.

masking, sputtering and etching. Masking creates the desired pattern. Sputtering then again deposits atoms of different metals or materials repeatedly over the pattern. Chemical etching removes any unwanted deposited material after each deposition cycle. Molybdenum bonds strongly to the glass substrate and solid state devices, and it conducts electricity to operate the devices. It also covers the fragile wiring traces to protect them from chemicals used in the etching process that would otherwise destroy them. Molybdenum is extremely important to the successful operation of the finished display. For a detailed animation of the process of manufacturing a flat-panel display, visit the Website: tinyurl.com/tftprocess

Bigger and better

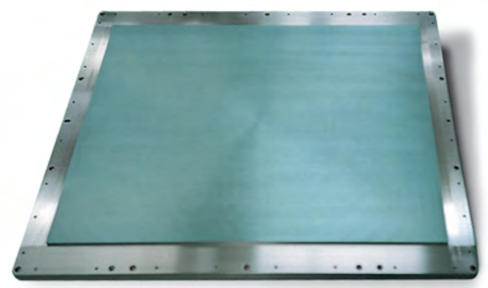
Consumers have a voracious appetite for better and larger screens. Large screens ease eyestrain and provide a more theater-like viewing experience. Display sizes have grown dramatically in the short time that flat-panel technology has existed. It is not unusual to find one-meter LCD panels in homes, and even larger screens are on the way.

Increasing screen size requires that production methods evolve and that new methods are developed. Conventionally-produced large panels can require a glass substrate panel nearly 3 m x 2 m in size. Targets for these substrates require some of the largest molybdenum flat-rolled sheets ever produced by the industry, 1.7 m x 1.4 m. The limitations of the conventional process, however, have required that fundamental changes in manufacturing methods take place. Manufacturers have had to rethink how they coat large areas. An answer has been to re-shape the target used in the sputtering machine. New machines now use arrays of long, narrow plate or long cylinders as targets and can coat almost any arbitrarily-sized sheet of substrate glass.

Molybdenum usage in LCD flat panels

The TFT LCD technology has been a success story for the consumer and the electronics industries. Consumer satisfaction can be measured by the tremendous growth in large flat-panel sales. This application is now one of the largest uses for molybdenum metal. Even though its use in each panel is small, the total amount used last year was about 1,000 tons.

IMOA gratefully acknowledges assistance with this article from PLANSEE Metall who provided technical and market information and illustrations.



A GEN 5 molybdenum target, mounted on its backing plate, is made from one of the largest molybdenum plates ever produced. Photo: PLANSEE Metall.

An array of eight narrow targets behaves like a monolithic target nearly 2-1/2 meters square. Photo: PLANSEE Metall.

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Molybdenum preserving Venice

However, Venice's position and marshy ground imposed massive limitations on construction. To keep buildings from sinking into the swamps, millions of wooden piles had to be driven into the bottomless marches. The Rialto Bridge alone required 12,000 piles to support its weight when built in 1588.

Over the centuries, the maintenance of infrastructure, monuments and works of art was always of vital importance. The Great Council constantly gave orders to dredge the canals, preserve the waters of the lagoon from contamination, adopt precautions at times of plague, preserve the state of cemeteries, and to conduct many other activities. In short, Venice has a long tradition of being "high maintenance".

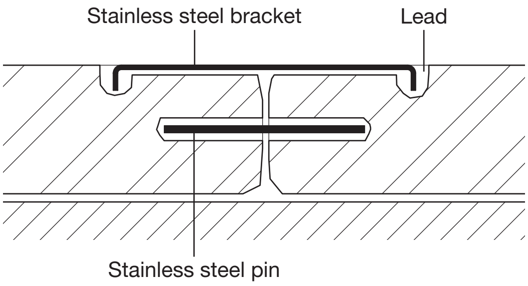
Maintaining the unmaintainable

Today, the municipal agency Insula is in charge of planning and organizing the maintenance and repair of public spaces and services of Venice. The agency employs almost 100 people, half of which are engineers, architects and other technical professionals. Dr. Ivano Turlon, who leads the Insula team stated: "Because Venice is such a unique city with such unique problems, the agency can often not use standard repair and maintenance practices which work in other cities but has to develop unique, custom-made solutions."

Type 316 moly-grade stainless steel is one of the tools that the agency uses successfully in its battle with sea water, wind, erosion, high tides, rising waters, sagging ground, polluting industries on the mainland, and the effects of millions of tourists. Molybdenum gives the stainless steel the good corrosion resistance needed, particularly in coastal areas where chlorides (salts) are present.

Stainless steels stabilize walls

Along many canals low walls separate the walkways from the water. These brick walls are capped with heavy slabs of white Istrian stone. Traditionally, the tops of the slabs were connected with iron or copper brackets. In recent years, Insula systematically replaced them with Type 316L stainless steel brackets whenever walls had to be repaired or rebuilt. Unlike copper and iron, stainless steel is able to resist the corrosive environment here. Modern masons use the same ancient method for cementing the brackets into the stone. They fill the holes where the two ends of the bracket grip the stones with liquid lead and then strengthen the connection between the stone and the steel by hammering a pointed tool repeatedly into the soft lead, compressing it. Additionally, the stone caps are connected internally with Type 316L pins, which are cemented in place with epoxy. →



The white stone caps of the brick walls are secured with metal brackets. The original copper or iron brackets (right) are now being replaced with Type 316L stainless steel (far right).

Traditional handrails in Venice are wrought iron, protected with black paint. As the paint thins and chips it has to be reapplied. Even then, wrought iron does corrode and has to be replaced every so often. Stainless steel handrails need much less maintenance and are therefore the most cost effective solution for Insula. The agency installs Type 316 stainless steel wherever old handrails have to be replaced and where new handrails are fitted. Because the population of Venice is aging and its citizens have to walk so much to get around, additional handrails are continually being added.

Invisible molybdenum in and under bridges

Even such an ancient and romantic city as Venice has to provide modern services to its inhabitants. Early builders had not made any provisions for power services, let alone high speed Internet. Adding gas, water, telephone and electricity to the homes of Venice meant tearing up walkways to install underground piping. To cross a canal, the first engineers to install the pipes hid them within the original cross section of the old stone bridges. To fit the pipes into the bridge, they removed several layers of bricks from the substructure of the bridges and put the pipes into the channels they so created. As it turned out much later, the channels cut into the bridges weakened the structure causing longitudinal cracks to form.

Insula restored many of these bridges during the “grande intervento”, the big push between 1996 and 2005 to catch up with maintenance and repairs that had been neglected for decades. They removed the water and gas carrying cast iron pipes from about 140 stone bridges and reinstalled the bricks to fill the channels and stabilize the structure. Then the agency replaced the cast iron gas and water pipes with Type 316 stainless steel ducts, which were only 10 cm high. The cross section of the ducts was wide and flat instead of round. The flat ducts could fit between the newly repaired supporting structure and the top layer of the bridge.

Installation of a flat stainless steel duct for water and gas services on the San Boldo bridge. Photo: Daniele Resini for Insula spa, municipal agency for the urban maintenance of Venice.

Insula selected stainless steel for this application because maintenance of buried pipes would be very costly and difficult, and because they wanted a long-lasting solution. This same idea of using flat stainless steel rectangular ducts to transport fluids and gas across canals is also used on old cast iron bridges. These bridges are light and consist only of a frame and steps, all in cast iron. There is no place to bury the duct, so the stainless steel duct with its low profile is nestled directly under the bridge. It is hidden a bit by the face of the bridge and painted black to blend with the color of the bridge. In this way utility services can cross the bridge without being noticed.

Some of the cast iron bridges, which were built in the 1850s to 1880s, are starting to show structural deterioration and have to be restored. In the case of the Ponte della Donna Onesta (picture below), the engineers reinforced the bridge from the inside with a Type 316 stainless steel plate. ➔

Stainless steel reinforcing plates were welded to the inside faces in a workshop (below). From the outside, the restored bridge looks like the original, the repairs are invisible. Photo below: Insula spa, municipal agency for the urban maintenance of Venice.

The structure of Ponte dei Lavraneri is made of 2205 duplex stainless steel. It is the longest bridge in Venice.

In a similar case Insula tried a different technology, using fiber reinforced plastic (FRP) strips for strengthening. This solution is simpler because the FRP can be applied in place. However, reinforcing with a stainless steel plate is the preferred solution for low bridges. These bridges are occasionally hit by boats, which can crack the FRP. Stainless steel is resistant to small collisions.

A leading role for stainless steel

With their expanding experience using stainless steel in maintenance applications, engineers at Insula are now convinced of the suitability of stainless steel as a building material for new installations in Venice's demanding environment. Proving the point, they have recently built some larger structures entirely from stainless steel: two footbridges and a terminal for the vaporetto, the famous waterbus.

Ponte delle Capuccine (shown on the photo below) is a new bridge located on Burano. This modern structure is made entirely of Type 316L stainless steel, painted black to blend with the historic environment. The other new bridge, Ponte dei Lavraneri, (shown on the left) is the longest bridge in Venice and connects La Giudecca with Sacca Fisola, the small island in the west. This bridge replaces an old wooden bridge which had to be demolished. The structure of the bridge is made entirely of 2205 duplex stainless steel. However, from the outside it looks like a wood bridge because it has been clad with wood panels to resemble the old structure and to fit the context of Venice. There is also a new waterbus terminal on Burano. It is built of stainless steel structural shapes and glass. Here the stainless steel remains in plain sight and is not hidden or concealed – a glimpse into the future?

Stainless steel behind the scenes

The corrosion resistance, strength and toughness of stainless steel make it an ideal building material for demanding environments where longevity is a prime concern. Stainless steel makes Insula's work easier because, once installed, it guarantees a long, low maintenance life for new and repaired structures. This means the engineers can focus on more than just keeping up with painting and replacing the most obviously deteriorated structures. They can improve their coverage of maintenance and can plan further ahead. This will guarantee the survival of this fragile jewel in the Venetian Lagoon for many more centuries.

Ponte delle Capuccine on Burano is built from Type 316L and painted black to blend with the historic environment.

Chrome-moly steels are cranking the engines

Molybdenum, used in many airplane components, played an important role in the air war during World War II. The lack of availability of some alloying elements put the German planes at a distinct disadvantage during the decisive air battles. The allied planes performed better and were more reliable thanks to the strong and tough molybdenum steels and alloys used in their engines.

Two of the premier fighter aircraft of World War II were the British Supermarine Spitfire and the North American P-51 Mustang. Despite their radically different airframe designs, the Spitfire and the Mustang did have one thing in common – one of the most successful airplane engines of the war. Both were powered by variants of the 12 cylinder, liquid cooled, Vee-type Rolls-Royce Merlin Engine. The Spitfire was equipped with the original British Merlin; the Mustang with the V-1650 Merlin that was built under license by the Packard Motor Car Company in Detroit, Michigan. The Merlin was so successful that by the time production of its various models ended in 1950, some 168,000 had been built: 112,500 in Britain and 55,000 in the U.S.

Molybdenum essential to engines

In the 1930s, well before the start of World War II, aircraft engine designers began utilizing molybdenum-grade steels in order to increase performance, life and reliability. Out of these efforts, and the approaching war, came the Merlin. The heart of the Merlin was its one-piece crankshaft that must carry tremendous bending loads while rotating at high speed. The crankshaft was manufactured from 4340 chrome-moly steel which contains 0.80% Cr and 0.25% Mo. This versatile steel was selected because it delivers outstanding strength and toughness. The properties are so outstanding that the steel is still widely used today.

The Merlin Model 1650, with a 2-stage/2-speed supercharger, produced 1,735 horsepower, all in a compact package weighing just 770 kg. Powered with the Merlin, the Spitfire could reach speeds of 650 km/h and altitudes of over 7,600 m; the Mustang, speeds of 710 km/h and an altitude of well over 9,000 m. This performance was unrivaled by other fighter aircraft of the time.

German aircraft engine manufacturers, among the best in the world, were well aware of the advantages of using "chrome-moly steel" in their engines. However, shortages of alloying elements like chromium and molybdenum severely limited their use as the war dragged on. Simple metals were used instead, to the detriment of both engine and aircraft performance, according to Dr. Daniel Uziel, an expert on Germany's wartime aircraft industry.

Availability is important

The metal availability problem was acute in the development of jet engines as well. According to Dr. Uziel, heat resistance of alloys was the key requirement. However, the best alloys had limited availability, so a special cooling system was devised to keep substitute alloys from getting too hot. Nevertheless, the hot gases quickly damaged the turbine blades, so that the average lifespan of production jet engines was only 25 hours. Former Air & Space Museum Director, Walter J. Boyne, agreed in his article "Goering's Big Bungle": The initial Jumo 004A development design was built in small numbers, so the necessary high alloy steels required for a jet engine could be made available. But, because of the alloy metal shortage, the production engine was built with only about a third of the vital alloy steels required, and the compressor blades failed early and often.

North American P-51 Mustangs, like this one dressed for performance, are popular at air shows around the world.

Memories in history

Some sixty years later "the engine that won the Battle of Britain" remains in Royal Air Force (RAF) service, powering the Spitfires, Hurricanes, and the Lancaster bomber operated by the RAF Battle of Britain Memorial Flight. Merlins also power hundreds of P-51 Mustangs and Spitfire warbirds flown by private owners and seen by thrilled spectators at air shows around the world.

Small wonder then that the Merlin is considered by many historians as the best liquid-cooled piston engine of World War II. Reasons for this abound, but suffice it to say that the use of 4340 chrome-moly nitrided steel in the Merlin's forged crankshaft had a huge bearing on the engine's success.

Studies reveal low toxicity of moly in fresh waters

IMOA has sponsored research to find out to what extent molybdenum may be toxic to organisms in fresh water. The results were favorable: Molybdenum is far less toxic than most metals that have been similarly evaluated. National authorities around the globe now have access to these new data for use in setting water quality standards.

In today's world all of us should be aware of our "footprint" on the environment. The effects of human activity on every aspect of our ecological systems are just too important to be ignored. Responsibility lies not only with individuals but with institutions of all kinds. The molybdenum industry, through IMOA, responds to this challenge in many ways. One way has been to determine to what extent molybdenum may be toxic to organisms in fresh waters.

The project is important because as we use molybdenum, a percentage of it will eventually find its way back to the environment from which it came. Some may enter freshwaters on which we all depend. It is therefore important to have robust, scientifically-sound data about possible ecological effects related to molybdenum in water. Government regulators are interested in this question as well since they are responsible for keeping water safe. With scientific data, governments can develop sound regulations when imposing maximum limits for compounds. Without robust data, government regulations tend to be overly conservative. This could adversely affect the molybdenum industry and lead to more costly water processing.

Two main objectives of the project are:
- to better understand what effects molybdenum might have on plant and animal species living in fresh waters;
- to determine a safe level of Mo concentration in water in relation to any possible adverse effects.

The project had two phases: a comprehensive critical evaluation of existing data, followed by an ecotoxicity testing program. Molybdenum is not generally considered to be a metal having high toxicity. This was reflected in the scientific literature evaluation. However, the data were too scarce, insufficient and often of poor scientific quality to determine a safe level of molybdenum in water.

For the testing phase IMOA's Health, Safety and Environment Committee set a goal of filling data gaps in a scientifically sound manner. Tests were conducted on a variety of sensitive small plant and animal species. The tests and species were chosen to generate an acceptable database for rigorous assessment. Standard testing protocols were used to ensure high-quality data. The actual testing was conducted at internationally known and accepted laboratories across the globe. The resulting data were then analyzed using state-of-the-art statistical methodology known as species sensitivity distribution (SSD). This method is approved by European and American regulators.

The scientific test results showed that molybdenum is minimally toxic to freshwater species. It is comparatively far less toxic than most other metals that have been similarly evaluated. A safe level for Mo of 12.7 mg/l of water was established from the data. This level is well above the amount of molybdenum occurring in most natural fresh waters (about 1 µg/l). It is also well above the levels sometimes found to occur in waters affected by industrial activity.

These new IMOA freshwater data are directly usable by national authorities around the globe to set water quality standards. For example, new EU REACH legislation on safe use and management of chemicals and metals will report the 12.7 mg/l value as the $\text{PNEC}_{\text{freshwater}}$ (Predicted No Effect Concentration) for molybdenum. IMOA is proactively sharing and discussing the data with European, North American and Asian regulators to make sure they are known worldwide. Likewise it is anticipated that the results of this Mo ecotoxicity research will be published in peer-reviewed journals in the near future.

Following the success of the freshwater study, IMOA has commissioned a similar set of ecotoxicity testing programs for species living in marine waters. These freshwater and marine species projects are part of IMOA's commitment to environmental protection and sound water quality standards.

Stainless steel lets wastewater treatment plant shine

New York has a new, high profile stainless steel architectural landmark, and it is not a skyscraper. It is the attractive and expanded Newton Creek wastewater treatment plant. This is an example of municipalities around the world retaining architects to transform traditional unsightly infrastructure into attractive urban art and to stimulate redevelopment. Mo containing stainless steel has played an important role in this worthy project.

The Newtown Creek plant is the largest of New York City's 14 wastewater treatment facilities, serving approximately 1 million residents and a drainage area of more than 65 km^2. It is located on Newton Creek, a 5.6 km long polluted waterway on Long Island. The plant began operation in 1967 with a capacity of 1.2 million cubic meters per day during dry weather. Upgrade work began in 1998 and will eventually raise plant capacity by 125%. The completion of Phase 1 in 2008 increased capacity by 50%. Completion of Phase 2 is expected in 2016. In addition to the fundamental need to expand capacity and eliminate odor problems, the city had other requirements.

The facility is visible from vantage points in the Brooklyn, Queens and Manhattan city boroughs, including the Long Island Expressway, the Brooklyn-Queens Expressway and the Kosciusko Bridge, making aesthetic revitalization highly desirable. Hence, the New York Department of Environmental Protection (DEP) engaged the architecture firm Polshek Partnership to work with the engineers to create an attractive facility along the estuary. Since long service life was required, material durability and resistance to the coastal salt-laden air were as important as aesthetics

Function and form

Eight gracefully curved egg-shaped silver towers rise 44 m above the site like an alien apartment complex in a science fiction movie. These digester "eggs", which are the project's most visible component, will process up to 5.7 million liters of sludge every day, using anaerobic technology. At their widest point, the eggs are over 24 m in diameter.

Polshek chose to highlight these towers and make them an important sculptural element by wrapping them in 22,297 m^2 of 9.5 mm thick Type 316 stainless steel. Using the strong lines of a batten seam roof system and a proprietary low reflectivity finish to softly reflect light further highlighted the elegant shape of the digesters. Type 316 stainless steel with 2% molybdenum has become the standard specification for projects in locations with coastal or deicing salt exposure for Polshek Partnership and some other prominent US architecture firms. The more commonly used Type 304 does not contain molybdenum and can have aesthetically unacceptable surface staining in environments with corrosive salt or pollution, and regular cleaning is required. This stainless steel will not be manually cleaned making Type 316 the logical choice.

Newton Creek Type 316 stainless digester "eggs" displaying their low reflectivity finish in the daytime light. Photo: NYC Department of Environmental Protection/nyc.gov/DEP

Type 316 stainless steel was also used for numerous other architectural applications including the wall panels and curved batten seam roof on six buildings, canopy cladding, louvers, railings, ladders and doors (both interior and exterior) and handrails in the facility. In addition, stainless steel was used extensively for plant equipment that is traditionally stainless steel.

Satisfying addition to the neighborhood

George Trakas, a renowned environmental sculptor, designed a new, 0.4 km nature walk that is located next to the plant. It offers stunning views of the City and the plant's unique architectural features. State-of-the-art odor elimination technology made the nature walk possible; it will eventually wrap around three sides of the facility. The walk is a popular addition to the community providing recreation and a romantic view. Type 316 was used for handrails, gates and other items along the walk.

The DEP's Frank Giardina stated, "Facility materials reflect the community's desire for a clean, modern and durable presence within the neighborhood. Stainless steel was chosen as one component of a coherent palette of materials used throughout the site as a maintenance-free, glossy and impervious material, thereby retaining the fresh look of the facility for many years. Specifically, Type 316 stainless steel was chosen as a corrosion resistant material for use within a coastal environment."

Hervé Descottes of L'Observatoire International, who has worked on other high profile projects by well-known architects, was commissioned to design illumination for the new facility. At night, a thin ➔

layer of blue light highlights the unique sculptural appearance of the digesters and active areas of the plant, like the loading docks. The pedestrian walkways in the surrounding park are highlighted with blue and yellow light and white lights are used to illuminate the plant's other buildings. The colors were chosen to contrast with the bright orange lights of the city.

"It is thrilling to see form and function beautifully expressed in the structure we are illuminating tonight," said DEP Commissioner Emily Lloyd. "Each evening we will be reminded of the elegant combination of engineering and art in the blue aura of the structure…. This stunning plant demonstrates that with care even the most utilitarian infrastructure can be an exciting and inviting neighbor."

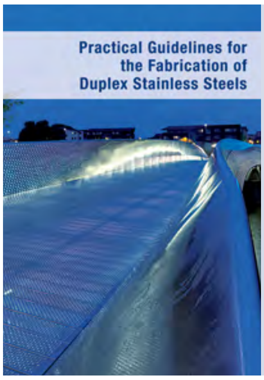
Night time view of the digester "eggs" showing their shroud of thin blue light that highlights their unique sculptural appearance. Photo: NYC Department of Environmental Protection/nyc.gov/DEP

IMOA – 21st annual general meeting, 2009

2009 saw IMOA's first ever visit to Japan for its AGM. It was a popular venue, with delegates from over 80 companies and 19 different countries attending the event in Kobe. In keeping with IMOA tradition, members proved keen to embrace local culture…

Opening the proceedings, Victor Perez, IMOA President, thanked IMOA's Japanese members, led by Taiyo Koko, for generously acting as hosts. In this nation so important for the use of molybdenum, Perez began on the theme of Market Development, telling delegates that it was IMOA's mission to "inspire the world about molybdenum's importance for technology and the quality of life" and "to continue advancing molybdenum as the material of choice for current markets and new applications". He pointed to the Association's considerable past successes in this field and commented that IMOA's significant stature as an independent, expert and non-commercial voice positioned it well to influence market growth and shape the industry's future.

Members sample a little eastern culture and more than a little sake!



IMOA publishes "Practical Guidelines for the Fabrication of Duplex Stainless Steel – Second Edition", with the cooperation of Euro Inox and the International Stainless Steel Forum (ISSF). The second edition has been updated to include new data and new grades (hyper and lean duplex) and incorporates European standards. The brochure is available in English and Chinese and can be downloaded at www.imoa.info and a printed copy may be requested free of charge from info@imoa.info.

Turning to Health, Safety and the Environment, Perez praised the technical committees for their intensive efforts towards timely EU-REACH compliance and other regulatory issues, generating scientifically robust risk assessments about Mo in the environment and in human health. He commented that they "form a virtual Molybdenum University, carrying out necessary, molybdenum-related science on behalf of IMOA and its members". Finally he reminded all present that membership in IMOA is an investment, enabling members to influence outcomes that would be unachievable acting alone.