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2022/2023

ANNUAL REVIEW



IMOA ANNUAL REVIEW

Overview from the Secretary-General

Eva Model
Secretary-General



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Business as usual returns amid on-going challenges

It has been encouraging to see a return to normality over the course of the past year, and the emergence of business as usual following the pandemic. However, against this backdrop, there are still dynamics at play that make the working world a challenging place to navigate, not least the continuing conflict in the Ukraine and the increase in energy prices.

On a brighter note, there are signs of inflation falling in parts of the world which raises consumer confidence. And despite a rollercoaster of fluctuating prices in metal and other commodities, the molybdenum industry has remained resilient and has adapted working practices to increase efficiency where necessary.

Last year, global production fell and use of molybdenum rose and while production and use fell in the first quarter of 2023, SMR predicts that in the next 10 years the total market for molybdenum volume use will increase by 30%, with stainless steel being the main driver for growth.

“During the year the introduction of new networking events were valued by our members.”

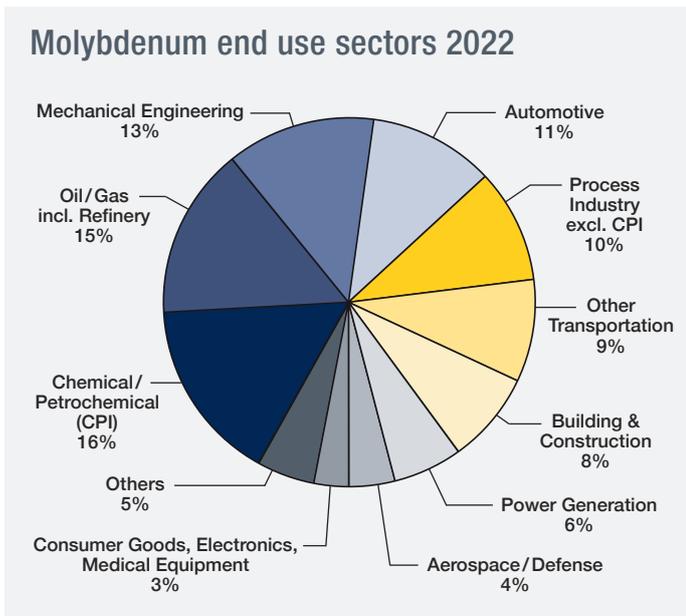


Emerging trends in molybdenum market demand

From a global macroeconomic perspective, the International Monetary Fund reports the baseline forecast is for growth to fall from 3.4% in 2022 to 2.8% in 2023 before settling at 3% in 2024. This may impact molybdenum end uses.

However, compared to many other commodities, molybdenum has a diverse end-use structure. A variety of end uses ensures molybdenum is not as dependent on a few specific industries, making it more stable from a demand perspective.

Most recent SMR 2022 data indicate growth in many sectors, most significantly in aerospace and defense (+26.8%), but also in mechanical engineering (+5.7%), oil and gas (+4.8%) and chemical/petrochemical (+4.5%).



SMR predicts that over the next 10 years, most growth will occur in the chemical and petrochemical industry, including the hydrogen sector, as well as building and construction and power generation due to the demand for sustainable construction and energy.

As discussed in our new videos, IMOAA-authored articles, and the well-attended *In Focus* webinar series, there are many exciting opportunities that will likely lead to increased demand for molybdenum. For example, SMR predicts a 50% growth in molybdenum use by 2032 by the global glass industry as demand for glass melting electrodes increases due to decarbonization and the switch from gas burners to electrically heated furnaces.



And in a new video produced this year, Hardy Mohrbacher highlights the growth of molybdenum-containing special steels in wind power fueled by the increasing size and power output of wind turbines and the expansion of the sector. Analysis suggests that a year's worth of molybdenum production will be required to realize predicted wind turbine capacity until 2050.

There will be continued need for supply to keep pace with demand as existing and new applications increase the use of molybdenum.

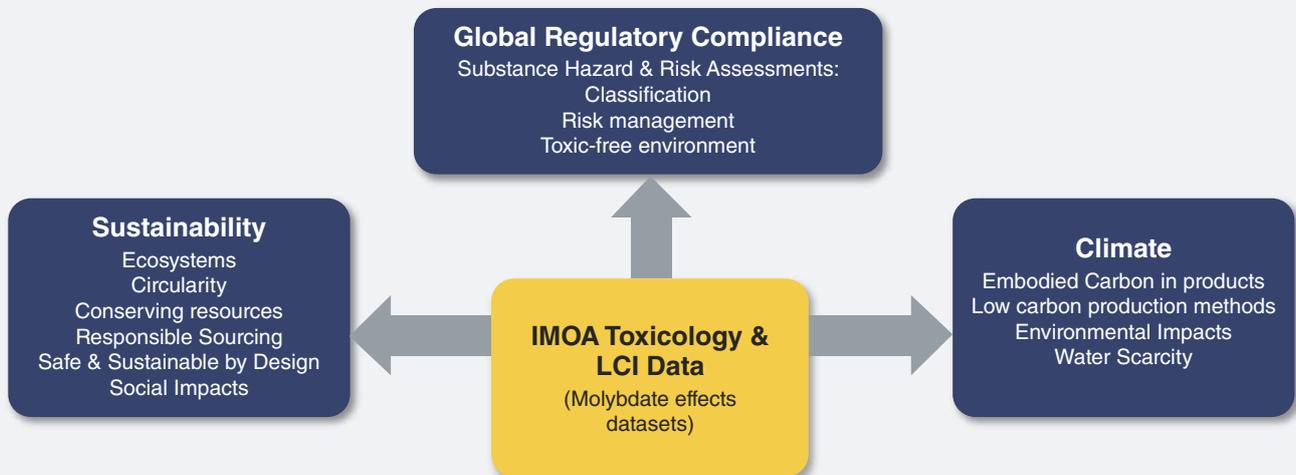
Sustainable working practices

Responsible sourcing remains a key focus for IMOAA. Providing downstream users with transparency of sustainable working practices continues to gather momentum with the implementation of the Molybdenum Mark Pilot.

IMOAA first began collaborating with Copper Mark in 2021 to develop a molybdenum-specific option to demonstrate responsible production practices. This collaboration resulted in the development of the Molybdenum Mark, part of the Copper Mark's assurance framework for responsible production. It is designed to assist producers to meet increasing market demands and growing regulatory requirements relating to responsible sourcing.

I am delighted to report that so far two primary molybdenum mines have been awarded the Molybdenum Mark and 11 by-product mines have been awarded the Molybdenum Mark extension. And since its launch in November 2022, six molybdenum roasters and FeMo converters confirmed participation in the Molybdenum Mark pilot. A further three copper mines with molybdenum as a by-product are awaiting the Molybdenum Mark extension. This positive response signals a firm commitment to responsible sourcing from our producing members.

Data-demands & applicability sectors are significantly increasing, as regulations & planet-earth concerns intensify with climate-change:



Climate change challenges and the goal of carbon neutrality by 2050 drive increasing demand in the mining and metals sector for carbon footprint data. IMOA is actively working to support our member companies with their climate change challenges via engagement in the ICMM Life Cycle Management Working Group, which is currently tasked with carrying out a comprehensive multi-part project entitled, Carbon Footprinting in Metals Life Cycle Assessments.

across the USA, Europe and the Far East; extensive regulatory compliance revisions to Safety Data Sheet templates in multiple languages for use by IMOA and MoCon members; updating the IMOA assaying booklet for molybdenite concentrate; environmental exposure data-gathering projects; and ferromolybdenum hazard classification test work.

Supporting market access

IMOIA's HSE Executive Sandra Carey and the team continue to lead from the front to secure continued access to markets for members, using rigorous scientific evidence to support appropriate regulation setting and chemical management.

The work of IMOA and others to conduct research and build reliable scientific data is invaluable to the submissions and outcomes made to a number of country-specific and regional regulatory authorities. And as the focus on carbon footprinting gathers momentum, reliable LCI data will become increasingly essential.

Our HSE work streams are as diverse as ever. Key efforts include environmental testing, scientific manuscript authoring for regulatory audiences, literature reviews, and technical submissions to enable appropriate safeguarding from exposure in the workplace and the environment.

Particular highlights include six regulatory outreach submissions in as many months, to authorities ranging

SDS Template Updates 2022

	EC Substance Name
1	Molybdenum Sulfide (MoS ₂), roasted
2	Molybdenum Trioxide
3	Molybdenum
4	Disodium Molybdate
5	Diammonium Dimolybdate
6	Hexaammonium Heptamolybdate
7	Tetraammonium Hexamolybdate
8	Ferromolybdenum: [Iron, compound with molybdenum (2:3)] Ferromolybdenum: Molybdenum alloy, base, Mo 60-70, Fe 38-40
9	Slags, Ferromolybdenum
10	Molybdenum Dioxide
11	Calcium Molybdate
12	Diiron Trimolybdenum Dodecaoxide
13	Chemically-Produced Molybdenum Sulfide*
14	Unroasted molybdenite concentrate

* This is not the naturally-occurring Molybdenum Disulfide, which is number 14 in the list.

Market development supporting increase of moly use

IMOA's Market Development team, led by Dr. Nicole Kinsman and supported by Karlee Williston, focuses on expanding uses of molybdenum. This work relies on developing relationships with a variety of manufacturers, universities, industry associations, and government agencies. Therefore, I am pleased to report the return of more in-person conferences, presentations, and meetings this year.

Our work supporting the development of new and improved molybdenum-containing steel grades continues to deliver results. For example, a European steel maker successfully introduced the first 'Super-HSLA' steel to market, developed with IMOA.

I believe that education is instrumental in increasing the use of molybdenum. We educate through an extensive program of webinars and conference presentations. Our role as an American Institute of Architects education provider enables us to present influential courses to architects, fabricators, and structural engineers about the benefits of molybdenum-containing stainless steels.

FREE AIA STAINLESS STEEL WEBINAR SERIES

Nickel INSTITUTE **IMOA**
Know better for a healthier future

Stainless Steel for Sustainable Design

Tuesday, May 16, 2023
1 PM EDT
(SSS22, 1 LU/HSW, Intermediate, Live)

Catherine Houska
International expert on architectural and structural metals

AIA CES Provider G465 International Molybdenum Association (IMOA) sponsored by the Nickel Institute

As a critical global issue, I am particularly passionate about our work with Team Stainless to prevent water leakage. The implementation of stainless flexible service lines as a solution to water loss has delivered significant results in Asia. And now in Italy, service line promotion has led to four utilities planning proof-of-concept trials with hundreds of connections. Upon these trials concluding successfully, there is the potential for large volumes of molybdenum-containing stainless steel use in the future.

“Italian utilities are testing stainless flexible service lines.”



Expanding communication outreach

Our communications program continues to deliver positive results for our members. Our media outreach program disseminates our messaging globally, with ten IMOA-authored articles in trade media reaching an audience of over 90,000. IMOA's global production and usage statistics have seen coverage across a wider range of trade media publications this year, including Stainless Steel World, Iron & Steel Today, Argus Metals, Investing News and Mordor Intelligence.

Many members know that I am a great advocate of using social media to promote our work. We continued to see solid growth this year and positive engagement with a 50% increase in followers on LinkedIn and a 16% increase on WeChat since May 2022.

With video content increasing in popularity, IMOA published a further three topical videos on our YouTube channel with Professor Hardy Mohrbacher discussing molybdenum use in wind turbines, the automotive industry, and molybdenum's role in combating hydrogen embrittlement. A further technical video, featuring Professor Philip Mitchell, on the Molybdenum Cofactor, is available for use with regulatory audiences.



The Role of Molybdenum in Light weighting Vehicles

The IMOA website has a wealth of information. This year, we focused on improving user experience with enhanced navigation, so users can effectively access our high-quality content. A new Knowledge Center also curates information to match users' specific needs.



Membership goes from strength to strength

A personal focus this year was expanding our membership. I am therefore pleased to report five new members being put forward for ratification at the 2023 AGM. This takes our membership to 69 organizations. We welcome our first Australian molybdenum-producing member and first member from the logistics and warehousing service sector. We also developed a value proposition to encourage more members from the recycling sector to join us.

I know our members value networking opportunities, which is why I was delighted to introduce two new in-person member events coinciding with our April 2023 committee meetings: a drinks reception and a tour of a FeMo plant at Stowmarket kindly hosted by Anglo American and Climax Molybdenum respectively. Based on the positive feedback received, we will continue to maximize networking opportunities in the future.

2023/2024 will see the development of IMOA's new strategic plan where we will actively seek input from IMOA's committees and wider membership. This activity will gather pace from September onwards, leading to a strategic planning session with the Executive Committee in April 2024. I look forward to engaging with the membership to ensure that our next strategic plan meets members' ongoing needs.

I remain incredibly grateful for the support of my knowledgeable and experienced IMOA team colleagues: Sandra, Nicole, Jo, Cristina, and Karlee. The immense support of our expert consultants is also of huge value in delivering the work of our Association. I would like to thank the Executive Committee members and those who work tirelessly to support our technical committees for their time and support which is crucial for the successful delivery of our strategic aims. Finally, to you, our members, a big thank you for your continued engagement and support, and please keep your questions and ideas coming!

THIS YEAR'S HIGHLIGHTS

> Value-led benefits see growing global membership

Membership

Existing membership

represents **95%**
of production outside
China, CIS and Mongolia.



69 members including molybdenum producers, converters, traders, steel makers, assaying providers, and a logistics and warehousing service provider.

NEW NETWORKING events well received.

> Securing access to markets with rigorous scientific evidence to support appropriate regulation and chemical management

HSE



Ferromolybdenum hazard classification test work completed for Cu content.

Regulatory engagement template developed to signpost sources of reliable **molybdate toxicology data.**

Molybdenum concentrate **assaying procedure updated & published.**



6 regulatory outreach submissions to authorities ranging across the USA, Europe & the Far East.

MoCon

14 Safety Data Sheet (SDS) templates extensively updated to meet current **EU regulatory compliance requirements.**

Updated SDS/Exposure Scenarios available in multiple languages

on the MoCon & IMO A websites.



MEED project determines molybdenum is **not an Inorganic-Priority Contributing Substance** in water or soil for combined chemical toxicity.

ECHA Assessment of Regulatory Needs concludes **no requirement for immediate further regulatory action** for 11 MoCon substances.

> Promoting the advantages of molybdenum-containing alloys in a range of applications

Market Development

Our webinars and conference contributions reached over

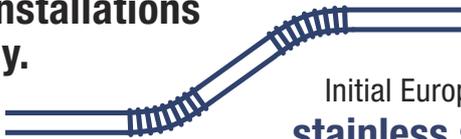
9,000 attendees.



6 building and construction webinars on the IMOA website.



5 Type 316 stainless steel service line **trial installations** in Italy.



Initial European supply chain for **stainless steel service line** established.

IMOA co-developed **'Super-HSLA'** steel introduced to European market.

> Raising awareness of molybdenum's unique properties and sustainability credentials

Communications



Website navigation and structure ensures ease of access for users.



Knowledge Center launched to curate IMOA web content for users.



1,250 followers 50% increase since May 2022.



4,366 followers 16% increase since May 2022.

10 IMOA-authored articles in trade media publications reached an audience of over **90,000.**

4 NEW VIDEOS CREATED

with IMOA experts talking about the **benefits of molybdenum.**



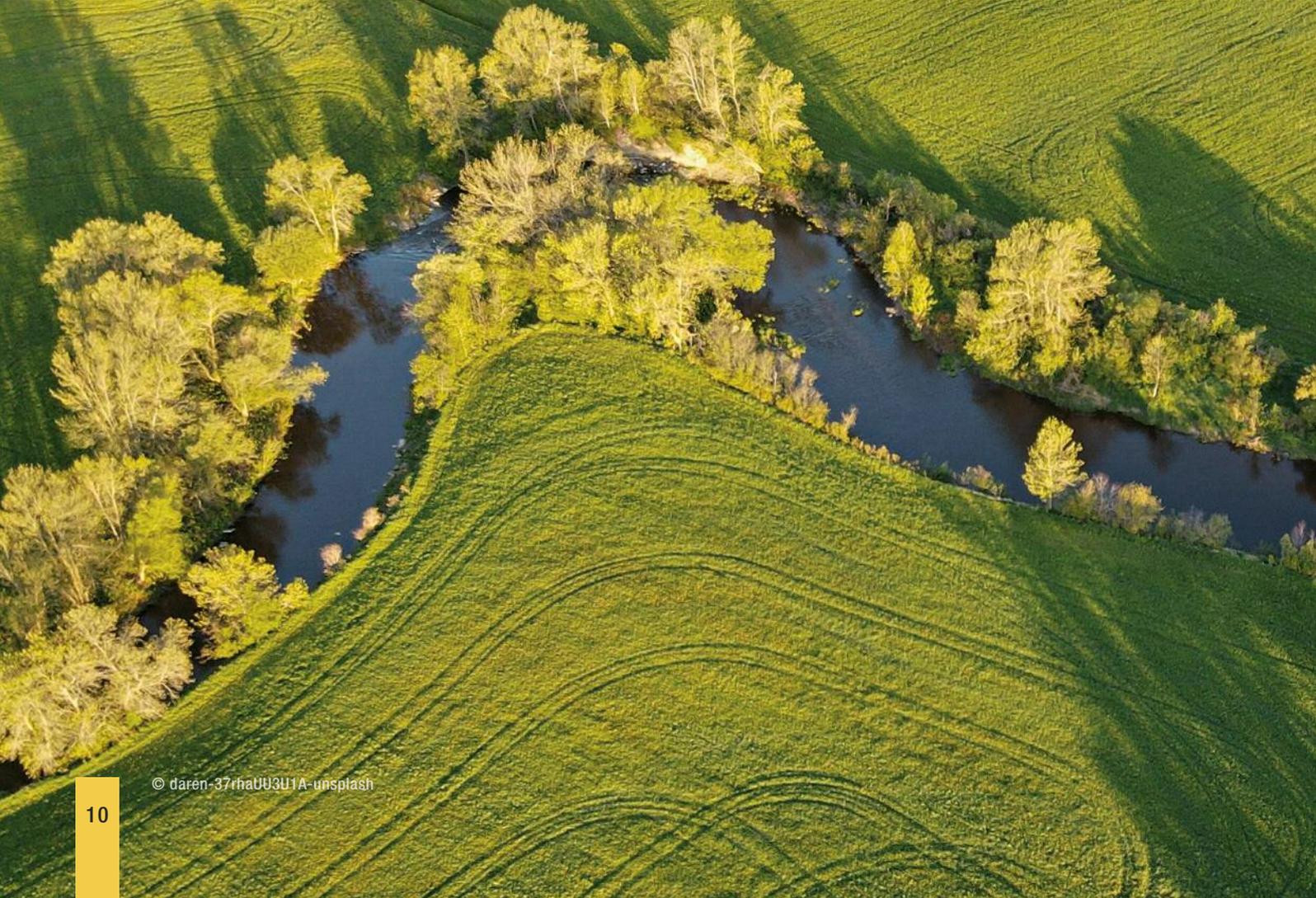


HEALTH, SAFETY AND ENVIRONMENT

Key Activities and Achievements in 2022/2023



Sandra Carey
IMO HSE Executive



© daren-37rhaUU3U1A-unsplash

IMOA HSE Committee activities

Appropriate regulation setting, compliance with chemical management legislation, and excellence in product stewardship remain the cornerstones of our work to maintain continued access to markets for the IMOA membership. We strive to achieve this amidst a landscape of evermore stringent industrial regulations, and the proliferation of new policies and political ambitions responding to ongoing global geo-political changes.

Ferromolybdenum (FeMo)

EU changes in the environmental reference value for copper metal, lowered recently to 11 µg Cu/L for acute exposure and just 4 µg Cu/L for chronic, can potentially adversely impact the hazard classification profile of products containing Cu metal. This remains the case even when present as an impurity, as in ferromolybdenum. These very low threshold trigger values for Cu hazard classification as an environmental toxicant, coupled with the fact that RMC feedstocks for ferromolybdenum production often contain some minor copper content, prompted IMOA to take action in early 2023.

“Appropriate regulation, legislative compliance and product stewardship are our continued focus.”



We assessed the potential environmental hazard classification threat by testing to determine the extent of Cu bioavailability from ferromolybdenum, in both its massive and powder forms. The results from the Transformation Dissolution Protocol 24-hour screening test, using several representative samples from industry, gave the following outcomes:

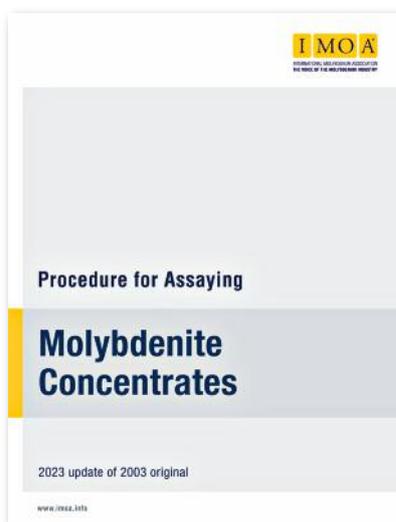
Massive FeMo (> 1mm)	not classified for the acute/chronic endpoints
FeMo-powder containing < 0.25% Cu	not classified for the acute/chronic endpoints
FeMo-powder containing 0.25%–2.5% Cu	classified Aquatic Chronic Category 3*

*A full 28-day TdP test may remove that hazard classification

In today's world where toxicology 'green credentials' increasingly influence regulatory and operational impacts, these are welcome findings.

IMOA assaying booklet update

Twenty years have elapsed since IMOA published its first edition booklet detailing a wet chemical methodology to assay molybdenite concentrate, for use both routinely by industry and for dispute resolution. The updated 2023 version makes no changes to the gravimetric methodology which is the core of the publication, but contains an acknowledgement that nowadays analysis by X-ray fluorescence (XRF) is a widespread and equally acceptable methodology, provided the device is appropriately calibrated. The project drew on IMOA members' relevant technical expertise, and was co-chaired by expert representatives from two independent assaying companies.



Regulatory outreach

The combination of initiatives by IMOA, scientific academia and regulatory authorities over the last 15 years has generated a sizable body of reliable scientific data about molybdenum in human health and the environment. IMOA recently developed this data into a regulatory engagement template that succinctly signposts interested parties to sources of reliable molybdate toxicology data. The engagement template makes it easier to identify and access credible data sources to facilitate the goal of hazard and risk assessment based on best available science. The fact, for example, that the US Integrated Risk Information System (IRIS) database on molybdenum remains untouched since it was first created in 1992, evidences why such a signposting template is useful and supportive in the early stages of IMOA's regulatory outreach activities. The table below illustrates its recent frequent use:

Competent Authorities in:	Issue:	Date:
USA-ILLINOIS	Introduction of Mo water quality standard	September 2022
JAPAN	Data call-in on 5 molybdenum substances inc. Mo Trioxide	December 2022
USA-WISCONSIN	Review of existing groundwater Mo water quality standard	December 2022
USA-NEW YORK	Toxic Chemicals in Children's Products	March 2023
EUROPEAN UNION	Assessment of Regulatory Needs on 11 molybdenum substances (MoCon)	February 2023
DENMARK	Introduction of Mo water quality standard	February 2023

Below is some further brief detail about the diverse reasons prompting IMOA's regulatory outreach:

Japan: In response to a data call-in by the Japanese National Institute of Technology and Evaluation for molybdenum trioxide, sodium molybdate, ammonium dimolybdate, ammonium heptamolybdate and molybdenum. Their goal is the data-use in a future review of existing Japan NITE GHS hazard classification assessments and conclusions for these substances. Japan NITE hazard classifications are influential in the Asia-Pacific region, where several nations are gearing up their chemicals management legislation, so activities that offer an opportunity to enhance the global alignment of hazard classifications are consistently of interest to IMOA.

The New York Toxic Chemicals in Children's Product Rule (NY TCCP): as of 2023 is in the process of determining which chemicals should be subject to that legislation. In addition to data-source signposting, IMOA's submission also shared information about the delisting of molybdenum substances in several US states after

similar processes in Washington, Oregon and Minnesota. (IMOA engaged in regulatory outreach with each of those states between 2014 and 2020). It is worth noting that an earlier unsuccessful NY state bid to legislate on this topic around 2015 had proposed molybdenum as a 'priority substance' for stringent regulatory measures. IMOA submitted its rationale against such a ranking at that time.

The current legislation is proposing molybdenum and compounds in the lesser category known as 'chemicals of concern', whereas IMOA is requesting substance delisting with the exception of molybdenum trioxide and RMC which are hazard classified as Category 2 Carcinogens.

Denmark: IMOA initially reached out to the Danish competent authorities in 2021 after they announced their intention to review their existing water quality standards for molybdenum. The current standards are 20 µg Mo/L for drinking water, 67 µg Mo/L for freshwater, and 6.7 µg Mo/L for marine waters. More recently in February 2023, IMOA proactively signposted available molybdate datasets and assessments for their consideration when conducting their future review.

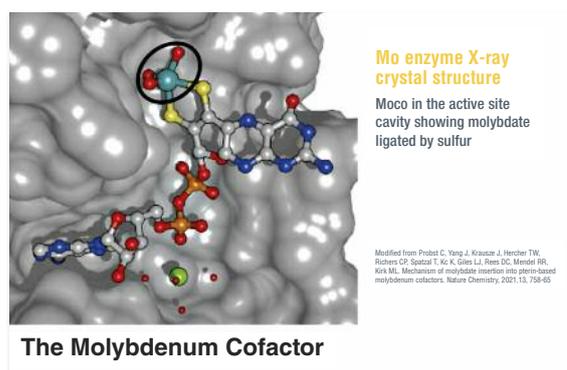
Illinois and Wisconsin US states: In 2023, Illinois is proposing to introduce a groundwater quality standard for molybdenum of just 19 µg Mo/L, whereas Wisconsin in 2022 was reviewing their existing standard of 40 µg Mo/L, in place since 2006. IMOA outreach has taken place several times in both states, ranging from data-source signposting, to providing verbal testimony and written submissions that the available sound science supports higher values. The Wisconsin 10th cycle revised recommendations were not approved by the Wisconsin Natural Resources Board, so all substance values remain unchanged for the time being.

Illinois is still in the review process, and three written submissions by IMOA include the request that any ruling on molybdenum be deferred until such time as the substance can be assessed on best available science instead of the vastly outdated 1992 US IRIS database entry for molybdenum. US Environmental Protection Agency (EPA) data hierarchy rules require referring to US IRIS as a primary data-source when assessing molybdenum in human health. This directive completely overlooks the availability of more recent assessments by other US Government agencies, such as US Agency for Toxic Substances & Disease Registry (ATSDR), who produced the Toxicological Profile for Molybdenum in 2020. IMOA contributed data to that US ATSDR initiative.

EU: IMOA's submission to the European Chemicals Agency in relation to their Assessment of Regulatory Needs process for molybdenum compounds is summarized in the Molybdenum Consortium section of this Review (see page 14).

Moco video

In the field of regulatory outreach for technical audiences, IMOA has produced a video about the molybdenum cofactor (Moco) as part of our regulatory outreach work. Aimed at a technical audience, the video summarizes recent important findings by scientific experts in academia. Likewise, it explains what Moco is; how it is formed within certain enzymes; why it is essential for the proper functioning of certain enzymes in humans, and why copper is neither needed nor displaced in the Moco synthesis process, in contrast to what had been suggested in some earlier scientific literature.



Looking ahead

We continue to service data-sharing opportunities for national REACH-type hazard and risk assessment programs. Requests from Korea and Türkiye are the current focus, with India and UK in prospect.

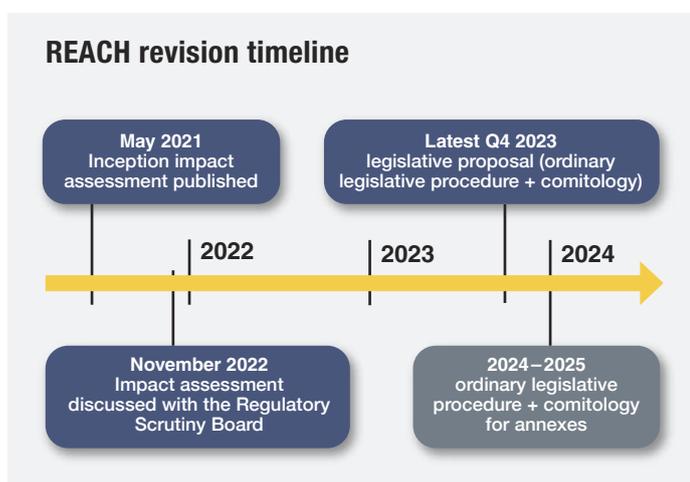
Product carbon footprint data requests are trending upwards across supply chains as industries work to achieve carbon neutrality by 2050. These requests are a compelling driver for IMOA to update its Life Cycle Inventory datasets for molybdenum products for metallurgical applications, i.e. RMC in powder and briquette forms, and ferromolybdenum. The updating process will start during Summer 2023.

IMOA is also currently working to support its member companies with their carbon footprint (CF) challenges by engaging in the 'Carbon Footprinting in Metals Life Cycle Assessments' multi-metals project. Led by the International Council on Mining and Metals, where IMOA is an Association member, the deliverables will be metals-specific, harmonized guidance on CF calculations and Life Cycle Assessment methodologies.

The HSE and MoCon activities featured in this section and the next are both managed and driven forward by the corporate members of the HSE Committee and MoCon Technical Working Group, the HSE Executive and our invaluable team of technical service providers. We are immensely grateful for their continuing dedication and professionalism.

EU REACH Molybdenum Consortium (MoCon)

Following public consultation, the European Commission and the European Chemicals Agency (ECHA) are both in the process of finalizing the revised content of the EU REACH Regulation No. 1907/2006. The legislative proposal to the EU Parliament is expected during the second half of 2023. In scope for existing and future registrants are aspects such as significantly increasing the mandatory data requirements for registration compliance, to include endocrine disruption, neuro and immunotoxicity. Introducing non-animal New Approach Methodologies (NAMs) is another EU regulatory authorities' goal, which is a welcome development provided the NAMs are sufficiently validated and there is appropriate laboratory capacity and expertise.



Endocrine Disruption (ED)

This hazard class was introduced into EU chemicals management legislation when it was formally adopted in March 2023 into the updated EU CLP Regulation (Classification, Labelling and Packaging), and likewise it will feature in the upcoming revised EU REACH Regulation. Recent MoCon focus on this topic includes authoring a manuscript entitled 'Molybdenum is not a risk factor for changes in serum testosterone' which was recently accepted for peer-reviewed publication in the Health & Environmental Risk Assessment Journal. The article is a considered response to some earlier existing published literature. The authors explain why evaluating and placing earlier published statistical exercises within the real-life context of biological plausibility supports the absence of causal links between molybdenum and serum testosterone levels in men.

IMO/MoCon also recently initiated a wider-scoped project to meet EU requirements, to assess all relevant published

literature on molybdenum in relation to endocrine disruption (60+ publications), using an evaluation and scoring methodology prescribed by EU authorities. The outcome will be an important factor in determining the extent of the future ED work to be conducted by MoCon for REACH compliance purposes.

The critical distinction between normal endocrine modulation activity and adverse endocrine disruption, especially for bio-essential trace elements like molybdenum, zinc and iron, is the topic of an upcoming peer-reviewed publication in 2023. Several metal commodity associations, including IMO, considered it imperative for this critical distinction to be highlighted, and therefore supported this awareness-raising initiative for an environment-focused publication.

Assessment of Regulatory Needs (ARN)

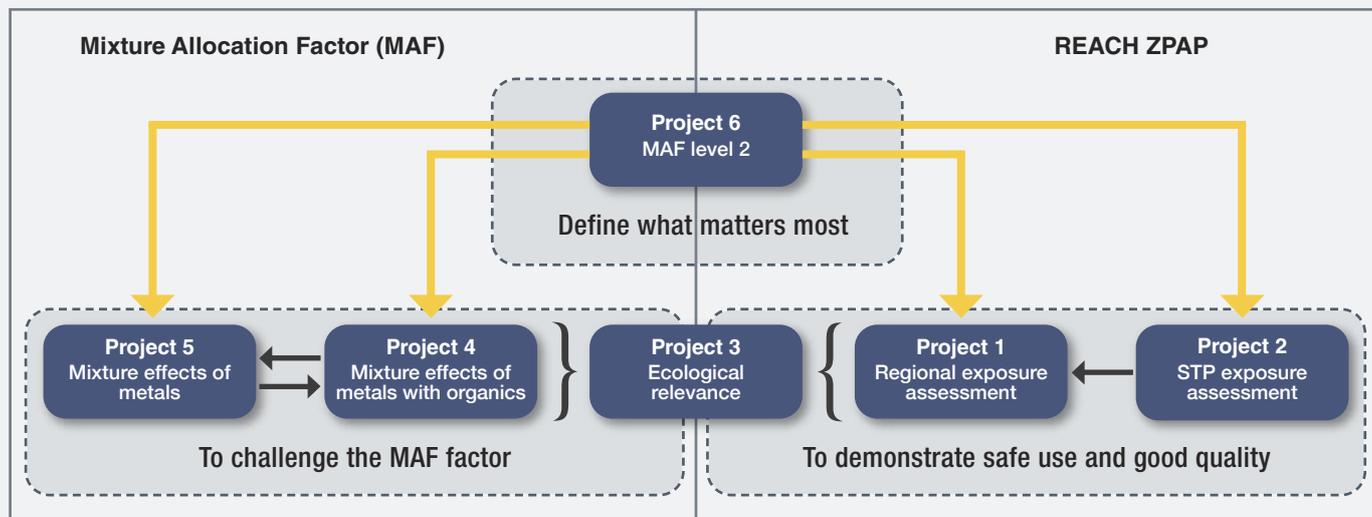
ECHA has introduced a so-called ARN 'voluntary mechanism' in order to meet its political commitment to screen all EU REACH registered substances (ca. 23,000 across ca. 102,500 registrations) by 2027. The voluntary mechanism groups together chemical substances it considers sufficiently structurally similar, to assess them for the likelihood of requiring further ECHA regulatory measures that seek to ensure safe handling and use, or even substance phase-out for most harmful chemicals.

A group of 'simple molybdenum compounds' that included 11 of the 12 substances in the MoCon portfolio, and other non-MoCon molybdenum substances, were selected by ECHA and went through the ARN process in 2022, with the results published in September that year. The overall key conclusion was that no *immediate* future regulatory action was necessary. This very positive key outcome is however tempered by ECHA's further action to put the 11 MoCon dossiers through their Comprehensive Compliance Check (CCH) process. This further in-depth scrutiny of the technical dossiers may result in further MoCon action being required by ECHA. There is no prescribed timeframe by when the CCH must be completed. The process started in January 2023, at which point MoCon made a technical submission to ECHA, intended to provide some helpful clarifications about points raised by the regulatory authority in its ARN report. The CCH outcome will be the trigger for further action by MoCon's Technical Working Group to respond to and conduct the work to secure regulatory compliance with any ECHA Draft Decision that may arise.

MEED Project

Comprising six data-gathering and analysis sub-projects necessary for continuing compliance with REACH environmental exposure assessments, the Metals Environmental Data-Gathering (MEED) initiative continues apace from its 2022 start. Twenty-four metals Consortia

MEED project interlinkages and scope of application



are working together to generate and risk assess the resulting extended datasets, ensuring cost and resource efficiencies for this exercise.

Project 1, Regional Exposure Assessment, required organizing and gathering molybdenum measurements in the aquatic and sediment environmental compartments. Using this measured data in models to predict environmental concentrations (PEC) shows a regional reduction over time of molybdate levels for both compartments. The ambient PEC_{regional} has been reduced by almost a factor of two, to a value of 1.29 µg Mo/L from 2.30 µg Mo/L in 2010, indicating that industrial activity is not causing levels of molybdate to increase in the aquatic environment. The new, lower ambient PEC_{regional} for water, sediment and soil will be included in a future update of the MoCon technical dossiers and in any relevant Exposure Scenarios.

ECHA will introduce a concept renamed in 2023 as the Mixture Allocation Factor, for use as a risk management measure (formerly Mixture Assessment Factor). Its purpose is to account for uncertainty in relation to the toxicity of combinations of chemicals, both in the environment and for human health. The default MAF value is now proposed as 5, instead of the earlier indications of 10 or even 100. The outcomes of MEED sub-projects 6 and 5 have already determined that molybdenum is unlikely to be an Inorganic-Priority Contributing Substance (i-PCS) in either the water or soil compartments. i-PCSs are those with the greatest potential for unintended co-occurrence and combination with other chemical substances, and hence potential combined toxic effects. The lower molybdenum measurements in the environment, the non i-PCS status of molybdate, and the MAF default of 5 instead of 10 or higher, are all welcome developments.

Safety Data Sheet Templates

Linked to EU REACH is Regulation 878/2020, that prescribes the contents of Safety Data Sheets. Achieving compliance with this current EU legislation by the 1 January 2023 deadline for MoCon hazardous substances (Mo Trioxide and RMC), was the compelling driver behind the 2022 MoCon project to update its existing set of SDS templates. The updated versions were generated and provided in English to all MoCon co-registrants and Letter of Access holders in advance of the compliance deadline.

REACH mandates that SDS and Exposure Scenarios (eSDS) for hazardous substances shall be available in the language of the EU country where the substance is placed on the market. To service this requirement, MoCon has to-date generated eSDS templates in ten languages for RMC, and eight for Mo Trioxide, all available to download from either the Molybdenum Consortium or the IMOIA websites. MoCon SDS templates for non-hazardous substances are available in English and a smaller language selection. Given the global relevance of Safety Data Sheets, MoCon and IMOIA shared the costs of this project, and the full set of templates was extended to also include Ferromolybdenum and Unroasted Molybdenite Concentrates.

Looking ahead

The outcome of the Comprehensive Compliance Checks (CCHs) linked to the Assessment of Regulatory Needs will be a watershed moment that determines the size and nature of the workload going forward for the Molybdenum Consortium. Work plans and funding will then be put in place to service any ECHA Draft Decisions arising as a result of those CCHs.



MARKET DEVELOPMENT

Key Activities and Achievements in 2022/2023



Dr Nicole Kinsman
IMO Technical Director



This year was characterized by a welcome return to in-person events. Face-to-face meetings with people, whether in small groups or at large conferences, feel more valuable than ever. We work with a variety of manufacturers, universities, industry associations, and government agencies. By cooperating with these institutions, IMOA amplifies its efforts in promoting the use of molybdenum-containing materials across diversified sectors. In total, we reached around 9,500 people via 27 conference presentations, 23 webinars, and a university workshop.

Carbon Steels

Professor Hardy Mohrbacher resumed both visiting steel producers and attending in-person conferences, with a focus on Europe and to a lesser extent, North America. He engaged in development activities, presentations, and discussions with experts from leading steel companies, intermediate steel processors, and end users. The topics covered a range of applications, including automotive, energy and structural uses of molybdenum-containing alloys.

Steel development

A leading European steel maker successfully introduced the first 'Super-HSLA' (high strength low alloy) steel grades into the market. The steels for thin cold rolled and galvanized sheet in automotive body applications in the strength range of 700–800 MPa were developed in cooperation with IMOA. Molybdenum alloying not only enables very high strength levels but also significantly improves the process robustness during the annealing stage after cold rolling.

“Our steel research is translating into new steels with improved performance.”



These steels can be produced using standard equipment available in any cold rolling mill. The combination of strength and local formability is unique and comparable to the benchmark set by hot rolled Nano-HiTen steel, which is notoriously challenging to produce. Ongoing research is further improving our understanding of the detailed metallurgical effects of molybdenum, with results being shared at conferences and published in scientific journals.



“Molybdenum helps reduce emissions in cars of all sizes.”

In a separate project, the development of hot rolled, direct-quenched steel grades in the 1000–1200 MPa strength range, the base alloy was modified to keep molybdenum additions between 0.15 and 0.30%. The researchers found that higher molybdenum additions within this range achieved better properties. A reduced carbon content is expected to improve the formability.

The beneficial effect of molybdenum alloying in press hardening steels (PHS) was further supported in both a 1500 MPa heavy gauge grade and in PHS with higher strength (1800–2000 MPa). Market-leading steelmakers increasingly choose molybdenum alloying for the higher strength PHS due to its improved hydrogen embrittlement resistance, as previously established in the IMOA - Okayama project. Additional fundamental results are being gathered to further consolidate the argumentation.

Visits to two major North American steelmakers included discussions on the development of heavy gauge pipe steel and ultra-high strength HSLA steels for automotive applications. Respective production trials are being supported by on-demand consulting.

Presentations and publications

Hardy’s seminars and conference presentations reached an audience of over 1,800 participants. Topics included fatigue performance results of welded heavy-gauge PHS for trucking components, Super-HSLA steels for automotive body applications, and PHS with improved hydrogen resistance. Sustainability-related topics were addressed at two conferences covering both renewable power generation and automotive steels. The conferences were held in Germany, Spain, Italy, and the US. The HSLA 2022 Conference held in China was attended online, with two presentations and a session chair role.

The various carbon steel achievements and developments were published through eight articles in peer-reviewed journals and proceedings. Furthermore, three videos were produced in cooperation with Stratia: *The Role of Molybdenum in Lightweighting Vehicles*; *The Role of Molybdenum in Combatting Hydrogen Embrittlement in Ultra-high Strength Steels*; and *The Role of Molybdenum in Wind Power Generation*.



Research projects

In collaboration with Ceit, Dillinger Hüttenwerke, and the Nickel Institute (NI), IMOA initiated a project to develop a 690 MPa steel grade for thick plates. The first set of four alloy compositions demonstrated the crucial role of molybdenum in achieving good hardenability. A second set of alloy concepts, building on the molybdenum-boron synergy effect, showed even better hardenability. These alloys will be the preferred approach for the targeted heavy plate gauges of 80 mm and more. Notably, an alloy containing 0.5% Mo, 1.0% Ni and 20 ppm B exhibited nearly constant hardenability regardless of the cooling rates applied in the production line. Additionally, we started publishing the available project results through two conference contributions.

Architecture, Building and Construction (ABC)

IMOA consultant Catherine Houska worked with several architectural firms, associations, standards committees, and government agencies this year to promote molybdenum-containing stainless steels in architecture, building, and construction. She reached over 1,600 people via live webinars and conference presentations.

For instance, Catherine gave the keynote speech at the first Stainless Steel World Asia conference (2022) in Singapore, which stressed the importance of structural stainless steel in resilient design. Additionally, she gave a hybrid presentation to the Singapore Institute of Architects, which drew 228 attendees. Throughout the year, IMOA and the NI have also jointly sponsored Catherine in webinars and live presentations in both India and Malaysia. Most of these presentations included sustainability or resilience content and highlighted relevant structural design specifications.

Webinars with the American Institute of Architects (AIA)

IMOA is an education provider for AIA. Our ability to present AIA accredited courses to architects, fabricators, and structural engineers about the benefits of molybdenum-containing stainless steels is critical for promoting greater adoption. A notable example of our impactful outreach is Catherine's Architectural Record webinar, which drew 750 attendees last fall and was jointly sponsored with the Ornamental Metals Institute of New York (OMINY) and the NI.

We are also delivering our own Zoom and LinkedIn webinars, jointly organized with the NI, offering attendees the opportunity to earn AIA continuing education credits.

Two prominent individual chapters of the AIA requested custom sessions, which were presented in early 2023. Recordings of Catherine's webinars are available on IMOA's website on the AIA webinar page:

- *Introduction to stainless steel finish and alloy specification*
- *New specifications for stainless steel structural design*
- *Planning for disaster – stainless steel resilient design*
- *Stainless steel for sustainable design*
- *Stainless steel selection to avoid corrosion*
- *Sunscreen and shade design in stainless steel*



Alloy and stainless steel promotion in China

China is the world's largest steel producer by far: its 2022 crude steel output exceeded one billion tonnes. The country's global market share in Q1 2023 was 57%, thanks to 6.1% growth over Q4 2022. However, molybdenum use per tonne of steel is lower in China than other parts of the world. Therefore, we focus on promoting the benefits of molybdenum alloying to major steelmakers, trade associations, and educational institutions.

This work is led by IMOA consultant, Dr Gaetano Ronchi. Despite travel restrictions, our proactive local team, including Chen Chao, Chen Wenlei, Fabio Ries, and Wu Yongkang (John), participated in a variety of events. Our webinars and presentations, which support the development of stronger, lighter, and thinner designs with superior welding properties and corrosion resistance, are well aligned with the technological ambitions of the Chinese steel industry.



Carbon and stainless steel events

Following the success of the first Molybdenum and Steel Symposium held in 2018 in Shanghai, IMOA member Jinduicheng (JDC) hosted two successive symposia in Xian in 2019 and Jilin City in 2021, with IMOA as a co-organizer. Given the popularity of these events, we are jointly working on planning the next conference. Additionally, we gave presentations at industry events discussing the role of molybdenum on the mechanisms of hydrogen embrittlement in ultra-high strength steels and developments in the high-performance stainless steels industry.



Architecture, building, and construction

Our ABC activities continue to support Chinese architects, designers, and curtain wall contractors in several building development projects in coastal cities such as Shanghai and China's greater bay area (Shenzhen, Hong Kong, Zhuhai, Macau). We participated in three important industry conferences, the Second Technical Forum on Stainless Steel in Modern Building and Construction in June of 2022, the 5th Seminar on the Application of Stainless Steel in Architecture and Curtain Walls in February 2023, and the Third National Technology Symposium on Stainless Steel Structures in May 2023. Nancy Baddoo of the Steel Construction Institute (SCI) delivered the keynote lecture at the latter to an audience of 250 delegates.

Secondary water systems

In May of 2023, the NI, Donghua University and the Jiangsu Urban Water Association jointly organized the 4th International Forum on Stainless Steel Application Technology in the Water Industry in Nanjing. Fabio discussed the advantages of molybdenum-containing stainless steel in secondary water systems.

Chinese website

Visit IMOA's Chinese website for dozens of brochures and MolyReview issues, translated by subject-matter-expert, Chen Wenlei www.imoa-cn.info and our WeChat channel, which has over 4,600 followers.

Team Stainless

Stainless steel service lines

Water leakage prevention must be improved worldwide to meet increasing demand for clean water. Some areas lose as much as 70% of their treated water during distribution. Often most is lost on the last few meters of its journey.

Although a variety of water distribution materials are used around the world, low-cost plastic pipes HDPE (High density polyethylene) and PEX (cross-linked polyethylene) dominate most markets. However, the upfront low material costs of plastic pipes are associated with greater leakage, more repair cases, and a shorter service life compared to a durable material like stainless steel.

The development of stainless steel tubing for the management of drinking water distribution networks dates to Japan in the late 1960s. Driven by frequent strong earthquakes, Tokyo's water authority decided to focus exclusively on metal pipes and slip-resistant joints. Today, Tokyo and 35 additional cities across Asia use stainless steel service lines to connect water mains running under the street to individual buildings. In Tokyo, implementing Type 316 stainless steel service lines across the board led to a 75% reduction in leakage and even greater reductions in repair cases.

In Italy, severe droughts in recent years highlighted the vulnerabilities of its ageing water distribution system. Stainless steel service connections provide a solution for improving the country's water infrastructure. Led by Gaetano Ronchi, our strategy to inform and influence Italian utilities and others to install Type 316 stainless steel service lines includes the following steps: validating the efficacy of the technology to utilities; establishing a viable supply chain; installing proof-of-concept (POC) trials at small-medium water utilities; and leveraging successful POCs to approach larger utilities.

As of May 2023, an initial supply chain is in place for POC trials across Italy. Four utilities are planning POC trials with hundreds of connections. These trials require several months of planning, but once they are in place, there will be a strong case to advance to adoption at larger utilities. Additionally, two utilities in Australia are planning trials for 2023.

Team Stainless is also working with the Taipei Water Department (TWD) in Taiwan to expound their documented success with stainless steel service lines. The utility decided to trial stainless steel water lines following a severe drought in 2002 that led to several weeks of intermittent supply. In the 15 years since initiating the installation of stainless steel tubing, TWD recorded a steady reduction in both leaks and repair cases. The drop in leakage was so great that the authority was able to significantly increase the amount of surplus water sold to its neighboring utility. TWD has also seen a 36% reduction in energy usage since 2006.

Structural market development

Nancy Baddoo and Francisco Meza of the SCI in the UK, along with Catherine Houska in the US, are actively promoting the use of two important American Institute of Steel Construction structural standards, ANSI/AISC 370-21 *Specification for Structural Stainless Steel Buildings* and ANSI/AISC 313-21 *Code of Standard Practice for Structural Stainless Steel Buildings*, both issued in 2022.



“Duplex stainless steel footbridges require minimal maintenance.”



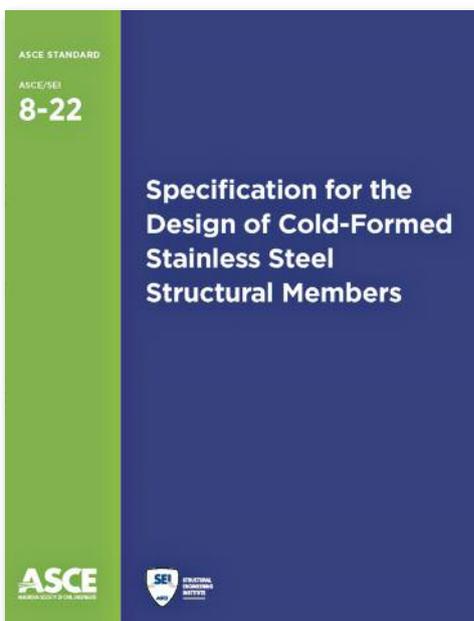
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Nancy gave a talk about using these new publications called ‘Speeding up design with stainless steel’ to a large audience both live and virtual, in April 2023 at the North American Steel Construction Conference (NASCC) in Charlotte, North Carolina. The conference session was recorded and is available in the [AISC Learning Portal](#). An article discussing the Design Guide 27 was also published in the widely circulated magazine *Modern Steel Construction* in September 2022.

Updated standard for cold-formed structural steel members

SCI and Catherine both contributed to developing new design rules for a significantly expanded and revised edition of American Society of Civil Engineers’ SEI/ASCE 8 *Specification for the Design of Cold-Formed Stainless Steel Structural Members*. This revised specification now includes the addition of duplex and higher alloyed austenitic stainless steels and was published in May 2023. The new standard serves as a guide for designing cold-formed load-bearing applications in building-type structures, as well as transit vehicle frames. An introduction to the revised standard was given at the SEI/ASCE Structures Congress in New Orleans in the US during the same month.



Advancing duplex stainless steel vehicular bridges

As part of an initiative with the American Association of State Highway and Transportation Officials (AASHTO) and AISC’s National Steel Bridge Alliance (NSBA), SCI authored a comprehensive design specification for duplex stainless steel bridge girders. This draft specification was presented at a meeting of US Department of Transport Engineers in October 2022. The broader plan is to prepare a series of five specifications covering materials, design, welding, fabrication, and construction for duplex stainless steel in highway, pedestrian, and rail bridges in the US by 2025.

Duplex stainless steel is an excellent choice for bridge structures due to its high strength, which reduces weight, and its great corrosion resistance, which minimizes maintenance. Maintaining bridges is often very costly, especially those spanning roadways or water, or those in coastal areas. Therefore, the ability to reduce upkeep with duplex stainless steel can significantly lower ongoing expenses throughout the life of a structure. Although written for the US market, the specifications are broadly applicable to other regions.

International Experts Seminar

In September 2022, SCI organized the Sixth Stainless Steel in Structures International Experts Seminar in London. Researchers from around the world gathered both in-person and online to share recent advances in their structural stainless steel research. Developments in design codes from different regions were shared alongside presentations of recent stainless steel structural projects, showcasing the practical implementation of research findings. The proceedings of the seminar will be published in a peer-reviewed special issue of the international *Journal of Constructional Steel Research* later in 2023.

Sustainable stainless steel

Catherine Houska serves as chair of the American Society for Testing and Materials (ASTM) E60.80 Committee on General Sustainability Standards, which released two crucial publications in 2022: the first an international standard to define resilient design and a standard on recycling calculations in life cycle assessment (LCA). As a result of her efforts, ASCE and the US Federal Highway Administration are working with the committee to develop three resilient culverts standards.

These standards will be the first in a suite of road infrastructure publications focused on both sustainable and resilient design. The development of international standards within ASTM complements Catherine’s and SCI’s efforts in structural design specifications described above. Molybdenum-containing alloys provide the longevity and corrosion resistance needed for sustainable design combined with the fire, blast, impact, and seismic resistance needed for resilient design.

“Stainless steel profiles enable slender and elegant structures.”



Paddington



FINANCIAL REPORT 2022

Income and expenditure account

For the year ended 31 December 2022

IMOA/Molybdenum Consortium

	2022 \$	2021 \$
Turnover	2,922,342	3,445,287
Operating and administrative expenses	2,744,708	2,749,916
Operating surplus/(deficit)	177,634	695,371
Other interest receivable and similar income	18,854	1,336
Surplus/(deficit) on ordinary activities before taxation	196,488	696,707
Tax on surplus/(deficit) on ordinary activities	8,366	8,690
Surplus/(deficit) on ordinary activities after taxation	188,122	688,017

Balance sheet

For the year ended 31 December 2022

IMOA/Molybdenum Consortium

	2022		2021
	\$	\$	\$
Fixed assets			
Tangible assets		0	0
Current assets			
Debtors	127,235		161,212
Cash at bank and in hand	5,285,593		4,985,818
	5,412,828		5,147,030
Creditors – amounts falling due within one year	(430,163)		(352,486)
Net current assets		4,982,666	4,794,544
Total assets less current liabilities		4,982,666	4,794,544
Reserves			
Profit and loss account		4,982,666	4,794,544
Accumulated funds		4,982,666	4,794,544

Financial commentary

The 2022 audited accounts presented here are consolidated figures for IMOA and the Molybdenum Consortium and were approved by members in June 2023. Income from subscriptions and other revenue amounted to US\$2,922,342. After expenses of US\$2,744,708 a surplus (after taxation) of US\$188,122 was carried forward bringing the combined accumulated funds to US\$4,982,666. Of this, US\$4,477,542 was attributed to IMOA and US\$505,124 to the Consortium. In the case of IMOA, below-budget expenditure, largely due to a phased return to travel in line with Covid-19 pandemic restrictions easing and also favorable GBP and Euro exchange rates to the US\$ during the second half

of 2022, resulted in a surplus accruing to the reserves, maintaining the accumulated funds in line with the Executive Committee's objective of holding one year's expenditure in reserves.

The funding call to Consortium members and Letter of Access holders mandated by the Molybdenum Consortium Steering Committee in 2020, raised further funds in 2022, in addition to License to Use and Letter of Access income which in total raised approximately US\$83,900. The Molybdenum Consortium reserves will contribute to funding the Consortium's essential activities around standard information and maintaining dossier compliance.

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* Member to be ratified at the 2023 AGM

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