

I M O A[®]

INTERNATIONAL MOLYBDENUM ASSOCIATION
THE VOICE OF THE MOLYBDENUM INDUSTRY



IMOA Annual Review 2017/2018

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IMO A Annual Review

Overview from the Secretary-General



Tim Outteridge
Secretary-General

As the independent voice of the molybdenum industry, IMOA is committed to delivering value for our members and wider stakeholders. Our Annual Review summarizes the developments and key milestones achieved during the past year through the work of our committees, staff and consultants.

Protecting our access to markets

An important part of our work is promoting evidence-based regulation, engaging with authorities and commissioning research on the effects of molybdenum on human health and the environment. The Health, Safety and Environment (HSE) Committee continued to work hard on a number of key issues.

In the U.S., a notable achievement was the successful removal of molybdenum and molybdenum compounds from the List of Chemicals of High Concern to Children (CHCC) in Washington State's Children's Product Safety Rule. This is a significant outcome for everybody in the industry as it addresses misconceptions held by some authorities about the toxicity of molybdenum and it sets a positive precedent for other U.S. states to follow. It also demonstrates the value of the relentless work we do entering into dialogue and presenting quality science and robust toxicological data to promote appropriate decisions.

The HSE Committee contributed IMOA's most recent data to support the drafting of the Agency for Toxic Substances and Disease Registry's (ATSDR) toxicological profile of molybdenum. Subsequent detailed review and correction of the document and securing joint industry endorsement was critical, as the profile will be a key source of toxicological information about molybdenum for regulators worldwide.

In the EU, work is underway to address regulatory initiatives relating to a number

of substances, their classification and potential read-across which could impact on molybdenum substances. These include crystalline silica, Poorly Soluble Low Toxicity Particles and cobalt metal. The latter is present as an impurity (if not deliberately added) in all stainless steel. Our collective work is designed to minimize the impact of such initiatives on our member organizations.

The HSE Committee broadens stakeholder knowledge of molybdenum by actively disseminating environmental tools, data and findings on human health and environmental studies. The updated Life Cycle Inventories (LCI) for roasted molybdenite concentrates (in powder and briquette form) and ferromolybdenum will be released next year.

With the main registration phase of 12 REACH technical dossiers completed, the REACH Molybdenum Consortium (MoCon) retains the responsibility to update them as new information becomes available. Content is being examined in-depth to ensure that molybdenum substances are not incorrectly earmarked as potential Substances of Very High Concern (SVHC) or Substances of Equivalent Concern (SEC). Preparing the technical arguments to defend the Prenatal Development Toxicity (PNDT) study has also been a key focus for the MoCon Technical Working Group (TWG) during the past year.



Promoting the use of molybdenum

We continue to make excellent progress in our work to promote the use of molybdenum. The activities of the Market Development Committee are designed to drive demand through the increased use of molybdenum in new and existing applications.

In carbon steels, the results of the IMOA-funded gear steel project are bearing fruit with two major Chinese gear producers already trialing the molybdenum-alloyed steel. Our consultant also had positive meetings with steel producers in the U.S. and Korea. Progress has been made with other steel producers, manufacturers and engineering companies to fully promote the benefits of molybdenum alloying in steel.

Promotion of molybdenum-containing stainless steels amongst Architecture, Building and Construction (ABC) audiences remains a core activity in North America and elsewhere. Workshops, presentations and project meetings on design, specification and construction, including resiliency, sustainability and safety, are organized regularly, in cooperation with the Nickel Institute (NI). We also share and disseminate knowledge and information broadly amongst architects, engineers and fabricators through published articles, the 'Stainless Solutions' newsletter, and the Stainless Steel Library.

China is an area of focus for IMOA's Market Development Committee. 'Made in China 2025', the country's blueprint for industrial modernization, presents new opportunities for increased molybdenum use and engagement. Activity has intensified around specialty steel promotion where there is a high potential for molybdenum use.

Dialogue with the Chinese end-users continues to develop. We held two round tables on curtain walls, the first with the largest stainless steel maker and a number of industry participants; the second with the roofing supply chain, in collaboration with the CSCPG (China Stainless Steel Cooperation and Promotion Group).

The latest results of our research project with Japan's Okayama University have reconfirmed the benefit of adding molybdenum to ultra high-strength hot-stamped steel in terms of adding strength and resistance to delayed cracking.

Our joint service water pipe project with the Nickel Institute is gaining momentum with water authorities expressing an interest in the leak-resistant stainless steel piping solution. This is an important project in helping to address non-revenue water loss globally – the total cost of which is estimated to be \$39 billion per year.

Our work with Team Stainless included two main events, both focused on structural stainless steel and the collaborative development of standards and its use in the design and fabrication of bridges and highway structures. This year also marked the publication of new structural stainless steel design tables, available to download at <https://tinyurl.com/designtables>.

Increasing awareness through communications

Throughout the year, communications played an important role in raising awareness of molybdenum – its properties, applications and contribution to sustainable development. A key part of what we do supports market development activity.

Our media program aims to reach industry audiences with topical articles,



features and news releases. Strong relationships continue to be fostered with trade and specialist media outlets, resulting in the publication of numerous articles covering topics including global molybdenum production, molybdenum properties and a variety of applications – as diverse as storage tanks, water distribution, automotive steel and an innovative zoo enclosure for tigers. Two editions of MolyReview were published during the year, with many articles adapted and featured in the trade media. Our members are kept informed of Committee activities and media coverage through regular e-bulletins.

On-line communication is now a core part of our communications program. The IMO A website attracts 12,000 visitors on average each month. Our social media channels, Twitter and LinkedIn, grow in popularity with followers increasing by almost 50% over the year. In China, WeChat interest is also growing quickly. Set up in March 2018, the channel and the content we post has received positive comments from its followers.

As well as regular posts, we actively refresh the blog section of the IMO A website to add new and dynamic content. The video 'A World with Molybdenum', published in November 2017, has already been viewed more than 1,300 times on YouTube.

We recognize the value of video content in driving traffic to the website and social media pages which is why we have developed a series of topical videos. Due for release in September 2018, subjects include the essentiality of molybdenum, the use of stainless steel in ABC and the use of steel in the automotive sector.

Statistics

We regularly publish global production and use statistics in the members' area of the website. The data is also condensed into quarterly summaries for release to the media. Based on the feedback we receive, this activity is valued highly by our members and supports our strategic aim of being recognized as the most reliable source of information on molybdenum.

Health, Safety and Environment (HSE)



Sandra Carey
IMOA HSE Executive



Health, Safety and Environment

Key activities and achievements in 2017/2018

IMOA HSE Committee activities

A key role of the HSE Committee is to identify and participate in global regulatory initiatives about molybdenum, seeking to ensure appropriate legislation based on sound science.

Child-focused Mo rule makings in the U.S.

In the U.S., regulatory dialogue between IMOA and the Washington State Department of Ecology, resulted in the successful removal of molybdenum and molybdenum compounds from the List of Chemicals of High Concern to Children (CHCC) in their Children's Product Safety Rule. We made the delisting request in September 2016, based on a technical submission where we shared and advocated more recent toxicological and risk assessment data than had been available when the substances were first listed in 2009.

The 14-month review process included two public consultations and two webinars in which IMOA participated. In October 2017, the revised Rule became effective, adding 20 chemicals to the CHCC List, and removing just three. Outcomes such as these are highly beneficial to the IMOA membership because they:

- Halt unwarranted substance stigmatization and the unnecessary phasing out of substances

- Lift the lowering of a barrier to market access
- Correct the misconception of molybdenum toxicology amongst authorities
- Dissociate molybdenum from other so-called 'heavy metals' and from being misconstrued as severely 'toxic'
- Set a positive precedent for other States to follow

Oregon State has similar child-oriented legislation in place, and their CHCC list is based on the Washington State list. A review of Oregon Health Authority's 'Toxic Free Kids Act' was announced in May 2018 and to date, IMOA has achieved inclusion of molybdenum and molybdenum compounds in their proposal to delist. This follows our submission of a technical report and the leveraging of the Washington State outcome.

U.S. ATSDR toxicological profile for molybdenum

In 2017, IMOA's HSE Committee scrutinized the circa 260-page draft document: U.S. Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profile for molybdenum. It merited such scrutiny because once finalized, it will become a 'go-to' document worldwide for regulators and the general public seeking toxicological information about molybdenum.

When ATSDR's drafting process started in 2015, we provided a significant number of IMOA studies to contribute towards the health effects risk assessment. IMOA's technical review documents were subsequently supported and endorsed by submissions from the American Chemistry Council, the American Petroleum Association, the Mining Association of Canada, the US National Mining Association, and the North American Metals Council (NAMC). Multi-association solidarity ensures a further in-depth review of all submissions to the Agency following the public consultation period. ATSDR's online publication of their response-to-comments is expected in September 2018, which will explain why each of the submitted comments have either been incorporated or left out of the revised document.

EU enacted and prospective legislation

Tracking regulatory initiatives about certain substances and their hazard classifications is important to the IMOA membership as they could feasibly impact on some molybdenum products:

Carcinogens and Mutagens at Work EU Directive 2017/2398, amending Directive 2004/37/EC:

A Binding Occupational Exposure Limit Value (BOELV) of 0.1 mg/m³ for respirable crystalline silica was agreed by the EU Parliament and Council. This legislative

measure is to be transposed into EU Member State national legislation by 17 January 2020 at the latest. The French competent authority ANSES initially postponed and then withdrew its plan to submit an EU Harmonised Classification and Labelling (CLH) dossier for crystalline silica to the EU Registry of Intentions.

Crystalline silica, also in respirable form, can be a constituent of some molybdenum ores and concentrates, and some roasted molybdenite concentrates (also known as technical grade molybdenum oxide).

Poorly Soluble Low Toxicity Particles:

The European Chemical Agency (ECHA) Risk Assessment Committee is currently considering a proposal to hazard classify titanium dioxide as a Category 2 carcinogen. The concern from IMO's perspective is that ECHA is also considering extending that classification as a default classification to all Poorly Soluble Low Toxicity Particles, which could potentially impact upon MoS₂ and MoO₂. EU Member States are currently split as to whether to proceed. IMO is monitoring developments in case the initiative proceeds further.

Cobalt metal:

Cobalt metal is proposed for classification as a Category 1B carcinogen in the EU. All stainless steel, except for a few grades in which it is deliberately added, contains trace amounts of cobalt as an impurity. This has triggered a Specific Concentration Limit (SCL) for cobalt of 0.01%, above which hazard classification applies. Industry responded by mounting an intensive awareness-raising campaign about the largely unintended consequences this SCL would have on all stainless steel, effectively making it also a Category 1B carcinogen. The imposed SCL takes no account of the fact that cobalt in stainless steel is bound in a matrix at atomic level, and there is no unsafe human exposure

to cobalt in normal use. IMO's HSE Committee reviewed the draft advocacy documentation and a submission was made by Team Stainless to the EU public consultation on this issue.

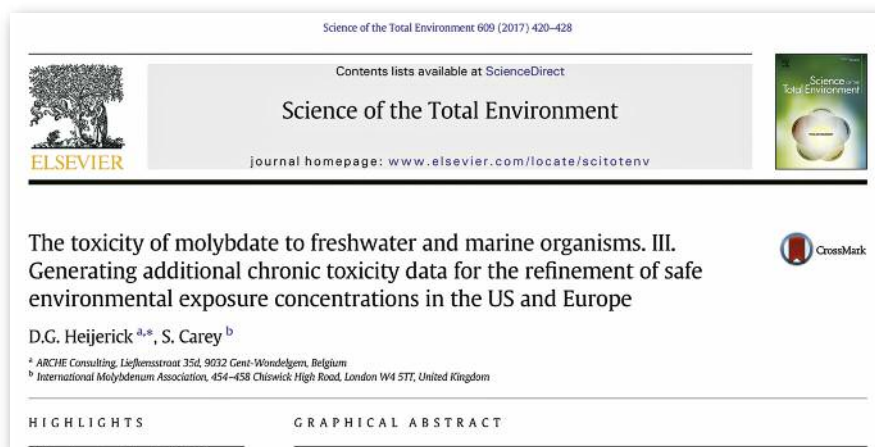
Life Cycle Inventory activities

The IMO project to update the Life Cycle Inventories (LCI) for roasted molybdenite concentrates in powder and briquette forms, and ferromolybdenum, is on schedule for completion in 2018. An LCI is an inventory of flows from and to nature for a product system. Inventory flows include inputs of water, energy and raw materials, and releases to air, land and water. This is IMO's third update of the dataset for molybdenum in metallurgical applications since the original was produced back in 2005.

exercises. IMO has achieved enhanced global geographic representation of its latest dataset through several new participants, including one for the first time from Asia.

Peer-reviewed publications

Disseminating the findings of human health and environmental studies about molybdenum, conducted by IMO, is a regular HSE Committee activity. We are currently drafting a manuscript about a reproductive toxicity study, and in 2017, we added a new environmental effects paper to our growing family of publications: 'The toxicity of molybdate to freshwater and marine organisms: III. Generating additional chronic toxicity data for the refinement of safe environmental exposure concentrations

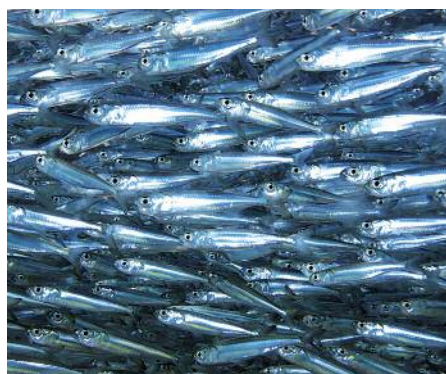


IMO regularly receives enquiries for its LCI datasets for metallurgical and chemical applications as companies seek to assess the green credentials of their own and competing products. Nowadays, LCI datasets are embedded into proprietary LCI software used for substance, product and even company sustainability assessments, so the availability of recent datasets is very important for the accuracy of such

in the U.S. and Europe', was published in the journal 'Science of the Total Environment'.

It reports on the *Hyalella Azteca* (benthic amphipod crustacean) and *Menidia beryllina* (marine fish) studies commissioned by IMO. The paper then uses that data, plus existing data, to derive U.S. Final Chronic Values (FCVs) (safe concentrations) for the freshwater

and marine compartments, and also compares those U.S. FCVs to the values derived using the EU Predicted No-Effect Concentration (PNEC) derivation methodology. Reassuringly, the freshwater HC5, 50% and FCV/ Criterion Continuous Concentration are almost identical. A factor of just two difference is noted between both approaches for the marine environment. (The fact that the EU methodology does not take unbounded values into account likely explains the observed difference).



IMOA's publications are always Open Access, meaning free of charge, to ensure maximum dissemination to the scientific, academic and regulatory communities, as well as to interested members of the general public.

Environmental activities

The HSE Committee also looks at broader environmental issues on behalf of the membership. Other environment-related topics progressed over the last year include:

Threshold Calculator for Metals in Soil V2.0:

Molybdenum environmental effects data on soil organisms (plants, invertebrates and microbial processes) are included in a chronic toxicity data spreadsheet within the calculator. It can be used in

various parts of the world to derive soil type-specific ecotox thresholds for different terrestrial environmental protection goals, for example soil remediation. The calculator also contains datasets about five other metals: Cd, Co, Cu, Pb, Ni and Zn, making it a very useful addition to corporate and regulator toolkits for risk assessment.

MeClas (Metals Classification) tool:

IMOA is one of several metals associations which sponsors this free of charge, web-based tool that enables compliance with GHS, EU CLP and U.S. OSHA requirements for the hazard identification and classification of complex inorganic mixtures and materials, e.g. ores and concentrates, based on the hazards of their constituents. Individual companies can benefit enormously from using MeClas to create their own company-specific hazard classification that reflects the actual composition of their inorganic mixtures and materials. Actual composition data may result in less classification than if using a generic or default composition. In turn, this may lead to lower handling and transportation costs while maintaining the highest standards of product stewardship.

Water Quality Standards (WQS):

In July 2017 we contacted the U.S. Department of Environmental Protection for New Jersey about the extensive environmental molybdate effects dataset they can access if molybdenum is one of the substances they select for their announced review of the NJ WQS. This is in line with our proactive policy to raise awareness about IMOA's scientific resources that are publicly available to interested parties.

Aquatic life water standard:

Saskatchewan Province, Canada, is processing a proposal to significantly uplift the current molybdenum water quality standard for aquatic life from just 0.07 mg Mo/liter to 26 mg Mo/liter.

The proposal is very largely based on IMOA's environmental dataset which benefits from OECD Mutual Acceptance of Data status, a point emphasized by the Saskatchewan authorities in their publicly available documentation. They also express their support for the proposed increased value.

Looking ahead

In preparation for the HSE part of IMOA's next Strategic Plan 2019–2023, the HSE Committee held a three-day Science Brainstorming Workshop in March 2018, to identify and determine key areas for further scientific investigations in the coming years. The output was a two-page document outlining eleven issues of concern that will serve as a starting point for scoping out potential future projects.

REACH Molybdenum Consortium (MoCon)

May 2018 marked the last tonnage band deadline for substance registrations, and completion of the core mission of the REACH Molybdenum Consortium to help its members achieve EU REACH Regulation compliance.

Technical Dossier submissions and updates

Since MoCon's inception in 2007, we have generated extensive hazard identification and risk assessment data for 12 molybdenum substances which is incorporated into technical dossiers (TDs), often referred to as Chemical Safety Reports. The TDs were first submitted to the European Chemical Agency (ECHA) in 2010, with three subsequent updates in 2011, 2013 and 2015/16. The REACH regulation requires dossier updates each time significant new information becomes available, such as human health or environmental endpoint studies. As such, the TDs are 'living documents'.



Now that the main registration phase is complete, a key ECHA concern is that industry may not continue to update their dossiers. This dispels any notion that REACH is over or that it ends with registration. Such is their concern that ECHA is considering introducing a legal instrument called an 'Implementing Act', to compel industry to prepare and submit periodic updates.

What next for REACH?

In reality, R is only the first letter of REACH. Now the focus moves to E for Evaluation, meaning in-depth examination of technical dossier content. ECHA has received 88,319 registrations for 21,551 substances in the last eight years of the phased Registration period. It now has a commitment, referred to as 'mapping the chemical universe' with the EU Commission.



This involves screening all the registered substances, within the short timeframe of 2018–2020, to decide which substances merit further scrutiny, and identification either as Substances of Very High Concern (SVHC) or Substances of Equivalent Concern (SEC).

Being earmarked either as a SVHC or SEC carries the likely consequence of the substance being added to REACH Annex XIV, known as the Candidate List, which is the precursor to the REACH stages of Restriction or Authorisation. The latter grants permission for the use of a particular substance for a specific

application, but also carries a 'sunset' date, effectively meaning the phase-out of the substance from the EU market. It is a process that ECHA claims drives innovation and substitution by using less hazardous substances, thereby achieving greater protection of human health and the environment.

Technical work

Preparing the technical argumentation to defend the PNDD study has been the main focus of the MoCon Technical Working Group (TWG) during 2017. Progress in other aspects of dossier continuous improvement includes the addition of Boundary Conditions (BCs)

We commission peer-reviewed research and engage in dialogue with regulators to support an evidence-based approach for molybdenum

Therefore, having a substance included in the Candidate List is highly undesirable. The more information ECHA have the better, to facilitate a conclusion of absence of concern with regard to toxicity data and minimal substance exposure levels. This reduces the likelihood of being earmarked as a potential SVHC or SEC. This motivation underpins the continuous enhancement process of the MoCon dossiers over recent years. To date, ECHA has selected several of our substances for routine Dossier Evaluation, but none for the more in-depth Substance Evaluation.

Prenatal Developmental Toxicity (PNDD) study

An issue we currently have with ECHA relates to the First Species Prenatal Developmental Toxicity (PNDD) study in our Technical Dossiers. The Agency is asserting that our study has not tested high enough concentrations for their hazard assessment purposes. We maintain that our study is valid, for the multiple reasons set out in our recent Board of Appeal (BoA) written correspondence. A formal ECHA BoA hearing date is set for October 2018. Their decision may not be known for several weeks after the hearing.

for each substance. BCs enable ECHA to better determine if co-registrants do definitely have the 'same substance' as the Lead Registrant, and that it is therefore appropriate for the Agency to grant them co-registrant REACH registration numbers under the One Substance One Registration (OSOR) principle enshrined in REACH.

The MoCon Secretariat also created a new webpage so that the BCs are publicly available to interested parties. The English language versions of the eSDS for molybdenum trioxide (EC No.215-204-7), and for roasted molybdenum concentrate (RMC) also known as technical grade molybdenum oxide (EC No. 289-178-0) were updated to align them with the latest 2016 version of the Technical Dossiers (TDs). This information is available to members on the eSDS and PIDS pages on the MoCon website. Similarly, the SDS for ferromolybdenum was updated in English and Spanish.

ECHA recently published a REACH guidance document entitled 'Read-Across Assessment Framework'. It sets out the assessment elements required in a TD to i) substantiate the read-across rationale between given substances, and ii) enable ECHA to assess if it

agrees with that scientific rationale or requires further information. In response, the MoCon TWG has developed a report for inclusion in the TD that details the MoCon read-across rationale for human health and environmental endpoints.

Looking ahead

Through its Directors Contact Group webpage, ECHA is strongly encouraging lead registrants and all co-registrants to maintain a cooperation platform, similar to the SIEF communication mechanism. Given the REACH OSOR principle of 'One Substance One Dossier', industry is obligated to continue its collaborative approach to REACH compliance in terms of its ability to respond to ECHA enquiries and requirements, and periodic dossier updating.

MoCon TWG is embarking on a project to update the Exposure Scenarios (ESs) that form part of the eSDS for hazardous substances. For MoCon this means the two forms of molybdenum trioxide – pure grade and technical grade. Whereas the original (and current) Exposure Scenarios are based on dustiness criteria, ECHA has now moved to task-based ES. This means a significant overhaul of the existing documentation to generate task-based ESs for all uses of these two substances. MoCon TWG is considering a move to using the CHESAR technical tool to generate these new ESs. While this will make future technical dossiers much easier to update, it requires a major rework of the data in the IUCLID 6 software where technical datasets are held.

Letters of Access (LoA) will continue to be available to any non-member companies of MoCon, who still need to register for REACH MoCon substances. In the five months leading up to May 2018 REACH registration deadline, we saw an increase in LoA activity, with 50

Summary of MoCon substance REACH-Registration

MoCon substance	Total registrations as at June 2018
Molybdenum	92
Molybdenum Sulfide, roasted	33
Molybdenum Trioxide, pure	54
Disodium Molybdate	15
Diammonium Dimolybdate	9
Hexammonium Heptomolybdate	15
Tetraammonium Hexamolybdate	2
Molybdenum Dioxide	3
Slags, Ferromolybdenum	2
Iron Molybdate	5
Calcium Molybdate	5
Chemically-produced MoS ₂	40
Total	275

LoAs purchased during this period, out of a total of 150 since the inception of the LoA facility in 2009. Back then, it was impossible to predict how many REACH registrations in total there may be for MoCon substances. The most recent count, via the ECHA Data Dissemination Portal soon after the May 2018 deadline, is that there have been 275 REACH registrations across the 12 MoCon substances.

Outside the EU, many other countries worldwide are progressively introducing and enhancing their chemicals management legislation. This is to ensure their safe handling and use through better identification and communication of substance hazards and effective risk management measures. Korea, for example, has introduced legislation known as K-REACH for its similarity to EU REACH. MoCon is ready to

organize data-sharing with K-REACH lead registrants as they ramp up for compliance with the first K-REACH registration deadline in 2021 for >1000 tonnes and CMR substances.

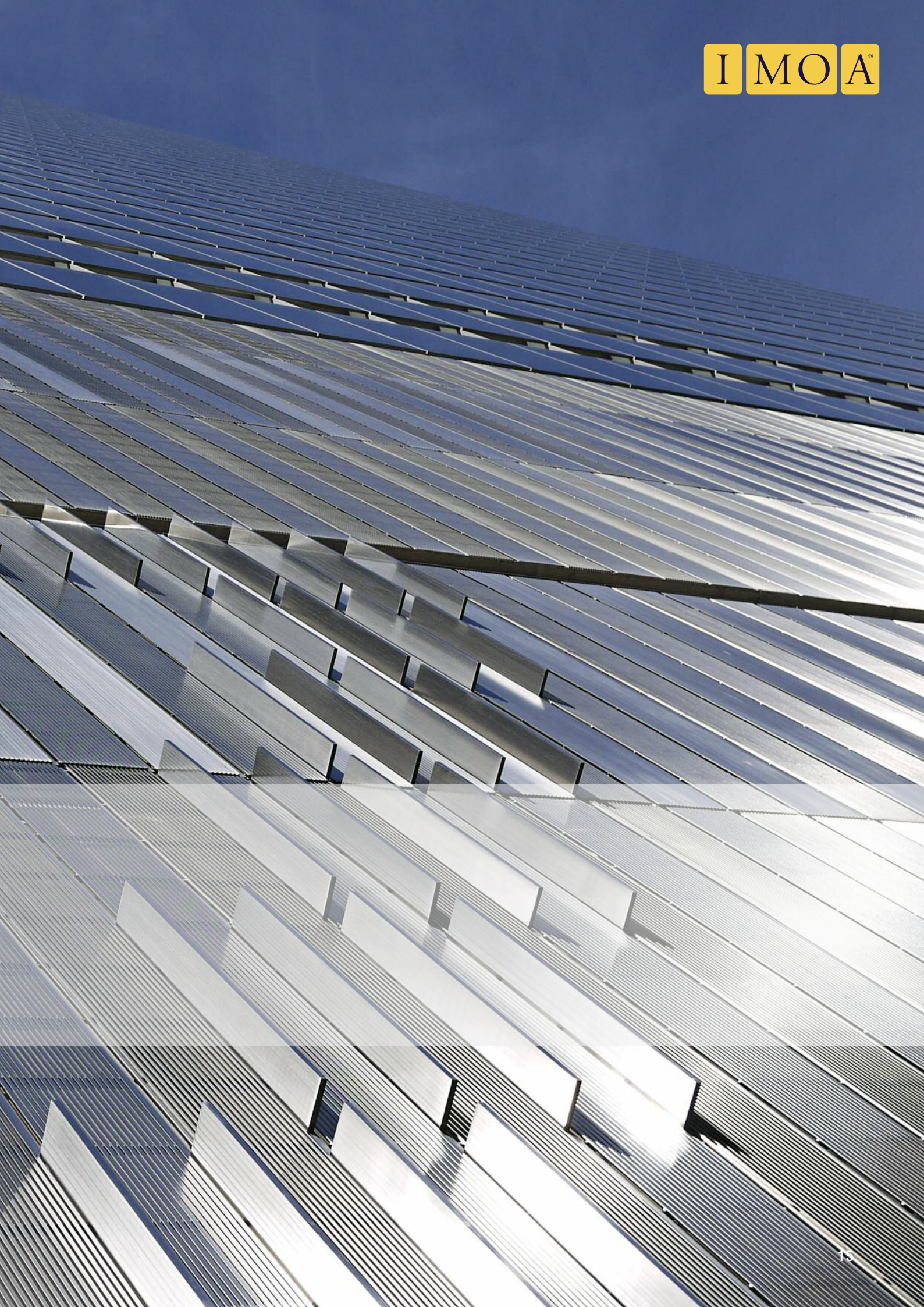
The MoCon Steering Committee, Secretariat and Technical Working Group continue to manage the work of the REACH Molybdenum Consortium, seeking to ensure continuing compliance with the EU REACH Regulation No. 1907/2006 for its 61 member companies.

All the MoCon and HSE technical activities are managed and driven forward by the corporate members of the respective HSE Committee and MoCon Technical Working Group, the HSE Executive staff member and our technical support service providers. We express our sincere gratitude for their continued dedication and professionalism.

Market Development



Dr. Nicole Kinsman
IMOA Technical Director



Market Development

Key activities and achievements in 2017/2018

Carbon steels

The year's activity resulted in around 30 visits, events and in-house seminars in support of market development. They related broadly to disseminating results from IMOA research projects; development of the North American market; increased activity in China; and market development in the rest of the world.

Extracting value from research projects

A key focus for the year was to extract the value of IMOA-funded research in

support of market development. The very positive results of the gear steel project were published in the highly reputable journal 'Metals' and were presented at the '5th International Conference on Steels in Cars and Trucks' in Amsterdam in June 2017. The results were also shared with two major Chinese gear producers, who have already started their own trials with the material. Furthermore, the alloy concept and its benefits were introduced at meetings with Gerdau Macsteel (U.S.) and SeAH Besteel (Korea).

The results of the IMOA direct quench steel project had considerable impact on

product development within SSAB Europe. Their product development team is now more aware of several specific advantages of molybdenum in ultra high-strength structural steels, particularly with regard to welding and quenching during end-user processing. Part of the project results have already been published in metallurgical journals.

A detailed evaluation of the IMOA/ Voestalpine welding project results clearly demonstrated the beneficial effects of molybdenum on weldability of pipeline and structural steels. These effects were also substantiated by other weldability studies and summarized in a publication presented at the Association for Iron and Steel Technology 'Developments in plate steels' conference in Orlando in June 2018.

The ongoing project on molybdenum-related effects in ultra high-strength press-hardening steel with Okayama University continues to deliver excellent results. Most notably, it demonstrates that molybdenum significantly increases the resistance of these steels to the well-known problem of delayed cracking. The results have already been used to produce a full-scale industrial heat of steel for truck applications at SSAB Europe. The steel is being processed into components by Bruning Tecnometal in Brazil and demonstrated to major European truck makers.



Focus on North America

Our program has included several visits to steelmakers and users in the U.S. Discussions mainly addressed the use of molybdenum in automotive and special steels. We presented papers on molybdenum effects in press-hardening steel and on optimized hot-working tool steel at the '6th International Conference on Hot Sheet Metal Forming' in Atlanta in June 2017. Some of the latest results were presented at the 'Great Design in Steels' conference in Detroit in May 2018.

Increased activity in China

Since the 2017 Comelan event in Harbin, we have intensified our efforts in demonstrating IMO A's work to the Chinese market, culminating in a joint IMO A/JDC visit to Shaanxi FAST Auto Drive (gear producer) to present the results of the IMO A gear study. We also organized the visit of a delegation from Nanjing-based gear maker NGC to Germany (BGH, ALD, Munich University) to discuss the principles of high-performance gear steel.

More recently, we started cooperation with two Chinese special steelmakers (NISCO and Zenith Steel) to prepare for future local production. We have also teamed up with Shanghai University (SHU), one of the top metallurgical universities in China, to establish a local R&D hub for molybdenum in steels. One of the first areas covered is molybdenum effects in iron and steel castings. Furthermore, IMO A is jointly organizing a Molybdenum Symposium with SHU in Shanghai in late 2018, to demonstrate the advantages of molybdenum alloying in iron and steel products.

Rest of the world

Much of the general market development activities have been around third-

generation automotive steels designed to close the gap between advanced high-strength steels and press-hardening steel. These steels have a good potential for molybdenum alloying and we are highlighting this to the leading market players. Increased market demand for these steels is expected after 2020.

Architecture, Building and Construction (ABC)

Delivering stainless steel workshops

IMO A now has nine courses accredited by the American Institute of Architects (AIA). All but one qualify for sustainable design (Health, Safety and Welfare) continuing education credit. Also, a new presentation on resilience was developed and registered this year. In North America, IMO A and the Nickel Institute (NI) jointly sponsored building and construction workshops and project meetings at some of the world's most prestigious architecture and engineering firms in Chicago, Pittsburgh, and New York. Additionally, IMO A helped to sponsor a paper and presentation at the ASTM E60 symposium on 'Balancing Resiliency, Safety and Sustainability'. In total, these events attracted more than 500 attendees from over 100 companies.

U.S. architects and engineers play a major role in global design and construction. The ongoing interaction provided by these face-to-face workshops builds and strengthens relationships, influences global projects and has actively increased the use of molybdenum-containing stainless steel in building and construction, in North America and elsewhere.

Publications and articles

IMO A's 'Stainless Solutions' e-newsletter is emailed monthly to a distribution of about 1,500 opted-in architects, engineers and fabricators. Covering a different technical topic or emerging application

each month, the content is also posted on LinkedIn and featured on the IMO A website. Links to IMO A literature and web page resources serve to substantially increase traffic to the ABC area of the website.



A 2018 version of the jointly-developed NI and IMO A ABC Stainless Steel Library was released in December 2017, increasing the content to over 550 PDFs, and bringing the total distributed to more than 5,500 industry decision makers. Feedback from architectural and engineering firms suggests that this comprehensive library is highly valued.

In September 2017, IMO A's consultant Catherine Houska was awarded a second national Construction Specifications Institute (CSI) Technical Award for the industry contribution made by the article



‘Proving its Long-term Mettle: Longevity, whole-building LCAs and stainless steel’, jointly sponsored by IMO A and NI. The CSI Middle Atlantic chapter gave her a Technical Award for the same article in March 2018. A significantly revised version of this feature article was published as the cover story in ‘Construct Canada’ in June 2017.

‘Transportation Builder’ published an article on the use of duplex stainless steel in vehicular bridges, the newly-published American Institute of Steel Construction (AISC) design tables, and an associated webinar. A ‘MolyReview’ article on the first large-scale use of 2205 duplex stainless steel in a North American vehicular bridge was reprinted in ‘Stainless Steel World News’, along with a ‘Stainless Solutions’ article on galvanic corrosion.

Structural market development

Market development for structural stainless steel, including the promotion of the AISC ‘Steel Design Guide 27: Structural Stainless Steel (DG 27)’, is an important activity. IMO A’s consultant gave technical support to many structural projects during the past year. She has also helped in drafting a new ASTM International Standard for the structural use of stainless steel in bridges, highways and other infrastructure, and advised on the addition of large duplex stainless steel structural sections to ASTM A709, the standard for bridge steel.

An IMO A, NI and New Castle Stainless Steel Plate-sponsored presentation was given to the steel bridge committee of the American Association of State Highway and Transportation Officials, in support of efforts to promote the use of duplex stainless steels in vehicular bridges and to have them added to ASTM A709. IMO A also contributed to Team Stainless structural steel market development activities, discussed later.

Market development in China

In 2015, China’s government initiated a very comprehensive masterplan for economic and industrial modernization: ‘MIC 2025 – Made in China 2025’, which aims to turn the country into a manufacturing superpower over the coming decades.

Originally approved by China’s State Council in 2015, the plan specifically targets ten high-tech industries, including numerical control machine tools and robotics; aerospace equipment; road, rail and sea transport applications; power equipment; and agricultural machinery. Phrases like “indigenous innovations” (自主创新) and “self-sufficiency” (自主保障) are omnipresent in the document.

先进钢铁材料 and special steels dominate.

Chinese steel production is more than half of the world’s total, but its share of molybdenum use is much lower, therefore MIC 2025 presents new opportunities to increase molybdenum use. In mid 2017, we aligned CMAPG (China Molybdenum Application Promotion Group 中国钼应用促进小组) activities with the goals of MIC and dedicated much of our work to raising awareness of these opportunities amongst the Chinese molybdenum industry.

We have therefore intensified our focus on special steels and widened our activities from advanced structural steels



A greater focus on special steels

All the key industry sectors in the MIC 2025 have raw material requirements. Chapter 9.1 ‘Advanced base material’ 先进基础材料 is a particularly significant section where advanced steel materials

(flat products) to engineering steels (long products) and to cast iron (foundries) to cover all areas of potential molybdenum uptake. Other market development activities in this area are covered in the carbon steels section.

Stainless steel

The impact of private Chinese steel mills, with Nickel Pig Iron (NPI) as their specific competitive edge, is stabilizing in the domestic and Asian stainless steel markets. The state-owned stainless steel makers meanwhile are focusing on higher value grades, including ferritic and duplex.

The CSCPG (China Stainless Steel Cooperation and Promotion Group 中国不锈钢合作推进小组) was formed by IMO, ICDA, NI and CITIC metal under the auspices of the China Stainless Steel Council (CSSC 中国特钢协不锈钢分会).

The cooperation with CSCPG has continued over the past year, with two round tables organized for more than 40 selected executives from the façade and roofing supply chain. As a result, the CSCPG will hold a larger industry forum dedicated to stainless steel building envelopes in autumn 2018. We also monitor the progress of high-rise buildings with stainless steel façades and offer assistance as part of our regular

contact with curtain wall contractors and manufacturers.

Flue gas desulfurization

In China, coal-fired power plants account for more than 70% of power generation. These plants are usually equipped with wet flue gas desulfurization (FGD) units to reduce their harmful sulfur dioxide emissions. The FGD units mostly use a limestone slurry to neutralize and remove the acidic exhaust gases, making them prone to serious corrosion. In May 2018, we finalized the definition

of a project to assess the condition of these plants, scope the application of molybdenum-containing stainless steel and nickel-based replacement materials, and to provide guidelines for correct material selection.

Welding workshops

In autumn 2017, we also gave presentations on welding high-molybdenum stainless and nickel alloys to two Chinese welding societies and to the China Academy of Machinery Science and Technology 机械科学研究总院集团有限公司, in cooperation with the NI.

Research projects

The IMO-sponsored research project at Japan's Okayama University, referenced earlier, is studying the effect

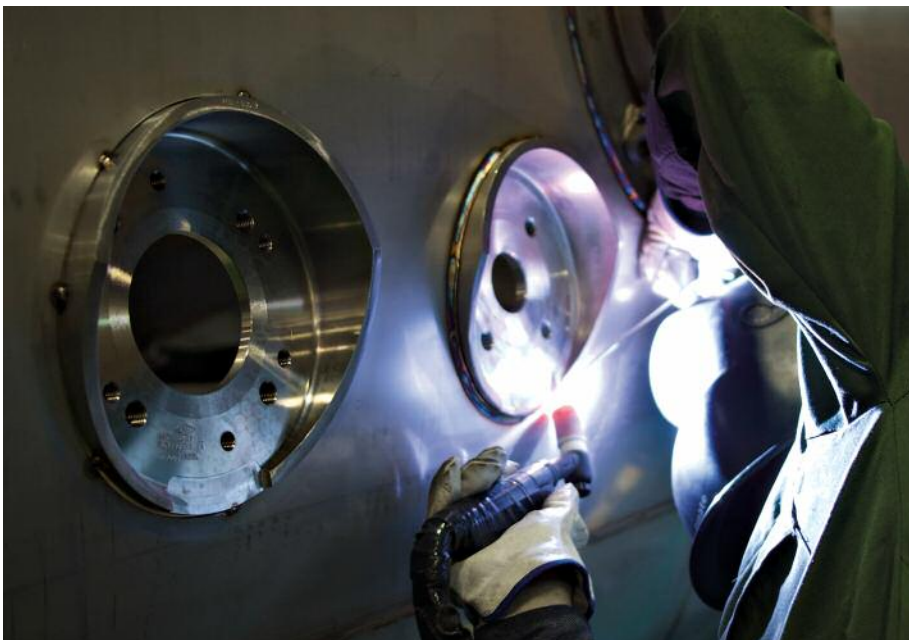
We sponsor a range of research projects to discover and develop new or expanded uses for molybdenum

of molybdenum in 2000 MPa ultra high-strength hot-stamped steel by increasing the molybdenum content from 0% to 0.15%, 0.3% and 0.5%. The latest results, involving additional heating cycles, reconfirm the positive influence of molybdenum on strength, critical bending angle and, most importantly, the resistance to delayed cracking in these steels.

Early in 2018, IMO started a new research project with Spanish research center Ceit and a German steel producer on the synergistic effects of molybdenum and niobium in high-strength medium carbon Q/Q&T (quenched and quenched and tempered) steels. The five heats are cast and are being prepared for testing.

Service water pipe project

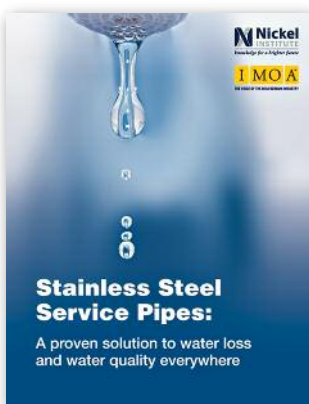
Water loss is a global problem. The service water pipe project, run together with the Nickel Institute, is helping to introduce a leak-resistant stainless steel piping solution to address this increasingly important issue. Our joint work includes workshops, conferences





and meetings with engineering firms, water authorities and suppliers in the U.S., Canada, Australia, China, India, UK, Italy and South Africa. The proven solution has already helped in Taiwan and Tokyo with annual water savings reported of 146 million cubic meters and 240 million cubic meters respectively.

As well as developing educational materials including an overview brochure, we are supporting the formation of new supply chains for corrugated stainless steel service pipe outside the home markets of Japan, Taiwan and Korea.



The overall project is gathering momentum with a number of water authorities now showing an interest in the system. It also means that we

need to invest additional time in helping to establish standards, conduct testing in accordance with local standards, and ensure that the right local skills are available for the new service pipe material.

Team Stainless

IMO A continues to be a member of Team Stainless, formed from the global trade associations of the stainless steel and alloying element industries to promote the benefits of stainless steel. Notable activity during the year included:

Fifth International Stainless Steel in Structures Experts Seminar:

The seminar held in September 2017 was attended by delegates from 15 countries. The event shared advances in research with the aim of building a strong and effective community of cooperative researchers. This in turn will contribute to the development of practical, economic and comprehensive design standards. Some 40 topical presentations were given, with topics including fire performance, 3D printing, blast resistance and the new Chinese stainless steel design standard. Most of the papers are being published in the 'Journal of Constructional Steel Research'.

U.S. Bridge Webinar:

The two-hour webinar promoted the use

of structural stainless steel bridges and highway structures in North America. Presentations covered material selection, design and fabrication as well as procurement. The audience included 14 State departments of transportation, the U.S. Federal Highway Administration, academics and engineering firms. The webinar and other key resources are available online (www.steel-stainless.org/bridges).

Structural Stainless Steel Design Tables:

Comprehensive design tables were produced for a wide range of structural stainless steel sections available in North America. The tables give section properties and member capacities for austenitic and duplex stainless steels, in accordance with the rules in the American Institute of Steel Construction's (AISC) Design Guide 27: Structural Stainless Steel.

Designers have been using such tables for carbon steel section and size selection for a long time, to speed up the design process. The need for design tables for stainless steel structures is even greater because there are many shapes and sizes with no standardized library, complicating design and procurement. The tables are available on the AISC web site and also directly from <https://tinyurl.com/designstables>.

Comprehensive Multi-level Cycle of Stainless Steels:

A Team Stainless-sponsored study on the stocks and flows of stainless steel in 2015 has been conducted by Yale University, complementing prior studies that date back to 2000. An update of the final report, incorporating feedback from Team Stainless, is imminent. It describes and quantifies the full cycle of stainless steel from melt production to end of life recycling for some 50 countries around the world, with a summary leaflet planned for the general public.

Financial Report 2017

Income and expenditure account

For the year ended 31 December 2017

IMOA/Molybdenum Consortium

	2017 \$	2016 \$
Turnover	2,829,181	2,757,877
Operating and administrative expenses	2,888,246	3,066,686
Operating surplus/(deficit)	(59,065)	(308,809)
Other interest receivable and similar income	12,088	6,730
Surplus/(deficit) on ordinary activities before taxation	(46,977)	(302,079)
Tax on surplus/(deficit) on ordinary activities	3,867	5,616
Surplus/(deficit) on ordinary activities after taxation	(50,844)	(307,695)

Balance sheet

For the year ended 31 December 2017

IMO A/Molybdenum Consortium

	2017		2016	
	\$	\$	\$	\$
Fixed assets				
Tangible assets		20,976		28,251
Current assets				
Debtors	128,164		100,472	
Cash at bank and in hand	3,380,821		3,385,430	
	3,508,985		3,485,902	
Creditors – amounts falling due within one year	(766,152)		(699,500)	
Net current assets		2,742,833		2,786,402
Total assets less current liabilities		2,763,809		2,814,653
Reserves				
Profit and loss account		2,763,809		2,814,653
Accumulated funds		2,763,809		2,814,653

Financial commentary

The 2017 audited accounts presented here are consolidated figures for IMO A and the Molybdenum Consortium and are subject to approval at the 2018 AGM. Income from subscriptions and levies amounted to US\$2,829,181. After expenses of US\$2,888,246 a deficit (after taxation) of US\$50,844 was carried forward bringing the combined accumulated funds to US\$2,763,809. Of this US\$1,908,774 was attributable to IMO A and US\$855,035 to the Consortium.

In the case of IMO A, expenditure and income were essentially balanced with a small surplus accruing to the reserves, however the year-end balance remained below the Executive Committee's longer-term objective. The Molybdenum Consortium reserves and additional Letter of Access funds will finance the Consortium's essential activities for the balance of the year and beyond.



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THE VOICE OF THE MOLYBDENUM INDUSTRY



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