INTERNATIONAL MOLYBDENUM ASSOCIATION

NEWSLETTER

JANUARY 2002

APPOINTMENT OF TECHNICAL DIRECTOR TO IMOA

The International Molybdenum Association (IMOA) has appointed Dr Nicole Kinsman as Technical Director from 1 January 2002.

Since its formation in 1989, IMOA has vigorously extended the scope of its activities and the need for a technical expert to take charge of its market development programme is realised by this appointment.

Nicole has worked for IMOA for several years in her capacity as an employee of Technical Marketing Resources, the firm of US consultants which has been largely responsible for promoting IMOA's image as a recognised worldwide organisation with technical expertise.

Nicole has a PhD in Metallurgy from the Swiss Federal Institute of Technology and an MBA from Carnegie Mellon University and is fluent in German, English and French. Her expertise lies in the stainless steel industry (where some 30-35% of moly is consumed) and she is the author of numerous technical papers.

IMOA and Nicole look forward to working together on an ambitious market development programme.

13th Annual General Meeting, 2001

The Association's AGM was hosted by AvestaPolarit in the Nordic Hotel, Stockholm, with various meetings held over 10-13 September and a visit to AvestaPolarit's plant on 14 September. Nearly 60 delegates attended, to listen to expert papers at the AGM as follows:

- *Report on the work of Weighing, Sampling & Assaying Committee (Sandra Carey)*
- *Report on the work of the Health, Safety & Environment Committee (Carmen Venezia, Osram Sylvania Products) presented by Sandra Carey*
- *"The use of LCI" by Camilla Kaplin (R&D Centre Avesta, AvestaPolarit)*
- *"Stainless Steel Consolidation and Growth" by John Newborn, Executive Vice President, AvestaPolarit*
- *"Supply and Demand" by Terry Adams (Adams Metals)*
- *IMOA Market Development by Hans Imgrund (Climax Molybdenum)*

John Graell, President of Molymet, was elected as the new IMOA President in succession to Richard De Cesare (Vice President of Thompson Creek Metals) and Skip Sullivan, Director of Kennecott Sales America was elected as Vice President. The existing members of the Executive Committee were re-elected. The normal period of office as President is two years but, due to unforeseen circumstances in the carefully planned succession back in 1999, De Cesare kindly agreed to serve for an extra two years. In recognition of this burden, Graell made a presentation, observing that a four-year term of office had involved a considerable amount of work and dedication to IMOA's interests. De Cesare had co-ordinated and implemented a highly successful work programme during his Presidency and IMOA owed him a big vote of thanks.

14th Annual General Meeting, 2002

This year's AGM will be held in Hermosillo, Mexico at the kind invitation of Molymet and Grupo Mexico with a provisional programme as follows:

Monday 21 October - Sub-Committee Meetings

Tuesday 22 October - Executive Committee Meeting

Wednesday 23 October - AGM

Thursday 24 October - Works' visit to the La Caridad mine and Molymex

INTERNATIONAL MOLYBDENUM ASSOCIATION
2 Baron's Gate, 33 Rothschild Road, London W4 5HT, UK
Tel: +44 20 8742 2274 Fax: + 44 20 8742 7345
email: ITIA_IMOA@compuserve.com web: www.imoa.org.uk

Moly Does the Job

This article is the latest in a series of case histories where the application of moly has helped companies to solve technical problems . It has been written by an IMOA consultant, Catherine Houska of TMR Stainless, who will play a leading part in IMOA's new effort to promote molybdenum containing stainless steels in the area of outdoor applications in architecture, building and construction in 2002.

Molybdenum Keeps Street Handrails Safe and Attractive

Summary

Handrails are expected to meet both structural safety and aesthetic requirements. Traditional carbon steel, cast iron, and aluminum handrails can deteriorate quickly in exterior or industrial installations with aggressive pollution and/or chloride exposure. In these environments, molybdenum-free Type 304 stainless steel handrails provide longer service life, but regular cleaning and/or coatings are required to maintain an attractive appearance.

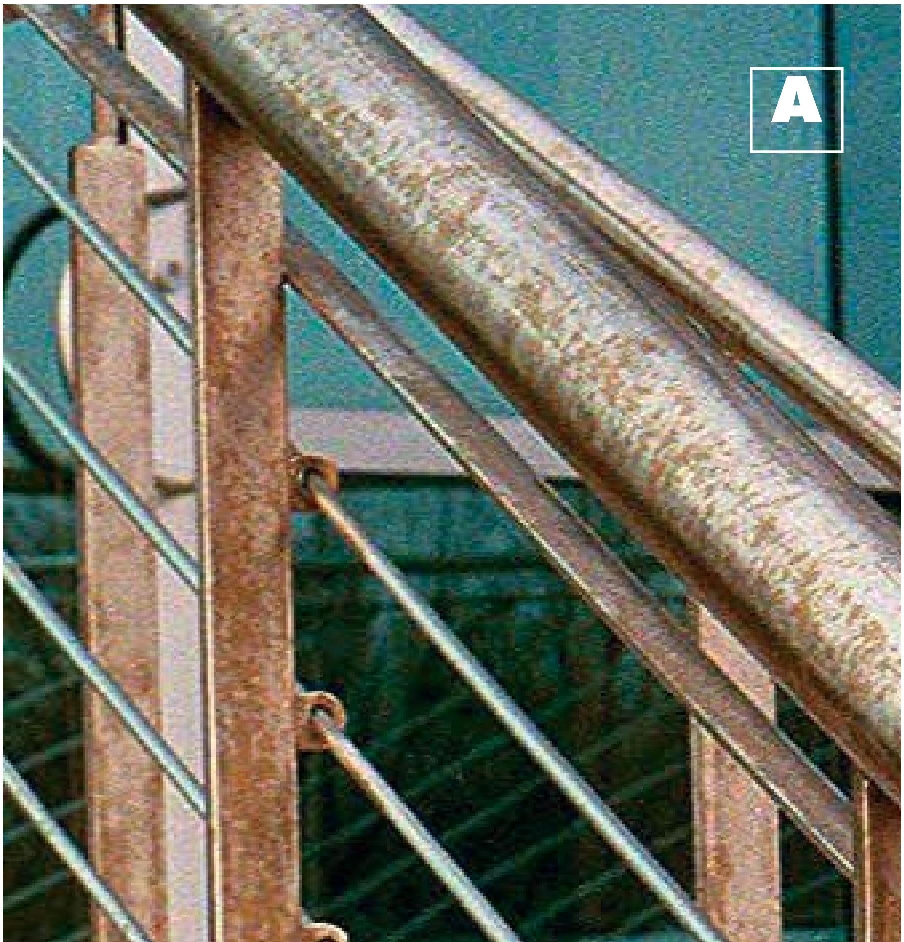
More corrosion resistant Type 316 stainless steel handrails, which contain 2% molybdenum, are the most cost effective choice in demanding environments. They require minimal maintenance, no paint or coating and provide safety and an attractive appearance. In stainless steel, molybdenum improves resistance to pitting and crevice corrosion and is particularly helpful in preventing chloride damage.

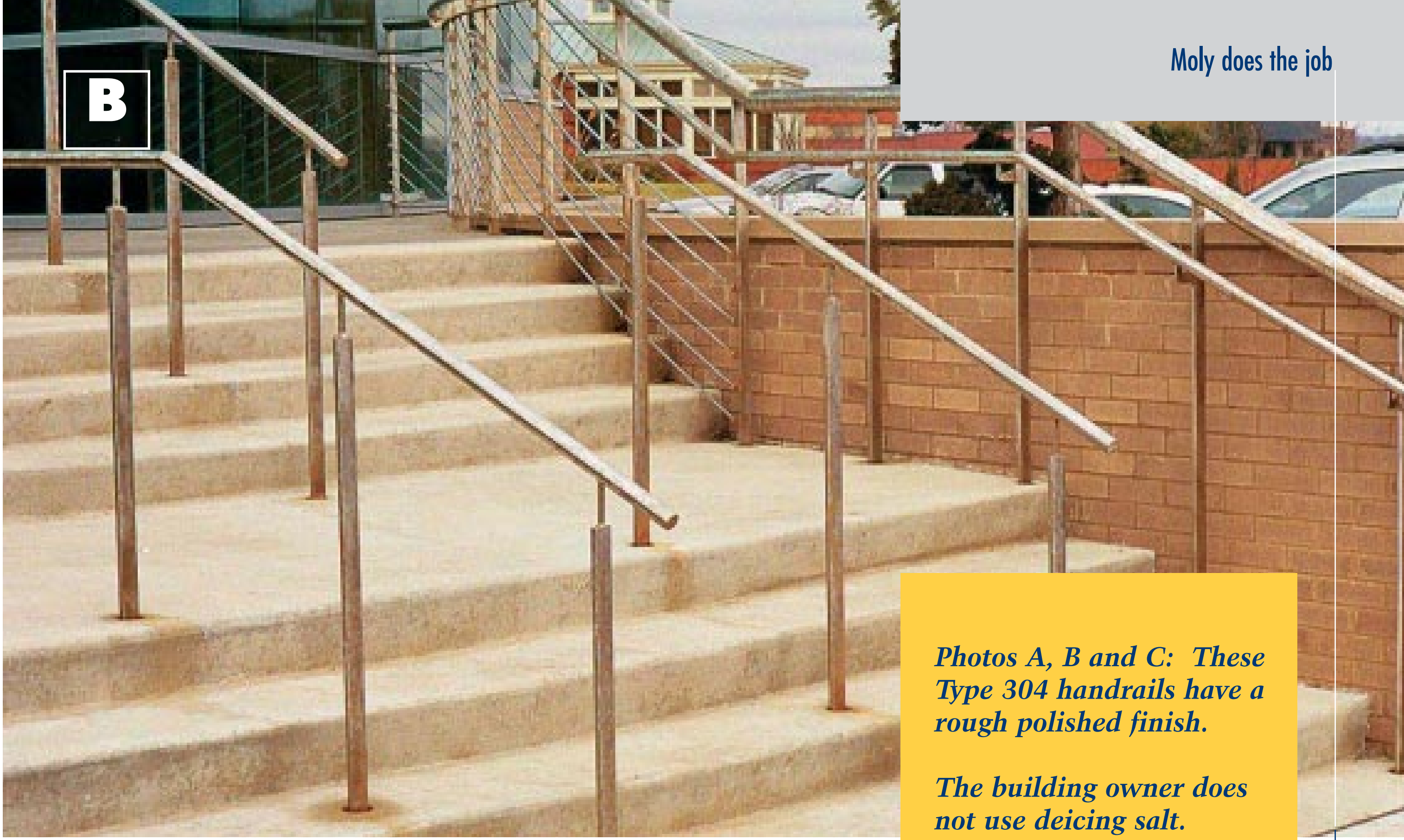
The growth potential for Type 316 stainless steel in aggressive exterior applications is significant and is not limited to handrails. Doors, canopies, store fronts, street furniture, bus shelters, trash cans, bicycle racks, security barriers, gates, fences, wall panels and column covers, all face the same corrosion challenges in salty or polluted environments.

The Application

In new or existing applications, stainless steel is increasingly replacing carbon steel and aluminum handrails because of concern about safety, long-term maintenance and replacement costs, and because of fashion. Growth in stainless steel handrail use has been greatest in areas where coastal or deicing salts are present and/or where pollution levels are high. In some sectors of the North American exterior handrail market, stainless steel has close to a 30% market share. Industrial applications are a small but rapidly growing market for stainless steel, particularly in corrosive plant environments.

Fabricators and specifiers are often unaware of the benefits of using a molybdenum-containing stainless steel. The stainless steel most commonly specified is Type 304 with a polished finish. Type 316 is most likely to be specified in industrial applications or within a few hundred feet of a saltwater body. It is rarely used in locations with deicing salt exposure.



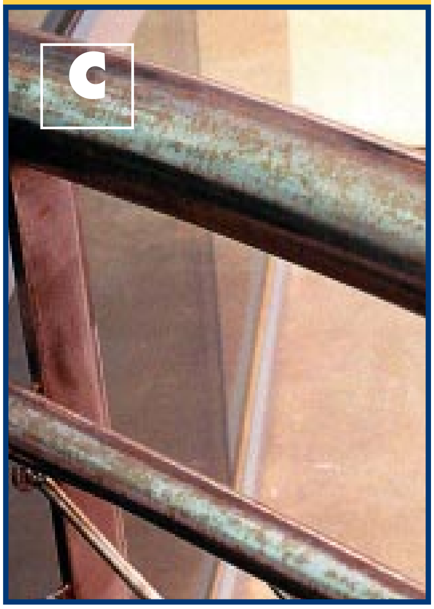


Photos A, B and C: These Type 304 handrails have a rough polished finish.

The building owner does not use deicing salt.

The chloride source is road salt mist from a busy highway about 300 yards downhill from the building.

The handrails were installed in the fall and had no signs of corrosion prior to winter. Heavy staining was visible the following spring.



The Corrosion

Deicing salt can create a more aggressive environment than what is found in most coastal applications. It is not unusual to see piles of salt crystals around exterior handrails. Even with regular maintenance, traditional carbon steel and aluminum handrails may have to be replaced in as little as five to ten years.

Type 304 handrails are increasingly being selected for locations where deicing salt is used because building owners and architects assume it will remain "stainless". They usually become very unhappy when finding red rust on Type 304 after the first winter as in photos A, B and C. Corrosion is particularly severe when rough surface finishes are used, the handrails are sheltered, the design encourages salt accumulation, or piles of salt are left around the handrail base. Conditions are often made worse by lack of maintenance.

Deicing salt is not a seasonal corrosion problem. Salt accumulates in soil near roadways and salt-containing dust can be blown onto surfaces during the warmer months. Salt particles remain on surfaces unless they are washed off by hand or heavy rain. An aggressive slurry is formed when salt combines with the humidity in the air. This can occur once temperatures are above 0ºC and humidity levels exceed 45%. This salt slurry can form without the presence of rain or other sources of liquid water.

Type 304 handrails, which are exposed to deicing salt, must be cleaned at least once a year in the spring to restore their appearance. When pitting becomes visible, refinishing may be required or handrails have to be replaced. Either option is expensive. In an effort to prevent corrosion, building owners often have cleaning companies apply clear polyurethane or wax coatings. To be effective, these coatings must be stripped and reapplied annually making maintenance costs high.

The Solution

The fabricators of stainless steel handrails and the architects and building owners who specify handrails must be informed so that they understand that all stainless steels are not alike. In most installations with deicing or marine salt exposure, Type 316 handrails will remain attractive and safe with little or no maintenance as photo D shows. Designers must be warned to avoid crevices and designs that allow the accumulation of salt, and encouraged to use smooth finishes and the right grade of stainless steel.

The Cost Savings

Type 316 handrails provide significant life cycle cost savings when compared to traditional carbon steel, iron or aluminum handrails which need regular maintenance and, in aggressive locations, may provide as little as five to ten years of service.

The service life of carbon steel and aluminum is typically limited by corrosion damage which reduces structural integrity and appearance. An important aspect of structural integrity is the perceived ability of a handrail to withstand the load associated with one or more large persons or individuals accidentally falling against or climbing on it. In comparison, Type 316 handrails often receive little or no maintenance and could remain structurally sound for hundreds of years.

Photo D: This Type 316 handrail on a coastal pier is exposed to a much more aggressive environment than the Type 304 handrail (Photos A,B,&C). This handrail is exposed to coastal and deicing salt. However, it shows no signs of corrosion. For maximum performance, a very smooth polished finish was selected and joint crevices were sealed after installation. The design allows salt to be easily washed off by rain.

In corrosive locations with aggressive pollution and/or chloride exposure, Type 316 also provides a maintenance cost savings over Type 304 stainless steel. Type 304 must be cleaned regularly in these environments to remove salt accumulation and corrosion staining. When staining is severe, refinishing or replacement may be required.

Photos are courtesy of Technical Marketing Resources Inc.

New, High-Molybdenum Ferritic Stainless Steel Replaces Aluminum Brass Condenser Tubing in Japanese Power Plants

IMOA is grateful to Kiyosha Fujiwara of Sumitomo Metal Technology Inc, Hyogo, Japan for the following article which focuses on a new application for moly-containing stainless steel as a replacement for an existing moly-free material. This is the kind of good news which the moly industry needs and towards which IMOA's market development efforts are directed.

Traditionally, aluminum brass tubing has been used extensively in seawater cooled condensers in Japan because of its great heat transfer properties and its moderate cost. However, this tubing is susceptible to erosion and corrosion from the inside and to ammonia attack from the outside. Because of this, the tubing has to be replaced at regular intervals.

To reduce the cost of frequent re-tubing of condensers, a Japanese stainless steel producer has developed a high-molybdenum ferritic stainless steel which resists both erosion and corrosion in seawater service. This new stainless steel grade (ASTM A268/A268M, UNS S44800) with the proprietary name Sumitomo FS10 contains 4% molybdenum, 29% chromium and 2% nickel.

The new grade has first been installed as thin-walled tube at the 500-MW Buzen thermal power plant, operated by Kyushu Electric Power of Japan. Forty test pieces have been in service since 1993 without problems. Because of the great performance of these tubes, the power company went on to replace over 1000 (out of a total of 23,300) aluminum brass tubes with FS10 at another Buzen plant in 1997.

The most important physical property for a power plant condenser tubing material is its thermal conductivity. With increasing thermal conductivity, the heat transfer increases and yield losses of power generation decrease. A small improvement in thermal conductivity and therefore in the thermal efficiency of a power plant can have a huge impact on its profitability.

The mechanical and physical properties of different condenser materials are listed in **table 1**. The thermal conductivity of aluminum brass is much higher than the one for FS10. However, because of its higher strength, its higher modulus of elasticity and its resistance to corrosion and erosion tubing of FS10 can be much thinner than aluminum brass tubing (0.5 mm versus 1.24 mm for brass). The consequence of thinner tubes is an improved heat transfer coefficient.

Figure 1 shows the heat transfer coefficients for aluminum brass and high performance stainless steel tubes in three states:
1. new, 2. after 3.5 years of service and 3. same as 2. but after cleaning with a tubing brush.
The aluminum brass tubes yield a better thermal performance than the stainless steel tubes when they are brand new. However, after a few months of operation, scale forms on the interior walls of the tubing. The scale that forms on aluminum brass is thicker and harder than the one on stainless steel. This may be related to the corrosion suffered on the interior surface of the brass tubing.

Figure 2 shows the cross sections of the two types of tubing and the difference in scale build-up. The scale acts as an insulator and reduces the heat transfer coefficient of both aluminum brass and stainless steel tubing.

Table 1: Physical and Mechanical Properties of Condenser Tube Material

Material	Density (g/cm^3)	Thermal Conductivity (20-100°C) (W/m°C)	Thermal Expansion Coefficient (20-100°C) (10^{-6}/°C)	Elastic Modulus (20°C) (x10^4MPa)	Yield Strength (MPa)	TensileStrength (MPa)
FS10	7.7	17	9	205	415	550
Aluminum brass	8.3	90	18	110	125	345

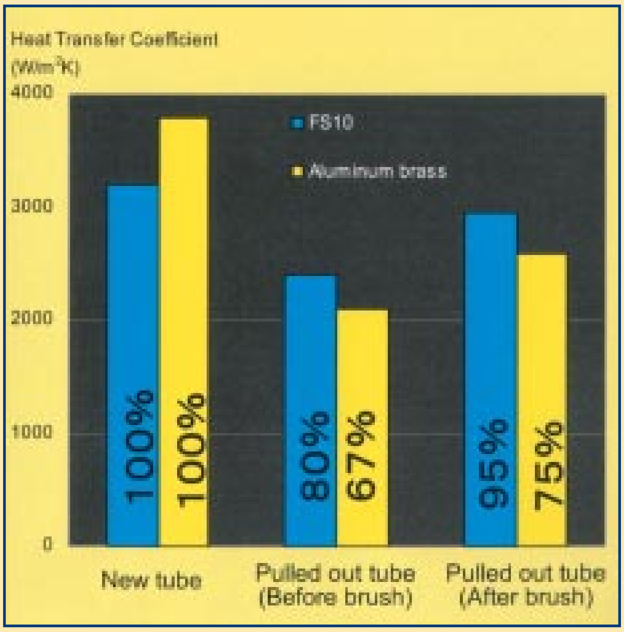


Figure 1: *Heat Transfer coefficient for ferritic stainless steel FS10 and aluminum brass tubing in three states: new, pulled out after 3.5 years of service, and pulled out after 3.5 years and subsequent cleaning with a brush.*

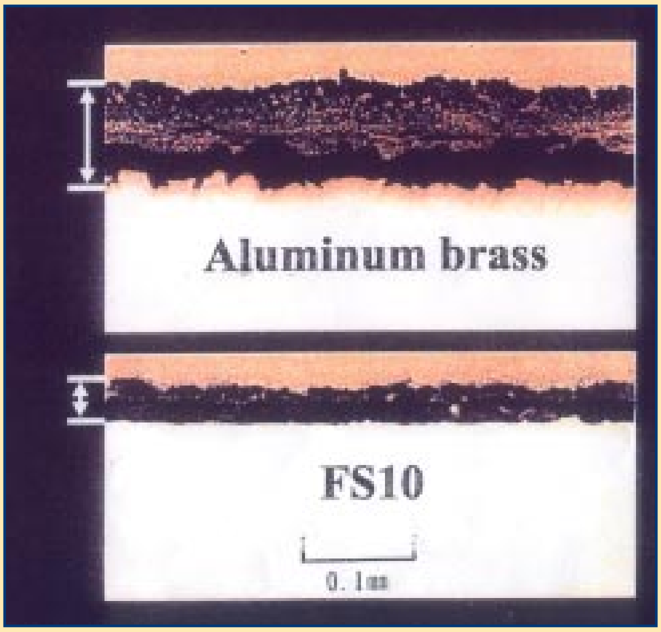


Figure 2: *Deposits on the inner surfaces of the FS10 and aluminum brass tubes. Note how much thicker the scale on the aluminum brass tube is than the scale on the stainless steel tube.*

The remaining heat transfer coefficient of stainless steel is larger than that of aluminum brass after a few years of service **(Figure1).**

After brush cleaning of the interior of the tubes, the heat transfer through the stainless steel tubes can be restored to almost its original value while the one through the aluminum brass tubes remains relatively low. The scale on the aluminum brass is much more tenacious and cannot be removed easily.

The pulled-out high-molybdenum stainless steel tubes were also inspected for corrosion, erosion and possible degradation of mechanical properties after several years of service. No degradation of any kind was found.

As a consequence of this great performance Kyushu Electric Power Company replaced another 650 aluminum brass tubes at their Shinkokura thermal plant Unit 3 (600 MW) with FS10 high performance stainless steel tubes.

FS10, a high molybdenum super ferritic stainless steel, has been found to improve plant performance because of its better thermal properties over time and to reduce maintenance and replacement costs because of its resistance to corrosion and degradation.

Membership

IMOA welcomes:

Bear Metallurgical Company
679 East Butler Road
Butler, PA 16001, USA
Tel: + 1 724 283 6800;
Fax: + 1 724 283 6078
E-mail: kjones@bearmet.com
Produces Mo pillow bricks and FeMo

Also, Jinduicheng Molybdenum Mining Corporation has decided to become a member in its own right, replacing the China Molybdenum Producers Association.

Jinduicheng Molybdenum Mining Corporation
17th Floor, Jie Rui Mansion, No. 5 West section of the second south Ring Road, Xian, Shaanxi Province, P.C. 710068 P.R. CHINA
Tel: +86 29 837 8676;
Fax: +86 29 837 8771
E-mail: jck@jdcmmc.com
http://www.jdcmmc.com
The biggest complex of molybdenum mining, dressing, smelting, processing, research and trade in Asia

IMOA's Training Seminars on the Fabrication of Duplex Stainless Steel

Avid readers of these Newsletters will have read about this programme, which was extended in October to cover China, Malaysia, Singapore, Thailand and Australia.

First China. Jinduicheng Molybdenum Mining Corp. (JDC) and IMOA initiated this series of seminars in co-operation with the Nickel Development Institute (NiDI) Beijing, the International Chrome Development Association (ICDA) and the Stainless Steel Council of China Special Steel Enterprises Association (SSC). JDC asked IMOA to present their seminar on Fabrication of Duplex Stainless Steels. The proposed series of seminars in three Chinese cities (Beijing, Nanjing, Shanghai) was aimed as a first step of a market development programme to increase the use of molybdenum and moly-containing stainless steel in China.

IMOA's usual consultants, Nicole Kinsman and Heike Helfen, were joined as speakers by Chang-Ching Sun (the China Manager and Chief Metallurgist of AvestaPolarti Asia Pacific) - see photo - and Professor Wu Jin (SSC) introduced the seminars and chaired the question / answer sessions.

The programme covered the following main headings:

Introduction to IMOA and to duplex stainless steels

- *The duplex family*
- *The benefits of duplex*
- *Applications of duplex stainless steel*

Metallurgy of duplex stainless steels.

- *Microstructure*
- *Phase stability*
- *Implications for fabricating duplex*

Standards for duplex stainless steels.

- *European*
- *US*
- *Chinese*

Welding of duplex stainless steels.

- *Difference to standard stainless steel*
- *Microstructural changes*
- *Tests for welding procedure qualification*
- *Post weld clean-up*

Saving cost with duplex stainless steels.

Questionnaires were completed by delegates (190 in all) and 95% voted on the excellence of the presentations (the remaining 5% said 'OK'!) Professor Wu expressed concern that the seminars did not cover production of duplex, but this is beyond the scope of IMOA.

Our thanks to all involved, especially at JDC, SSC, NiDI and ICDA for their support and organisation of a successful joint venture. IMOA hopes that this project will be a stepping-stone to further activities to promote the domestic usage of moly-containing stainless steel in China.

Our team then moved on to Malaysia, Singapore, Thailand and Australia in an exhausting 7 day tour co-ordinated by NiDI (and particularly by David Jenkinson, the Director of NiDI Australasia). These seminars followed much the same pattern although there was an added paper on the application of duplex stainless steel by Pierre Soulignac (Chief Metallurgist Usinor Industeel, Le Creuset, France).

Apart from NiDI, also involved were the Institute of Materials in Malaysia; the Thai Stainless Steel Development Association; the Singapore Welding Society; and the Australian Stainless Steel Development Association.

There were lively discussions and many questions at each location, which indicated that there is still a lack of understanding in this region of how to select, specify & fabricate stainless steels correctly. NiDI is now focusing its market development efforts on developing countries because they see the greatest potential for growth and need for information there.

IMOA is grateful to NiDI for this chance to present its seminars and hopes to explore further opportunities to pursue its market development programme in the region with NiDI and other interested parties, especially local Stainless Steel Development Associations. Again, thanks to all involved.

Photo courtesy of JDC

IMOA®
INTERNATIONAL MOLYBDENUM ASSOCIATION

LIST of MEMBERS

Secretary-General:Michael Maby

AUSTRIA

Interalloys Trading & Business Consulting GmbH
A-1040 Vienna, AUSTRIA
Tel: + 43 1 504 6138; Fax: + 43 1 504 6192
E-mail: interal@ycn.com

Treibacher Industrie AG
A-9330 Althofen, AUSTRIA
Tel: + 43 4262 5050; Fax: + 43 4262 2813
E-mail: tam@treibacher.at http://www.treibacher.at/

BELGIUM

ALZ NV
Genk-Zuid: Zone 6A, B-3600 Genk, BELGIUM
Tel: + 32 89 302 401; Fax: + 32 89 302 106
E-mail: info@alz.bc http://www.alz.be

Sadaci NV
Langerbruggekaai 13, B-9000 Gent, BELGIUM.
Tel: + 32 92 540 511; Fax: + 32 92 540 571
E-mail: msmeets@sadaci.be

CANADA

Highland Valley Copper
Suite 400 – Oceanic Plaza,1066 West Hastings Street
Vancouver BC V6E 3X1, CANADA
Tel: +1 604 688 2211; Fax: +1 604 688 0646
E-mail: greynard@hvcopper.com

CHILE

Codelco Chile
Huerfanos 1270, Santiago, CHILE
Tel: + 56 2 690 3406; Fax: + 56 2 690 3366
E-mail: jleibbra@stgo.codelco.cl

Molibdenos y Metales S.A.
Huærfanos 812, 6th Floor, Santiago, CHILE
Tel: + 56 2 368 3600; Fax: + 56 2 633 4429
E-mail: info@molymet.cl http://www.molymet.cl/

CHINA

Jiangsu Fengfeng Tungsten & Molybdenum Products Co., Ltd
Tang Jia Se, The Northern Suburbs of Dongtai
Jiangsu, CHINA
Tel: + 86 515 523 1237; Fax: + 86 515 523 5949
E-mail: Y5231237@pub.yc.jsinfo.net

Jinduicheng Molybdenum Mining Corporation
17th Floor, Jie Rui Mansion, No. 5 West section of the second south Ring Road, Xian Shaanxi, Province, P.C. 710068, P.R. CHINA
Tel: +86 29 837 8676 Fax: +86 29 837 8771
E-mail: jck@jdcmmc.com http://www.jdcmmc.com

Liaoning Chaoyang Dongfeng Ferroalloy Plant
8 Nanda Street, Chaoyang, Liaoning, 122000, P R CHINA
Tel: + 86 421 2651 117 Fax: + 86 421 2651 887
E-mail: cymoly@mail.cyptt.ln.cn

Linghai Sing Horn Enterprise Co., Ltd
No.56, Shangdali, Taihe District, Jinzhou Liaoning, CHINA
Tel: + 86 416 517 1930; Fax: + 86 416 517 1944
E-mail: jzlhshs@mail.jzptt.ln.cn http://www.singhorn.com/

GERMANY

F W Hempel Metallurgical GmbH
Leopoldstr. 16, D-40211 Düsseldorf GERMANY
Tel: + 49 211 168 060; Fax: + 49 211 168 0644
E-mail: f.-w.hempel@fwhempel.com http://www.fwhempel.de/

Metherma GmbH
Arnheimer Str. 103, D-40489 Düsseldorf, GERMANY
Tel: + 49 211 40 80 840; Fax: + 49 211 40 71 26
E-mail: metherma.molybdenum@t-online.de

H C Starck GmbH & Co KG
Im Schleeke 78 - 91, Postfach 25 40
D-38615 Goslar, GERMANY
Tel: + 49 5321 751 0; Fax: + 49 5321 751 192
E-mail: georg.nietfeld.gn@hcstarck.de http://www.hcstarck.de/

ITALY

Gerli Metalli SpA
Piazza S. Maria Beltrade 1, I-20123 Milan ITALY
Tel: + 39 02 809 511; Fax: + 39 02 890 0714
E-mail: gerlimetalli@mail.mdsnet.it

Italchimici SpA
Via M. D'Azeglio 62, I-25067 Lumezzane ITALY
Tel: + 39 030 892 2255; Fax: + 39 030 892 0661
E-mail: italchim@lumetel.it

JAPAN

Kohsei Co., Ltd
Marukashiwa Building, 6F 1-6-1 Honcho Nihonbashi Chuo-ku,
103-0023 Tokyo, JAPAN
Tel: + 81 3 3270 0303; Fax: + 81 3 3270 7504
E-mail: furuta@kohsei.co.jp

Nissho Iwai Corp
Tradepia Odaiba, 3-1, Daiba 2-chome, Minato-ku, Tokyo 135-8655, JAPAN
Tel: + 81 3 5520 3529; Fax: + 81 3 5520 3517
E-mail: matsumura.hiroshi@nisshoiwai.co.jp

Taiyo Koko Co., Ltd
3-1, 3-chome Marunouchi, Chiyoda-ku, Tokyo 100-0005, JAPAN.
Tel: + 81 3 3216 6041; Fax: + 81 3 3216 6045
E-mail: trade@taiyokoko.co.jp

LUXEMBOURG

Considar Europe SA
3 rue Pletzer, Centre Helfent, L-8080 Bertrange LUXEMBOURG.
Tel: + 352 45 99 99 1 Fax: + 352 45 99 99 223
E-mail: heinz.duechting@considar.lu

MEXICO

Mexicana de Cobre SA de CV
Av. Baja California 200, Col. Roma Sur, 06760 Mexico DF, MEXICO
Tel: + 52 5 264 7775; Fax: + 52 5 264 7769
E-mail: adenekeng@gmexico.com.mx http://www.gmexico.com/

PERU

Southern Peru Copper Corporation
Av. Caminos del Inca 171, Chacarilla del Estanque, Surco, Lima 33, PERU
Tel: + 51 1 372 1414; Fax: + 51 1 372 0237
E-mail: jdlheros@southernperu.com.pe http://www.southernperu.com/

SWEDEN

AvestaPolarit Oyj Abp
S-774 80 Avesta, SWEDEN
Tel: + 46 226 810 00; Fax: + 46 226 813 05
E-mail: marie.louise.falkland@avestapolarit.com

Scandinavian Steel AB
Birger Jarlsgatan 15, SE 111 45 Stockholm, SWEDEN
Tel: + 46 8 614 2850; Fax: + 46 8 611 6434
E-mail: metals@scandinaviansteel.se

SWITZERLAND

Glencore International AG
Baarermattstrasse 3, P O Box 555, CH-6341 Baar, SWITZERLAND
Tel: + 41 41 709 2000; Fax: + 41 41 709 3000
E-mail: isaac.levy@ch.glencore.com

UK

Adams Metals Ltd
Norwich House, 14 North Street, Guildford, Surrey GU1 4AF,UK
Tel: + 44 1483 577900; Fax: + 44 1483 578008
Toll Free/ USA– Tel: +1 800 473 8427; Fax: +1 800 473 8428
E-mail: adamsmetals@btinternet.com http://www.adamsmetals.com/

Brandeis Ltd
Pechiney House, The Grove, Slough, Berkshire SL1 1QF
Tel: +44 1753 522 800; Fax: +44 1753 825 033
E-mail: Christian_Masson-Brandeis@Pechiney.com

Eastlink Ferro Alloys Ltd
Surrey Street, Glossop, Derbyshire SK13 7AL UK
Tel: + 44 1457 852333; Fax: + 44 1457 855655
E-mail: david.l@eastlinklanker.com

Alfred H Knight International Ltd
Eccleston Grange, Prescot Road, St Helens, Merseyside WA10 3BQ, UK
Tel: + 44 1744 733757; Fax: + 44 1744 27062
E-mail: st-helens@alfred-h-knight.co.uk

Derek Raphael & Co Ltd
2nd Floor, 6 York Street, London W1U 6PL, UK
Tel: + 44 20 7535 1690; Fax: + 44 20 7535 1691
E-mail: DRaphael@derek-raphael.co.uk http://www.derek-raphael.co.uk/

Alex Stewart (Assayers) Ltd
Caddick Road, Knowsley Industrial Estate , Merseyside LL34 9ER, UK.
Tel: + 44 151 548 7777; Fax: + 44 151 548 0714
E-mail: enquiries@ alexstewart.com

Wogen Resources Ltd
4 The Sanctuary, Westminster, London SW1P 3JS, UK.
Tel: + 44 20 7222 2171; Fax: + 44 20 7222 5862
E-mail: akerr@wogen.co.uk http://www.wogen.com/

USA

Alldyne Powder Technologies
7300 Hiway 20 West, Huntsville, Ala 35806, USA
Tel: + 1 256 837 1311; Fax: 1 256 722 2283
E-mail: jjohnson@alldyne.com

American Flux & Metal
P O Box 74 - Fleming Pike, Winslow, NJ 08095, USA
Tel: + 1 609 561 7500; Fax: + 1 609 561 3724
E-mail: flux@bellatlantic.net http://www.americanflux.thomasregister.com/

Bear Metallurgical Company
679 East Butler Road, Butler, PA 16001, USA
Tel: + 1 724 283 6800; Fax: + 1 724 283 6078
E-mail: kjones@bearmet.com

The Chem-Met Co
P O Box 819, Clinton, MD 20735-0819, USA
Tel: + 1 301 868 3355; Fax: + 1 301 868 8946
E-mail: afox@chem-metco.com

Climax Molybdenum Company
1501 West Fountainhead Parkway, P O Box 22015, Tempe, AZ 85285-2015, USA
Tel: + 1 602 929 4400; Fax: + 1 602 929 4410
E-mail: dthornton@phelpsdodge.com

Comsup Commodities Inc
1 Bridge Plaza North, Fort Lee, NJ 07024, USA
Tel: + 1 201 947 9400; Fax: + 1 201 461 7577
E-mail: comsup@earthlink.net

Kennecott Utah Copper Corp
8315 West 3595 South, P O Box 6001, Magna Utah 84044-6001, USA
Tel: + 1 801 252 3000; Fax: + 1 801 252 3292
E-mail: sullivas@kennecott.com

Molycorp Inc
376 S. Valencia Avenue, Brea, California 92823, USA
Tel: + 1 714 577 1757 ; Fax: + 1 714 577 2779
E-mail: cjcynor@unocal.com

Osram Sylvania Products Inc
Hawes Street, Towanda, PA 18848, USA.
Tel: + 1 570 268 5000; Fax: + 1 570 268 5113
E-mail: susan.dunn@sylvania.com

Powmet Inc
P O Box 5086, 2625 Sewell Street, Rockford, IL 61125, USA.
Tel: + 1 815 398 6900; Fax: + 1 815 398 6907
E-mail: wct@powmet.com

H. C. Starck
21801 Tungsten Road, Cleveland, Ohio 44117, USA
Tel: + 1 216 692 4452; Fax: + 1 216 692 0031
E-mail: jcdurham@worldnet.att.net

Thompson Creek Metal Company
945 West Kenyon Avenue, Englewood, CO 80110-3469, USA
Tel: + 1 303 761 8801; Fax: + 1 303 761 7420
E-mail: marionc@tcrk.com