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JANUARY 2001

News Letter

12TH ANNUAL GENERAL MEETING

With Paris as a venue, it was not surprising that the meeting attracted 60 delegates (and a number of partners).

Dick de Cesare, President of IMOA and Vice-President of Thompson Creek Metals, opened the meeting with an address of which an edited version follows:

"We are meeting in this beautiful and historic city at a time of great difficulties for the molybdenum industry. Some members of IMOA, my own company included, face a critical challenge to maintain profitability in the face of present market conditions. Despite a high current level of moly consumption worldwide, the industry continues to experience an imbalance of oversupply. IMOA of course cannot influence the level or trend of future supply. But through its market promotion and development efforts, this association can influence the trend of future moly consumption. It should be in the interest of all IMOA members who produce, convert, consume, trade or weigh and assay molybdenum to have a healthy and growing industry. And IMOA can contribute to the renewal of a healthy growing moly industry in a meaningful way. In order to do this, IMOA must maintain its efforts to protect and enhance the reputation of molybdenum as an environmentally safe product and, to the extent possible under current market conditions, IMOA should increase its efforts and resources to stimulate greater moly consumption through effective market promotion and product development activities.

Today you will receive updates on these efforts and activities from our Committee Chairmen. You will also hear from several guest speakers whom we have engaged as consultants relating to IMOA's programs on life cycle analysis and market development.

As you know, a lot of work is accomplished by our three sub-committees: Sampling and Assaying, Health, Safety and Environment and Market Promotion. On behalf of IMOA's membership, I want once again to thank the chairmen and members of these Committees for their very dedicated efforts, and for the positive results they achieved for our Association during this year and in years past. We very much appreciate the considerable time they devote to IMOA. I also want to thank the members of the Executive Committee for their active participation and valuable input.

At last year's meeting I commented that it is obviously more easy to support effective associations like IMOA when business is good than when business is bad. This year has been even worse than last year for the moly industry. And right now it is difficult to predict whether next year will be better or worse than this year. Nevertheless we must push ahead on those essential programs and projects that have the realistic possibility to make a meaningful contribution to the long-term health and expansion of the moly industry. More than ever, and in spite of the current prevailing pessimism in this business, we need your continued financial commitment to IMOA and your active participation in its various activities.

Thank you all for showing your support of IMOA by coming to today's meeting. I hope you will enjoy the program."

Elections

The following were elected to the Executive Committee:
Marie-Louise Falkland (Avesta Sheffield AB)
Guido Provoost (Sadaci NV), and

John Graell (President of Molymet) was elected as Vice-President of the Association

The President expressed the Association's warmest thanks to Patrick Sheridan who would be retiring from Sadaci early in 2001 and was therefore resigning from the Executive Committee. Sheridan had served on the Executive Committee since IMOA's inception in 1989; he had made a substantial contribution to IMOA's development and work programmes with a flow of good ideas. A place at his table at social functions, especially if accompanied by his wife Brigitte, was always sought after and he (and she) will be greatly missed.

HSE / Sampling & Assaying Committees

Presentations at the AGM included a summary of IMOA's work on HSE activities by Carmen Venezia (Osram Sylvania Products) which was supplemented by a paper from Anne Landfield (Ecobalance) regarding the conclusion of a Life Cycle Inventory for the metallurgical moly industry.

Staf Laget (Sadaci) reviewed the work of the S & A Committee which is working towards the publication of guideline procedures for the assaying of tech oxide, concentrate and FeMo, similar to the guidelines for sampling which were so welcomed by the industry worldwide in 1997. Publication is expected in 2002.

Bad news for IMOA and the moly industry - Staf Laget is leaving! Staf was the first Chairman of the Sampling & Assaying Committee when set up in 1993, and has been a member of the Health, Safety & Environment Committee since 1994. He has been a key contributor to our work programme in both areas; a valued liaison with the EU industry organisations and authorities; an unmatched source of technical expertise; and a real friend to many of us, during and after work.

Market Development

The July Newsletter reviewed IMOA's progress to promote duplex stainless steels and its initiation of a market survey to explore the principal areas on which to focus efforts to increase moly consumption.

The duplex project is a continuing success story (see the box on page X), and further training seminars will be held in March and April in the UK in conjunction with the British Stainless Steel Association, and in Italy in May in conjunction with Centro Inox. Marie-Louise Falkland (Avesta Sheffield) gave a paper at the AGM on Codes and Cost Aspects of Duplex Stainless Steels.

Preliminary results of the market survey were presented at the AGM by Heinz Pariser and the Association will soon be examining the final results and planning its work programme.

At the AGM, the delegates from Jinduicheng Mining Corporation (the largest moly mine in China) proposed a joint project with IMOA to develop moly consumption in China. China is far behind other countries in terms of moly used in steel production and this exciting opportunity will be explored.

Lastly, many consumers have suggested to IMOA that another brochure on austenitic stainless steel be prepared along the lines of the duplex brochure (with accompanying training seminars). Our consultants, Technical Marketing Resources, have drafted proposals for a brochure entitled 'Practical Guidelines for the Fabrication of Austenitic Stainless Steels' which will cover the standard stainless steel grades as well as the high performance austenitic stainless steels, comparing them whenever possible to the carbon steels. IMOA will be discussing their ideas, not only internally but jointly with the Nickel Development Institute and the International Chrome Development Association, as a combined project by the alloy suppliers to the stainless steel industry has an obvious appeal.

More news on IMOA's Market Development Programme will appear in the next Newsletter.

Future Meetings

- the next Executive Committee meeting will be held in Atlanta on 24 April 2001
- the 13th Annual General Meeting will be held in Stockholm at the kind invitation of Avesta Polarit over Tuesday, 11th - Friday, 14th September 2001
- the 14th Annual General Meeting will be held in Hermosillo, Mexico at the kind invitation of Molymet (date to be finalised).

Further details will be published in these Newsletters and added in due course to IMOA's website.

Moly Does the Job

This article is the fourth in a series of case histories where the application of moly has helped companies to solve technical problems which have occurred. Nicole Kinsman of Technical Marketing Resources, consultants to IMOA, is the author and she will continue to write similar articles for future issues of this Newsletter.

Readers with similar experiences, where moly has assisted in solving problems, are invited to contact the Secretariat.

Summary

A large, international, food manufacturing company encountered through-wall leaks in a Type 304 stainless steel hot water line after only two years of service. The leaks were caused by a combination of Microbiologically Influenced Corrosion (MIC) and manganese pitting corrosion. An upgrade to the more corrosion resistant 6% molybdenum stainless steel permanently solved the problem. Three years after the initial piping replacement, the plant completed replacement of the entire hot water line with 6% molybdenum high performance stainless steels.

The Process

Well water, which is used as a food ingredient is pre-chlorinated and passed through a green sand/carbon filter and pumped into a reservoir. From there it is chlorinated again and brought into the plant. A Type 316 heat exchanger heats the water to 150°F (65°C). The water is carried into the food processing area by an overhead "hot water line". The insulated line is about 2,000 feet (610 m) long and was originally built in Type 304 stainless steel. It has a main header of Type 304, 4-inch (100 mm) diameter schedule 10 pipe (0.12 inch / 3.2 mm wall thickness). At the far end of the insulated water line, the water temperature decreases to 80° – 120°F (25° – 50°C). Leaking of smaller diameter pipe began in less than two years. Within five years, leaking was evident along the entire line.

The Corrosion

The chloride content of the hot water is 50 to 100 ppm. The chlorination target is 0.2 to 0.3 ppm and never exceeds 0.5 ppm free chlorine. These are moderate concentrations which normally are considered to be below the critical level which might cause pitting in Type 304. However, pitting occurred in numerous places, predominantly in the mid-length section of the line in the lower third of the piping cross section.

The pitting was thought to be related to the high manganese content of the water. If manganese-metabolizing bacteria are

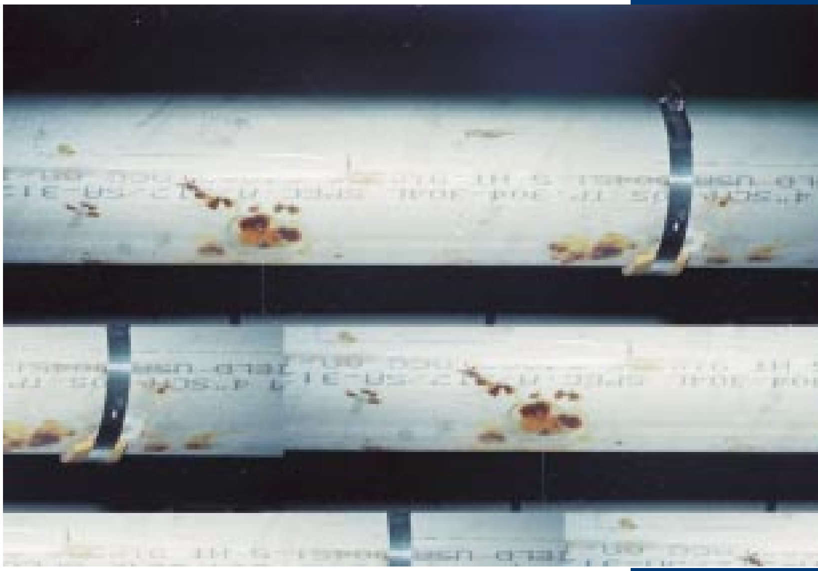


Fig 1: Numerous pits are found on the lower third of the pipe. A patch, covering a leak, is seen in the picture.

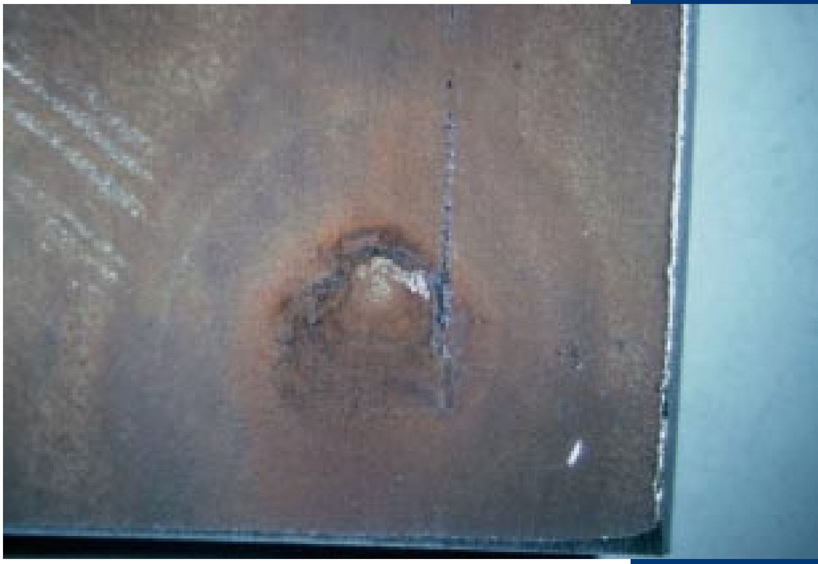


Fig 2: Close-up of the pitting corrosion.

present, manganese can be transformed into the permanganate ion. In association with the chloride ion, permanganate can initiate pitting in Type 304 stainless steel. This form of corrosion is relatively rare, but if it occurs, propagation may be rapid. Further evidence for this mechanism, in addition to the presence of metal-oxidizing microbes in the water, was the location of the pitting in portions of the line where intermediate temperatures prevailed. It did not occur initially with the high temperatures in the heat exchanger or the relatively cool ones at the end of the water line. Bacterial activity is greatest at somewhat elevated temperatures.

In most practical situations, it is difficult to prove conclusively that MIC is the cause of pitting. This case was further complicated by the possibility that the rapid pitting corrosion was caused by the interaction of chlorine and manganese to form permanganate.

The Solution

It could not be determined whether the pitting was caused by MIC (due to the manganese-metabolizing bacteria) or by manganese pitting (due to the interaction with chlorine). However, both mechanisms can be prevented through a change in water chemistry, which is usually not practical, or through a significant upgrade in the corrosion performance of the piping material. In this case, the company decided to replace the Type 304 with the 6% molybdenum stainless steels, UNS S31254 and UNS N08367. Upgrading only to Type 316 stainless steel (2% Mo) is normally not sufficient to prevent MIC or manganese pitting.

The Cost Savings

The plant began their piping replacement in small stages within a maintenance budget which did not require detailed cost saving analysis. However, the final upgrades were two capital projects for which detailed justification was required. Management determined that benefits including food product integrity, maintenance cost savings, and safety issues, easily justified the remaining pipe replacement. The problem-solving experience with the 6% Mo high performance stainless steels was communicated to the many other plants operated by this international company.

"Once again – Moly does the Job."

Table 1: Typical chemical compositions of the stainless steel grades in this article. Note: The company used two different 6% molybdenum stainless steels in their hot water line, 254 SMO and AL-6XN.

	UNS No.	Molybdenum	Chromium	Nickel	Nitrogen	Other
Type 304	S30400	**-**	18	9	-	
Type 316	S31600	**2**	17	11	-	
254 SMO®	S31254	**6**	20	18	0.2	0.75 Cu
AL–6XN®	N08367	**6**	20	24	0.2	

The 6% molybdenum stainless steel names are protected trademarks of the following companies:

254 SMO Avesta Polarit AL-6XN Allegheny Ludlum

6th World Duplex 2000 Conference and Expo 17 – 20 October 2000, Venice, Italy

This Conference was organized by Associazione Italiana di Metallurgia (AIM) and jointly sponsored by IMOA. Some 280 delegates from all over the world attended and there were 80 presentations plus a visit to the De Poli shipyard.

IMOA conducted a workshop which outlined the programme for its full duplex training seminars on offer.

Heike Helfen (Climax Molybdenum GmbH) and Nicole Kinsman (Technical Marketing Resources) attended on behalf of IMOA and have written the following articles for this Newsletter.

Most of the papers had a strong emphasis on recent scientific developments and therefore did not attract many representatives from the end-user and engineering industries.

One of the keynote papers, which definitely focused not only on the scientific developments but practical applications, will now be summarised.

Duplex Stainless Steels: Past, Present and Future

Kåre Johansson - Statoil, Norway

Research and Development

Finding the usability limits for the material in connection with corrosion is an important aspect of industrial research. Alloy development can therefore be regarded as the practical side of the research effort.

Since the first duplex grades appeared significant improvements have been achieved for example through the addition of molybdenum and copper. The beneficial effect of these elements on both corrosion and mechanical properties were well known in the early years.

In the 1940's, it became obvious that some ferrite in the austenite gave protection against chloride induced stress corrosion cracking. This resulted in further developments promoted at that time as the final solution to all chloride induced stress corrosion cracking. This attitude towards SCC has stuck to the duplex family, but it is well known today that this is not entirely true. Given the right conditions SCC can still occur even in duplex stainless steels.

Early in the 1950's, due to the nickel shortage, there was a lot of activity with respect to the high chrome low nickel stainless steels, which benefited the further development of duplex steels. In the 1960's the progress in the steelmaking process allowed the reduction of carbon to 0.03% helping to avoid the observed intergranular corrosion. But at that time the welding of duplex stainless steel was still difficult.

In the early 1970's, the 22Cr type was developed and further alloy improvement without significant cost penalties came along with the introduction of the AOD converter and a better understanding of thermal treatments. Oxygen, Sulphur, Carbon and residual elements could now be kept to low levels and it was possible to add nitrogen at low cost.

The 1980's brought an even better understanding of the importance of nitrogen and its effect on structural balance in the heat affected zone (HAZ) and corrosion resistance. At the same time, the development of the 25Cr grades accelerated leading to the super-duplex grades.

Today three main groups of duplex stainless steel exist:

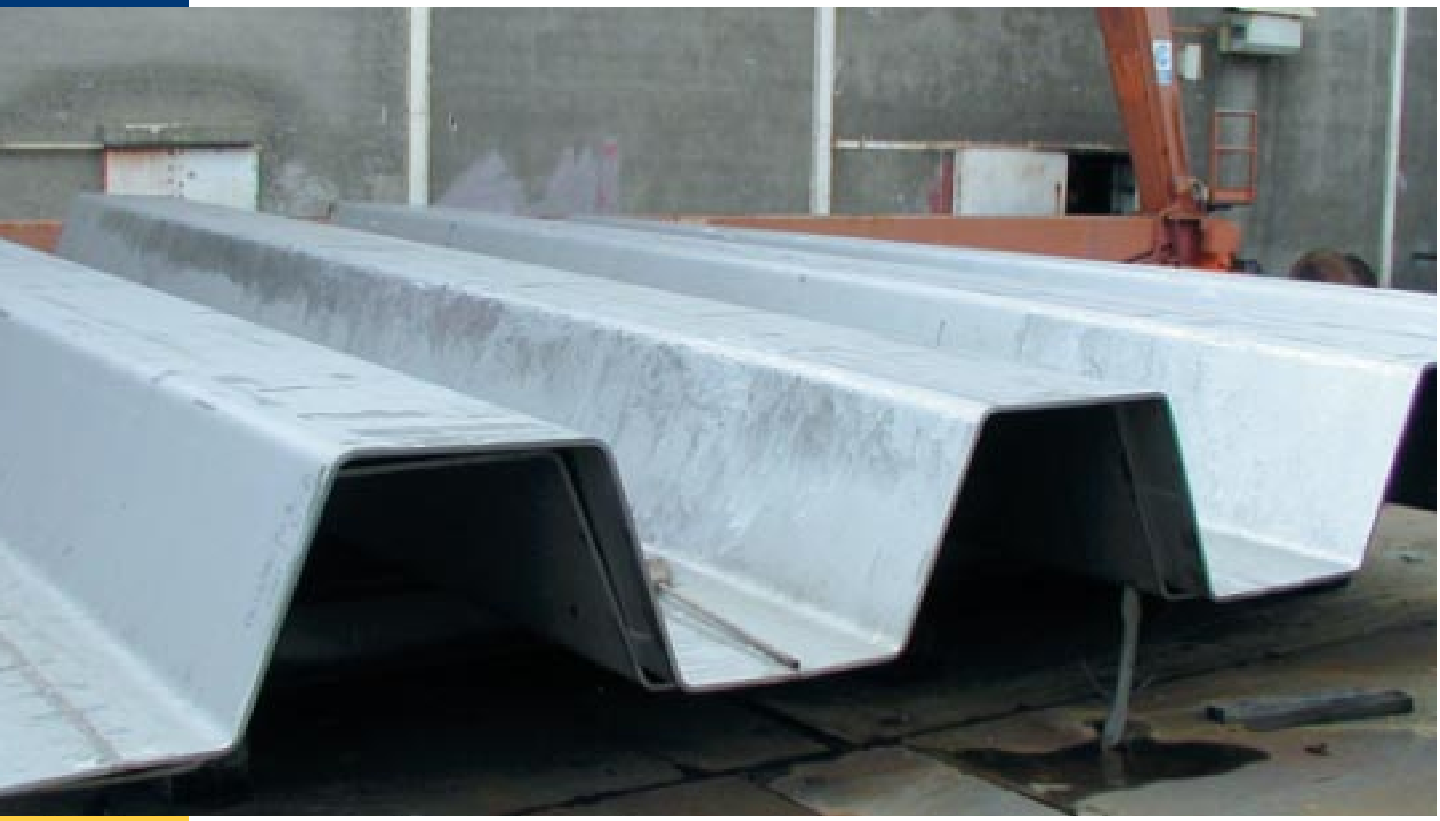
- Lean alloys like S32304 (2304)
- Standard grades like S31803 and S32205 (2205)
- Super-duplex grades like S32750 and S32760 (2507)

In the future the introduction of HIP can change alloy development, as it will overcome the limitations of alloy composition due to segregation or phase transformation. Specially prepared powders can then be mixed with suitable austenitic powders to get alloy compositions which otherwise would be impossible to produce. This would be a significant possibility for the development of tailor-made duplex grades.

Comprehension and Understanding

In the last decades significant improvements have been made regarding the understanding of these materials. And today the dissemination of this information has to be seen as the main obstacle to further use of duplex stainless steels.

"Full credit must therefore go to IMOA for their practical guidelines published last year which gives a very good and condensed story with practical advice. Perhaps this ought to be translated to all the European languages and a copy given to every engineering student? It is important to understand the behaviour of the material and work together with, rather than against, the nature of the material."



Visit to the De Poli Shipyard in Venice, Italy

Before the Duplex World 2000 Conference in Venice in October of 2000, the delegates had the opportunity to visit Cantiere Navale De Poli, the De Poli shipyard. De Poli was founded in 1880 and is situated on the Island of Pellestrina near Venice.

De Poli fabricates marine chemical tankers, the ships which transport a wide variety of liquid cargo across the oceans from port to port. Typical cargoes include chemical, petrochemical and food products. Examples are phosphoric acid, sulphuric acid, petroleum products, vegetable oils and molasses.

At the port, the product is pumped directly into one of the several tanks on the ship. Tanks are typically 10 meters (33 feet) wide, 12 meters (39 feet) long, and 11.5 meters (38 feet) high and carry about 1380 m3 (365,000 gallons) of liquid. However, a marine chemical tanker usually has tanks of various capacities to accommodate different cargo sizes.

Because of the wide range of possible cargo, the tanks have to be as corrosion resistant as possible, while still affordable. With tanks of increasing corrosion resistance, the potential range of cargo and, therefore, the customer base increase for the owner of the ship.

At our visit to De Poli, a 140-meter (462 feet) long, 16,000 dead-weight-tons heavy chemical cargo tanker was under construction. It is the seventh fabricated by De Poli with all duplex tanks and will take about 16 month to complete. All of the 17 tanks on the ship are made from 2205 duplex stainless steel. This molybdenum-containing stainless steel is the standard stainless steel for marine chemical tank applications, replacing the lower alloyed austenitic stainless steels 316LN and 317L.

Figure 1: The cargo vessel as it is being built. The corrugated interior of a duplex stainless steel tank is open to the view.

Figure 2: Prefabricated, corrugated duplex stainless steel panels are ready to be installed on the ship to form liquid cargo tanks.

The duplex stainless steel 2205 is about twice as strong as the above-mentioned austenitics and, therefore, allows a lighter wall construction. This saves fuel or allows for higher cargo weight – always an important consideration in freight transportation. This stainless steel is also much more corrosion resistant than its predecessors. Because of this, a wider variety of chemicals can be transported over a wider temperature range. Some of the chemicals are transported at temperatures up to 80°C (176°F).

The interior tank walls, called the bulkheads, are usually corrugated (Figure 1). The corrugated construction provides structural strength for the whole ship. At the same time, the vertical corrugation in these tanks also facilitates the cleaning of the tanks after each cargo. In older designs it was necessary to use internal stiffeners to give the tanks stability and strength. These tanks were, of course, much more difficult to clean.

Wherever possible, De Poli uses automatic submerged arc welding in the horizontal position for the corrugated panel fabrication (Figure 2). For position welding on-board, flux cored wire and covered electrodes are used. After the tank fabrication the interior of the tanks is pickled and passivated.

Over the last several years, marine chemical tankers were the single largest consumer of duplex stainless steel. Approximately, 900 tons of molybdenum was consumed in 1998 by this application.

Observing the construction of a marine chemical tanker is awe inspiring; it is exciting to see how molybdenum-containing stainless steels contribute to the save and economical transportation of chemicals in such a massive scale.

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