INTERNATIONAL MOLYBDENUM ASSOCIATION

NEWSLETTER

JULY 2006

Membership

Welcome to:

- **Gfm Fesil GmbH,**

a German trading company involved in Molybdenum products

- **Jiangsu Fengfeng Tungsten and Molybdenum Materials Co Ltd,**

a Chinese producer of Mo Metal and Chemicals

New Office Premises

Please ensure records are changed to reflect the move from London at the beginning of April of IMOA (and ITIA) to:

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Website: www.imoa.info

Both Associations have always been registered under Belgian Law and the proximity to allied organisations will be advantageous.

IMOA's leading role as Team Stainless film wins "Oscar" ....

Or the near equivalent – first prize at a Belgian Corporate video competition.

There were 57 competitors at the 7th Festival van de Bedrijfsfilm and a professional jury of film directors, journalists and business people awarded first prize to the Team Stainless video "Alloyed for Lasting Value" in the category "Production and Product".

Team Stainless is a group comprising:

- **International Chromium Development Association (ICDA)**
- **Euro Inox**
- **International Molybdenum Association (IMOA)**
- **Nickel Institute (NI)**
- **International Stainless Steel Forum (ISSF)**

It was reconstituted in 2002, from an informal group, to explore collaborative efforts regarding market development and market defence and to focus on defining essential messages to be delivered to various audiences along the life cycle of stainless steel products.

Within the space of one year (the year of IMOA's Presidency of the Team), the concept was mooted and agreed; a director found (Tim Yates of Sovifo); the project completed; and prize won.

18th Annual General Meeting

This event will be held at Le Meridien Hotel, Vienna,
12-14 September,
hosted by Plansee and Treibacher.

New IMOA Website

The new Website was launched in May and the site now consists of three separate sections, with a considerable amount of added information.

- the main site, where information about IMOA can be found;

- the Moly Info Centre, with information on molybdenum production, processing and applications. A completely new section has been developed on the metallurgy and use of molybdenum in steels other than stainless steels;

- the HSE site. This section so far mainly comprises the Database on moly but IMOA is working on extending the contents.

Thanks are due to the many who have contributed time, effort and materials to the reconstruction of the website.

High Molybdenum Containing Stainless Steels Help Provide Fresh Water to the World

By Dr. Jim Fritz, TMR Stainless (Consultants to IMOA)

SUMMARY

Seawater reverse osmosis (SWRO) plants are vital for meeting the fresh water needs in many arid regions of the world. The SWRO process requires materials of construction that can contain high pressures and resist exposure to seawater. The early use of 316L (S31603) stainless steel for high pressure piping components was found to be inadequate to resist corrosive attack and resulted in costly replacements. Intermediate grades of stainless steel such as 904L (N08904) and 2205 (S32205) were also found to be at risk of corrosive attack in SWRO systems. This experience has resulted in the 6% molybdenum grades becoming the material of choice for high-pressure piping in SWRO plants. The 6% molybdenum grades provide exceptional performance and are now used in more than 30 SWRO plants in more then 10 different countries.

THE APPLICATION

In the last fifty years population growth, pollution, and climate shifts have reduced the world wide available fresh water per person by approximately 50%. Because of these trends, desalination has evolved into a vital tool for meeting the growing demand for fresh water. Today many arid countries rely on seawater desalination as their primary source of fresh water.

Although there are various commercial desalination processes available, recent advances in membrane technology have enabled the reverse osmosis (RO) process to become the leading desalination process based on worldwide capacity.

THE PROCESS

Seawater reverse osmosis systems consist of three major components; pretreatment, high-pressure pumps, and RO membranes ***(see Figure 1)***. The pretreatment process typically involves filtration and chlorination to prevent fouling and biofouling of membranes. The high-pressure pumps are used to achieve the high operating pressure, which for SWRO units is usually in the range of 54 to 80 bar (800 to 1200 psi). The membranes provide a barrier, which allows pure water molecules to pass through while restricting the passage of dissolved solids like salts or other contaminants.

THE CORROSION

The combination of high service pressure and exposure to seawater requires materials of construction for SWRO plants to have high strength and outstanding corrosion resistance. Early SWRO plants, such as the 12,000 m^3/day Jeddah plant in Saudi Arabia commissioned in 1979, used type 316L stainless steel (S31603) for the plant's high-pressure piping components. The corrosion resistance of the 316L grade proved to be inadequate and the plant suffered extensive crevice corrosion at high-pressure couplings resulting in major refurbishing within a couple years of service ***(see Figure 2)***. The Ghar Lapsi SWRO plant in Malta reported similar problems with their original 316L high-pressure piping resulting in premature replacement.

Over the years intermediate grades of stainless steel such as 317L, 904L, and 2205 duplex stainless steel ***(see Table 1)*** have been used for SWRO plants. However, many of these plants reported pitting and crevice corrosion. This experience has demonstrated that the use of these intermediate grades of stainless steel will not guarantee acceptable performance.

THE SOLUTION

Because of these corrosion problems, the desalination industry now recognizes that SWRO high-pressure piping requires a 6% molybdenum stainless steel or a grade with equivalent corrosion resistance to ensure adequate service life. Many of the world's largest SWRO plants have specified 6% molybdenum stainless steel ***(see Figure 3)*** and this family of stainless steel has provided excellent service in more than 30

Table 1. Stainless steels used in SWRO plants (nominal compositions in weight %, balance iron)

Grade	UNS No.	EN	C (max.)	Cr	Ni	Mo	N	Other
Austenitic Stainless Steels								
316L	S31603	1.4404	0.03	17	11	2.1		
317L	S31703	1.4438	0.03	18	12	3.1		
904L	N08904	1.4539	0.02	19.5	24.5	4.5		
6% Moly grades	S31254	1.4547	0.02	20	18	6.1	0.20	Cu - 0.70
	N08926	1.4529	0.02	19. 5	24.5	6.1	0.20	Cu - 0.70
	N08367	------	0.03	20.5	23	6.1	0.20	------
Duplex Stainless Steels								
2205	S32205	1.4462	0.03	22	5	3.3	0.16	
2507	S32750	1.4410	0.03	25	7	3.7	0.27	

SWRO plants located in more than 10 different countries. More recently super duplex stainless steels have been used for this application. For example, 2507 (S32750) duplex stainless steel has been specified for the recently constructed Ashkelon plant in Israel. Based on the relative corrosion resistance of the S32750 grade, its performance in this application should be very similar to the 6% molybdenum grades.

The improved performance of a 6% molybdenum grade is demonstrated quite dramatically in ***Figure 4***, which contrasts the condition of a 316L and a 6% molybdenum high-pressure coupling after exposure in the same SWRO plant. The 316L coupling suffered severe crevice corrosion after only 6 months of service while the 6% molybdenum coupling shows no visible evidence of corrosion after seven years of service.

THE COST SAVING

The use of high molybdenum bearing stainless steels provides excellent long-term service in SWRO plants and eliminates the need for costly retrofits. The cost of a major retrofit is huge and can be 30% of the initial capital investment of the plant. In addition to the cost savings, the use of proper materials of construction will guarantee an uninterrupted flow of fresh water, a vital resource for the health and well being of the community.

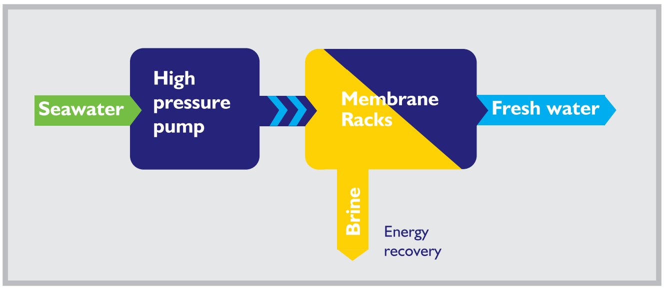


Figure1.

Schematic of the SWRO process which uses membrane technology to recover fresh water from seawater.
(Courtesy of Outokumpu)

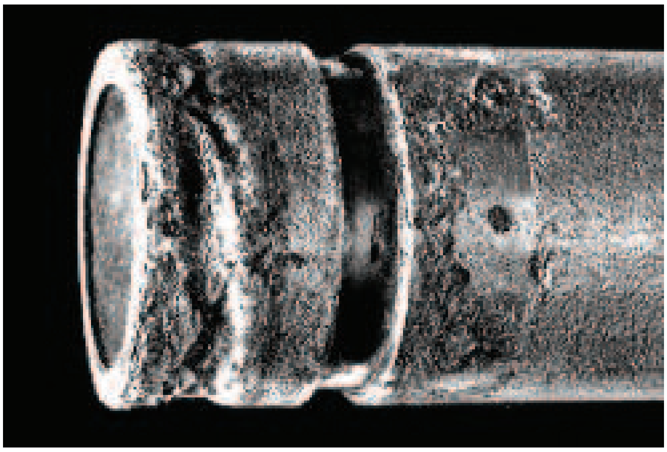


Figure 2.

Crevice corrosion at a 316L high pressure coupling from the Jeddah SWRO plant.

(Photo: Courtesy of Outokumpu)

Figure 3.

Fujairah SWRO plant in the United Arab Emirates showing 6% molybdenum (S31254) stainless steel piping.

(Photo: Courtesy of Degrémont)

Figure 4.

High-pressure couplings from a 40,000 m^3/day SWRO plant in the Mediterranean Basin. The 6% molybdenum coupling was in service for 7 years compared to only 6 months for the 316L coupling.

(Photo: Courtesy of Piedmont City Corps.)

Type 316L Stainless Steel Used in the Largest Potable Water Ultrafiltration Plant in the Western Hemisphere

By Dr. Jim Fritz, TMR Stainless, Pittsburgh, USA

Although membrane technology is often associated with the reverse osmosis process for desalting water, membranes are also used for a wide array of filtration processes for water treatment. Industry classifies membranes into four broad categories based on the size of the particles that are rejected by the membrane. The categories of membrane filtration are reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), and microfiltration (MF). See ***Figure 1.***

Membrane filtration has several advantages over conventional filtration treatments including improved water quality, reduced chemical consumption, and the potential to reduce capital and operating costs.

Membrane processes are used for clarification, disinfection, water softening, desalting, and removal of organic and inorganic chemicals. The choice of the membrane process depends on the specific contaminant to be removed. (***see Table 1***)

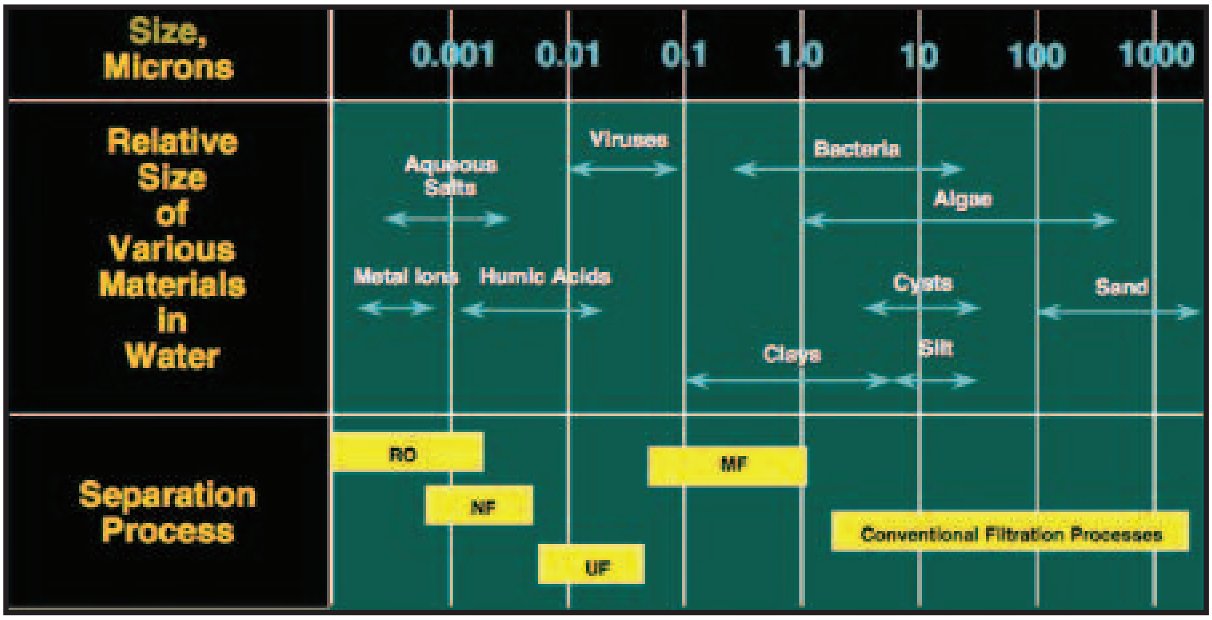


Figure 1: Comparison of membrane filtration processes (Courtesy of Montgomery Watson Harza)

Table 1: **Target Contaminants for Membrane Filtration Processes**

Contaminant	Membrane Filtration Process
Particulates, protozoa, bacteria	Microfiltration
Particulates, protozoa, bacteria, viruses	Ultrafiltration
Synthetic organic compounds	Nanofiltration, Reverse osmosis
Inorganic compounds	Nanofiltration, Reverse osmosis

Molybdenum containing stainless steels have long been the material of choice for the high pressure piping in RO units and their use and performance have been well documented. However, molybdenum-containing stainless steel is also a common material of construction for nanofiltration and ultrafiltration plants. A recent example is the Minneapolis Water Works new $65 million ultrafiltration plant.

In the mid 1990's the city of Minneapolis began to investigate possible improvements in the existing granular media filters used to treat the city's drinking water. Because the water is pumped from the Mississippi River, one of the primary concerns is the possibility of widespread illness due to pathogens such as Cryptosporidium and Giardia. This concern was heightened in 1993 when the city of Milwaukee, Wisconsin experienced an outbreak of Cryptosporidium caused by contaminated drinking water. This outbreak resulted in 403,000 illnesses and an estimated 30 to 100 deaths. Because of the increased health concerns it was decided that 99.9999% of all bacteria, protozoa, and viruses be removed to insure a safe water supply for the city of Minneapolis. To achieve this goal the city decided to replace their existing granular filters with a new state of the art ultrafiltration plant.

Black & Veatch designed the Minneapolis Water Works ultrafiltration plant and GE Water provided the membrane filtration equipment. Construction began in 2003 and the plant became operational in 2005. This facility uses over 9000 feet of type 316L stainless steel pipe and tubing ranging from 50 to 1524 mm (2 to 60 inches) in diameter ***(see Figures 2 and 3).*** It has a capacity of 262,500 m^3/day (70 million gallons per day) which makes it the largest potable water ultrafiltration plant in the Western Hemisphere.

With the increased concerns for safe drinking water and the more stringent regulatory standards the world demand for membrane filtration will continue to grow. This growth will provide an important market for molybdenum-bearing stainless steels.

Figure 2:

Type 316L piping at the Minneapolis Water Works membrane filtration plant.

Courtesy of Dale A. Folen, City of Minneapolis

Figure 3:

Ultrafiltration vessels and auxiliary 316L stainless steel piping.

Courtesy of Dale A. Folen, City of Minneapolis

Molybdenum Containing Alloy Sales for FGD Applications are Booming

By Dr. Gary Carinci, TMR Stainless, Pittsburgh, USA

The worldwide market demand for Flue Gas Desulfurization (FGD) systems to remove sulfur dioxide from exhaust gases of coal-fired electrical power plants has outpaced the supply by equipment manufacturers. FGD equipment greatly reduces the discharge of sulfur dioxide to the atmosphere and prevents acid rain.

Over the past year an unprecedented number of coal-fired power plant projects have been initiated around the world. China is the leader, but the U.S. and India also have a number of projects in planning and construction. The U.S. Clean Air Interstate Rule (CAIR) requires many coal fired power plants (with a total capacity of 100,000 MW) to install FGD systems by 2010. This deadline has been the major catalyst for the unprecedented demand in this market segment, and these new FGD installations will require over 50,000 metric tons of corrosion resistant alloys that contain over 1,500 metric tons of molybdenum.

Current predictions show that power plants will spend U.S. $168 billion worldwide for FGD systems during the period 2005-2020. This prediction assumes that two-thirds of the world's coal-fired generators will have installed FGD systems by 2020. FGD equipment orders are estimated at over $11 billion in 2006 and corrosion resistant molybdenum bearing alloy sales of over $1 billion will be required for these FGD projects in 2006. The impact of CAIR, the EU 2008 deadline (EU's key instrument to fight climate change under the Kyoto Protocol), the Chinese State Environmental Protection Administration (SEPA) rules and other regulatory impacts continue to fuel the demand for air pollution control systems.

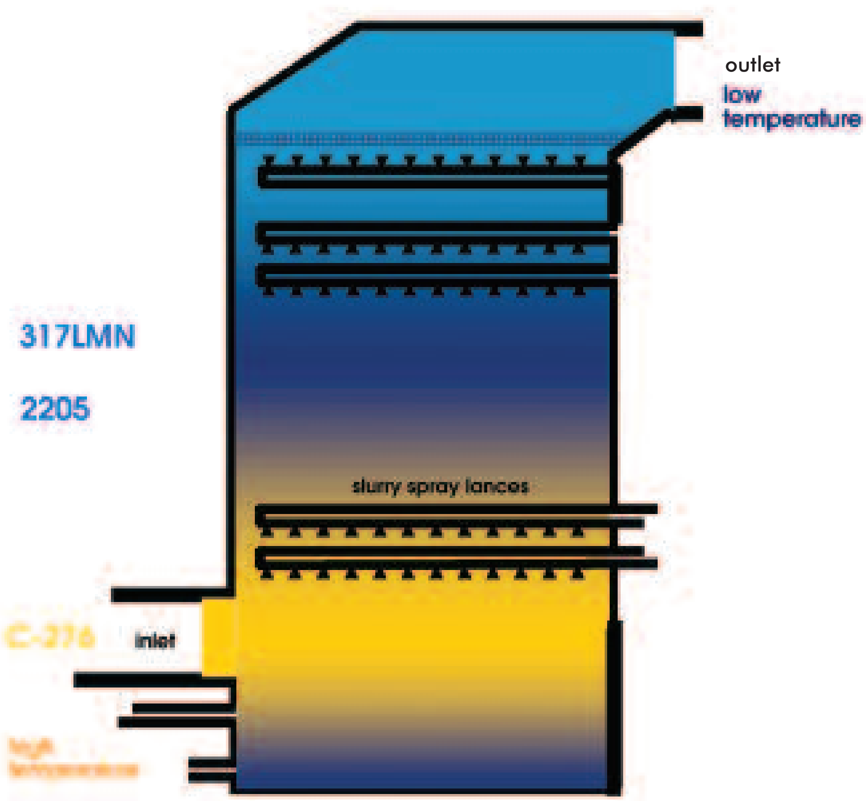
FGD technologies are used to remove the sulfur bearing gaseous emissions after combustion of the coal, and wet FGD units tend to dominate the global FGD market. The technology uses alkaline sorbent slurry, which is predominantly lime or

Table 1. **Typical chemical compositions of FGD alloys (wt%).**

Alloy	UNS Number	EN	Molybdenum	Chromium	Nickel	Nitrogen
C-276	N10276	2.4819	16	16	58	-
317LMN	S31726	1.4439	4	18	14	0.16
2205	S32205	1.4462	3	22	5	0.16

limestone based, to neutralize and "scrub" the exhaust gases. The sulfur dioxide in the flue gas reacts with the water and limestone slurry to form gypsum. This process takes place in the absorber which is located downstream of the boiler.

The high temperature flue gas forms high concentrations of hot sulfuric acid at the inlet of the absorber and highly corrosion resistant molybdenum bearing nickel base alloys such as C-276 are used to maintain adequate corrosion resistance in this section of the unit. After flowing through the inlet, the limestone slurry quenches the combustion gas in the absorber, and the operating environment becomes less aggressive with a higher pH and lower temperature (***Figure 1***). Molybdenum-bearing stainless steels such as 317LMN and 2205 are typically used as materials of construction for the absorber tower (***Table 1***).



ABSORBER VESSEL

Figure 1:

Schematic of a FGD absorber vessel showing the major components and common materials of construction.

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