# Stainless steel and molybdenum

by

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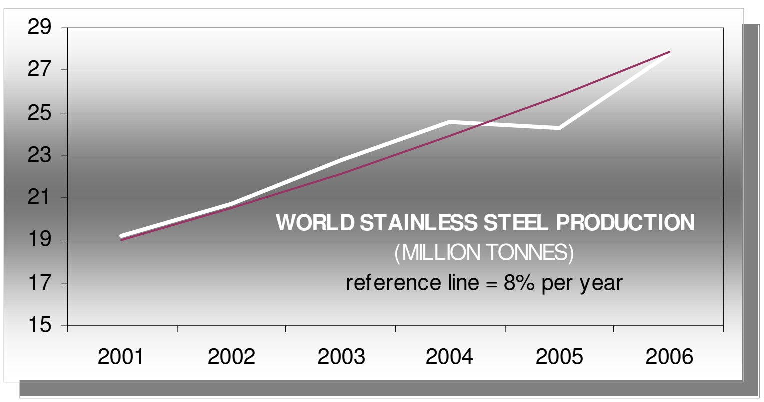
ABSTRACT: Stainless steel remains the fastest growing metal. Beyond a point, adding molybdenum is three times more effective than adding chromium to resist corrosion. Although molybdenum-bearing stainless steels are only a small part of the overall world market for stainless steels – under 10% – some molybdenum can be found in more than 40% of stainless grades. Molybdenum use in 316 stainless steel accounts for about one quarter of molybdenum demand. Because of the nature of the stainless market, stainless headlines usually do not reflect activity in the molybdenum grades. Therefore, it is difficult for investors to obtain good information on molybdenum-bearing stainless steels on a consistent basis. Recycling of stainless scrap is not keeping up with demand for molybdenum units, which will put more pressure on mine production. The desalination application is driving double-digit growth for molybdenum-bearing stainless steels. Offshore drilling and production is increasing relative to that onshore, driving an increased use of molybdenum in drill steels and ancillary equipment; seawater- and process piping; umbilicals; pumps; valves; coolers; manifolds and separators. Molybdenum-bearing lean duplex stainless steels are substituting for 304 stainless (no molybdenum) in applications like storage tanks for products such as flour, palm oil, wine, white liquor, potable and sewage water, ethanol, fruit juice and biodiesel. First U.S. deliveries of road tankers made of lean duplex stainless are expected this year. After a 3-decade hiatus, U.S. utilities have started applications for nuclear power plants as the result of enhanced subsidies enacted by Congress in December. Nuclear power plants use significant quantities of molybdenum-bearing stainless steels and other molybdenum alloys. New research that solves the hardness/corrosion resistance tradeoff in austenitic stainless steels bodes well for molybdenum-bearing 316 stainless.

# Stainless steel and molybdenum

How do you spell stainless steel?

| | |
|---|---|
| German | Nichtrostende Stal |
| French | Acier inoxydable |
| English | Stainless steel |
| Czech | Nerezova ocel |
| Dutch | In roestvast staal |
| Italian | Acciaio inossidabile |
| Polish | Gatunkow stali |
| Portuguese | Aco inox |
| Russian | Nerzhaveiushchei stali |
| Spanish | Acero inoxidable |
| Swedish | Rostfritt stal |




Stainless steels, technically "stain-resistant steels", came onto the radar in the 1900-1915 period, although relevant research has been traced back to 1821, when a French researcher named Berthier found that iron alloyed with chromium resisted some acids. The common definition of stainless steel today includes a chromium minimum of 10.5 percent.

Not everyone is in agreement as to who actually invented stainless steel. The origins seem quite diverse:

In 1872, Woods and Clark applied for a British patent for an "acid and weather resistant" alloy containing 30-35 percent chromium and 1.5-2 percent tungsten.
While many others investigated the chromium-iron relationship, there remained for many years a difficulty in achieving low carbon in the melt – another requirement.

Things started to progress after 1895, when Hans Goldschmidt developed the aluminothermic reduction process for producing carbon-free chromium.

It was in 1904 that Leon Guillet published research on alloys with compositions that today would be known as martensitic and ferritic stainless steels (martensitic grades 410, 420, 440, and ferritic grades 442, 446). In 1906, he also published a detailed study of an iron-nickel-chromium alloy that is the basic metallurgical structure for the 300 series stainless steels. (Strainless Steel Institute of North America)

In 1908, Monnartz and Borchers detailed the role of molybdenum in increasing corrosion resistance to chlorides.

In 1909, Giesen published in England a lengthy account on the chromium-nickel (austenitic 300 series) stainless steels, and Portevin published studies on an alloy that today would be 430 stainless steel. The chemical analysis for 430 stainless was patented in 1919. The first product was for table cutlery and still is today.

Many credit Harry Brearley for the commercialization of stainless steel. He melted a 0.24 percent carbon and 12.8 percent chromium (martensitic) stainless steel on the 13th of August, 1913. It was used for small arms gun barrels.

However, similar industrial developments were taking place contemporaneously at the Krupp Iron Works where Eduard Maurer and Benno Strauss were developing an austenitic alloy (21% Cr, 7% Ni), and in the United States, where Christian Dantsizen and Frederick Becket were industrializing ferritic stainless.

The chart below shows generally how chromium improves corrosion resistance. The better corrosion resistance is due to a chromium oxide film that is formed on the steel surface.

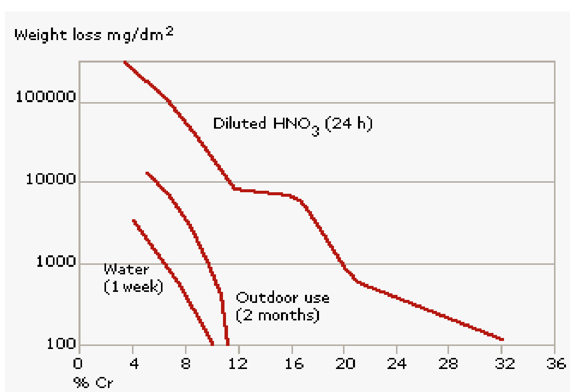



Chart shows how weight loss per unit of surface area is reduced with higher percentages of chromium (Cr).

Besides chromium, typical alloying elements are molybdenum, nickel and nitrogen. Nickel is mostly alloyed to improve the formability and ductility of stainless steel. Alloying these elements brings out different crystal structures to enable different properties – not just in corrosion or heat resistance, for example – but also in machining, forming, and welding.

Molybdenum is recognized in the fact that once you get past about 18 percent chromium in stainless steel, molybdenum is three times as important in further enhancing corrosion resistance. A Pitting Resistance Equivalent (PRE) number is defined with chromium (Cr), molybdenum (Mo) and nitrogen (N), below:

$$PRE = Cr + 3.3\ Mo + 16\ N$$

Beyond a point in corrosive conditions, PRE becomes everything.

There are five types of stainless steels; austenitic; ferritic; martensitic; duplex (austenitic-ferritic), and precipitation hardening (PH). The latter group isn't frequently mentioned, but it does have relevance to molybdenum, so I'd like to include a few words about PH stainless:

Precipitation hardening was first discovered in 1906 by the German metallurgist Alfred Wilm, yet it took another 15 years after this to fully understand and exploit the mechanism.

Precipitation hardening, also called age hardening or dispersion hardening, is a heat treatment technique used to strengthen malleable materials, including most structural alloys of aluminum, magnesium and titanium, and some stainless steels. It relies on changes in solid solubility with temperature to produce fine particles of an impurity phase, which impede the movement of dislocations, or defects in a crystal's lattice

Precipitation hardening stainless steels are chromium- and nickel-containing steels that provide an optimum combination of the properties of martensitic and austenitic grades. Like martensitic grades, they are known for their ability to gain high strength through heat treatment plus they possess the corrosion resistance of austenitic stainless steels.

The high tensile strength of PH stainless steels come after a heat treatment process that leads to precipitation hardening of a martensitic or austenitic matrix. Hardening is achieved through the addition of one or more of the elements copper, aluminum, titanium, niobium, and molybdenum.

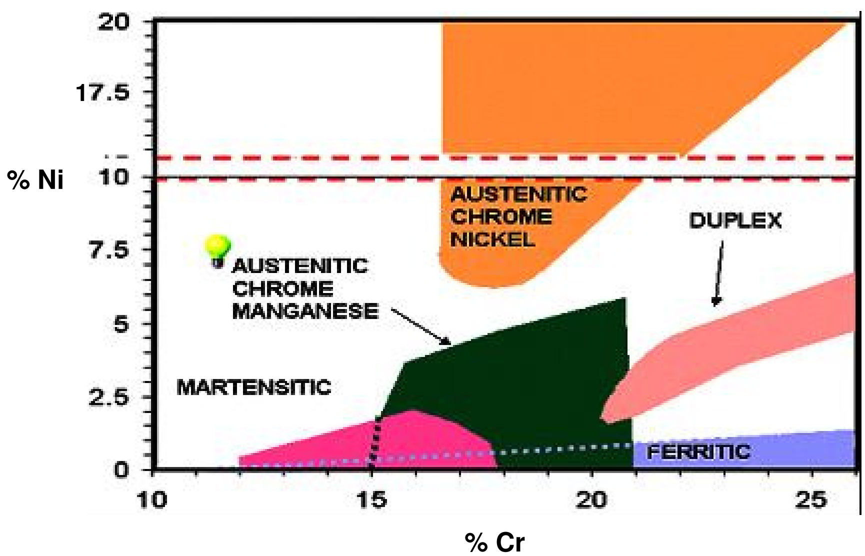
Precipitation hardening steels are further subdivided into one of three groups based on their final microstructures after heat treatment: martensitic, semi-austenitic and austenitic

More than half the precipitation-hardening stainless steels that I reviewed contained molybdenum.

Alloy A286 is a popular austenitic precipitation hardening stainless containing 1-1.5 percent molybdenum . It possesses a level of corrosion resistance comparable to that of the austenitic stainless steels. In elevated temperature service, the level of corrosion resistance to environments such as those encountered in jet engine applications is excellent to at least 1,300°F (704°C). Oxidation resistance is high for continuous service up to 1,500°F (816°C) and intermittent service up to 1800°F (982°C). A286 can be found in jet engine nacelles, fasteners afterburners, for example.

Development of PH stainless steels continues, and Carpenter Technology has just introduced a 5 percent molybdenum PH stainless: Custom 475™.

Below is a chart showing the nickel-chromium content for the four major stainless types commonly discussed in the literature – austenitic-, ferritic-, martensitic-, and duplex (austenitic-ferritic) stainless steels. (Precipitation-hardening stainless steels, not shown, range from 11-18 percent chrome and from 3-11 percent nickel, and would occupy the lower left-hand corner of this chart.)




Chrome (Cr) and nickel (Ni) chemistry of the major stainless steel families. (Source: Jindal Stainless)

This chart is from a major Indian producer of chrome-manganese stainless steels, and thus it further breaks down the austenitic category into a chrome-nickel subtype and a chrome-manganese subtype.

India, has grown their basic stainless production around manganese, as opposed to nickel.

Stainless steels are categorized under various schemes globally. Below, for example, is a list showing how 24 countries describe the world's most popular stainless steel, grade 304.

| | |
|---|---|
| USA | 304; 30304; S30400 |
| Hungary | AoX; 7CrNi 18-9; KO 33 |
| European | EN 1.4301; X5CrNi 18-10 |
| India | 04Cr18Ni 11 |
| International | ISO X5CrNi 18-10 |
| Italy | X8CrNi 19-10 |
| Australia | 304; S30400 |
| Japan | SUS 304 |
| Austria | X5CrNi 18-10 KKW |
| Korea | STS 304 |
| Brazil | E304 |
| Mexico | MT304 |
| Bulgaria | 0Ch18N10 |
| Poland | 0H8N |
| Canada | 304; S30400 |
| PRC China | 0Cr19Ni9; S30408 |
| Czech Rep. | 240 |
| Rumania | T6NiCr180 |
| France | Z6CN18-09; 304F01 |
| Spain | X6CrNi 19-10; F.3504; E-304 |
| Germany | 1.4301; X5CrNi 18-10 |
| Sweden | 2332 |
| U.K. | En 58E; S30418 |
| Russia | 08Ch18N11 |

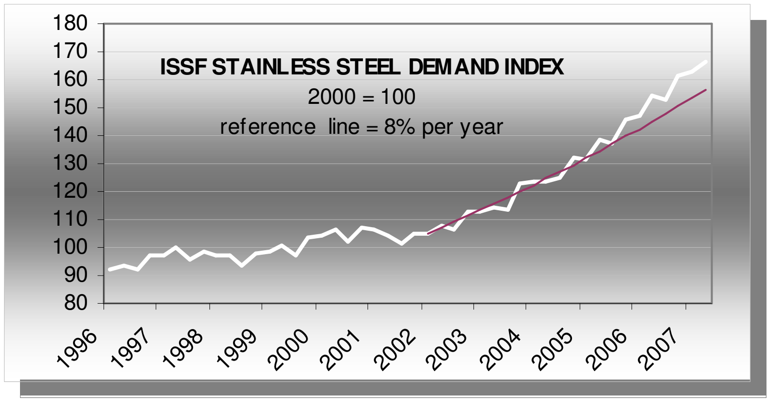
How 24 countries designate the world's most popular stainless steel, grade 304.

There are eight numbered series that correspond, almost, to the five stainless steel classes mentioned: 200- and 300- series stainless steels are austenitic, with the 200-series representing the chrome-manganese austenitics and the 300-series representing the chrome-nickel austenitics. 400-series stainless steels can be either martensitic or ferritic. The 500-series are martensitic, and the 600-series are precipitation-hardening stainless steels.

The duplex (austenitic-ferritic) stainless steels are represented in a 2000-series and, lately, some 3000-series designations are being introduced for so-called hyper-duplex grades – Sandvik SAF 3207HD, for example.

There are a number of stainless steel grades that do not fall into this numerical designation, like the precipitation-hardening stainless PH 13-8Mo, for example, containing 2-2.5 percent Mo, or Ferralium, a duplex stainless steel containing 2.9-3.9 percent Mo.

World stainless steel demand is shown in the cart below, along with an 8 percent trend line plotted from 2002.  Demand has accelerated beyond that trend in the last couple of years. The raw data are from the International Stainless Steel Federation (ISSF).




In the world stainless steel market, four grades, 304, 409, 430, and 316, account for over 80 percent of the tonnage. If you add the 200 series, you can account for over 90 percent. This breakdown is shown in the chart below.

| **MARKET SHARE OF THE MAJOR STAINLESS GRADES**[1] | |
|---|---|
| Grades | % of market |
| 2xx | 9 |
| 304 | 53 |
| 430 | 13 |
| 409 | 12 |
| 316 | 7 |
| **Total** | **94** |

[1]2xx is the entire series.
Source: Nickel Institute, ISSF

316 stainless (2-3 percent Mo) is the major moly-bearing grade, but not the entirety.

In fact, all stainless categories contain some molybdenum-bearing grades. The duplex stainless steels all contain molybdenum.

A random sampling of stainless warehouses came up with 136 stainless steel grades, of which 60 (44 percent) contained some molybdenum. (See table below.)

| COMMON STAINLESS STEEL GRADES | | | |
|---|---|---|---|
| | No. of Grades | No. with Mo | % with Mo |
| Austenitic | 66 | 19 | 29 |
| Ferritic | 21 | 10 | 48 |
| Martensitic | 23 | 12 | 52 |
| Duplex | 12 | 12 | 100 |
| PH | 16 | 9 | 56 |
| **Total / Avg.** | **136** | **60** | **44** |

Random sample of stainless grades showing how molybdenum-bearing grades populate the stainless steel space. Molybdenum bearing grades exist in all categories. New grades are continually being added. PH = precipitation-hardening.

Molybdenum is found even in the 200-series since the introduction of 216 stainless to compete with 316 stainless: Increased use of the 200 series may modify nickel demand but not molybdenum: Both 216 and 316 contain the same level of molybdenum, as is shown in the table, below.

| CHEMISTRY OF STAINLESS GRADES 316 AND 216 COMPARED | | |
|---|---|---|
| | Weight % | |
| | **316** | **216** |
| C | 0.08 | 0.08 |
| Mn | 2.00 | 7.5-9.0 |
| Si | 1.00 | 1.00 |
| Cr | 16.0-18.0 | 17.5-22.0 |
| Ni | 10.0-14.0 | 5.0-7.0 |
| P | 0.045 | 0.045 |
| S | 0.03 | 0.03 |
| **Mo** | **2.0-3.0** | **2.0-3.0** |
| N | - | 0.25-0.50 |

AISI 316 and AISI 216 chemistry

Several sources report that 150 different stainless grades exist. What is known for certain is that new stainless grades continue to be introduced as materials science advances.

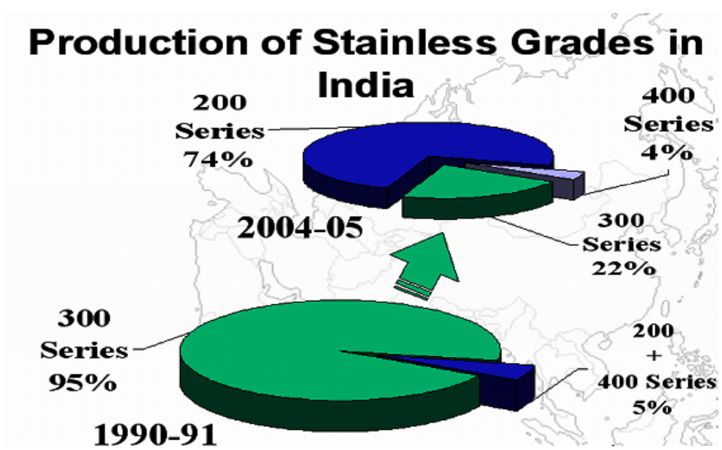
Looking at the stainless steel market overall, we can conclude two things:

1. While stainless steel is important to molybdenum, it is certainly not the entire story. Using 316 stainless as the moly flagship in the stainless fleet – 7 percent of 30 million tonnes at say 2.5 percent Mo – we can account for roughly a quarter of molybdenum's overall 440 million pound market.

2. The vast majority of what we read about stainless steel in the trade press will have nothing whatsoever to do with molybdenum demand. Assuming unbiased reporting, on an overall tonnage basis, less than 10 percent of the stainless headlines would be relevant to molybdenum. Most of the market news about stainless will concern (non-moly) grades used for food processing equipment or sinks or tableware (304 and 430 grades), or automotive exhaust systems (grade 409).

In fact, because the molybdenum-bearing stainless grades tend to be higher-tech, sometimes proprietary, and usually more profitable, we may hear about moly-bearing stainless even less than 10 percent of the time. So molyphiles will have to be discriminating readers in their stainless steel market research.

An example of the moly-irrelevant news that tends to dominate the stainless steel headlines is the 200-series substitution for (mostly) 304 stainless. From the chart below, which shows the development of 200-series stainless production in India – the world leader – we can see that this substitution has been a trend for over a decade and a half and not, as some publications would suggest, simply a response to recent higher nickel prices.




Production of 200-series stainless in India has developed over 15+ years mainly in response to a kitchenware market. Three quarters of their stainless demand is for kitchenware, which is expected to increase from just under 1 million tonnes now to over 2 million tonnes in 8 years. (Source: Jindal Stainless).

Developments

In no particular order, following are some recent developments which are driving increased demand for molybdenum-bearing stainless steels:

Although stainless steel is highly recycled, scrap supply is not keeping up with annual increments in stainless steel production. Over the last five years, traded scrap supply has increased on average just over 500 tonnes per year, but stainless steel production has increased about 1,900 tonnes per year. Home scrap supply, scrap generated at the steelmaking operations themselves, is trending down through improved operating technique. The net result is a deficit in recycled supply.

This trend will put more pressure on the suppliers of virgin units of molybdenum and other stainless steelmaking additives. (See chart below.)

**STAINLESS STEEL PRODUCTION AND SCRAP TRADED**
**2002-2006**
( tonnes, thousands )

| | STAINLESS PRODUCTION | CHANGE[1] | SCRAP TRADED | CHANGE |
|---|---|---|---|---|
| 2006 | 28,359 | 4,040 | 4,991 | 1,020 |
| 2005 | 24,319 | -251 | 3,970 | 119 |
| 2004 | 24,570 | 1,730 | 3,852 | 600 |
| 2003 | 22,840 | 2,150 | 3,252 | 366 |
| 2002 | 20,690 | | 2,886 | |
| AVG. | | 1,917 | | 526 |

[1]Change from preceding year. Data sourced from ISSF.

Desalination is a rapidly growing application for molybdenum-bearing stainlesses, including grades at the 6-percent Mo level. Research shows that with organic growth in the sector and apparent substitution towards molybdenum-bearing stainless steels, molybdenum demand here is growing in the double digits. Note: desalination is growing not just for drinking water but also to provide process water for industrial activities like power generation; chemical manufacture; LNG production; oil refining; methanol production; cement; sugar refining and mining and mineral processing.

Fujairah, United Arab Emirates, desalination plant showing 254 SMO (6% Mo) high-pressure piping.

SAF 2507 duplex stainless steel (3-5% Mo) piping in a reverse osmosis desalination plant.

Offshore drilling is increasing relative to onshore activity. The chart below shows offshore rig utilization steady even as the supply of new drilling equipment increases. Rigs are committed before they are launched. The offshore drilling and production industry is increasingly reliant on molybdenum stainless steels.

| 2007 OFFSHORE RIG UTILIZATION REPORT | | | | |
|---|---|---|---|---|
| | Current | Month Ago | 6 Mo Ago | 1 Yr Ago |
| Rigs Working | 513 | 518 | 511 | 495 |
| Total Rigs | 601 | 600 | 590 | 580 |
| Utilization | 85.4% | 86.3% | 86.6% | 85.3% |
| Competitive rigs. Data for week ending December 28, 2007. | | | | |

For example, wellheads on the seafloor and the drilling platform are often connected by flexible pipe. The core of the pipe is built of profiled stainless steel strip, surrounded by layers of mild steel insulation. Duplex stainless grades are the fastest growing in this application.

Wellheads on the seafloor and the drilling platform are often connected by flexible pipe. Shown in the cutaway, the core of the pipe is built of profiled stainless steel strip, surrounded by layers of mild steel insulation. Duplex stainless grades are the fastest growing in this application. (Source: NKT Flexibles)

Umbilical tubing on spools prior to loading on pipelaying vessel.

(Source: Wellstream, Alex Kvaerner)

Hybrid umbilicals were developed as self-contained delivery lines for hydraulic fluids, production chemical feeds, lubrication oil, power and communications to subsea equipment.

Profile and plan views of an ultradeepwater hybrid umbilical with power control and communications cables and 13 duplex stainless steel tubes.

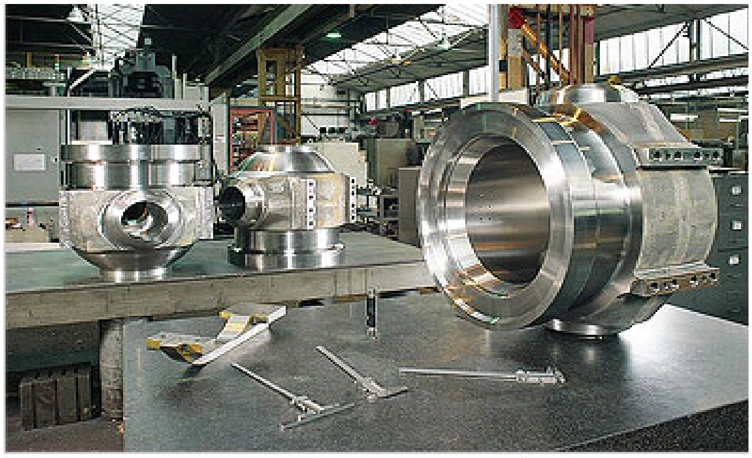
Umbilicals for the Dolphin Gas project connecting two platforms to the Ras Laffan processing plant in Qatar supply corrosion inhibitor, hydrate inhibitor and diesel fuel to the platforms, and required 684km of super duplex steel tubes.

Subsea umbilicals for the BP-operated Greater Plutonio development, Block 18, offshore Angola. required over 1,300 kilometers of super-duplex steel tubing.

Oil and gas production naturally declines as reservoir pressure drops. Subsea boosting can reduce well back-pressure, thus improving reservoir recovery and increasing hydrocarbon flow rate. Duplex stainless steels containing molybdenum are increasingly found in subsea pumps.

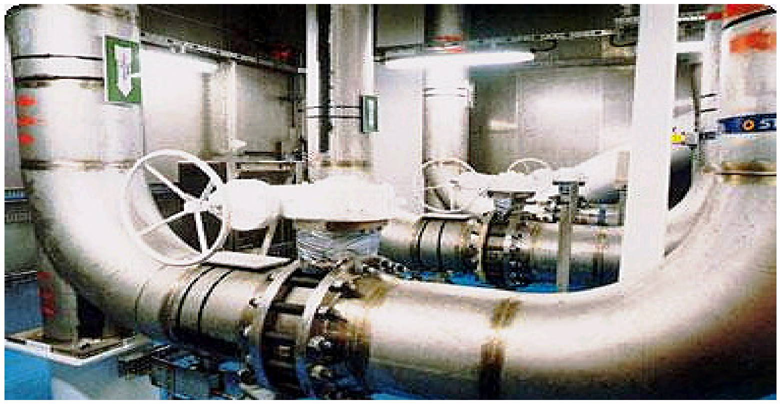
2,500kW, 9kV engineered variable speed deepwater subsea motor driving a multiphase pump in super duplex stainless steel.

Many other parts associated with offshore oil and gas production are made of molybdenum-bearing stainless steels:



Subsea ball valves - Class 5,000 metal-seated subsea diverless intervention ball valve body castings. These valve bodies were produced in duplex stainless steel with nickel alloy 625 weld overlay. The 50:50 ferrite:austenite casting (duplex) gives improved corrosion and abrasion resistance together with much improved tensile and yield properties which result in significant weight savings. (Source: Goodwin Steel Castings, Ltd.)

Cast gate valve bodies in duplex stainless steel.

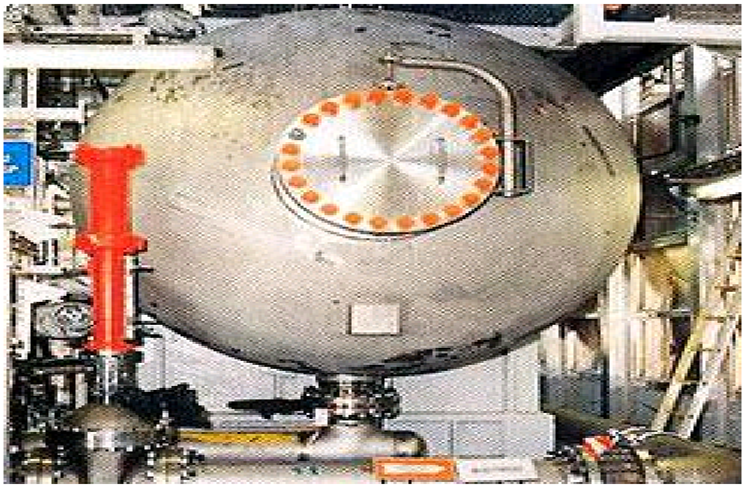


Seawater piping - Normal corrosiveness of the seawater is increased by the chlorine chemical addition necessary to kill biological growth that would otherwise clog the heat exchanger. 254 SMO (6% Mo) has been used in these systems up to about 30°C. By using 654 SMO (7-8% Mo) castings for the flanges and other parts with crevices, the process can be run about 20°C hotter, thus reducing the cost of cooling.

Main process piping – The main process piping has to handle incoming oil and gas, sand, hydrogen sulfide, seawater and carbon dioxide ( the "produced" mixture ). Stainless grades 254 SMO (6% Mo) and 2507 (3-5% Mo) are common in this application.

Oil and gas coolers – The corrosiveness of process fluids increases with temperature. Oil and gas must be cooled before piping it to shore or before further processing. Seawater is used as the coolant and stainless steels like 254 SMO (6% Mo) or SAF 2507 (3-5% Mo) are used in this application.

Manifolds – The flows from several wells are combined through use of manifolds built of duplex stainless steels like 2205 (3% Mo) or 2507 (3-5% Mo).



Gravity separators – The individual components of the produced mixture are separated by gravity separators. Commonly used grades for separators are 904L–clad (4-5% Mo) mild steel and duplex stainless grade 2205 (3% Mo).

Centrifugal separators – Separators built of duplex stainless grades like 2205 (3% Mo) or 2507 (3-5% Mo) can be used for cleaning produced water.

254 SMO (6% Mo) pipes running to an offshore Qatari platform, itself rich in austenitic and duplex stainless steels containing molybdenum. (Source: Maersk Oil)

So called “lean duplex” stainless steels containing about 0.3 percent molybdenum have started to substitute in traditional 304 stainless applications. 304 stainless is half the stainless steel market and, in possible substitution, represents a significant potential for new molybdenum demand. For every 1 percent of the 304 stainless market converted to a typical 0.3 percent Mo lean duplex stainless we add over 800,000 pounds to the annual mined-molybdenum requirement. (Assumes nominal 15 percent weight saving from the use of lean duplex stainless. Not all applications will save 15 percent. See below.)

The strength of the duplex grade is much higher than that of 304 stainless and allows use of considerably thinner gauge material resulting in meaningful weight- and cost savings. When nickel prices are high, the lean duplex stainless option becomes that much more attractive, because the nickel content is significantly lower. Comparative chemistries are shown in the table below.

| **LEAN DUPLEX GRADES vs. 304 STAINLESS** | | | | |
|---|---|---|---|---|
| | **Cr** | **Ni** | **Mo** | **Mn** |
| **2101** | 21 | 1.5 | 0.3 | 5 |
| **2304** | 23 | 4.8 | 0.3 | 0 |
| **304** | 18 | 8 | 0 | 0 |
| Nominal %. Source: Outokumpu | | | | |

One example of this new substitution is lean duplex stainless starting to take the place of 304 stainless in the manufacture of storage tanks: A storage facility in Barcelona, built for bulk-liquid storage company Relisa SA realized a weight saving of approximately 200 tonnes on one 13-tank farm, eventually using 1,350 tonnes of lean duplex plate (a 13 percent weight reduction). On a second group of 9 tanks built with 730 tonnes of lean duplex stainless, the company saved 150 tonnes (a 17 percent weight reduction).

Similar savings have been recorded using lean duplex stainless in tank construction for storage of flour, palm oil, wine, white liquor (caustic soda and sodium sulfate), potable- and sewage water, ethanol, fruit juice and biodiesel.

Lean duplex stainless steel containing about 0.3% molybdenum has started to take the place of molybdenum-free austenitic 304 stainless in the manufacture of storage tanks.

Road tankers can carry more payable freight as the tare weight of the unit is reduced by using stronger lean duplex stainless steels. A major U.S. shipper noted that deliveries of these new trailers will begin in January 2008. They are already in use in Europe, as shown in the photo, below.


Road tankers can carry more payable freight as the tare weight of the unit is reduced by using stronger lean duplex stainless steels. The U.S. Department of Transportation has granted an exemption for the use of this material, Special Permit 14467, a copy of which must be carried with the tank – the rule is that new.  A major shipper noted that deliveries of these trailers will begin in January 2008. They are already in use in Europe, as shown in the photo.

Nuclear power plants are a major user of molybdenum-bearing stainless steels.

News of yet another new reactor order for China has become a regular occurrence in the second half of 2007.

China Guangdong Nuclear Power Group (CGNPG) and Areva signed an 8 billion euro (11.87 billion U.S. dollars) civil nuclear energy cooperation deal in late November, as a result of which the French company will help build two reactors in Taishan City in southern Guangdong Province.

China reached an agreement in July with Westinghouse Electric Co. (Toshiba) to build four nuclear power plants in China and transfer core technologies for third-generation AP1000 reactors.

Currently, 11 nuclear generating units are in operation on the mainland with another eight units under construction. By 2020, China's installed nuclear power capacity will have doubled, according to reports.

China is the world's second-largest power consumer after the United States where things are also starting to warm-up on the nuclear front:

NRG Energy, in September, submitted a full application for a combined construction and operating license (COL) for two 1350 MWe ABWR reactors at the South Texas site.

A second COL application was made to the Nuclear Regulatory Commission (NRC) in October. This was submitted by the NuStart Energy consortium, and Tennessee Valley Authority (TVA) for two 1100 MWe Westinghouse (now Toshiba) AP1000 reactors at the Bellefonte site in Alabama.

A third full COL application was submitted in November, by Dominion, for a GE Nuclear Energy (now GE-Hitachi Nuclear Energy) 1520 MWe ESBWR reactor at its North Anna site.

And Duke Energy filed an application in December 2007 to build a nuclear power plant South of Charlotte, North Carolina, making it the fourth application filed with the NRC this year. Already operating three nuclear power facilities in the region, Duke wants to construct the plant on the same site in Cherokee County, South Carolina, that was originally picked as one of six sites for new power plants Duke had planned to build three decades ago. Plans for all of them were scrapped after the Three Mile Island incident in 1979. As the table below shows, 15 COL applications covering 22 reactors are currently expected in 2008.

| Company (reactor) | Site |
|---|---|
| South Carolina E&G | Summer (2 units) |
| Progress Energy | Harris (2 units) |
| Progress Energy | Levy County (2 units) |
| Southern Nuclear | Vogtle (2 units) |
| Entergy | River Bend (1 unit) |
| NuStart Energy | Grand Gulf (1 unit) |
| UniStar | Calvert Cliffs (1 unit) |
| PPL Generation | Berwick (1 unit) |
| AmerenUE | Callaway (1 unit) |
| UniStar | Nine Mile Point (1 unit) |
| TXU Power US | Comanche Peak (2 units) |
| Exelon | Matagorda or Victoria County (2 units) |
| Detroit Edison | Fermi (1 unit) |
| Amarillo Power | Vicinity of Amarillo (2 units) |
| Alternate Energy | Bruneau (1 unit) |

Expected 2008 Combined construction/operating licence (COL) Applications (Source: Modern Power System)

This recent activity on the U.S. nuclear power front has been prompted by two government initiatives: the Nuclear Power 2010 program, which provides support for the licensing of lead (or "reference") reactor projects using new technologies (e.g. ESBWR and AP1000); and provisions in the 2005 Energy Policy Act (EPACT 2005) designed to incentivise "first movers." These provisions include loan guarantees, risk insurance and production tax credits designed to reduce the burden of first of a kind costs, indemnify the first six plants against delays due to regulation and litigation, and improve the economics of the first 6,000 megawatts of new nuclear capacity once it is operating.

In December 2007, Congress expanded the loan guarantee program to up to 80 percent of nuclear reactor construction costs – $20.5 billion in total. It was accomplished within the fiscal 2008 Omnibus Appropriations bill. Nuclear regulators say the review process for new plants will take up to 42 months, however, utilities have already started placing contracts for long lead items such as heavy castings and forgings, generators and steam turbines. For example, in mid-November 2007, a letter of intent was signed by UniStar with Alstom for the supply of "a minimum of four" Arabelle steam turbine generators for its planned fleet of EPR reactors.

This new funding level appears to be what the utility industry was waiting for, and if the result of other generous federal energy subsidies is any guide – ethanol, for example – there's going to be a raw materials purchasing rush.

It is worth pointing out, however, that regardless of the direction of the U.S. nuclear industry, molybdenum is well-hedged. The various alloys and stainless steels containing molybdenum are found in coal-fired plants as well.

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The U.S. company, Swagelok, has developed a new form of stainless steel that the company says maintains its hardness and corrosion resistance at the same time. They are using a patented Low-Temperature Colossal Supersaturation (LTCSS) heat treating process which, according to the company, enables large-scale carbon absorption into austenitic stainless steels to dramatically improve their hardness and other performance characteristics.

To-date, materials scientists have observed that carbon atoms cannot be introduced into austenitic stainless steel through heat treatment without the formation of chromium carbides, which compromise the corrosion resistant properties of the alloy. Thus hardness and corrosion resistance are typically regarded as tradeoffs.

Swagelok says surface hardness of austenitic stainless steels treated with the LTCSS process increases by about three to four times. At the same time, the company says there is evidence of improved corrosion resistance; wear resistance increases by 100 times; erosion resistance increases by 5.5 times; and fatigue strength increases by approximately 50 percent. Much of their work has centered around 316 stainless. Developments here will be interesting to watch.