

# Hempel Special Metals: Alloy 24 resurrected to tackle demanding applications



**Super austenite Alloy 24 is a material that lives up to its name, distinguishing itself from standard stainless steels, 6%Mo steels and all duplex grades thanks to its corrosion resistance, strength and attractive pricing. Developed in the 1990s, production of Alloy 24 ceased following a merger of the manufacturer. Now, however, Hempel Special Metals has resurrected Alloy 24 and sees a bright future ahead for this material which is ideally suited to demanding applications such as marine scrubbers and the chemical process industry. Stainless Steel World met with CEO Mr. André Hempel and materials specialist Mr. Rolf Kirchheiner (Dipl.-Ing.) to learn about the history of Alloy 24 and the exciting future that lies ahead for this remarkable alloy.**

*By Joanne McIntyre*

The Hempel Special Metals Group is an international sales specialist for high-performance materials in demanding industries such as implants, offshore, aviation and the process industry. The company has been active in distributing nitrogen-enriched stainless steels since 2004 when it patented grade 316LMoNCu (1.4435NCu). This stainless steel has added nitrogen to create a

delta-ferrite free material in demand most notably for the high-end watches. Another alloy the company is selling in that field is the P2000, a double melted no nickel, high containing nitrogen austenitic stainless steel, which has interesting properties for special bearings, springs and for medical applications. Finally the company offers the 1.4318 which is a low-nickel 304

standard grade. Given the volatility of nickel prices, nitrogen and manganese added, low-nickel stainless steel offer interesting economical alternatives with superior properties as increasing strength. Hempel's most recent endeavour is the resurrection of the super austenitic Alloy 24, for which the company see a bright future indeed.



would be an ideal addition to our range, with Alloy 24 being up to 30% cheaper than its closest equivalent, Alloy 31. Three years ago, we started partnering with Industeel, a specialist plate mill, to introduce Alloy 24 to the market. We had some success with the chemical process industry and in the scrubber market.”

### What is Alloy 24?

Alloy 24 is a super austenitic alloy that positively distinguishes itself from classic stainless steels, duplex and other alloyed 6%Mo steels. In a variety of industrial applications, it can replace the established lower representatives of nickel-based alloys.

With their highly developed application potential, super austenitics fill the gap between the standard grades of stainless steels and nickel-based alloys. One of the driving forces for the use of super austenitics is economy, as they must be able to stand up technically and economically against the higher alloyed

nickel-based alloys. The technical superiority of super austenitics over standard steels is assumed, and Alloy 24 is an outstanding example of this.

“With the development of Alloy 24, a new austenitic stainless steel has become available – delivering the highest strength and excellent weldability with outstanding corrosion resistance in chloride-containing media,” explains Mr. Kirchheiner.

The neutral designation ‘Alloy 24’ is derived from the proportion of the materials average chromium content of 24%. The material number for the original material is 1.4565; the UNS number is S34565.

In Alloy 24, the role of the cheapest alloying element nitrogen (N max 0.6%) is exploited in several ways. Nitrogen has several positive features in the formation of the fully austenitic structure of Alloy 24:

- Austenite stabilisation
- Significant increase in strength

### History of Alloys 24 & 31

Alloy 24 was developed together with Alloy 31 in the 1990s by Thyssen Edelstahlwerke and VDM.

“Both Alloy 24 and Alloy 31 are super austenitics developed to fill a niche between nickel alloys and high alloyed stainless steels such as 254MO, the 6 Moly grades, and the lowest nickel alloy grades such as the 400 series, alloy 625, etc.,” begins Mr. Hempel. “Alloy 24 has properties which make it ideal for the construction of submarines and highly-stressed containers. However, when Thyssen took over VDM, they chose to focus on nickel content, so the production of Alloy 24 was halted.”

Twenty years later, Hempel was looking to add a new material to their portfolio, which would differentiate them in the market.

“We were aware of Alloy 24 and that there was still demand from the chemical process industry, although it was no longer obtainable. Research showed this



Hempel suppliers Alloy 24, 904L (1.4539) and Alloy 59 (2.4605) for scrubber technology designed in German and built in China. Pictures courtesy of Saacke GmbH



Hempel specializes in providing complete packages for customers including pipes, elbows, flanges, fittings and more.

- Minimisation of negative carbide precipitation
- Increase of corrosion resistance in synergy with chromium and molybdenum.

This technically and economically sophisticated alloy design allows Alloy 24 to be labelled as a Smart Super Austenite. The chemical composition is shown in Table 1.

### Properties & processing of Alloy 24

Due to its high nitrogen content, Alloy 24 achieves significantly higher mechanical strength compared to standard steels. At room temperature, the values of the 0.2%-yield strength are at minimum 420 MPa. The tensile strengths range from 800-1000 MPa. Alloy 24 demonstrates good toughness with at least 30% elongation even at low temperatures.

The processing of Alloy 24 is not different from other high-alloy stainless steels. The behaviour of the proportionally steeply increasing work hardening with cold deformation is known for this material group. Appropriate heat treatments are necessary after cold forming from a critical degree of deformation. In the heat treatment of Alloy 24, the first goal is to achieve a precipitation-free microstructure with homogeneous grain size distribution in the delivery condition. Fine grain size and the freedom from precipitations are the

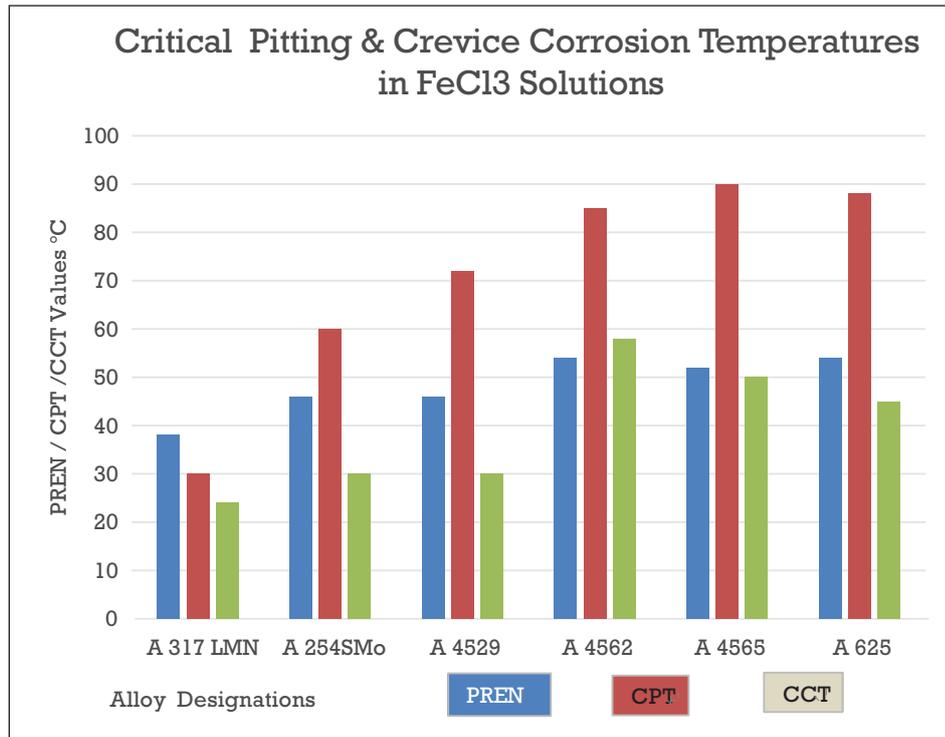


Figure 1. Critical pitting & crevice corrosion temperatures in FeCl3 solutions; tests according to ASTM G48 E & F (1)

(1)  $PREN = \%Cr + 3.3 \times \%Mo + 30 \times \%N$  > Calculation focused on pitting corrosion

prerequisites for successful further processing by forming operations and for hassle-free welding technology. A particular strength of Alloy 24 is its minimal susceptibility to segregation in the solidification of molten zones in the welding process. This is one of the reasons for the excellent local corrosion resistance of Alloy 24 in halide-containing media, even in welded condition.

### Corrosion behaviour

Testing Alloy 24 in ferric chloride solution according to standard ASTM G 48 (E), an actual critical pitting temperature (CPT) = 85°C was determined. Under these testing conditions, the same CPT was achieved only by the Ni-base Alloy 625 N06625 (Figure 1). Similar behaviour was found testing Alloy 24 in ferric chloride solution under crevice conditions according to the MTI standard or ASTM G 48 (F). Again, the actual critical crevice temperature range of 45-55°C is

achieved only by the Ni-base alloy 625, under the same conditions.

### Demanding applications

Mr. Rolf Kirchheiner further explained the unique properties of this alloy. "Alloy 24 was initially developed for seawater applications, as well as the chemical process, pulp and paper, and scrubber industries. It has remarkably better strength than any other austenitic stainless steel, and is fully stable and non-magnetic, which is important for applications such as down-hole drilling." The first 20 tonnes of 6mm plate rolled off the presses four years ago.

### Technical expertise

The Hempel team knew they needed an in-house expert to reintroduce Alloy 24 to the market effectively. Therefore, Mr. Rolf Kirchheiner (Dipl.-Ing. / Master of Science) was recruited to the team last year. "He was the right expert for us since we have known him for more than 20 years, the time he worked within VDM's R&D and technical marketing," explains Mr. Hempel. "He was involved in the initial development of both Alloy 24 and Alloy 31 and was, in fact, one of the patent holders for Alloy 31. He was deeply involved in the research and market qualification for Alloy 24. His expertise will be very valuable to promote the alloy further."

Table 1. Chemical composition of Alloy 24/1.4565 (nominal) and Alloy 31 (1.4562)

Chemical composition (in mass %)	C	Cr	Mo	Ni	Mn	N	Nb	Cu
min Alloy 24		23.0	3.5	16.0	3.5	0.30		-
max	0.03	25.0	5.0	18.0	6.5	0.60	0.1	-
min Alloy 31		26.0	6.0	30.0		0.15		1.0
max	0.015	28.0	7.0	31.0	2.0	0.25		1.4



Hempel has in-house shear-, plasma-, waterjet- and laser cutting facilities

“Few mills are capable of producing Alloy 24. It’s a unique combination of low nickel, high manganese, high nitrogen, and chromium, with some specific additions to avoid embrittlement and make it easily weldable.”

In reinventing alloy 24, Hempel issued a propriety material data sheet which is proving decisive in convincing customers as well as engineering and equipment fabricators to use this material.

“The first customers – who required it for maintenance in the chemical process industry – were delighted to have a source for this alloy again. However, we knew that we needed to find a bigger market and also to raise awareness of Alloy 24.”

The search for new applications revealed an exciting new market: marine scrubbers.

### Marine scrubbers

“International Maritime Organisation regulations demand that heavy bunker fuel exhaust on ships must be scrubbed to remove sulphur through flue gas desulphurization,” explained Mr. Hempel. “Alloy 31 was already in use for this application, as the only alloy positioned between nickel alloys and high alloyed stainless steel. The fact that Alloy 24 is around 30% cheaper made it clear that this would become an important market.”



Hempel produces a very wide range of fittings and machined components, including German pressure vessel regulation AD 2000 accredited fittings.

Hempel’s customer Saacke, a marine technology company in northern Germany who quickly recognised the advantages of incorporating Alloy 24 into their scrubber technology, together with 904L (1.4539) and Alloy 59 (2.4605). The company provides several different marine scrubber designs and sizes to its customers around the world.

Scrubber fabrication uses a range of alloys and not everything is made of high-end alloys, continues Mr. Hempel.

“Our scrubber is a combination of Alloy 59, Alloy 24, and 904 L/2459, all of which we supply. This makes us the ideal partner for the end user; we are one of the largest distributors for Alloy 59 (2.4605) in Europe, we stock 904L (1.4539), and of course, we are the only stockist of Alloy 24.”

*“This technically and economically sophisticated alloy design allows Alloy 24 to be labelled as Smart Super Austenite.”*

Hempel provides a complete package for customers, cutting the pieces in its well-equipped workshop before packaging and dispatching them. “It’s a one-stop-shop concept offering great convenience and reliability for our customers. We also supply Alloy 59 pipes and fittings, from stock.”

### Added value services

In addition to launching new materials such as Alloy 24, the Hempel team continues to focus on value creation in its business development. New services are being integrated, among other things through acquisitions. Firmus Metals was purchased in the UK in 2016; TK Fittings in Germany one year later. The companies fit well into Hempel’s strategy, bringing new services (precision slitting and production of fittings) into the proven range of materials.

The company is continuously renewing and expanding its workshop equipment. In Oberhausen, a new plasma cutting machine with a 12.x meter bed was installed in 2019.

“We are constantly expanding our value-adding services for customers and can provide complete packages of specialist steels, cut, forged and machined,” explains Mr. Hempel.



Hempel is constantly expanding its value-adding services for customers and can machine special fittings on their equipment in Oberhausen.

The company is qualified with the German pressure vessel regulation AD 2000, which allows it to produce certified fittings for this sector. Hempel has a long history of forging strong partnerships in the industry. “You cannot develop success in our industry without the right partners,” explains Mr. Hempel. “We’ve done this with producers of titanium and stainless steels, we enjoyed a strong partnership with VDM for more than 30 years until 2008, and have optimised a special stainless steel for the watch industry together with our Japanese mill. Moreover, several other semi-product producers are long-term partners. So today we’re building up our close partnership with the mill producing Alloy 24. Working together with them and other stakeholders, we see a huge potential for Alloy 24.”

### Facts & Figures

Name:	Hempel Special Metals
Founded:	1919
Headquarters:	Dübendorf, Switzerland
Subsidiaries:	Germany, England, Hong Kong, Poland and Hempel Firmus Metals for Precision slit strip. Sales office in Shanghai, agents in Italy and Ireland
Products:	Stainless steel, special stainless steel, nickel alloys, titanium alloys, exotic materials, Alloy 24
Key markets:	Oil & gas, process industry, aerospace, defence, watches, medical
Website:	<a href="http://www.hempel-metals.com/en/">www.hempel-metals.com/en/</a>