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A WHITE PAPER BY OUTOKUMPU

Ultra Alloy 825 thrives in extremely corrosive environments

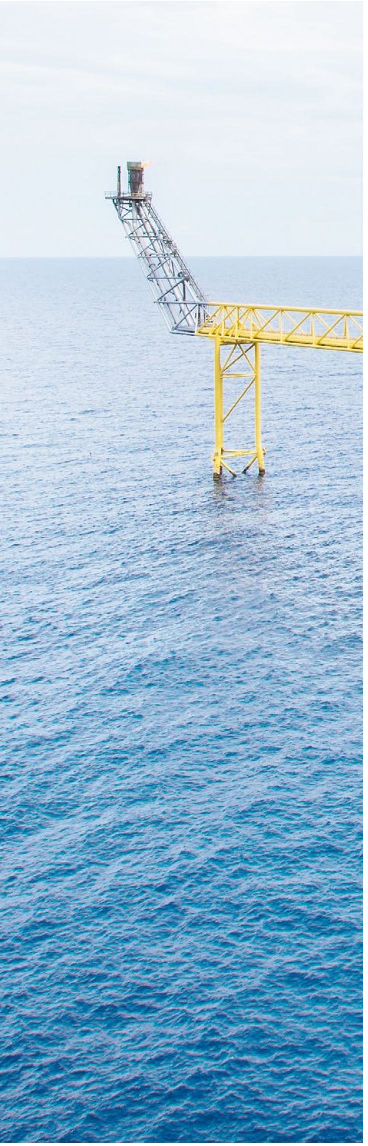
Ultra

Extremely corrosive environments

Outokumpu has developed the Ultra range of products for applications in extremely corrosive environments that require a Pitting Resistance Equivalent (PRE) value of more than 27.

This range offers improved wet-corrosion capabilities and includes our key products Ultra 904L and Ultra 254 SMO, as well as several alternatives for specific applications. The Ultra range is the best choice when a design engineer knows that grades like Core 304L/4307 or Supra 316L/4404 will not meet the wet-corrosion challenges of their application. The latest addition to this range is Ultra Alloy 825, a nickel base alloy that provides good resistance in sulfur containing “sour” environments, where it has superior resistance to hydrogen and hydrogen sulfide (H_2S) induced cracking.

Ultra Alloy 825 is intended for use in a wide variety of demanding applications and is especially suitable for components in offshore oil and gas pipelines, petroleum refineries, heating coils, heat exchangers, tanks and scrubbers. It also has potential uses in the food, chemical and nuclear industries.



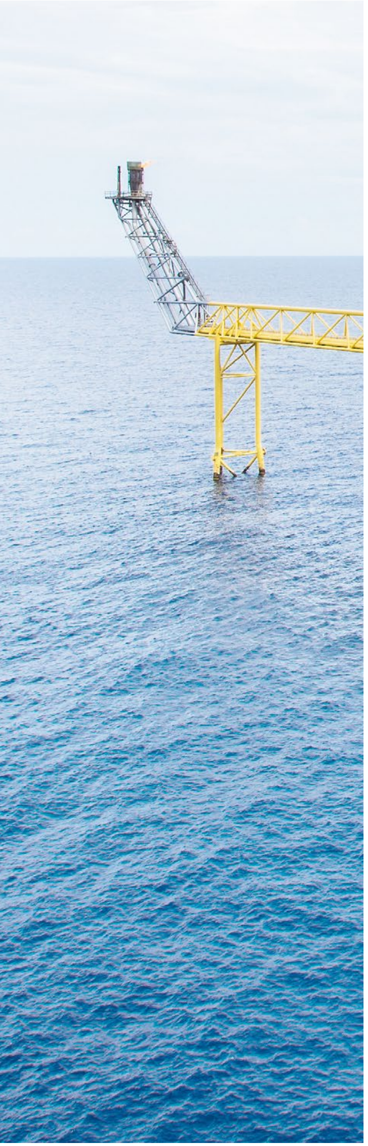
The chemical composition of Ultra 825 and its relative PRE. Table 1

Outokumpu name	W.-Nr.	UNS	PRE	C	Cr	Ni	Mo	N	Others
Ultra 904L	1.4539	N08904	34	0.01	19.8	24.2	4.3	–	Cu
Ultra 254 SMO	1.4547	S31254	43	0.01	20.0	18.0	6.1	0.20	Cu
Ultra Alloy 825	2.4858	N08825	34	0.01	23.0	39.5	3.2	–	Cu, Ti
Supra 316L/4404	1.4404	S31603	24	0.02	17.2	10.1	2.1	–	–
Forta DX 2205	1.4462	S32205	35	0.02	22.4	5.7	3.1	0.17	–

For welding applications, we offer different chemical compositions with a higher nickel content.

A titanium stabilized nickel-base alloy

Ultra Alloy 825 is a titanium stabilized nickel base alloy with the addition of copper. It contains about 40 percent nickel (see Table 1) and has an austenitic microstructure. The titanium stabilization, together with its low carbon content, reduces the risk of forming chromium carbide precipitates when used at temperatures where stainless steels may be sensitive to this phenomenon. This therefore makes the alloy less sensitive to intergranular corrosion.



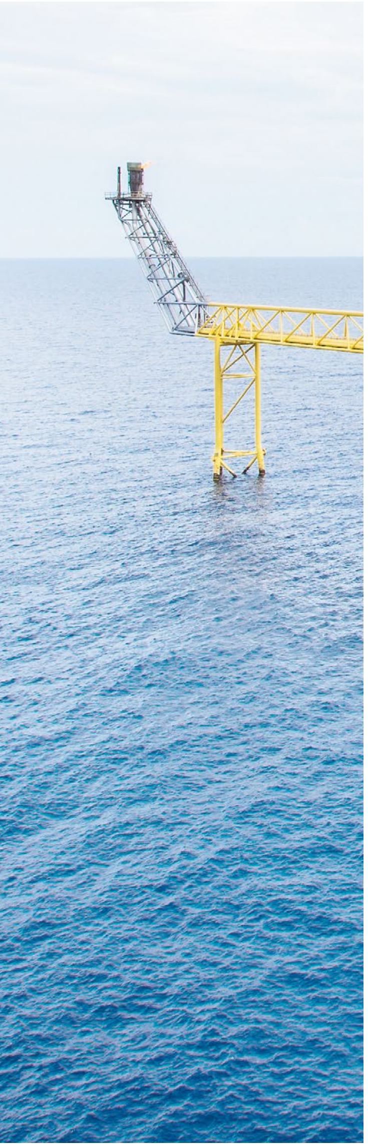
Tackling the sour gas challenge with Ultra Alloy 825

In the oil and gas industry, production fluids and gases are often classified as a “sweet” or “sour” environment, according to the level of hydrogen sulfide (H_2S) present. A sweet environment will contain no, or a negligible amount, of H_2S. While sour environments are those containing significant amounts of H_2S.

There is a growing need to consider the requirements of sour gas environments because natural gas is now playing an increasingly important role in the global energy mix. And a large proportion of the world’s natural gas reserves consist of sour gas containing significant levels of H_2S. The presence of H_2S is a particular challenge due to the tendency for it to cause corrosion and sulfide stress cracking (SSC) of steels, especially in pipelines.

As well as the corrosive environmental conditions, sour gas resources may need to be handled at temperatures up to 260°C and high pressures up to 1,700 bar. As a result, material selection becomes the critical factor in the success of the whole operation. It is vital to achieve the ideal, cost-effective combination of corrosion resistance and strength to ensure reliable operation over a typical 30-year service life. This is where Ultra Alloy 825 offers a particular advantage.

The petroleum and natural gas industries have been using Ultra Alloy 825 for components and equipment in sour environments for a long time. The reason is that the alloy has excellent resistance to SSC. In accordance with ISO 15156-3 (NACE MR0175), solution annealed and cold worked Ultra Alloy 825 is acceptable for use for any component or equipment up to 232 °C in sour environments, with no limits on chloride concentration and in situ pH, provided that the partial pressure of hydrogen sulfide (pH_2S) does not exceed 2 bar (30 psi). If the temperature does not exceed 132 °C, it is acceptable for use without restriction on partial pressure.



Pitting (CPT, critical pitting temperature) and crevice corrosion (CCT, critical crevice temperature) values for Ultra Alloy 825 in comparison to other stainless steel grades.

Table 2

Outokumpu name	CPT		CCT
	ASTM G150	ASTM G48 E	ASTM G48 F
Ultra Alloy 825	58	25	5
Ultra 904L	58	40	10
Ultra 254 SMO	87	65	35
Supra 316L/4404	20	20	< 0
Forta DX 2205	52	40	20

Outokumpu Ultra Alloy 825 shows excellent resistance to stress corrosion cracking.

Table 3

Outokumpu name	SCC testing methods		
	45% $MgCl_2$, boiling 24 h	40% $CaCl_2$, 100 °C 500 h	25% NaCl, pH 1.5 boiling 1,000 h
Ultra Alloy 825	● (green)	● (green)	● (green)
Ultra 904L	● (green)	● (yellow)	● (green)
Ultra 254 SMO	● (red)	● (green)	● (green)
Forta DX 2205	● (red)	● (green)	● (green)

● (red) SCC expected (test specimen failed)
● (yellow) SCC possible (a few samples failed)
● (green) SCC not expected (no test speciments)

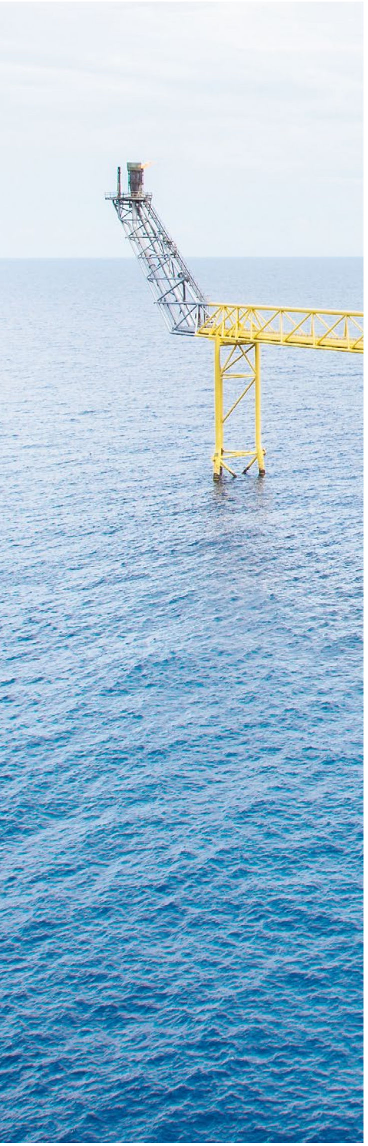
Resistance to localized corrosion

When considering its corrosion resistance in different environments, Ultra Alloy 825 offers very good resistance to acids such as sulfuric acid, phosphoric acid, nitric acid and organic acids. The addition of molybdenum (Mo) and copper (Cu) also enhances its corrosion resistance in solutions containing reducing acids. The alloy also has good resistance to alkaline solutions that contain sodium (Na) and potassium hydroxide (KOH).

There is another benefit of Ultra Alloy 825, as it offers higher resistance to pitting and crevice corrosion than stainless steel grades such as 316 – see Table 2. Although, for high levels of performance in these conditions we recommend Ultra 254 SMO. This is a specialist alloy used widely in applications subject to long-term exposure to seawater, flue gas and bleach, such as in the maritime or pulp and paper industries.

Stress corrosion cracking (SCC)

Due to its high nickel content, Ultra Alloy 825 has very high resistance to stress corrosion cracking (SCC) in chloride-induced and alkaline environments. It can withstand more than 24 hours exposure in the very aggressive ASTM G36 test without cracking. This rigorous test includes boiling in a 45% magnesium chloride ($MgCl_2$) solution (see Table 3).



Mechanical properties for Ultra Alloy 825.

Table 4

Standard	Product form	Yield strength $R_{p0.2}$ (MPa)	Tensile strength R_m (MPa)	Elongation $A^{1)}/A_{50}^{2)}$ (%)
Typical	cold rolled (3 mm)	305	625	44 [2]
	hot rolled plate (20 mm)	270	610	35 [1]
ISO 6208 (min values)	cold rolled (C) hot rolled plate (H)	240	590	30 [1, 2]
ASTM B424 (min values)	cold rolled (C) hot rolled plate (H)	241	586	30 [2]

1) Initial length = 5.65 x √S0 (A_5)
2) Initial length = 50 mm

Physical properties for Ultra Alloy 825.

Table 5

Density [kg/dm³]	Modulus of elasticity [Gpa]		Poisson's ratio	Coefficient of thermal expansion [10^{-6}/°C]		Thermal conductivity [W/m C]		Thermal capacity [J/kg °C]	Electrical resistivity [μΩm]	Magnetizable
RT	RT	400 °C	RT	20–100 °C	20–400 °C	RT	400 °C	RT	RT	RT
8.1	195	174	0.29	14.1	15.6	10.5	16.9	440	1.12	No *)

Good mechanical and physical properties

As illustrated in Tables 4 and 5, Ultra Alloy 825 exhibits good mechanical properties, including good yield strength and tensile strength. It can be used in temperatures that range from moderately high (+540 °C) down to cryogenic levels.

Fabrication is similar to other nickel-base alloys

In common with other types of nickel-base alloys, Ultra Alloy 825 has good ductility and can be formed using conventional methods.

For heat treatment, post fabrication annealing is done at 950 °C, followed by rapid air cooling or water quenching.

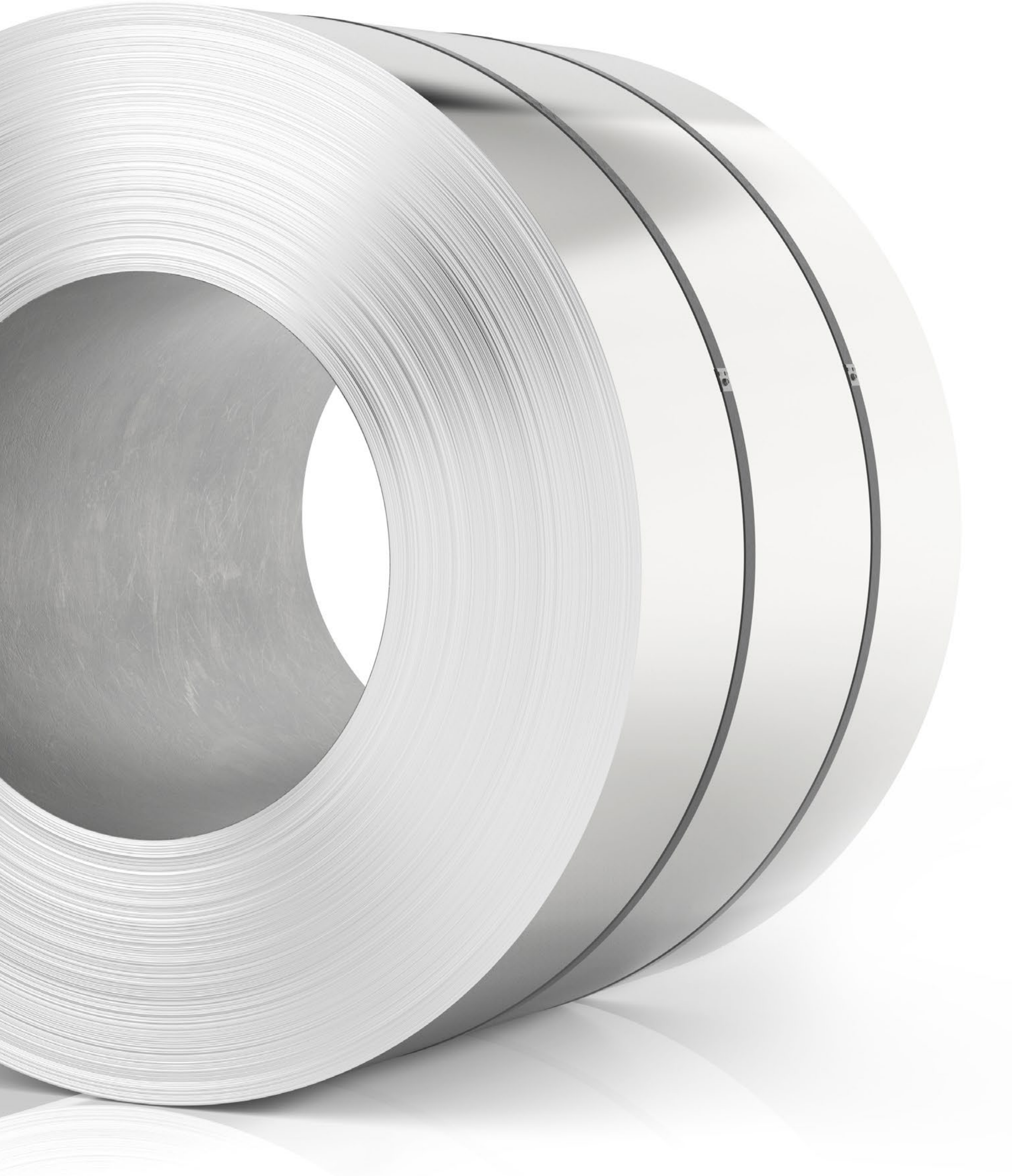
Conventional machining techniques can be used with Ultra Alloy 825. The material work hardens during machining.

Welding

Ultra Alloy 825 is readily weldable with conventional welding methods such as:

- Shielded metal arc welding (SMAW, MMA)
- Gas tungsten arc welding (GTAW, TIG)
- Gas metal arc welding (GMAW, MIG/MAG)
- Submerged arc welding (SAW)

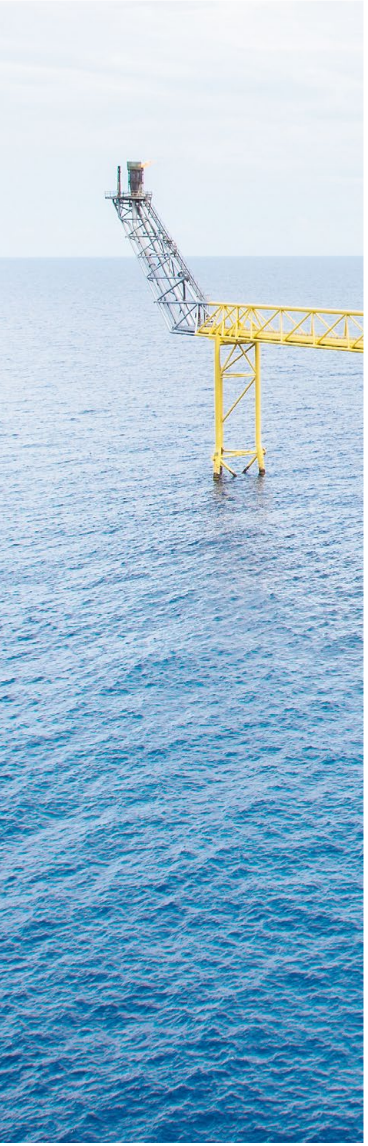
Preheating before welding is not necessary. The material can be welded using a matching filler. For example, with SMAW, covered electrodes of the type 2.4621 or 2.4652 can be used.



Availability in coil or plate formats

We use our melt shop in Avesta, Sweden for continuous casting of high-quality slabs of Ultra Alloy 825. That means we can offer large quantities with competitive lead-times for major projects.

We produce the material in coils up to 1,500 mm wide, both hot and cold rolled, in weights up to 12 tonnes or more. The advantage of this wider than usual coil is that it enables pipe and tube manufacturers to improve their productivity. At the same time, products produced from coil also have improved tolerances. We do understand that some customers require plate. So, we have also made Ultra Alloy 825 available in quarto plate format in thicknesses up to 40 mm. This approach enables customers to meet both their coil and plate needs from a single supplier.



Practical applications of Ultra Alloy 825 in processing applications

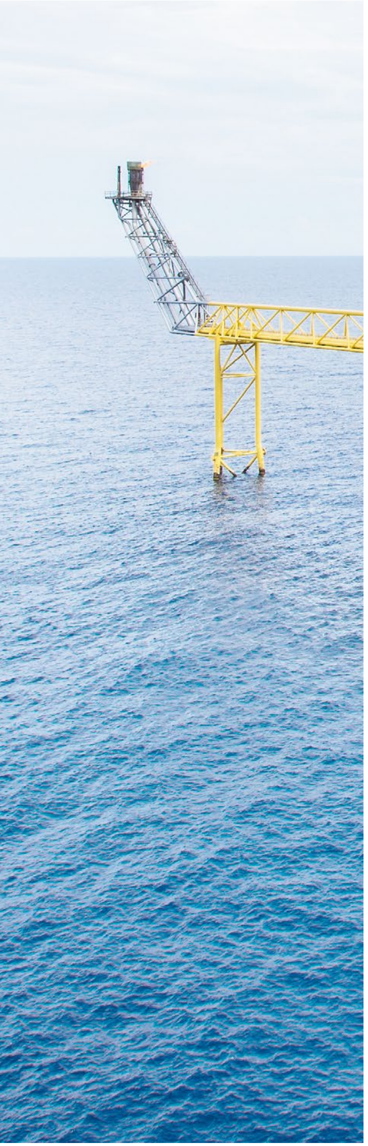
Clad and lined subsea pipelines

Subsea pipelines are essential to transport oil and gas from the production site to the refinery. At first sight, manufacturing them completely from Ultra Alloy 825 might seem the best option, especially in areas of the world where there is a naturally high sulfur level in combination with chlorides. However, this can be prohibitively expensive. A much more cost-effective approach is to use mechanically lined pipe (MLP) or clad pipe. In this case, Ultra Alloy 825 provides a thin corrosion-resistant layer on the inside diameter, while mechanical strength is provided by an outer shell made of carbon steel.

Clad pipe achieves a metallurgical bond between the layer of Ultra Alloy 825 and the outer pipe. This means that there is no void between the two layers that the product could potentially seep into. As a result, clad pipe helps to control risk in high pressure and high temperature applications.

One production route is through specialist rolling mills in which a sandwich of Ultra Alloy 825 and carbon steel is passed multiple times to create composite plates. Some manufacturers use explosion bonding to produce clad plate. This offers wide flexibility when combining materials and is mainly used for thick plates and small batch sizes. A third technique for making clad pipe is weld overlay, where Ultra Alloy 825 welding strip is bonded to the inner surface of a carbon steel pipe or fitting through welding.

MLP is produced by lining lengths of carbon steel pipe with Ultra Alloy 825. There are several options available to create a mechanical bond between the two layers. The most common process involves inserting an Ultra Alloy 825 liner pipe into a carbon steel shell and applying pressure with hydraulic fluid or mechanical force from a spinning mandrel to push the lining tightly into the pipe body. Some manufacturers also make use of heat on the outer pipe or adhesives to strengthen the bond between the two layers.



Weld overlay cladding

Some of our customers use thin strips of Ultra Alloy 825 in weld overlay cladding. This is a technique where a thin layer of the corrosion-resistant alloy is welded onto components made of carbon steel or another material. It is particularly helpful when an operator wants to achieve a high material performance for the surface of a component, without having the long lead time and expense of ordering special components in a high specification material.

Weld overlay cladding is used widely in the oil and gas industry in the construction of large vessels or metallic components such as pipes, valves, flanges, connectors and elbows, as well as pipework assemblies. OEMs can protect an entire component or restrict its use to high-risk areas, for example a valve bore or connector seal, or an area inside a pipeline that experiences unusually high pressure, such as inside a valve.

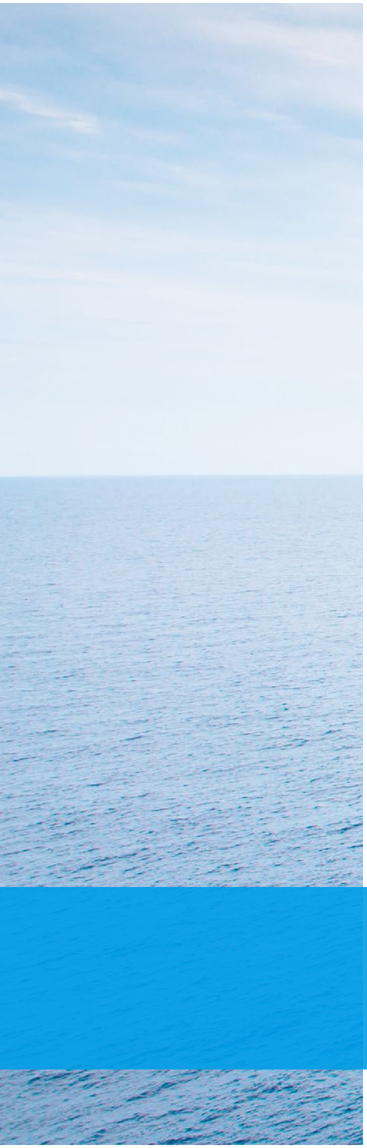
During the cladding process, an OEM will typically use a robotic welding solution to achieve a consistent high-quality finish. In a typical example, one of our customers is using a 0.5 mm thick weld strip to resist sour gas for offshore and onshore pipelines.

Fractionating columns

Ultra Alloy 825 found one of its first practical applications in the fractionating trays used widely in the distillation columns that separate crude oil into its component fractions. It is also used in the manufacture of vane inlet devices for sour gas processing applications.

Air cooled heat exchangers

Air-cooled heat exchangers, sometimes known as air fin coolers, play a vital in refineries in helping to remove process heat. We are finding a growing number of operators turning to Ultra Alloy 825 for demanding applications where other materials are failing prematurely.



A sweeter choice for sour applications

Ultra Alloy 825 is building a strong track record as an important alternative to stainless steel in demanding applications subject to extremely corrosive environments. It is ideally suited to help OEMs and operators in the oil and gas industries address the challenges of processing sour gas. experienced in sour applications. However, before making the final choice of material it is vital to undertake careful analysis of the specific conditions and carry out appropriate testing to ensure a cost-effective and long-lasting solution.

Learn more about Ultra Alloy 825:

Read more

Working towards a world that lasts forever

We work with our customers and partners to create long lasting solutions for the tools of modern life and the world's most critical problems: clean energy, clean water, and efficient infrastructure. Because we believe in a world that lasts forever.

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