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Printed in England by Toptown Printers Ltd Barnstaple Devon 017© July 2001 Parker Hannifin Issue 1.

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Parker Instrumentation

A-LOK® Exotic Materials

Bul 4200-Exotic

Parker Instrumentation

Exotic Materials

Material selection is proving increasingly critical in many of todays Instrumentation applications. There are many factors which metallurgists take into consideration before selecting the correct material to suit the media, or even the environment, products are being used with. This could simply be to work at higher temperatures or pressures than the industry standard 316 Stainless Steel will allow. Some applications call for a high strength versus weight ratio which allows a much thinner section of tubing to be used to achieve the pressure required but at a much reduced weight. The most common reason for selecting an Exotic material would be to combat media or environmental corrosion. There are many types of corrosion we find in our market place and if a product fails in service due to corrosion it can prove extremely expensive, and more importantly, very dangerous. The common types of corrosion Parker see include Pitting, Crevice, Stress, Microbially Influenced (MIC) and Galvanic.

The selection of material has to be cost effective for the user. For example, if the rate of corrosion is likely to be slow, it could be more cost effective to select a lower cost item and change it out when it has deteriorated, compared to paying a high initial product cost and not having to change out.
A number of criteria have to be taken into consideration by the user before the decision can be made on which material, or indeed which manufacturer should be used, such as:

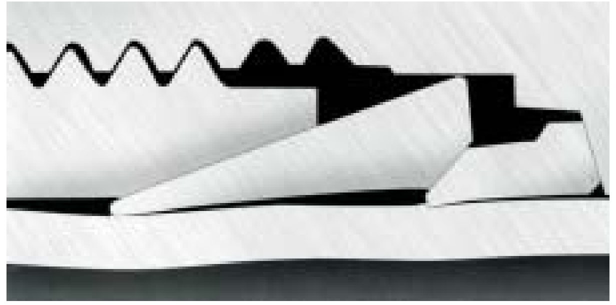
- Critical nature of the system
- Media contained within the system
- Environmental influences
- Rate of corrosion
- Frequency of change out
- Cost of product
- Installation costs
- Downtime costs when changing out product (i.e. loss of production)
- Inventory costs
- Product quality

In this booklet there are listed a range of alloys from which Parker manufacture a variety of Fittings and Valve products for Instrumentation and associated applications.

A-LOK Instrumentation fittings are equipped with Parker Suparcase® ferrules, which yield superior tube connection integrity and holding power to higher pressures without compromising the exceptional corrosion resistance of the various alloys. The Parker Suparcase® ferrule hardening process is unique in this regard; Parker has the only dedicated facility for performing this process for fittings in the world. Traditional hardening processes substantially reduce the corrosion resistance of the hardened region. As a consequence other fittings may experience corrosion problems in harsh environments, or they may utilise unhardened ferrules, which reduces their pressure ratings or cause the tubing to detach itself from the assembly with time due to hard tubing, temperature cycling, vibration or pressure surges and cycling.

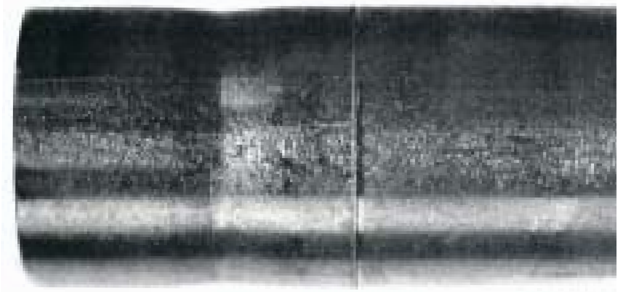
For tubing below 1/4” diameter, all alloys rely completely on the compressive action of the two ferrules to both seal and grip the tubing. For larger tube sizes, on most alloys, it is important for the rear ferrule to be harder than the tube it is designed to work on. The ferrule needs to break through the surface of the tube creating a mechanical hold onto it, thus preventing it from slipping out of the fitting when in service.

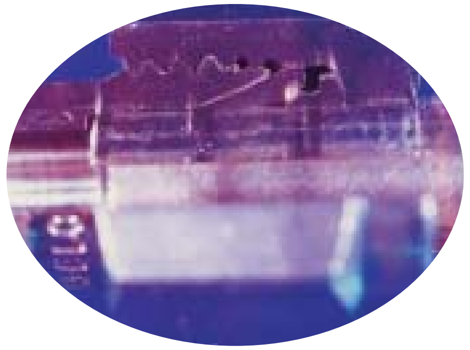
Cross section illustrating action of A-LOK® ferrules



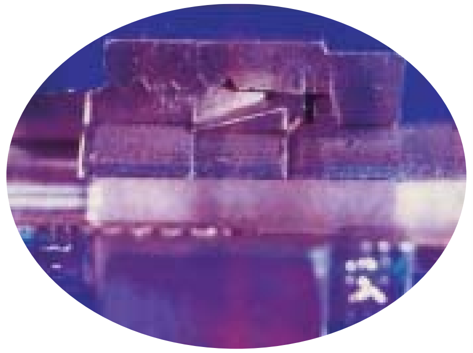
The rear ferrule, during make-up, is designed to shave the surface of the tube which smoothes out any slight imperfections on the tube. It also pushes a ‘dam’ of material in front of it, thus creating the positive hold on to the tube whilst producing a back up seal for the front ferrule.

Tubing shows ferrule grip points





The picture above indicates how the lack of hardness of the rear ferrule on an alloy 825 assembly can cause the tube to slip out of the fitting, which can lead to a catastrophic failure. The picture below however shows a Parker A-LOK® assembly, again in alloy 825, giving a superior grip with no tube movement due to the Suparcase® treated ferrule.



The differing chemical compositions of different materials means that not all alloys are receptive to the superior Suparcase® hardening process. To prevent compromising the corrosion resistance of any assembly Parker utilise a Suparcase® hardened back ferrule of an equal or superior alloy in those assemblies. Below is a table which outlines the fitting sizes and the ferrule and treatment normally applied to it

Suparcase® and exotic materials for A-LOK® back ferrules:

Fitting material	UNS No.	Back ferrule size, material and treatment		
		Below 1/4" (6mm) dia	1/4" (6mm) to 1/2" (12mm) dia	5/8" (14mm) and above
316	S31600	316 - No treatment	Suparcase 316	Suparcase 316
6MO	S312254	6MO - No treatment	Suparcase 6MO	Suparcase 6MO
Alloy 400	NO4400	Alloy 400 - No treatment	Alloy 400 - No treatment	Suparcase 825
Alloy 825	NO8825	Alloy 825 - No treatment	Suparcase 825	Suparcase 825
Alloy 625	NO6625	Alloy 625 - No treatment	Suparcase 825	Suparcase 825
Alloy C276	N10276	Alloy C276 - No treatment	Suparcase 825	Suparcase 825
Titanium	R50400	Titanium - Treated	Titanium - Treated	Titanium - Treated

Galvanic corrosion

Galvanic processes occur between different metals and even between different areas of the same metal in a water environment. Water is an electrolyte, a poorly conductive one at the low dissolved solids content of fresh waters, and a highly conductive one at the high dissolved solids content of seawater. When two different metals are immersed in an electrolyte and connected through a metallic path, current will flow. Oxidation (corrosion) occurs at the anode, and reduction (normally oxygen reduction) occurs at the cathode.

Galvanic series in sea water table
Corroded end
(anodic, or least noble)

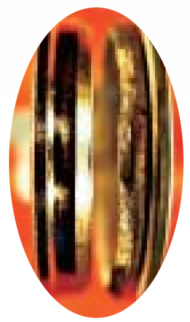
Magnesium
Magnesium Alloys
⇩
Zinc
Galvanised Steel or Galvanised wrought iron
⇩
Aluminium (Grades 5052, 3004, 3003, 1100, 6053)
⇩
Cadmium
⇩
Aluminium (Grades 2117, 2017, 2024)
⇩
Mild steel, Wrought Iron, Cast Iron
⇩
50-50 Lead tin solder
⇩
304,316 Stainless Steel (active)
⇩
Lead, Tin
⇩
Manganese Bronze
⇩
Nickel 200 (active)
Alloy 600 (active)
⇩
Yellow Brass
Aluminium Bronze
Copper70-30 Copper Nickel
⇩
Nickel 200 (passive)
Alloy 600 (passive)
⇩
Alloy 400
⇩
304,316 Stainless Steel (passive)
Alloy 825
⇩
Alloy 625
Alloy C-276
Titanium

Protected end
(cathodic, or most noble)

Corrosion

Here are some examples of what corrosion can do to ferrules that have had hardening treatments carried out which are not corrosion resistant, such as nitride hardening:

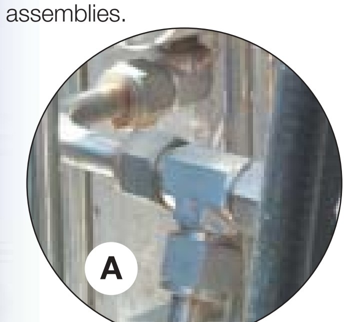
Unused Nitride hardened back ferrule

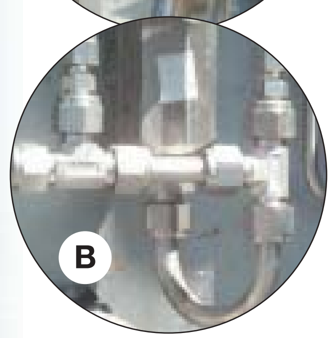


Corroded Nitride hardened back ferrule which caused a failure offshore

Close up of a corroded Back Ferrule in service

Below you will see the tell tale signs of fittings assembled using nitride hardened ferrules (A) compared to the picture (B) which has A-LOK® Suparcase® ferrules in their assemblies.



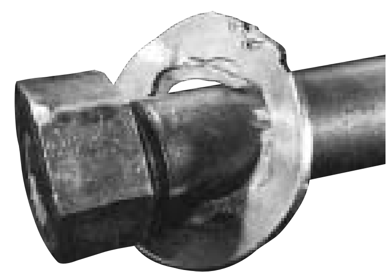


Pitting Corrosion

Pitting is localised penetration, normally at many different sites. The metal between the pits is relatively unaffected although pits may become connected as attack progresses. This photograph shows an example of Stainless steel tube with extreme surface pitting.

Crevice corrosion.

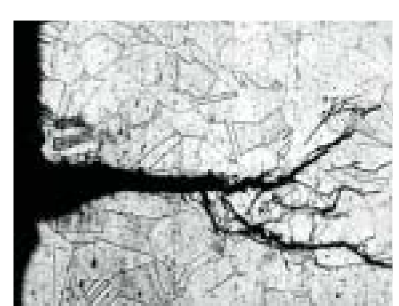
Crevice and surface deposits can result in different concentrations of dissolved matter, such as metal ions, leading to accelerated local corrosion as shown in this photograph of Stainless Steel tubing.



Stress Corrosion Cracking (SCC)

SCC is cracking of an alloy under tensile stress in the presence of specific corrosives. It occurs at stresses less than the tensile strength of the alloys and has the appearance of brittle fracture even in normally ductile alloys.

Example of Stress Corrosion cracking in stainless steel



TECHNOLOGY, APPLIED

Suparcase

Suparcase and exotic materials for A-LOK® back ferrules

The first step in ensuring the integrity of any system is to choose the right materials for the job. That's why Parker supply fittings in a wide range of exotic materials for applications where corrosion is an issue, and where new, harder materials for tubing for high-integrity applications are being used.

As previously stated, The Parker unique Suparcase® treated ferrules plays a key role in preventing corrosion and providing a mechanical hold onto these newer, harder tubing materials. The problem is, not all exotic materials can be Suparcased (they certainly can not be edge hardened successfully). Rather than manufacture a product which potentially could cause problems, the Parker solution, is to make the back ferrule of the fitting from a material which has equal or superior corrosion resistance, and of course can be Suparcase treated. So for example, for an Alloy 625 fitting, we would utilise an Alloy 825 back ferrule, which has been Suparcase-treated.

By selecting materials that are close to each other in the galvanic table, we reduce the risk of reaction between the different metals. Each combination has been salt-spray tested to the ASTM standard to ensure that the combination works well in terms of compatibility and fitting integrity.

Where a mix of materials are used in assembly, to recognise the combination, we utilise a 3 digit part number suffix as listed in the table below. The system identifies the material used as follows:-
1st digit - Body material
2nd digit - Nut material
3rd digit - Front and back ferrule material combinations

Body & nut material codes		Front & back ferrule material combination codes	
A	6Mo	Q	316 Ti front ferrule with 316 Suparcase back ferrule
E	316 Stainless Steel	R	C276 front ferrule with 825 Suparcase back ferrule
L	304L Stainless Steel	O	6MO front ferrule with 825 Suparcase back ferrule
I	Alloy 625	V	304 front ferrule with 316 Suparcase back ferrule
J	316 Ti Stainless Steel	W	Alloy 400 front ferrule with 316 Suparcase back ferrule
K	Alloy 825	X	Alloy 400 front ferrule with 825 Suparcase back ferrule
M	Alloy 400	Y	Alloy 625 front ferrule with 825 Suparcase back ferrule
N	Alloy C276	Z	Titanium front ferrule with 825 Suparcase back ferrule
S	316L Stainless Steel		
T	Titanium		

Examples:
An **IIY** suffix will indicate that the body, front ferrule and nut are Alloy 625 and the back ferrule is Alloy 825 Suparcased.
A **JEQ** suffix will indicate that the body and front ferrule is manufactured from 316 Ti Stainless Steel, with the suparcased nut manufactured from 316 Stainless Steel and the back ferrule is 316 Stainless Steel.
A **NNR** suffix will indicate that the body, front ferrule and nut are Alloy C276 and the back ferrule is Alloy 825 Suparcased.

6MO

UNS S31254

6MO is an austenitic stainless steel which because of its relatively high molybdenum content possesses a very good resistance to pitting and crevice corrosion.

This grade of steel was developed for use in halide containing environments where crevice, pitting and stress corrosion attacks are prone.

6Mo is especially suited to handle high-chloride environments such as brackish water, seawater, caustic chlorides and pulp bleach systems. Microbially Influenced Corrosion (MIC) can occur in brackish and waste water systems especially where equipment has been idle for extended periods. 6MO is extremely resistant to MIC and for this reason is also being used where bacteria and algae form "biofilms" on metal surfaces in warm seawater in areas such as the Middle East, Irish Sea and the Gulf of Mexico.

Typical applications include:

- Service water streams for nuclear power plants
- Offshore platform equipment
- Petrochemical and Seawater cooling systems
- Salt plant evaporators
- Bleach lines in pulp and paper mills
- Desalination plant equipment
- Fire fighting systems
- Tube heat exchangers
- Instrument measuring lines

Typical chemical composition: - %

C	0.02 max
Cr	20
Ni	18
Mo	6.25
N	0.2
Cu	0.75
Mn	1.0 max
P	0.03 max
S	0.01 max
Si	0.8 max
Fe	Remainder

Alloy 400

UNS N04400

Alloy 400 was the first nickel alloy invented, back in 1905 and remains one of the most extensively used nickel alloys due to its excellent corrosion resistance to a wide range of media. Alloy 400 has outstanding resistance to neutral and alkaline salts. It has been a standard material for salt plants for many years.

This alloy is one of the few metallic materials, which can be used in contact with fluorine, hydrofluoric acid, hydrogen fluoride or their derivatives. Alloy 400 shows very high resistance to caustic alkalis. Its behaviour in seawater is excellent, with improved resistance to cavitation corrosion compared with other copper based alloys. It can be used in contact with dilute solutions of mineral acids such as sulphuric and hydrochloric acids. However, it is important to note that, as the alloy contains no chromium, corrosion rates may be increased in oxidising conditions.

Whilst Alloy 400 can be considered immune to chloride-ion stress cracking, it can stress crack in the presence of mercury or in most aerated hydrogen/fluoride vapours.

Typical applications include:

- Service water streams for nuclear power plants
- Uranium refining & isotopes separation used in the production of nuclear fuel
- Offshore platform equipment
- Petrochemical and Seawater cooling systemsSalt plant evaporators
- Desalination plant equipment
- Fire fighting systems carrying seawater
- Tube heat exchangers
- Instrument measuring lines
- Feed-water and steam generator systems in power plants
- Equipment used in the manufacture of chlorinated hydrocarbons
- Sulphuric & hydrofluoric acid plants

Typical chemical composition: - %

C	0.3 max
Ni	63.0 min
Cu	31
Mn	3.0 max
S	0.024 max
Si	0.50 max
Fe	2.5 max

Alloy 825

UNS N08825

Alloy 825 is a titanium-stabilised fully austenitic nickel-iron-chromium alloy with additions of copper and molybdenum.

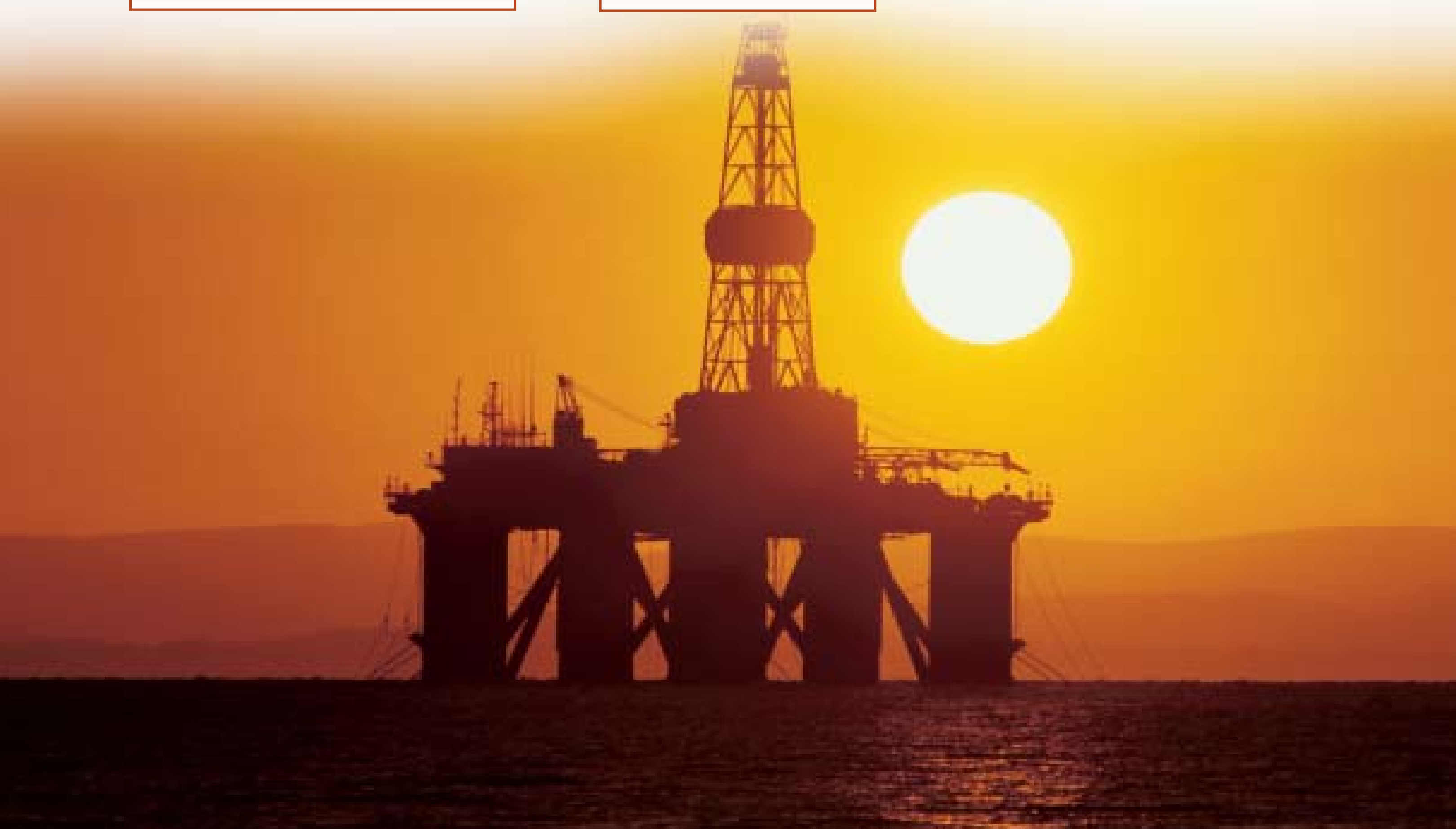
This alloy is characterised by its good resistance to stress corrosion cracking and to oxidising and non-oxidising hot acids alike. It also has a very satisfactory resistance to pitting and crevice corrosion. Alloy 825 is a versatile general engineering alloy with good resistance to corrosion in a wide range of media such as sulphuric, sulphurous, phosphoric, nitric and organic acids, alkalis such as sodium or potassium hydroxide, and aqueous chloride solutions. Its high nickel content gives this alloy almost complete immunity to stress corrosion cracking.

Typical applications include:

- Heat exchangers, evaporators and other equipment in phosphoric acid plants
- Fuel element dissolvers
- Sulphuric acid pickling plants
- Sea-water cooled heat exchangers
- Chemical plants
- Food processing
- Sour gas applications
- Down hole control lines for oil and gas production

Typical chemical composition: - %

Ni	42.0
C	0.05 max
Cr	21.5
Mo	3.0
Mn	1.0 max
S	0.03 max
Si	0.5 max
Al	0.2 max
Ti	0.9
Cu	2.25
Fe	22 Min



Alloy 625

UNS N06625

Alloy 625 is a low–carbon, nickel-chromium-molybdenum-niobium alloy which shows excellent resistance to a variety of corrosive media.

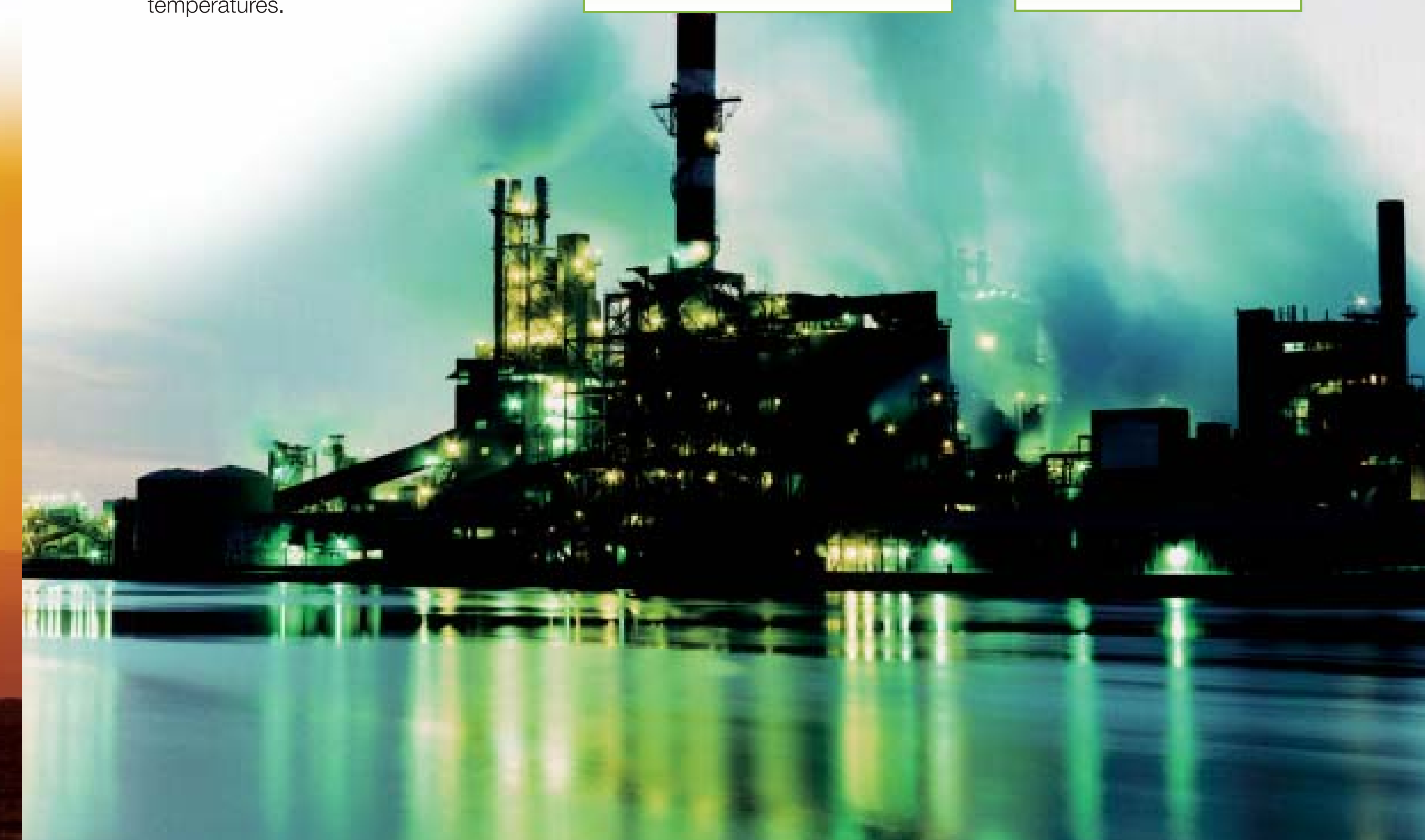
This alloy has outstanding resistance to pitting & crevice corrosion as well as good resistance to intergranular attack. It also has almost total resistance from chloride-induced stress corrosion cracking. With these properties of the alloy, it has extremely high resistance to attack by a wide range of media and environments including nitric, phosphoric, sulphuric and hydrochloric acids, as well as alkalis and organic acids in both oxidising and reducing conditions. Alloy 625 has virtually no corrosive attack in marine and industrial atmospheres with extremely good resistance to seawater, even at elevated temperatures.

Typical applications include:

- Flue gas scrubbers
- Phosphoric and other acid producing facilities
- Nuclear waste reprocessing equipment
- Sour gas applications
- Offshore industry particularly in warm environments
- Marine equipment applications
- Turbines
- Aerospace industry, particularly fuel and hydraulic lines

Typical chemical composition: - %

Fe	5.0 max
C	0.1 max
Cr	21.0 - 23.0
Mo	21.5
Mn	0.5 max
P	0.015 max
S	0.015 max
Si	0.5 max
Al	0.40 max
Ti	0.40 max
Nb	3.65
Ni	58.0 min



Alloy C-276

UNS N10276

Alloy C276 is a nickel-molybdenum-chromium wrought alloy, which is generally considered to be the most versatile corrosion resistant alloy currently available.

C276 has outstanding resistance to localised corrosion and to both oxidising and reducing media. It has very good resistance to a wide range of chemical process environments, including strong oxidisers such as ferric and cupric chlorides, hot contaminated media, chlorine, a variety of acids and seawater and brine solutions. It is one of the few materials that withstand the corrosive effects of wet chlorine gas, hypochlorite and chlorine dioxide.

This alloy is a favourite with chemical plants because of its excellent mechanical properties giving it good durability in addition to its resistance to aggressive process fluids.

Typical applications include:

- Heat exchangers
- Flue gas desulphurisation systems
- Production of hydrofluoric acid
- Transfer piping lines
- Reaction vessels
- Pollution control/stack gas equipment containing chlorides, sulphur oxides, nitrogen oxides, carbon dioxides and carbon monoxide.
- Waste treatment equipment
- Instrument measuring lines
- Pulp washing equipment
- Sulphuric acid applications such as pickling baths and detergent manufacture
- Chlorine dryers and other wet chlorine applications

Typical chemical composition: - %

C	0.02 max
Cr	15.5
Co	2.5 max
Mo	16
W	3.75
Fe	5.5
Mn	1.0 max
P	0.04 max
S	0.03 max
Si	0.08 max
V	0.35 max
Ni	Remainder

Titanium

UNS R56400

The titanium material used for Instrumentation products is what is known as commercially pure or unalloyed. It has proven to be technically superior and a very reliable and cost effective material in a wide range of chemical, industrial, marine and aerospace applications.

Titanium exhibits superior resistance to chlorides and many forms of corrosion. The material is immune to chloride pitting and intergranular attack and is highly resistant to crevice and stress corrosion. Titanium and its alloys have a number of unique properties, which make them a good choice even when strength or corrosion resistance may not be critical. These properties include important equipment design factors, such as low density, high melting point, non-magnetic, an extremely short radioactive half life, very low modulus of elasticity and co-efficient of expansion. These factors allow the material to be very flexible whilst giving extremely high strength properties against a very much reduced weight ratio

Typical applications include:

- Gas Turbines
- Heat Exchangers
- Chemical plants for the production of Chlorine, hypochlorites, acids and other aggressive compounds
- Desalination plants
- Cooling and piping systems in marine applications
- Hydrocarbon processing
- Pulp and Paper plants
- Condensers
- Nuclear waste re-pocessing systems
- Flue gas desulpurisation systems

Typical chemical composition: - %

C	0.10 max
Fe	0.40 max
H	0.01 max
N	0.05 max
O	0.02 max
Al	6.0
V	4.0
Ti	remainder