MANAGING RISK IN CORROSION-RESISTANT ALLOY PROCUREMENT

Reduce your exposure to poor quality, performance or availability from Alloys 625 and 6Mo for oil and gas projects.

Parker

CLARA MOYANO

Clara is a Material Scientist for Parker Instrumentation Products Division Europe and has published several works, including What To Consider When Specifying Non-Commercial Materials for Oil and Gas.

GRAHAM JOHNSON

Graham is a product marketing manager for Parker Instrumentation Products Division, Europe. He has 37 years experience with process control technology across a range of applications.

1. INTRODUCTION

In the search for cost-effective oil extraction in ever more complex and challenging locations, operators are increasing their reliance on corrosion-resistant alloys (CRAs).

Instrumentation components manufactured from CRAs like Alloy 625 (Inconel® 625, UNS N06625) and Alloy 6Mo (UNS S31254) allow companies to drill deeper at higher temperatures, pressures and concentrations of chloride and sour gas than would otherwise be possible.

But, while their balance of strength, corrosion resistance and thermal stability makes CRAs uniquely suited to drilling in hostile environments, their procurement cost is high, and prices remain volatile.

At the same time, the global marketplace is considering new suppliers that seemingly offer the same products at lower prices. However, the right quality and value proposition are difficult to find and even more difficult to assess.

The complex production of Alloys 625 and 6Mo means it's almost impossible to know whether you're getting the right quality without the relevant engineering knowledge.

If suppliers are using lower-quality raw materials or less rigorous production processes, the resulting components may demonstrate reduced corrosion resistance, substandard mechanical performance, embrittlement problems, and poorer high temperature performance.

Even a minor failure can lead to unplanned downtime, costing hundreds of thousands of US dollars per asset, on top of any associated regulatory fines. But a catastrophic failure of pressure-retaining equipment could cost lives, cause enormous environmental damage and result in long-term reputational harm.

In this white paper, we will explain the key aspects of CRA quality and availability that ensure your project receives the right material, in the right place, at the right time.

By assessing your procurement of CRA instrumentation components against the criteria outlined in this paper, you can ensure improved reliability and long-term profitability for your operation. You can also reduce your – and your company's - risk exposure in the event of equipment failing prematurely.

Because when it comes to metals and equipment, not everything that looks the same will perform identically under real service conditions.

The complex production of Alloys 625 and 6Mo means it's almost impossible to know whether you're getting the right value without the relevant engineering knowledge.

2. THREE FACTORS DRIVING THE COST OF PROCURING CRAs

One: The quality and price of metals have increased over time

In the drive for better reliability and performance of drilling operations, the industry has invested heavily in the research and development of new alloys with improved strength, corrosion resistance and thermal performance. Over the last century, this has led to a dramatic reduction in component failures and the improved safety of drilling operations.

However, with raw material prices rising, oil and gas producers have begun to compromise on the sourcing of Alloys 625 and 6Mo.

Allowing cheaper, less rigorous suppliers may reverse the trend of improvements to quality, performance and safety, causing a significant challenge to the industry.

1930s

Stainless Steel AISI 316 (UNS S31600) improved with molybdenum

Enhances the steel's overall corrosion resistance, resistance to pitting, and strength at elevated temperatures, making it ideal for oil and gas drilling.

1940s

Stainless Steel 316 widely used in oil and gas production

1962

First patent of Alloy 625 (UNS N06625)

- Alloy 625 offers significantly higher all-round performance than 316 stainless steel, including outstanding resistance to pitting and crevice corrosion, high corrosion-fatigue strength, high tensile strength and resistance to chloride-ion stress-corrosion cracking.
- Because it is highly sensitive to temperatures associated with processing, Alloy 625 requires controlled and efficient heat management cycles to deliver maximum performance in the field, resulting in very high energy costs during production.

1976

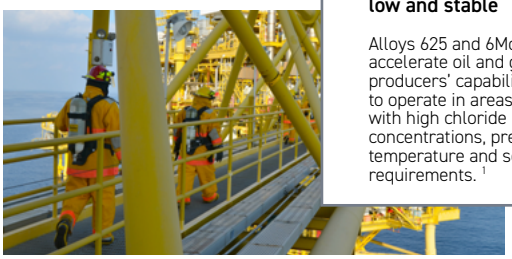
Patent introduced for the current version of Alloy 6Mo (UNS S31254)

- Alloy 6Mo offers 50% higher yield strength than 300-series austenitic stainless steels at a similar level of tooling as 316 stainless steel.
- Similarly sensitive to temperatures associated with processing as alloy 625, it too requires high energy costs during production to deliver maximum performance in the field.

1980s-90s

Metal prices remain low and stable

Alloys 625 and 6Mo accelerate oil and gas producers' capabilities to operate in areas with high chloride concentrations, pressure, temperature and sour gas requirements. [1]



1992-1997

New legislation drives safety improvements

Following the 1988 Piper Alpha disaster, operators increase reliance on corrosion-resistant alloys to improve the integrity of installations and the safety of offshore and onshore wells.

2003–2017

Metal market volatility

Leads to a marked increase in metal prices – leaving them 75% higher in 2017 than in 1995. [2]

2017-2021

Industrial metal prices climb again

Hitting a nine-year high post-pandemic. [3]

2021–now

High metal prices drive the search for cheaper procurement of corrosion-resistant alloys

But opting for Alloys 625 and 6Mo suppliers with lower-quality raw materials and less rigorous production processes means an increased risk of downtime and reduced worker safety due to poor performance under service conditions.

Two: Supply challenges and rising demand for raw materials

CRAs like Alloys 625 and 6Mo require high concentrations of nickel, chromium, and molybdenum, along with small additions of niobium, aluminium and titanium.

However, geopolitical instability, climate change and increased competition from other sectors such as electronics and aerospace are all impacting the metals market (Fig. 1).

The increasing frequency and severity of disruptions to global supply chains mean that the cost of raw materials will remain high for the medium-to-long term.

A global titanium shortage

- Titanium production has been dramatically disrupted by the Russia-Ukraine conflict.
- Russia is the third largest producer of titanium globally, accounting for 11% of all titanium sponge production in 2023. [4]
- Strict environmental regulations are restricting mining in other titanium-rich countries such as China and Japan.
- Production is further disrupted by labour shortages, geopolitical instability and factory shutdowns.
- Global demand is also increasing from industries such as aerospace. [5]

Competition for nickel

- Nickel prices have been on a sustained upward trend since 2020 thanks to growing battery demand and the Russia-Ukraine war, with Russia the third highest producer of nickel worldwide. [6]
- As an essential component of EVs, battery storage and geothermal energy technology, the IEA predicts that energy transition will increase demand for nickel by 82% by 2030 and 149% by 2040. [7]

Molybdenum market volatility

- Molybdenum prices jumped substantially in 2023, with price spikes driving numbers into the triple figures for the first time since 2005.
- This was driven by strong demand from offshore drilling, combined with supply deficits resulting from many primary molybdenum mines remaining idled for close to a decade.
- Key mining activity in Peru has been disrupted by civil unrest, while production issues in Europe have also added to the squeeze in supply. [8]

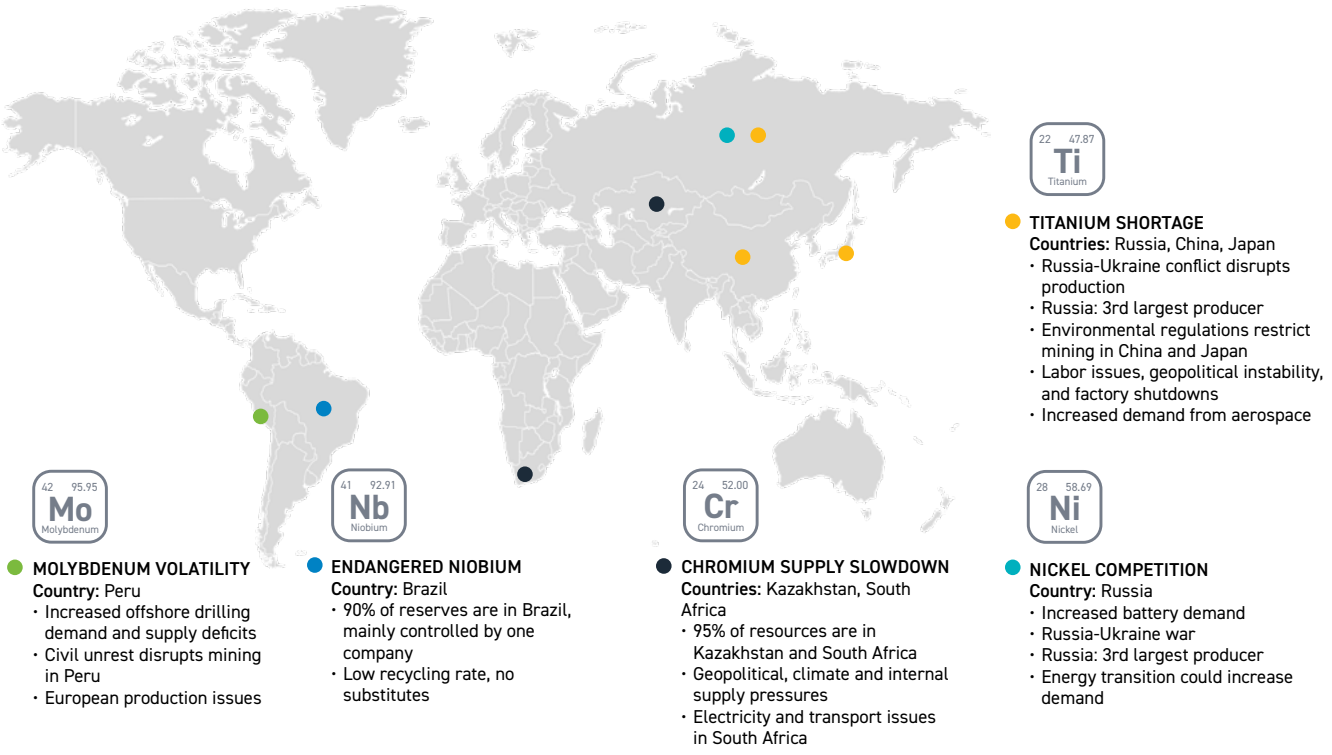
Endangered niobium availability

- Listed as a critical raw material by the European Union since 2011, the supply of niobium is at high risk of disruption due to 90% of its total reserves being located in Brazil and its production being mainly performed by a single company.
- With a relatively low recycling rate of just 20-30% and no valid substitute, demand for this endangered material will nevertheless increase by 8% annually according to the European Commission. [9]

Slowdown of chromium supply

- While world chromium resources are enough to meet centuries of demand, 95% are concentrated in Kazakhstan and the south of Africa, leaving the market vulnerable to fluctuations in geopolitics, climate and internal supply pressures.
- As the world's leading chromite ore producer, South Africa saw production decrease in 2023 due to electricity supply disruption and issues with transporting ore via rail. [10]

Fig. 1. Global metal supply challenges: key disruptions in the production and availability of essential metals like titanium, nickel, molybdenum, niobium, and chromium are driving up costs and impacting the supply chain for corrosion-resistant alloys.



Three: 80% of corrosion-resistant alloy production costs come from raw materials

Raw material constitutes an estimated 80% of the cost of a high-quality instrumentation fitting and this applies especially in corrosion-resistant alloys (Fig. 2). It is therefore very unlikely that large savings can be made without compromising on the quality of the raw material.

This compromise leads to significant operational risk. Cheaper raw materials simply do not perform as well in exacting services.

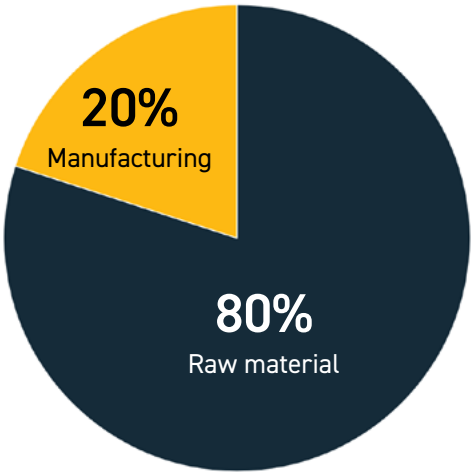


Fig. 2. The true cost of corrosion-resistant alloy production

Attempting to reduce costs by using cheaper alternatives significantly compromises material quality and increases operational risks.

3. HOW TO CHECK THE MATERIAL QUALITY

The performance of your corrosion-resistant alloy instrumentation component is directly linked to how well its raw materials are processed and heat-treated.

For example, while Alloy 6Mo requires tightly controlled material processing, Alloy 625 is exceptionally difficult to process and forge. Just like baking a cake, you can mix the right raw materials and still burn the final result.

Over the last 50 years, Parker has worked to perfect the complex chemistries and processing of Alloys 625 and 6Mo – because the consequences of getting it wrong can be severe.

Lower quality or improperly processed material has a high impact on performance, inevitably contributing to increased corrosion failure and galling on mating surfaces.

At best, this might just result in a leak. In the worst case, it's a catastrophic incident.

This is why supply chain traceability is also critical. Regulatory bodies demand effective material verification and validation because quality control is central to operational safety, reducing the risk of such an incident occurring.

Without unambiguous documentation to prove the origin and quality of your component's materials, your risk exposure grows by an order of magnitude.

Quality control is central to operational safety.

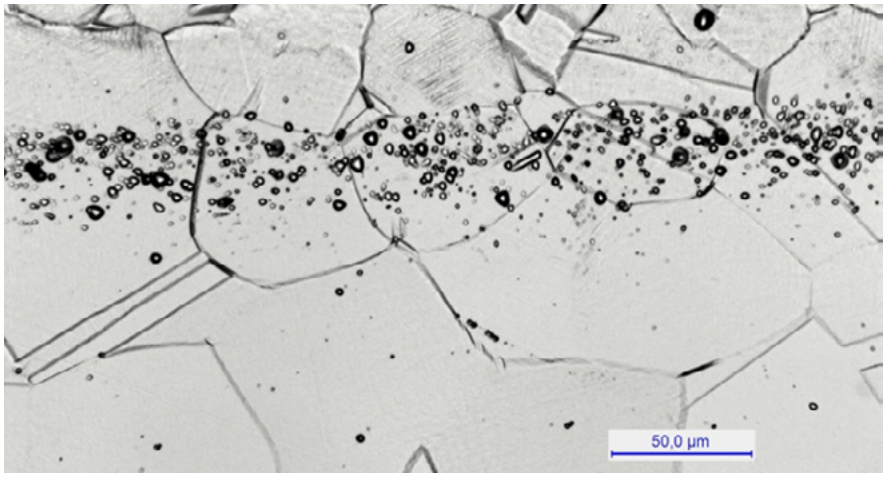


Fig. 3. Microscopic image of carbide precipitate stringers and sigma phase in alloy 6Mo, formed due to incorrect hot working temperatures and improper heat treatment.

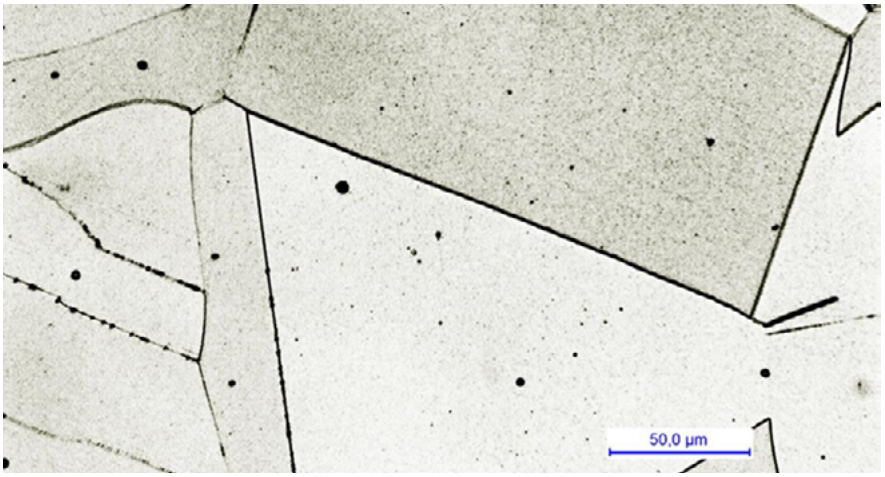


Fig. 4. Microscopic image of carbide precipitation at grain boundaries in Alloy 625, formed due to improper processing and insufficient heat treatment.

The impact of poor processing and heat treatment

Alloy 6Mo

- Incorrect heat treatment increases the risk of carbide precipitation and sigma phase – reducing the stability of the alloy so it loses ductility, toughness and corrosion resistance, resulting in increased risk of failure (Fig. 3).

Alloy 625

- Poor processing increases the risk of carbide precipitation and other intermetallics, weakening the structure of the alloy (Fig. 4). This directly impacts corrosion performance and causes embrittlement – a reduction of the material's ductility and toughness.
- If the processing temperature is too low, there is also a high risk of the component cracking, in addition to other potential defects in its material.

Four documents that prove quality and traceability

Your manufacturer should be able to prove they work to exceptionally high standards using tight controls, and that they only work with established mills with strong reputations for quality.

That means demonstrating full traceability to the source by:

- Proving the origin of materials through material certificates / original mill certificates (Fig. 5).
- Providing a material certificate for the converted product.
- Supplying an accompanying certificate of testing of the converted material.
- Documenting the material's cast number, mill run and heat treatment batch.

LEARN HOW TO

Evaluate material certificates with examples of both bad and comprehensive ones.

[redacted]

Customer

[redacted]

TEST CERTIFICATE IN ACCORDANCE WITH BS EN 10204 3.1/ISO 10474 3.1

Certificate No.	T60042	Product	Stainless steel bar		
Order No.	Consignment	Cast No.	148089	Specification	1.4404
Our Reference	Z111325/P42468	Quantity	42 Kgs	Size	.562" A/F Hex
Advice Note No.	DP609	Finish	Cold drawn		
Heat Treatment	Fully solution treated and water quenched prior to cold sizing				

Chemical Analysis

C	0,018	Si	0,462	Mn	1,332	S	0,0298	P	0,0243
Ni	10,082	Cr	16,682	Mo	2,038	Ti		Nb	
Co		Cu	0,484	N	0,038	W		Ca	
Sn		Ta		V		Al		Fe	

Mechanical Properties

Tensile Strength	737 Mpa	0.2% Proof Stress	533 Mpa
Reduction of Area	71,0%	Elongation	35,0%
Hardness	21.4 HRC	Impact Tests	

Special Conditions / Processing Details

In accordance with BS EN 10088-3 1.4404
In accordance with M019/1
Conforming to NACE MR0175/MR0103
Free from mercury and radioactive contamination
ICC test to ASTM A262 'E' - Satisfactory
Also conforming to ASTM A276/A479 Gr 316/316L
Country of origin : France

HCT No : 90M
Part No : 7710568203

Manufacturers Test Cert No.	Concessions Agreed

"Certified that the whole of the supplied detailed hereon, unless otherwise stated",are covered by the Sources Certificate of Conformity/Test Certificate referenced hereon,and has been subject to the Quality System requirements in accordance with the conditions of our BS EN ISO 9001 2015 registration.

"Certified that the supplies/services detailed hereon have been inspected and tested in accordance with the conditions/requirements of the contract or purchase order and,unless otherwise noted below,conform in all aspects to the specification(s)/drawing(s) relevant thereto".

14/11/2019

Certification Department

Fig. 5. Example of one page from a multi-page material certificate. Comprehensive certificates provide details on material origin, melting procedures, heat treatment, testing protocols, contamination status, and more.

Why Parker's material quality matters:

6Mo

- We tightly control our material specification and source from 100% NORSOK mills, meaning they follow some of the most stringent standards in the world.
- This removes the chance of incorrect heat treatment and processing while adding extra quality assurance on witnessed and validated manufacturing routes.
- Our material certificates illustrate each critical element of material processing and offer full traceability.
- Quality control and safety compliance are further established through positive material identification, a non-destructive testing method for verifying the chemical composition of metals and alloys.

Alloy 625

- We source only from established and respected mills, with material certificates that establish the same complete level of traceability as our Alloy 6Mo components.
- We also maintain strict statistical process controls to ASTM standards including additional ASTM G28 corrosion testing to ensure excellent corrosion performance and the correct processing and heat treatment of raw material.

Our Source of 6Mo Material

Norsok

4. ENSURE YOUR COMPONENTS ARE PROPERLY MANUFACTURED

The high concentrations of molybdenum and niobium in Alloy 625 makes it an exceptionally tough material that causes substantial tooling wear when you're trying to manufacture parts. Not only does this make it a very difficult material to work with, but it also impacts the rate of production.

For these reasons, running Alloy 625 components in high quantities is extremely challenging. If you are seeing promises of high productivity, this may be a sign of compromised quality in the material or its manufacturing.

A reduction in either will have a detrimental impact. Poor tooling increases the risk of contamination and surface roughness, significantly reducing corrosion performance.

Signs of high production standards:

- The tooling required for Alloy 625 is at least 600% more expensive than the equivalent for 316 stainless steel. As a result, manufacturers of Alloy 625 components should be able to demonstrate a high level of investment in high-quality tooling.
- They should also be able to show a high level of investment in the right production techniques and procedures to maximise effectiveness and efficiency. This requires a particular level of financial stability and established manufacturing experience working with corrosion-resistant alloys.
- Finally, new tooling requires high-pressure coolant machinery, which means manufacturers should have dedicated production support equipment.

Why Parker's production quality matters:

- We have invested millions of dollars in manufacturing and support equipment for Alloy 625.
- This includes a new turn-mill centre, which delivers outstanding flexibility and performance density to exacting quality requirements.
- We have also invested in high-quality carbide tooling with a central cooling system to increase tool life and improve cutting efficiency.
- We regularly review and adjust our manufacturing programme and procedures to maintain outstanding production quality standards, including monitoring of feeds and speeds, scrap reduction, material control and quality inspections.
- As a result, we are one of the few manufacturers capable of delivering consistently high-quality Alloy 625 instrumentation components on time and in high volumes.

5. CONFIRM GLOBAL AVAILABILITY

Getting the right material at the right time is not just a matter of materials and manufacturing, but logistics. Just as the supply of raw materials has been disrupted for component manufacturers, the same geopolitical, economic and climate instability has directly impacted the supply of components to oil and gas projects.

To remain on schedule, you need to be clear that your supplier can deliver what you need, in the right volumes, on deadline - wherever in the world your project is located.

How to ensure supply consistency

- Actions speak louder than promises. Make sure your component supplier has a proven history of similar order types and values delivered on deadline.
- There should be no question of any issues with quality or performance. Check for a demonstrable track record of high levels of investment, expertise and support for CRAs like Inconel® 625 and Alloy 6Mo.
- With production and supply chain disruptions becoming a universal norm, your supplier should be able to demonstrate they have the global manufacturing locations, capacity and lead times to deliver in the right volume to your project location.
- They must also be able to prove that robust contingencies are in place to ensure supply chain consistency.

Why Parker's supply chain matters:

- As part of a $19 Billion turnover organisation, we have the capacity and stability to guarantee the consistent supply of any volume of Alloys 625 and 6Mo components worldwide.
- With zero quality and performance issues reported, multiple global locations and a dedicated team to assist on large projects, we provide a unique breadth of reach and support.
- Thanks to four decades of investment and expertise in the supply of CRA instrumentation components, we have a long-term track record of meeting the high expectations of global oil and gas producers.

Corrosion-Resistant Alloy Manufacturing Experience **40 Years**

Quality & Performance Issues **Zero**

Dedicated project support across the globe

Orders

57

Materials

4 316 Stainless Steel, 6Mo, Alloy 400, Alloy 625

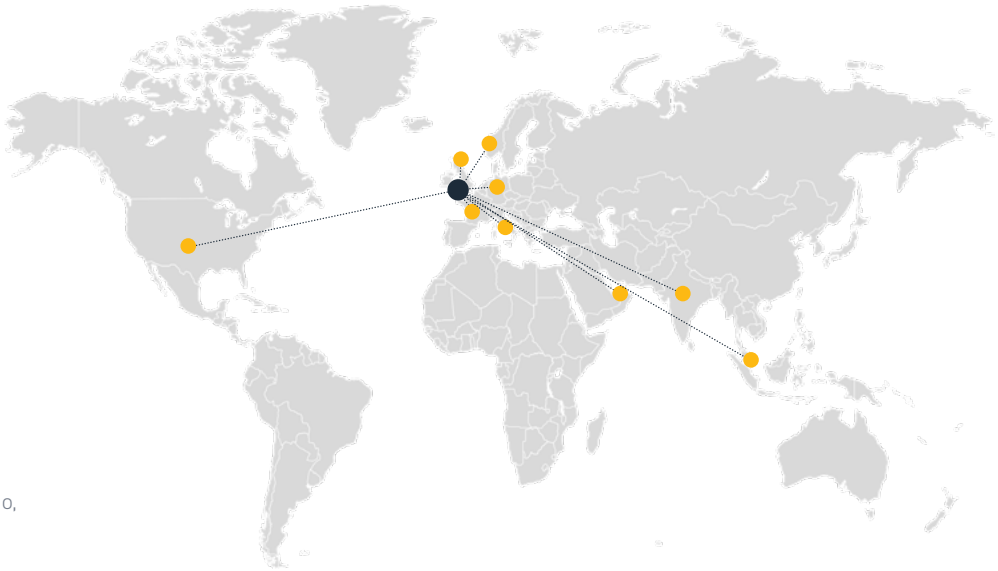


Fig. 6. Example Project: This map illustrates the distribution of shipments from Parker's manufacturing location in Barnstaple, UK, to multiple international destinations supported by dedicated project management team.

6. CONCLUSION

The safest choice for Alloys 625 and 6Mo component manufacturing and supply.

Depending on project application conditions, instrumentation components made from Alloys 625 and 6Mo are expected to last longer and deliver more consistent, leak-free performance than alternative materials. This is especially true when comparing the performance of high-quality products to lower-cost options of the same alloy types.

While the cost of their procurement remains high, this reflects their ability to cut the risk of failure and unscheduled downtime costs over the lifetime of your project, improving worker safety and reducing the risk of environmental damage.

However, your ability to rely on these components to perform under tough service conditions depends on the reliability of your supplier. As new offerings enter the marketplace at a seemingly lower price point, it's important to remember that any short-term savings will quickly turn into additional costs should your components fail to perform to the expected standard.

With more than 40 years of experience in processing, manufacturing and supplying Alloys 625 and 6Mo, Parker represents the safest, most reliable choice for instrumentation components that need to meet the highest standards of quality, performance and availability.

We continually invest millions of dollars in equipment, training and monitoring to ensure that the components we forge, process, manufacture and tool meet the highest standards in the world.

Our dedicated division project team is available to support operations wherever they're based on the map. And having managed projects worth more than $24 million per client, we are trusted by the industry's producers to deliver the volume they need, on time, every time.

Contact our expert team

To learn how we can support your project, contact our team.

Your ability to rely on corrosion-resistant alloy components to perform under tough service conditions depends on the reliability of your supplier.

References:

1. *Humphreys (1988) https://www.sciencedirect.com/science/article/abs/pii/0301420788900347 / European Central Bank (2017) https://www.sciencedirect.com/science/article/abs/pii/0301420788900347*
2. *European Central Bank (2017) https://www.ecb.europa.eu/pub/pdf/other/ebbox201708_01.en.pdf*
3. *IMF (2021) https://www.imf.org/en/Blogs/Articles/2021/06/08/four-factors-behind-the-metals-price-rally*
4. *Statista (2024) https://www.statista.com/statistics/1394495/global-titanium-sponge-production-capacity-by-country/*
5. *Thomas (2023) https://www.thomasnet.com/insights/titanium-shortage/*
6. *ISS Insights (2023) https://insights.issgovernance.com/posts/nickel-supply-risks-and-esg-issues/*
7. *IEA (2022) https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/mineral-requirements-for-clean-energy-transitions*
8. *S&P Global (2023) https://www.spglobal.com/commodityinsights/en/market-insights/blogs/metals/021323-ferromolybdenum-price-surge-molybdenum-perfect-storm*
9. *Springer (2024) https://link.springer.com/article/10.1007/s43615-024-00369-3*
10. *USGS https://pubs.usgs.gov/periodicals/mcs2024/mcs2024-chromium.pdf*

Parker Hannifin Manufacturing Ltd.
Instrumentation Products Division, Europe
Riverside Road
Barnstaple
United Kingdom
phone 0044 1271 313131
www.parker.com/ipd

WP-625-6Mo 625-6Mo 09/2024
Your Local Authorized Parker Distributor