

THE FREIGHT INDUSTRY

THE FERRITIC SOLUTION

ISSF
INTERNATIONAL
STAINLESS STEEL



FERRITIC STAINLESS STEEL APPLICATIONS



Foreword

UTILITY FERRITICS AND FREIGHT

"This booklet proclaims the merits of the so-called 'utility' 12% chromium stainless steels in the construction of freight wagons and containers. It is part of an ISSF drive to inform existing and potential users of stainless steel about ferritic grades of stainless steel.

"Ferritics are more affordable and price-stable than their austenitic cousins. Utility ferritics are basic grades with, already, extraordinarily advantageous properties. A lack of information available to users has meant that, in the past, ferritics have tended to be overlooked. To help fill this knowledge gap, ISSF has published the brochure 'The Ferritic Solution' and a video of the same title*. The present booklet is one of several follow-up publications on ferritic grades in specific application areas.

"I am grateful to the users and material suppliers who have kindly allowed us to publish their testimonials about the advantages of utility ferritic stainless steels in rail-freight applications. They show that for Life Cycle Costing reasons alone, fabricators and end-users of freight wagons and containers should rush to make utility ferritic stainless steels their material of choice. Sticking with painted, treated or galvanised carbon steel emerges as a clear false economy."

"As with these previous projects, the International Chromium Development Association (ICDA) has co-funded this booklet. I thank ICDA** for this help, as I do those users of ferritics who have contributed case studies about the excellence of these grades in the freight industry."

*Both brochure and video are available free of charge from ISSF (www.worldstainless.org). The video can also be viewed on the ISSF website and downloaded.

**ICDA website: www.icdachromium.com

Jürgen Fechter

Chairman

Marketing Development Committee

ISSF



International Stainless Steel Forum (ISSF)

Founded in 1996, the International Stainless Steel Forum (ISSF) is a non-profit research organisation that serves as the world forum on various aspects of the international stainless steel industry. Whilst having its own Board of Directors, budgets and Secretary General, ISSF is part of the International Iron and Steel Institute (IISI). ISSF now comprises some 73 company and affiliated members in 26 countries. Jointly, they are responsible for around 85 percent of worldwide stainless steel production. A full list of members can be found on the ISSF website: www.worldstainless.org.

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A STEEL FOR ALL SEASONS

With utility ferritics, stainless steel's corrosion/abrasion resistance is available at reasonable cost.



Utility stainless steels are low-cost, 12%-chromium ferritic stainless steels described by standards ASTM A240 / UNS S41003 and EN10088-2 1.4003.

The term "utility" refers to the great usefulness of these steels. Utility grades offer a particularly advantageous combination of toughness, weldability, strength, corrosion resistance and wet-abrasion resistance. This allows them to be used in thicker gauges. In addition, hot-rolled plate welds are very tough. This powerful combination makes utility grades suitable for a very wide range of applications.

These grades are a superior but affordable alternative to coated or galvanized carbon steels in many applications, notably those involving wet abrasive/corrosive conditions. In addition, their strength allows a reduction of weight in structural applications.



Designed with ease of fabrication in mind, utility grades have good forming, drawing, blanking and punching characteristics and are easily welded.

Freight is just one of a wide spectrum of sectors in which these grades have proved their worth. Over the years they have become widely appreciated for ultra-long service life and long-term economic gains.

THE UTILITY STAINLESS STEEL ADVANTAGE

Utility stainless steel is a tough, strong, weldable ferritic stainless steel. It is successfully used in hot rolled gauges.

- **Toughness and low DBTT (-30°C)**
- **Proof stress 320MPa**
- **Relatively easy to weld**
- **Sufficient corrosion resistance**
- **Reasonable cost**

THE MAGIC INGREDIENT

Stainless steel is renowned for its resistance to corrosion. This property is entirely due to the presence of chromium (Cr) as an alloying element. Steel has to contain at least 10.5 percent of it to become "stainless" (i.e. highly corrosion-resistant).

When alloyed with iron and carbon, chromium forms an invisible, protective surface film of chromium oxide. Impervious to air and water, this "passive" layer provides corrosion resistance and increases scaling resistance and wear resistance. If damaged, the layer repairs itself, re-forming spontaneously in the presence of oxygen.

Stainless steel boasts exceptional physical and mechanical properties. For fabricators, it offers ease of manufacture. For the end user, it guarantees important Life Cycle Cost (LCC) advantages. In many cases, its corrosion resistance makes protective surface treatments unnecessary and stainless steel needs little or no maintenance.

“...stainless steel needs little or no maintenance...”

FIVE FERRITIC FAMILIES

ISSF classifies ferritic grades in five groups – three families of “standard” grades and two of “special” grades.

Higher-alloyed ferritic grades contain more chromium and such additional elements as titanium (Ti), niobium (Nb) and molybdenum (Mo). They are equivalent to austenitic grades in performance – but at generally lower cost.

THE 5 GROUPS OF FERRITIC GRADES

Group 1	Group 2	Group 3	Group 4	Group 5
10%-14%	14%-18%	14%-18% stabilised	Added Mo	Others
Types 409, 410 Cr content: 10%-14%	Type 430 Cr content: 14%-18%	Types 430Ti, 439, 441, etc. Cr content: 14%-18%. Include stabilising elements such as Ti, Nb, etc.	Types 434, 436, 444, etc. Mo content above 0.5%	Cr content of 18%-30% or not belonging to the other groups

Non-exhaustive list. See ISSF brochure “The Ferritic Solution” pp. 60-61 for full details.

ECONOMICAL

Utility stainless steels are those found in Group 1 of the ISSF ferritic classification. Containing the basic levels of chromium needed to ensure the corrosion-resistant and wear-resistant properties of stainless steel, they are notably inexpensive.

The initial cost of utility stainless steel is greater than that of mild or galvanised steel but utility grades can be much the more economical solution in the long run, offering major economic benefits.

Low-to-zero maintenance

The corrosion resistance and wear resistance of utility stainless steels means they need little attention and are very durable. Downtime is therefore minimised and replacement costs slashed.

No protective coating or painting

Stainless steels need no surface protection against corrosion.

Under mildly corrosive conditions, utility grades may develop a uniform, rust-coloured patina. This does not affect the structural integrity of the steel and the phenomenon is of no importance in many typical applications.

Painting or coating will, usually, only be required for aesthetic or hygiene reasons or to provide an extra level of corrosion resistance.

“...utility grades can be much the more economical solution...”



UTILITY STAINLESS STEELS TYPICAL CHEMICAL ANALYSIS

Standard	Chemical component (maximum weight %)					
	C	Si	Mn	Cr	Ni	N
EN 10088-2 1.4003	0.03	1.0	1.5	10.5~12.5	0.3~1.0	0.03
ASTM A240 - UNS / S41003	0.03	1.0	1.5	10.5~12.5	1.5	0.03
JIS G 4305 SUS 410L	0.03	1.0	1.0	11.0~13.5		
JIS G 4305 SUS 410L	0.08	1.0	1.0	11.5~13.5	0.6	

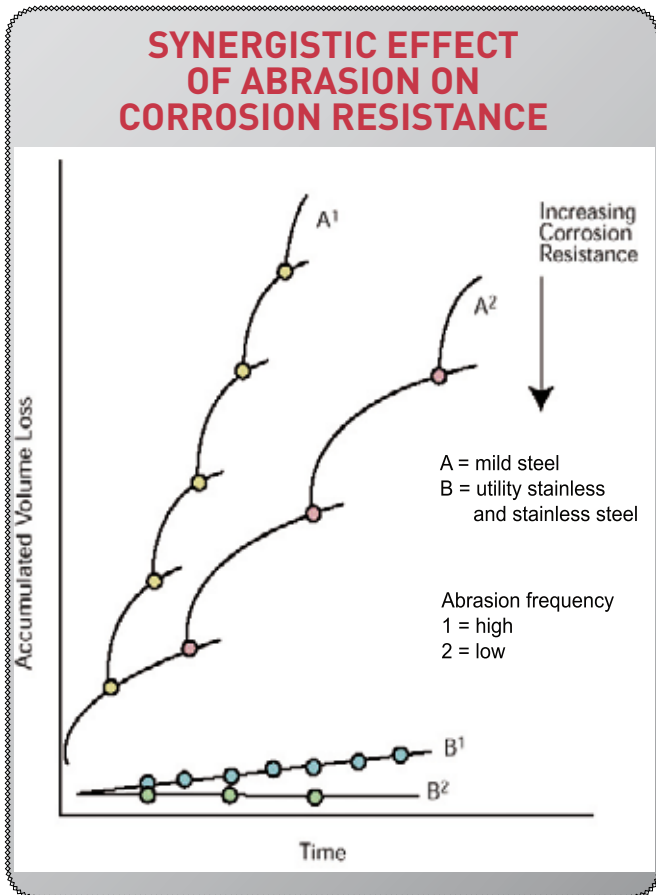
Other standards: ASTM A240, UNS S41008, UNS S40975, UNS S40977

High strength

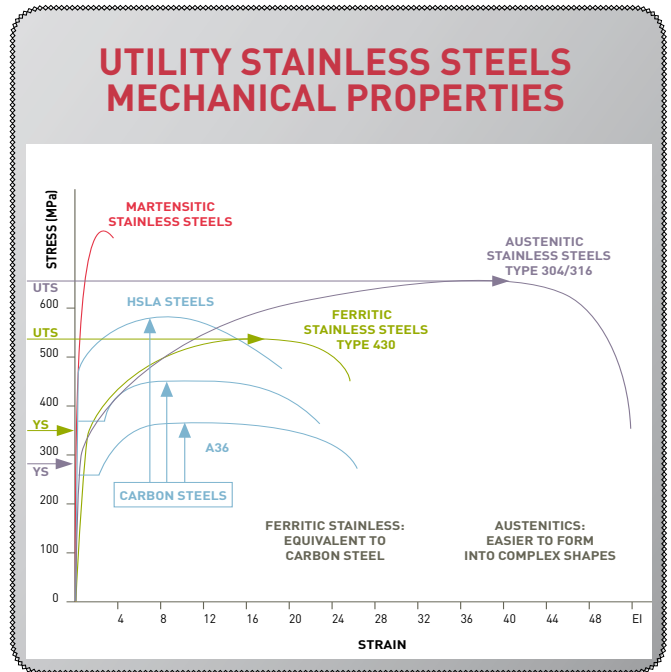
The strength of utility stainless steel makes possible reduced weight and greater load-bearing capacity in structural applications. Both are significant economic advantages.

Resistance to abrasion

The following graph compares the volume loss over time of mild steel and a utility stainless steel in response to two levels of abrasion frequency (high and low). Clearly, whatever the abrasion frequency, utility stainless steels behave exceptionally well. This high performance is directly linked to the chrome content of stainless steels and the ability of the passive layer to automatically self-repair if damaged by abrasion.



“...an improvement of up to 250 times the life of unpainted carbon steel...”



The mechanical properties of utility stainless steels are similar to those of carbon steel.

UTILITY GRADES – EASY FABRICATION

Utility stainless steels can be fabricated with the processes used for structural and other grades of stainless steel.

Cutting

Mechanical methods include guillotining, sawing, blanking and piercing. The most commonly used thermal processes are plasma and laser cutting.

Forming

Usually, utility stainless steels can be formed on the same equipment as would be used for carbon steel, with the same tooling.

Weldability

Utility stainless steels weld very well, using virtually any standard welding technique. Provided post weld pickling/cleaning and passivation is undertaken, no loss of corrosion resistance in the weld and adjacent areas will result.

CORROSION RESISTANCE

Utility stainless steel, with 12% chromium as its major alloying element, is not intended as a material for use in contact with process solutions such as acids, salts, etc.

Long term atmospheric corrosion programmes conducted over 10 years have shown utility stainless steel to have very good atmospheric corrosion resistance. These grades show an improvement of up to 250 times the life of unpainted carbon steel, in certain environments.

COATED APPLICATIONS

Utility stainless steel has exceptional under-paint corrosion resistance as well as resisting under-paint creep where the coating has been damaged.

Surface preparation is extremely important and may be performed either by acid pickling or mechanical means such as blasting.

Application as well as surface preparation should always follow the recommendations of the manufacturer of the coating system.



FANTASTIC FOR FREIGHT

Freight transportation – ranging from containers (painted or unpainted) to rail wagons for transporting virtually anything – is a notable application in which these basic grades offer huge advantages over competing materials.

This is a very “outdoor” sector, sometimes involving a corrosive, marine environment. Utility stainless steel grades love the big outdoors and enjoy a little bracing sea air. They will handle all environments without painting or surface treatment, outlasting carbon steel by years.

It is also a sector in which equipment gets knocked around and may be called upon to transport a corrosive and abrasive cargo. Utility grades thrive on a challenge and have shown amazing powers of endurance since their introduction in this sector late in the last century.

Needless to say, being down-to-earth, workmanlike steels, utility grades care little for their appearance. They do not pretend to the glossy allure of their expensive, higher-alloyed relatives. But then, aesthetic glamour is not a priority in freight handling.

Given their modest price, utility stainless steels have proved to be leagues ahead of carbon steel in LCC terms. In fact, they also make life easy for the fabricator, being notably easy to work and weld.

IN THE COAL INDUSTRY

Utility stainless steel is a highly cost-effective material in coal-preparation plants where its strength and resistance to wet abrasion/corrosion make it the preferred material in many applications.

In addition to being moisture-laden and carrying highly corrosive elements such as chlorine and sulfur, coal is highly abrasive. Carbon steels, galvanized mild steel and aluminum are often inadequate to such demanding conditions.

Utility stainless steels perform excellently here, resisting corrosive attack and thus maintaining better flow and slideability characteristics, compared to non-alloyed or low-alloyed steels (including abrasion-resistant grades). This superior slideability reduces “hang-up” in chutes.

By the same token, utility grades are plainly ideal for all types of rail wagon for transporting coal (or, indeed, other abrasive materials).

Under dry abrasion or impact conditions, utility steel performs no better than conventional mild steels. However, in wet-abrasion environments, utility stainless steels last far longer than carbon and low-alloy steels.

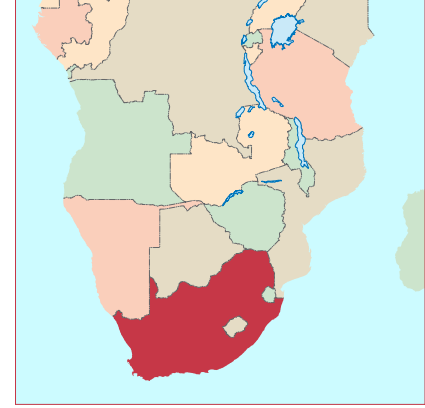


EQUIPMENT THAT LASTS

The following case study and testimonials show that utility stainless steels have proved their worth, beyond debate, over a considerable number of years in freight applications. They clearly provide every practical and economic advantage over competing materials and are especially necessary in more highly-demanding applications.

CASE STUDY

Coal wagons in South Africa



The South Africans chose the perfect material for transporting coal by rail, whatever the atmospheric conditions



In South Africa utility stainless steel was first used in the manufacture of monocoque coal wagons in 1985.

CCL-type wagons previously built in COR-TEN “weathering” steel were replaced with utility stainless steel, using 6 mm plate for the tubs and 4 mm plate for the sides. A CCL wagon is discharged by tipping and carries a load of approximately 82 metric tons.

Over 20 years later, these wagons are still in excellent condition. Their sides have a smooth, shiny surface, with excellent slideability. There are no apparent signs of fatigue, weld failure or pitting in the heat-affected zone. They can be expected to last for around 50 years. Many thousands of such wagons have now been put into service worldwide.

FREE OF CORROSION

The 1985 wagons are used on the rail line from the coalfields, in the interior of the country to the coal terminal at Richards Bay – the world’s largest coal-export facility. Even though exposed to corrosive marine conditions, the wagons are entirely free of corrosion to this day.

Inspection of COR-TEN wagons back in the 1980s, however, had found significant layers of corrosion product lifting off the steel surfaces. It would be knocked off when the wagons were loaded, only to form again. This corrosion/abrasion effect resulted in severe loss of thickness.

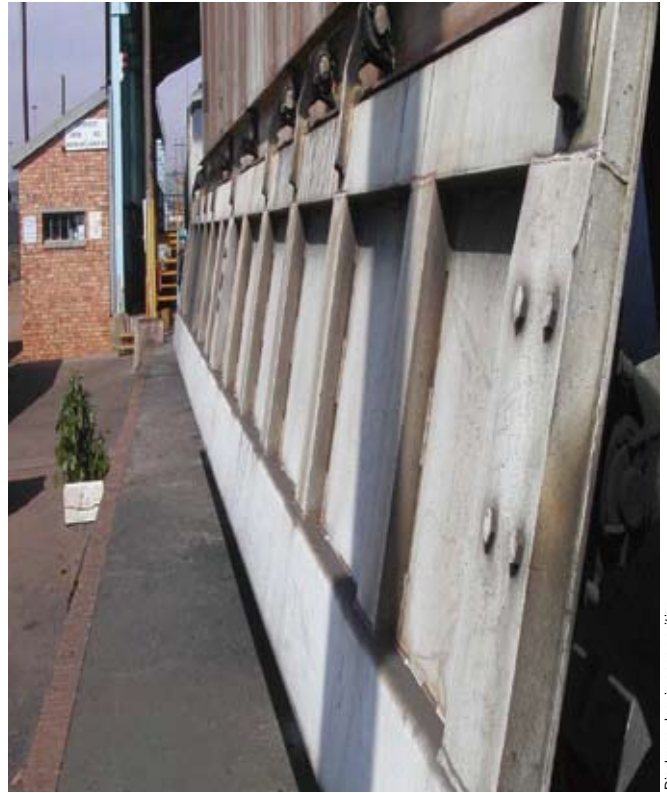
FURTHER SUCCESS

Another type of coal wagon built using utility stainless steel was a fleet of 58 wagons for the rail link between Duvha Open Cast mine and Middleburg Mine Services. These wagons, carrying loads of 57 metric tons, discharge through discharge doors.



Wagon originally painted white, hence unusual appearance.

Utility steel was used in the body sides, discharge doors, under-frame and bulkhead liners. After little more than 10 years in service, inspection showed the wagons to be in superb condition, with neither apparent wear nor signs of fatigue-related or weld-related defects.



Discharge door in open position.



Discharge door in open position – interior.

VIEWPOINT



Transnet Rail Engineering, S Africa

Viewpoint

OREDUS MATTHEUS

GENERAL MANAGER

PRODUCT DEVELOPMENT

TRANSNET RAIL ENGINEERING

SOUTH AFRICA

“We use utility steel in the manufacture of coal wagons, iron ore wagons and commuter coaches. Our current usage is some 8,000 tons/annum. In total, some 10,000 or more wagons have been built so far, using about 10 tons each, in just over 20 years.

“We built the first utility steel coal wagons in 1984 but volume manufacture only began in 1992. Now, for coal wagons and rebuilding commuter coaches, we use exclusively utility steel. For the total South African wagon market, including iron ore and general freight, it’s currently about 30 percent.

“Technical support from the steel producer allowed us to convert to utility steel with a minimum of difficulties. The major problem with these steels is variable springback during bending. Another factor we overcame was control of heat input during welding.

“COR-TEN, the material we used before, only lasted about 8 years before corrosion problems necessitated rebuilding. The improved corrosion resistance of utility steel is such that there’s been no meaningful loss of steel thickness after over 20 years in service. This eliminates the need for a ‘corrosion allowance’. Slideability improvement, particularly in bottom-discharge wagons, is also a substantial benefit to end-users.

“The overwhelming improvement in performance provided by utility steel in these applications is so clear that no rigorous LCC analysis has been necessary for our customers. An intuitive assessment tells you that utility steel offers massive LCC benefits. These steels are the ‘best of both worlds’, since they provide a solution to the corrosion and slideability problems of carbon steels and deliver great performance at much lower cost than traditional stainless steels.”



Wagony Świdnica SA, Poland

Viewpoint

BOGDANE NOWELLE

PURCHASING MANAGER

WAGONY ŚWIDNICA SA

POLAND

“My company has used utility stainless steels in hopper wagons for the UK market, designed to transport coal. At that time, stainless steel represented about 7 percent of our total consumption. We introduced this grade in 2000, because of the nature of the product to be transported and to meet the customer’s requirements.

“We found that using this material, as opposed to carbon steel, meant we had to polish the discoloured areas around welds and protect these areas with a special product. It was also necessary to use a special weld wire and special tools to avoid contact with carbon steel. And we had to develop a new system for stocking materials.

“We had no complaints from the customer about quality. Delivery was on time and we had no problems in terms of the material’s availability.”



OR Coal Wagons, Australia

Viewpoint

PAUL MICHELL
 PRODUCT MANAGER
 FLAT PRODUCTS
 SANDVIK AUSTRALIA
 AUSTRALIA

“Sandvik Australia currently supplies about 24,000 metric tons of stainless steel a year to numerous market segments, including transportation, environmental technology, the petrochemicals industry, oil & gas and general fabrication. Utility stainless steel represents about 40 percent, by volume.

“We started using it around 1994, to meet a specific need in the transportation market. It meant we could provide end-users with a superior product in terms of mechanical properties and weldability.

Our customers had no production problems and were very happy with this ferritic grade. In the beginning, much analysis was carried out when making the change from carbon steel for rail cars. Utility stainless steel turned out to provide significant ‘total cost’ savings over carbon steel and was more suitable than aluminium.

“Sandvik Australia has been successful in supplying these types of stainless steel over many years, as customers recognise the value in working with them.



CNR QIQIHAR Railway Rolling Stock (Group) Co. Ltd, PRC

Viewpoint

LIANYOU YU
 VICE-PRESIDENT
 CHIEF ENGINEER
 CNR QIQIHAR RAILWAY
 ROLLING STOCK (GROUP) CO. LTD
 PEOPLE’S REPUBLIC OF CHINA

“My company uses utility stainless steel strip and plate in railway wagons for transporting coal from mines. We first became interested in using stainless steel for coal wagons in 2003 and started using strip in 2005. Our use of utility stainless steel in wagons represents only a small part in relation to carbon steel but it is increasing rapidly. For example, our consumption went from about 20,000 tons in 2006 to about 30,000 tons in 2007. We started using utility stainless steel plate in 2008.

“Our main reason for using the material is the current requirement for higher capacity in rail freight transport. Stainless steel’s mechanical strength has allowed us to increase the capacity of our coal wagons from 60 tons to 80 tons. On the evidence of wagons produced so far, utility stainless steel’s high strength, weldability and excellent corrosion-resistance are obvious advantages. More time is required for the maintenance-cost gains to become clearer.

“We have no problems working with utility stainless, though we had to invest in new manufacturing equipment and learn how to use this material. For the customer, the investment cost of stainless steel wagons is greater than carbon steel but more can be transported than with a carbon steel wagon. So our customers are happy with stainless steel wagons and are gathering operational data for LCC analysis.”

THE TEST OF TIME

For materials-handling and freight applications, utility stainless steel has proved the best solution.



With carbon steel, once a surface oxide has formed, corrosion will continue – albeit at a decreasing rate if the product concerned is undisturbed. However, in materials handling applications, mechanical action will regularly remove the corrosion product, exposing the steel to a continually high corrosion rate.

To sum up the problem, carbon steel is simply worn away by the constant cycle of corrosion and abrasion. The answer of course, is to use utility stainless steel.

THE LONG-TERM SOLUTION

As we have seen, utility stainless steels have found extensive use in many materials-handling sectors, including coal extraction and transportation.

Examples could be cited of coal plant equipment that has required no significant maintenance since its installation

seven or eight years ago, compared with its carbon steel predecessor, which had to be replaced every three to four years. For the plants concerned, utility stainless steel has made an enormous difference.

Utility stainless steel is already extensively used in coal-wagon construction in South Africa, Australia, the U.S. and Europe and has been used with equal success for road coal transporters.

COAL AND COKE TRAILERS

Some years ago, coal and coke transportation trailers lined with utility stainless steel were built for a UK company. These trailers represent a great improvement over their predecessors are still in excellent condition – the slideability of the internal trailer remaining highly polished.



UK COAL WAGON

After some years of use, a check on the utility stainless steel of which this UK coal wagon is made revealed “excellent” performance. The wagon was constructed for EWS, the UK’s main railfreight operator.



IRON ORE IN OZ

This iron ore wagon, operating in Australia, was constructed using hot rolled (not descaled) utility stainless steel, or economy. Pickled stainless steel is not necessary here, because the application causes the wagon to discolour quickly. Years later, the steel shows no further degradation.



From a welder’s perspective

HERMAN NIEMAN

INDUSTRIAL PROCESS MANAGER
TRANSNET RAIL ENGINEERING
SOUTH AFRICA

“Using utility stainless steels in freight wagons certainly solves corrosion and abrasion problems. This material also behaves well in fabrication and assembly. There may, however, be slight issues with shrinkage due to welding.

“Perhaps this doesn’t matter in your assembly process, but it can affect the fitting together of sections. We found a solution recently, during manufacture of passenger rail coaches designed to be assembled from accurately-fabricated modular elements.

“If need be, we recommend introducing a recording process to monitor pre-weld and post-weld panel sizes. Should this system pick up any out-of-tolerance sizes after welding, the jigs can be adjusted to compensate. It is also advisable to reduce the risk of distortion by designing panels to minimise the heat input required during the welding process.

“This is not a big issue, however, and welding is otherwise straightforward. We weld manually with the MIG process, using 309L or 309LS solid wire, in dip-transfer or spray mode.”

Life Cycle Maintenance of COR-TEN v Utility Stainless Steel

Carbon steel (COR-TEN)								
Years in service	0	6	12	18	24	30	36	42
Sides					Replace			
Ends	Paint	Paint	Paint	Replace	Paint	Paint	Paint	Scrap
Bellies	Paint	Paint	Replace	Paint	Paint	Replace	Paint	Scrap
Days out of service		20	20	20	20	20	20	20
Utility stainless steel								
Years in service	0	6	12	18	24	30	36	42
		Inspection	Inspection	Inspection	Inspection	Inspection	Inspection	Inspection
Days out of service		3	3	3	3	3	3	3

UTILITY GRADES FOREVER



The Life Cycle Cost benefits of these fine steels have been proved in many other freight contexts.

Today, utility stainless steels are to be found everywhere in our world, in literally dozens of application sectors.

The economic and environmental requirements we must now take into account have opened the door to materials that offer improved performance, low maintenance and improved LCC.

The suitability of utility stainless steels has been conclusively demonstrated in rail-freight applications. More recently, in the field of transportation, the use of these grades has developed in containers and bus & coach applications, in the form of welded tubular frames. Many new applications also already exist.

IN CONTAINERS

Ferritic stainless steels are ideal for freight containers, offering longer life and better LCC benefits than carbon steel. They are most often used for “reefer” (refrigerated) containers, for the transfer of temperature-sensitive products such as foodstuffs, film or electronic parts, but are equally suitable for ordinary containers. The ideal grades, for exterior paneling, tunnel plate and reinforcement elements (such as corner posts and cross-members) alike, are Types 409L and 410L.

The advantages of ferritic stainless steels in this application include not only their excellent weldability, bendability, strength and flatness but also their corrosion resistance – and the significant economic gains this brings. Ferritics are a more expensive material than carbon steel in terms of initial investment but it has been estimated that these grades can bring savings in maintenance costs of 10-15% over 10 years.



In addition, the mechanical properties of ferritics are such that the material can be used in thinner gauges, which affects container manufacture from design stage. In some cases, corrosion-resistance can be supplemented by a coating process, such as painting on one side (after sand-blasting) and urethane on the other, but uncoated containers are also common.

The use of ferritic stainless steels in containers also brings the critical advantages of high energy-absorption capacity, remarkable toughness and the tendency of these grades to retain their mechanical properties over time. Ferritics can thus contribute to the long-term safety of a container.



Frames, Type 410

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SOME UTILITY STEEL APPLICATIONS

- Agriculture
- Chemical and petrochemical
- Coal extraction, preparation & handling
- Concrete product and brick industry
- Electronics cabinets and enclosures
- General engineering and fabrication
- Hot-gas ducting and dust extraction
- Materials handling
- Nuclear industry
- Overhead railway electrification
- Pulp and paper
- Rail & road transport and freight
- Sewage, waste and water treatment
- Sugar refining
- Ventilation ducting

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