

**Heat Resisting  
AUSTENITIC**  
stainless steel

*Adding stainless  
quality to life*



**COLUMBUS  
STAINLESS**  
— [Pty] Ltd —

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nox**

## Introduction

The **heat resisting austenitics** are highly alloyed stainless steel used for their excellent oxidation resistance, high temperature strength and creep resistance in high temperature applications. They are tough and ductile and can be readily fabricated and machined.

### **309S/1.4833**

has very good oxidation resistance and this is improved even further with

### **309S Si/1.4828**

which has a higher silicon content.

The 309S types have a lower nickel content compared to the 310S types and this improves their resistance to hydrogen sulphide (H<sub>2</sub>S) attack at high temperatures.

The 309S types are low carbon grades and are recommended for applications where sensitisation and subsequent corrosion by high temperature gasses or condensates during shutdown may pose a problem.

The 309S types are used, for example, in applications such as furnace parts, fire box sheets, high temperature containers, catalytic converters, exhaust systems, etc.

### The **310S types**

have higher chromium and nickel contents to enable them to resist oxidation in continuous service at temperatures up to 1200°C provided reducing sulphur gases are not present.

The higher silicon content in

### **310S Si/1.4841**

improves this oxidation resistance even further.

In intermittent high temperature service, the 310S types can be used at temperatures up to 1030°C as they resist scaling and have a relatively low coefficient of expansion differential between the metal and the scale. These stainless steels have superior resistance to both the 304 types and the 309S types in carburising and reducing environments.

The 310S types are used in applications such as furnace parts, muffles, radiant tubes, ammonia converters, etc.

## Product range

The latest revision of the Product Catalogue should be consulted, as the product range is subject to change without notice.

The Product Catalogue is available from the Technical Department or can be found at [www.columbus.co.za](http://www.columbus.co.za)

## Specifications and tolerances

Columbus Stainless (Pty) Ltd supplies the heat resisting austenitics to ASTM A167, ASTM A240, ASME SA240, EN 10095.

Columbus Stainless (Pty) Ltd normally supplies material to the following tolerances:

### HOT ROLLED

|                                         |             |            |          |
|-----------------------------------------|-------------|------------|----------|
| ISO 9444 - material processed as coil   |             | ISO 9444-2 |          |
| ISO 18286 - material processed as plate |             | ISO 18286  |          |
| ASTM A480                               | ASTM A480M  | EN 10051   | EN 10029 |
| ASME SA480                              | ASME SA480M | IS 6911    |          |
| JIS G 4304                              |             | JIS G 4312 |          |

### COLD ROLLED

|            |             |
|------------|-------------|
| ISO 9445   | ISO 9445-2  |
| ASTM A480  | ASTM A480M  |
| ASME SA480 | ASME SA480M |
| IS 6911    |             |
| JIS G 4305 | JIS G 4312  |

Other specifications and tolerances may be available on request.

Further information is available in the Product Catalogue, which can be obtained from the Technical Department or can be found at [www.columbus.co.za](http://www.columbus.co.za)

### Further information:

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## Chemical composition

In accordance with ASTM A240, ASTM A167, EN 10088-2 and EN 10095, as applicable.

|         | C    | Si           | Mn  | P     | S     | N    | Cr   | Ni   |
|---------|------|--------------|-----|-------|-------|------|------|------|
| 309S    | 0.08 | 0.75         | 2.0 | 0.045 | 0.015 | 0.11 | 22.0 | 12.0 |
| 1.4833  |      |              |     |       |       |      | 24.0 | 14.0 |
| 309S Si | 0.20 | 1.50<br>2.50 | 2.0 | 0.045 | 0.015 | 0.11 | 19.0 | 11.0 |
| 1.4828  |      |              |     |       |       |      | 21.0 | 13.0 |
| 310S    | 0.08 | 0.75         | 2.0 | 0.045 | 0.015 | 0.11 | 24.0 | 19.0 |
| 1.4845  |      |              |     |       |       |      | 26.0 | 22.0 |
| 310S Si | 0.20 | 1.50<br>2.50 | 2.0 | 0.045 | 0.015 | 0.11 | 24.0 | 19.0 |
| 1.4841  |      |              |     |       |       |      | 26.0 | 22.0 |

Compositions are ranges or maximum values.

## Mechanical properties

In accordance with ASTM A240, ASTM A167, EN 10088-2 and EN 10095, as applicable.

|                                 | <b>R<sub>m</sub> (MPa)</b> | <b>Rp<sub>0.2</sub> (MPa)</b> | <b>Rp<sub>1.0</sub> (MPa)</b> | <b>A (%)</b> | <b>Max Hardness (HRB)</b> |
|---------------------------------|----------------------------|-------------------------------|-------------------------------|--------------|---------------------------|
| <b>309S</b><br><b>1.4833</b>    | 515<br>700                 | 210                           | 250                           | 40           | 95                        |
| <b>309S Si</b><br><b>1.4828</b> | 550<br>750                 | 230                           | 270                           | 30           | 95                        |
| <b>310S</b><br><b>1.4845</b>    | 515<br>700                 | 210                           | 250                           | 40           | 95                        |
| <b>310S Si</b><br><b>1.4841</b> | 550<br>750                 | 230                           | 270                           | 30           | 95                        |

*Minimum values, unless Max or range is indicated.  
The table assumes certifications to ASTM A167, ASTM A240,  
EN 1088-2 and EN 10095 where applicable.*

## PROPERTIES AT ELEVATED TEMPERATURES

The properties quoted below are typical of annealed 309S and 310S steels. These values are given as a guideline only, and should not be used for design purposes.

### Short time elevated temperature tensile strength (MPa)

|      | 100°C | 200°C | 300°C | 400°C | 500°C | 600°C | 700°C | 800°C | 900°C | 1000°C | 1100°C |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|
| 309S | 580   | 570   | 560   | 520   | 465   | 390   | 300   | 210   | 130   | 65     | 25     |
| 310S | 600   | 590   | 570   | 530   | 475   | 405   | 315   | 225   | 140   | 80     | 45     |

### Short time elevated temperature 0.2 proof stress (MPa)

|      | 100°C | 200°C | 300°C | 400°C | 500°C | 600°C | 700°C | 800°C |
|------|-------|-------|-------|-------|-------|-------|-------|-------|
| 309S | 265   | 240   | 225   | 210   | 190   | 170   | 150   | 130   |
| 310S | 265   | 250   | 225   | 200   | 175   | 155   | 130   | 110   |

### Short time elevated temperature elongation (%)

|      | 100°C | 200°C | 300°C | 400°C | 500°C | 600°C | 700°C | 800°C | 900°C | 1000°C | 1100°C |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|
| 309S | 47    | 46    | 44    | 42    | 39    | 37    | 36    | 37    | 43    | 53     | 72     |
| 310S | 41    | 40    | 38    | 35    | 32    | 31    | 33    | 38    | 45    | 53     | 57     |

### Maximum recommended service temperature

|      | Continuous °C | Intermittent °C |
|------|---------------|-----------------|
| 309S | 1100          | 980             |
| 310S | 1200          | 1030            |

*In oxidizing conditions*

### Creep and creep rupture properties

| Temperature (°C) | Stress (MPa) to produce 1% strain |      |              |      | Stress (MPa) to produce rupture |      |             |      |
|------------------|-----------------------------------|------|--------------|------|---------------------------------|------|-------------|------|
|                  | 10000 hours                       |      | 100000 hours |      | 1000 hours                      |      | 10000 hours |      |
|                  | 309S                              | 310S | 309S         | 310S | 309S                            | 310S | 309S        | 310S |
| 450              | 210                               | 180  | 145          | 115  |                                 |      |             |      |
| 500              | 140                               | 145  | 95           | 95   | 375                             |      | 340         |      |
| 550              | 100                               | 115  | 65           | 75   | 270                             | 240  | 230         | 205  |
| 600              | 70                                | 85   | 45           | 60   | 190                             | 150  | 160         | 130  |
| 650              | 45                                | 55   | 30           | 40   | 130                             | 90   | 100         | 75   |
| 700              | 30                                | 35   | 15           | 25   | 80                              | 60   | 55          | 50   |
| 750              | 15                                | 20   | 10           | 15   | 50                              | 45   | 35          | 35   |
| 800              | 10                                | 10   | 5            | 10   | 35                              | 35   | 20          | 25   |
| 850              | 5                                 | 5    |              | 5    | 20                              | 25   | 15          | 20   |

## Physical properties

The values given below are for 20°C, unless otherwise stated.

|                                                      |                                                  | 309S types | 310S types |
|------------------------------------------------------|--------------------------------------------------|------------|------------|
| <b>Density (kg/m<sup>3</sup>)</b>                    |                                                  | 7900       | 7900       |
| <b>Modulus of Elasticity in Tension (GPa)</b>        |                                                  | 200        | 200        |
| <b>Modulus of Elasticity in Torsion (GPa)</b>        |                                                  | 70         | 70         |
| <b>Specific Heat Capacity (J/kg K)</b>               |                                                  | 500        | 500        |
| <b>Thermal Conductivity at</b>                       | 100°C (W/m K)                                    | 15.6       | 14.2       |
|                                                      | 500°C (W/m K)                                    | 18.7       | 18.5       |
| <b>Electrical Resistivity (x10<sup>-9</sup> Ω m)</b> |                                                  | 780        | 780        |
| <b>Mean Coefficient of Thermal Expansion from</b>    | 0 to 100°C (x10 <sup>-6</sup> K <sup>-1</sup> )  | 15.9       | 15.0       |
|                                                      | 0 to 300°C (x10 <sup>-6</sup> K <sup>-1</sup> )  | 16.6       | 16.2       |
|                                                      | 0 to 500°C (x10 <sup>-6</sup> K <sup>-1</sup> )  | 17.2       | 17.0       |
|                                                      | 0 to 700°C (x10 <sup>-6</sup> K <sup>-1</sup> )  | 18.3       | 17.8       |
|                                                      | 0 to 1000°C (x10 <sup>-6</sup> K <sup>-1</sup> ) | 19.5       | 18.9       |
| <b>Melting Range (°C)</b>                            |                                                  | 1400       | 1400       |
|                                                      |                                                  | 1450       | 1450       |

*These grades remain non-magnetic even after cold working.*

# Thermal processing and fabrication

## ANNEALING

Annealing of the heat resisting austenitics is achieved by heating to between 1030°C and 1150°C for 60 minutes per 25 mm thickness (2.5 min/mm) followed by water quenching. Annealing will ensure that any carbide precipitates are taken back into solution.

## HOT WORKING

The heat resisting austenitics can be forged, hot headed and upset satisfactorily. Uniform heating of the steel in the range of 1150°C to 1250°C is required. The finishing temperature should not be below 950°C.

Forgings should be cooled rapidly in air or water.

## COLD WORKING

The heat resisting austenitics can be deep drawn, stamped, headed and upset without difficulty.

Since austenitic stainless steels work harden, severe cold forming operations should be followed by annealing.

## MACHINING

Like all the austenitic stainless steels, this alloy group machines with a rough and stringy swarf. Rigidly supported tools with as heavy a cut as possible should be used to prevent glazing.

## WELDING

The heat resisting austenitics can be satisfactorily welded and brazed by all methods, giving a tough weld. Welding procedures for the 310S types have to be selected with care in order to avoid hot cracking due to the fully austenitic weld microstructure obtained from using matching filler metals.



## Corrosion resistance

The heat resisting austenitics are not usually used in aqueous conditions, but are usually used in high temperature gaseous environments.

The following aspects of this dry corrosion are pertinent.

### OXIDATION RESISTANCE

In many processes, isothermal (constant temperature) conditions are not maintained and process temperatures vary. Expansion differences between the base metal and the scale during heating and cooling can cause cracking and spalling of the protective scale. This allows the oxidising media to attack the exposed metal surface. The high chromium and nickel content of the heat resisting austenitics provides good resistance to high temperature oxidation. The spalling resistance is greatly improved with the higher nickel contents of the 310S types because nickel reduces the expansion differential between the scale and the base metal.

### EFFECT OF ATMOSPHERE

The presence of water vapour increases the corrosion rate. However, the increased nickel and chromium contents of the heat resisting austenitics provide good resistance to moist air at temperatures in excess of 980°C. They also have good scaling resistance to carbon dioxide and can be used at temperatures similar to those quoted for service in air.

### SULPHUR VAPOUR

Sulphur vapour readily attacks the austenitic grades. Typical corrosion rates for various stainless steels after 1300 hours exposure to flowing sulphur vapour at 570°C are shown alongside.

|                   | Corrosion Rate (mm/yr) |
|-------------------|------------------------|
| <b>310S types</b> | 0.48                   |
| <b>309S types</b> | 0.57                   |
| <b>304 types</b>  | 0.69                   |
| <b>316L types</b> | 0.79                   |
| <b>321</b>        | 1.39                   |

### HYDROGEN SULPHIDE

The rate of corrosion in hydrogen sulphide depends on concentration, temperature, pressure and permeability of the scale. The presence of chromium in the steel helps to stabilise the scale and slow the diffusion process. At high pressure and temperature when hydrogen is present, the attack is more severe and alloys such as the 309S types are more suited to these conditions.

### FLUE GASES

It is extremely difficult to generalise corrosion rates in flue and process gases since gas composition and temperature may vary considerably within the same process unit.

Combustion gases normally contain sulphur compounds, as sulphur dioxide is present as an oxidising gas, along with carbon dioxide, nitrogen, carbon monoxide and excess oxygen. Protective oxides are generally formed and depending on exact conditions, the corrosion rate may be similar or slightly greater than for service in air.

Reducing flue gases contain varying amounts of hydrogen sulphide, hydrogen, carbon monoxide, carbon dioxide and nitrogen. The corrosion rates encountered in these environments are sensitive to hydrogen sulphide content and temperature, and satisfactory material selection often necessitates service testing. The high nickel content of the 310S types may be deleterious in some instances due to sulphidation, in which case, the 309S types may be the preferred material.

### CARBURISATION

High chromium and nickel contents result in a slower diffusion rate of carbon into the steel. The heat resisting austenitics therefore have good resistance to carburising atmospheres.

### AMMONIA

The high nickel content of the 310S types ensures a good resistance to ammonia atmospheres at high temperatures. Typical corrosion rates for 310S types in an ammonia converter containing 5-6% NH<sub>3</sub> after 30000 hours at 500°C, are in the region of 0.00 3 mm/yr.

# Some recommendations

## Handling and transport

Before shipping, make sure every chain and steel element is not in contact with stainless steel. Raffia or wooden elements must be used at possible contact places.



When outside storage is required, material should be covered by a waterproof canvas.



Avoid contact with the ground using wooden blocks and store stainless steel and carbon steel separately. This way we avoid problems with contamination by oils, dirt or by contact among different materials.



When stainless steel has to be moved with lift trucks, the forks should be protected with nylon.



Avoid carbon steel slings, use nylon or polypropylene ones wherever possible.

## Fabrication and installation

Make sure stainless steel is contamination free before starting to work. If there is any, it will be removed by pickling or mechanical means (\*).



If cleaning is required, do it with pressurized water. Do not use sea or brackish water.



All tools employed in the installation must be made of stainless steel and these should have been never used with carbon steel. If this is not possible, tools must be carefully cleaned before use.



Stainless steel should be processed in machines exclusively dedicated to this material, in order to avoid contamination by projections or oxide traces from other materials.



Excessive temperature oxidation or *blueing* due to abrasive cutting, should be removed with pickling paste. Good refrigerated cutting tools help to avoid the problem.



If coating may be considered for aesthetic reasons, surface preparation is extremely important and may be performed either by acid pickling or mechanical means such as blasting.

(\*) It is always advisable to contact the supplier

## Some applications



### 309S types

Furnace parts

Fire box sheets



High temperature containers

Catalytic containers



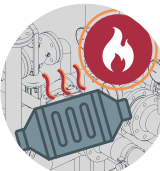
Exhaust systems

### 310S types

Furnace parts

Mufflers

Radiant tubes



Ammonia converters

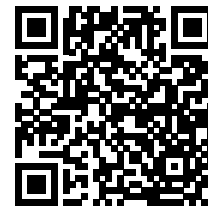


# Certificates

Columbus Stainless' product meets the following international standards:

|                                |                                             |
|--------------------------------|---------------------------------------------|
| PED 2014/68/EU Certificate     | BIS Certification Mark License              |
| CPR 305/2011/EU Certificate    | PESR Certificate                            |
| CPR Declaration of Performance | JIS G4304 & G4305 Certificate of Compliance |
|                                | JIS G4312 Certificate of Compliance         |

Available at [www.columbus.co.za/quality/product-certifications](http://www.columbus.co.za/quality/product-certifications) or scan the code:

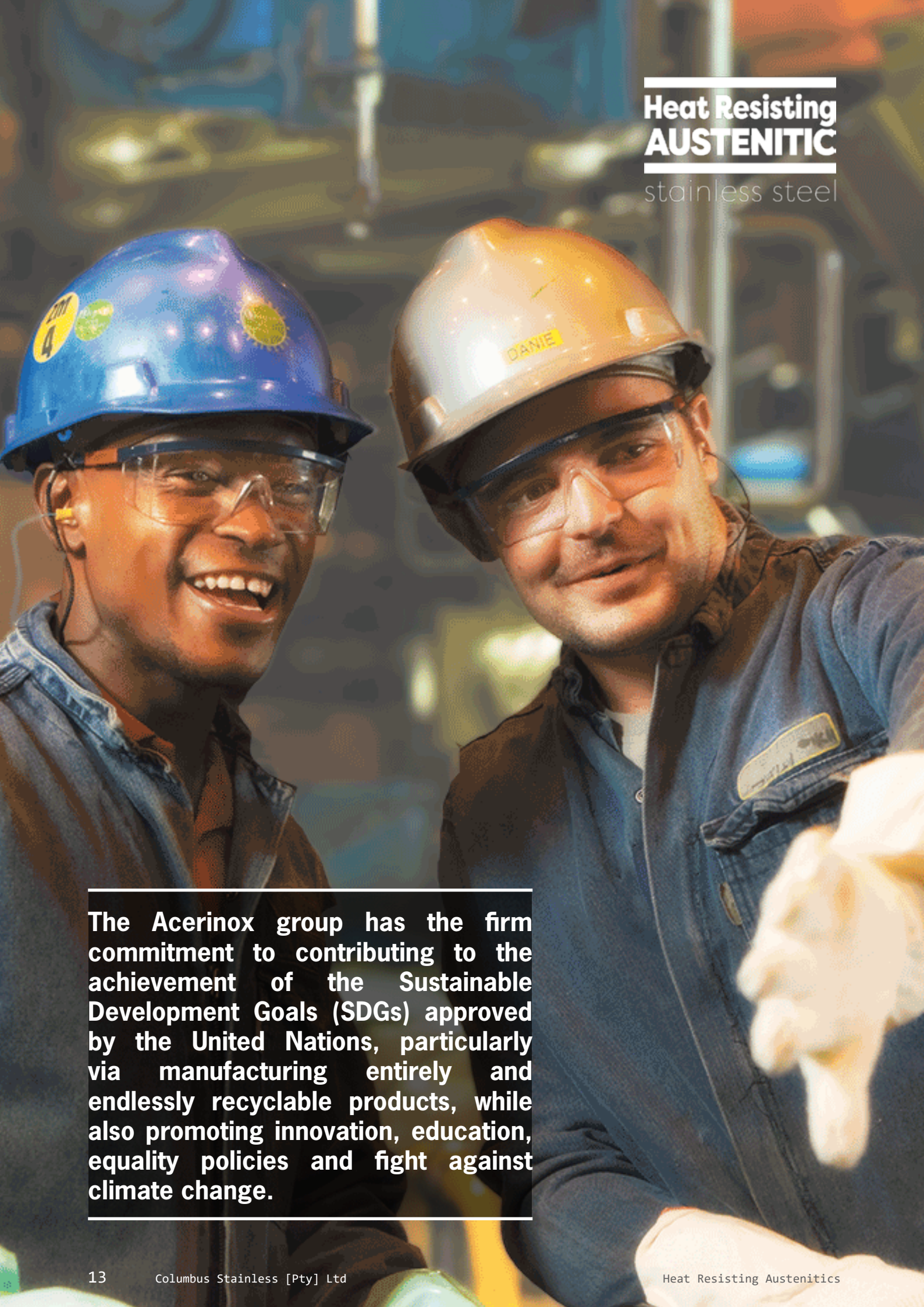


## Committed to sustainable growth

Acerinox is one of the major scrap recyclers wherever it is located. The production in the factories of Acerinox is transformed into final products which return to the factories as scrap to be melted again. This is a cycle that could be infinite due to the material properties.

Columbus Stainless also ensures optimum utilisation of raw materials and energy sources by focusing on the reduction of waste in both power, water and raw materials. Not only do these reduce the impact on the environment but also reduce the costs of producing quality products.





## Heat Resisting **AUSTENITIC** stainless steel

The Acerinox group has the firm commitment to contributing to the achievement of the Sustainable Development Goals (SDGs) approved by the United Nations, particularly via manufacturing entirely and endlessly recyclable products, while also promoting innovation, education, equality policies and fight against climate change.

## Acerinox: the confidence of a strong group



Acerinox is the Spanish multinational global leader in stainless steel manufacturing. With a total production capability of 3.5 million tonnes per year. Acerinox owns factories worldwide confirming its global presence, stainless steel flat products manufacturing at Acerinox Europa, North American Stainless and Columbus Stainless; and Roldan, Inoxfil and North American Stainless for long products manufacture. In March 2020, VDM Metals, worldwide leader in high performance alloys manufacture and design, has also become part of the group. In November 2024, Acerinox completes the acquisition of Haynes International, U.S. leading manufacturer and marketer of technologically advanced high-performance alloys.

Every Acerinox facility satisfies the quality and environmental controls required by each country legislation, apart from the application of the Environmental Management System according to ISO 14001. Furthermore, subsidiaries assume higher standards than legal requirements in areas such as quality, safety and sustainability.

Scrap plays a key role in all Acerinox fabrication processes. Thus, a great value is added bringing it back to the material life cycle, reducing the environmental impact with the use of the same material for centuries.

Columbus Stainless was founded in 1966 in South Africa. It is the only integrated stainless steel factory on the African continent and today is the main supplier of stainless steel solutions for both the domestic and the continent market.

The factory is equipped with the most efficient and technologically advanced machinery in the sector, has seen the most significant technological advances in the sector, and has a considerable competitive advantage due to its location, not only for distributing its finished products, but also thanks to its proximity to the raw material extraction sources, especially chrome. It also supplies semi-finished flat products to other Acerinox Group factories.

A worker wearing a blue hard hat and a dark jacket stands in a large industrial facility, looking towards the right. In the foreground and middle ground, there are several large, cylindrical rolls of stainless steel, wrapped in blue protective material. The rolls are arranged in rows. In the background, there are industrial structures, including a yellow overhead crane and a multi-level metal framework. The lighting is warm and industrial, with a bright light source creating a lens flare effect in the upper center.

## Heat Resisting **AUSTENITIC** stainless steel

Columbus Stainless is the premier Stainless Steel Manufacturer and Provider in Africa. Our plant is technologically advanced, fully integrated and a single-site operation. This gives us flexibility to adjust quickly to changes in the market. We supply high-quality flat-rolled stainless and carbon steel products.



VDM Metals

**HAYNES**  
International



**COLUMBUS  
STAINLESS**  
— [Pty] Ltd —

[www.columbus.co.za](http://www.columbus.co.za)