euro inox
The European Stainless Steel Development Association

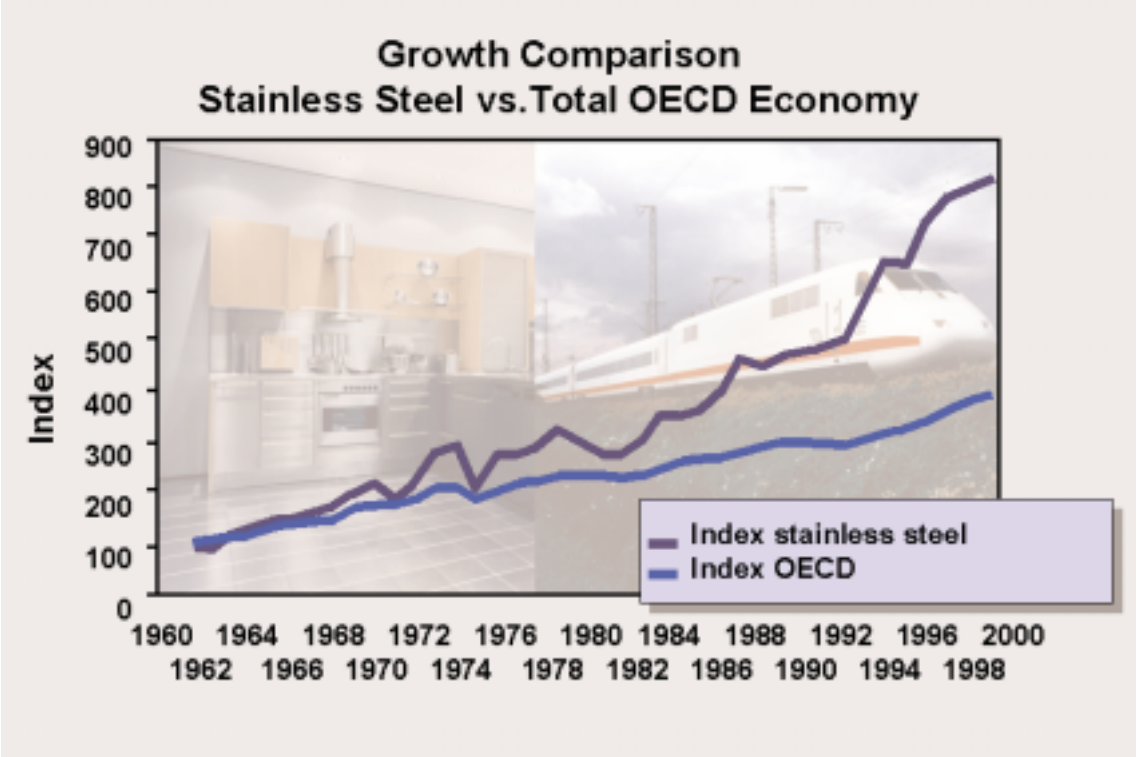
Stainless Steel – A Material for Architectural Visions

Dr. Alfred Otto, Krupp Thyssen Nirosta GmbH, Krefeld, Germany

Presentation on the occasion of the Symposium
Stainless Steel in Architecture on 15th June 2000 in Berlin
organised by Euro Inox Brussels (Belgium) and
Informationsstelle Edelstahl Rostfrei, Düsseldorf (Germany)

Naturally, we can't promise eternity – but our stainless steels are about as near as you can get to the absolute. Their resistance to corrosion is the material characteristic that makes these products such ideal building materials.

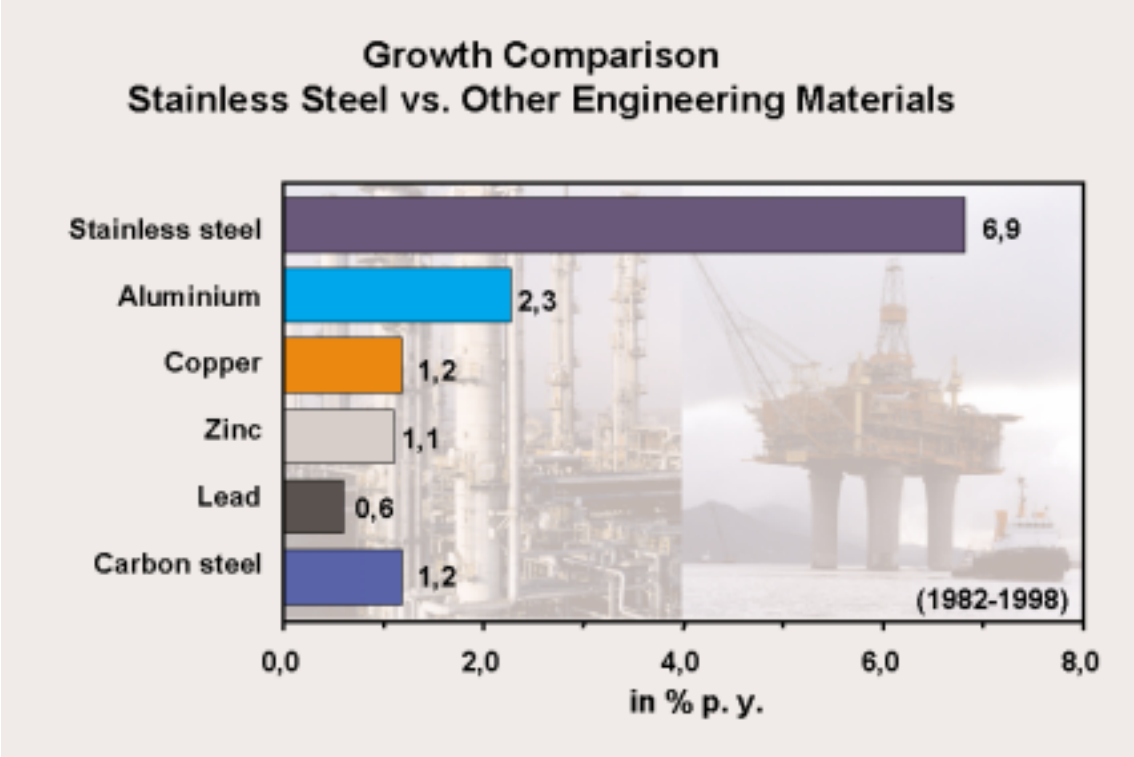
The aesthetic appeal of the surface and the ductility of the material are what make it so fascinating. The wide range of stainless steels that we offer opens up a huge creative potential for architects. They are available in all sorts of product forms and a wide variety of surface structures. With our stainless steels, there are no limits to creativity – they can be used alone, or in a dialogue with glass, stone or wood. And they last practically for ever.

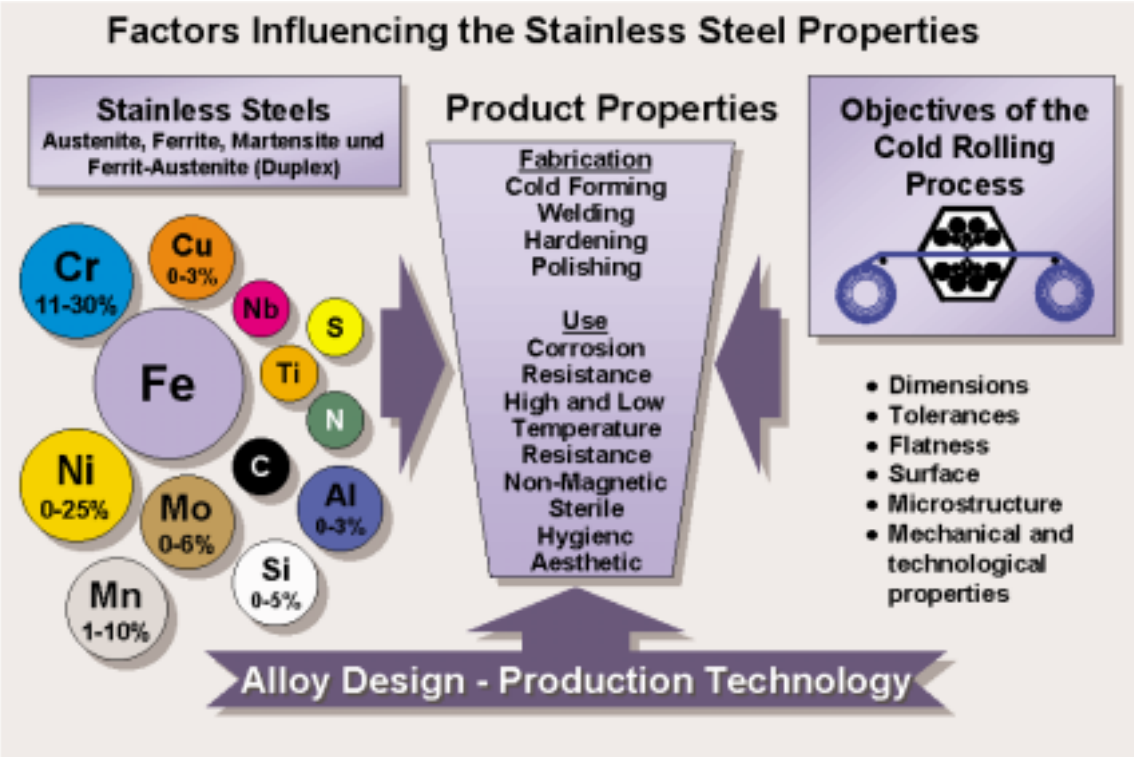


The steady increase in the use of stainless steel over the years shows the same kind of durability and confirms how attractive this material is. On the one hand, it meets the increasing demands made by highly technological industrial applications in terms of safety, quality, environmental compatibility and costs. On the other hand, stainless steel is a stylish material that reflects the spirit of our time and expresses the self-confidence of the modern industrial society which designers and architects embody with their stainless steel based designs.

Whilst the entire industrial production output of the OECD states has more or less tripled in the last 40 years, the comparative figure for stainless steel has increased by a factor of eight over the same period, and is continuing to show steady growth rates of 5-7% p.a.

In a growth comparison with other metal materials, stainless steel is also able to provide convincing evidence of its attractiveness. With an average annual increase in use of almost 7%, it is well above aluminium and aluminium alloys, for example, which are similarly innovative high-tech materials.

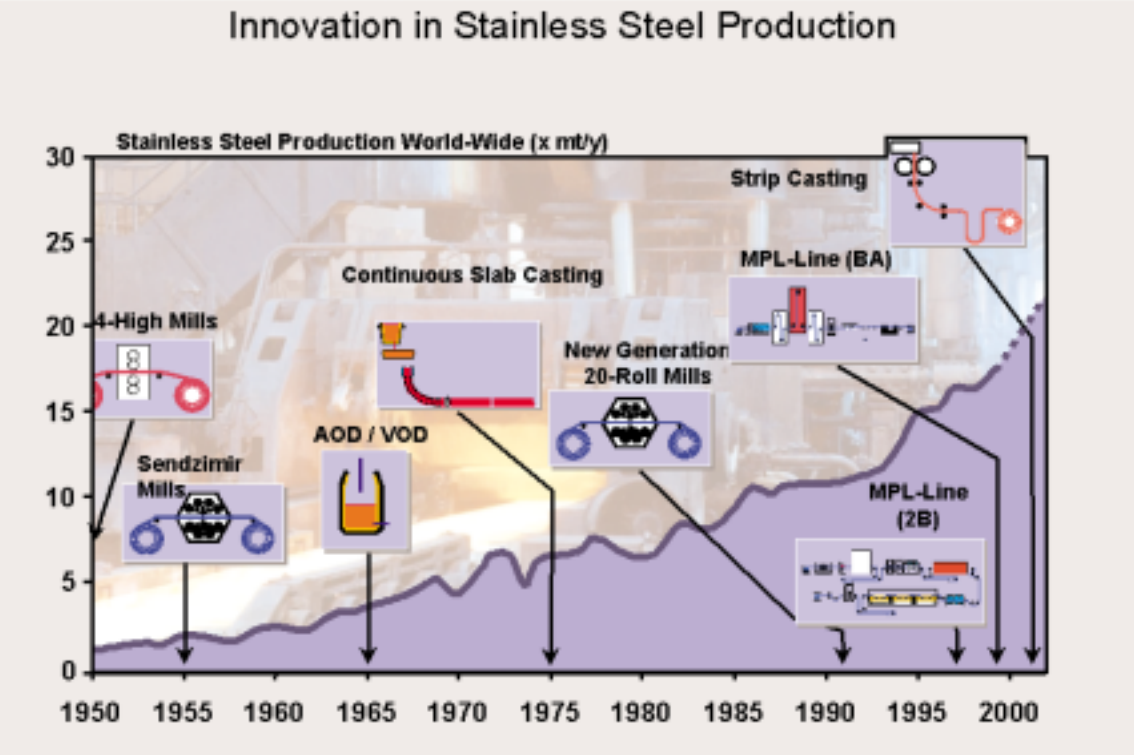




What are the keys to this success? Contrary to what the name "stainless steel" suggests, this is a group of materials comprising over 100 different types of steel. Stainless steel is an iron-based alloy with iron levels of between 50 and 90%. The main alloy element is chromium, which, if added in quantities of more than 11%, transfers its ability to coat itself with an atom-thick, dense layer coating to the iron alloy. This permanent passive oxide layer protects the metal from corrosion and spontaneously reforms in normal ambient air, even if the surface is damaged: so stainless steel contains an "integrated self-repairing mechanism".

Other elements such as Ni, Mo, Cu, N improve corrosion resistance so that use in the most aggressive acids is possible. The addition of Ni, Si and Al, for example, guarantee heat resistance so that this material can be used in aircraft engines. On the other hand, special-composition Fe-Ni-Cr steels can also be used for the transport of liquid gases, offering sufficient safety – as no other material can – against component failure through brittle fracture at temperatures of -250°C and below.

Depending on the processing and usage requirements, the material expert will choose the most suitable alloy, and the production engineers at the manufacturing plants will make use of the whole gamut of ultra-modern high-performance production lines available today to produce a tailor-made industrial product based on the process parameters that were laid down to meet the requirements of the final characteristics: reliability and reproducibility within the narrowest margins of the required material values – an individual performance profile for every application.



However much the different types of stainless steel may have gained support through their material performance profiles – the world-wide increase in consumption has only become possible through the creation of the appropriate production capacities using increasingly high-performance manufacturing systems.

Let us take a look at a few revolutionary innovative steps along the road to the present annual production capacity of around 18 million tonnes of stainless steel, around 75% of which is in the form of flat steel strip and steel sheets.

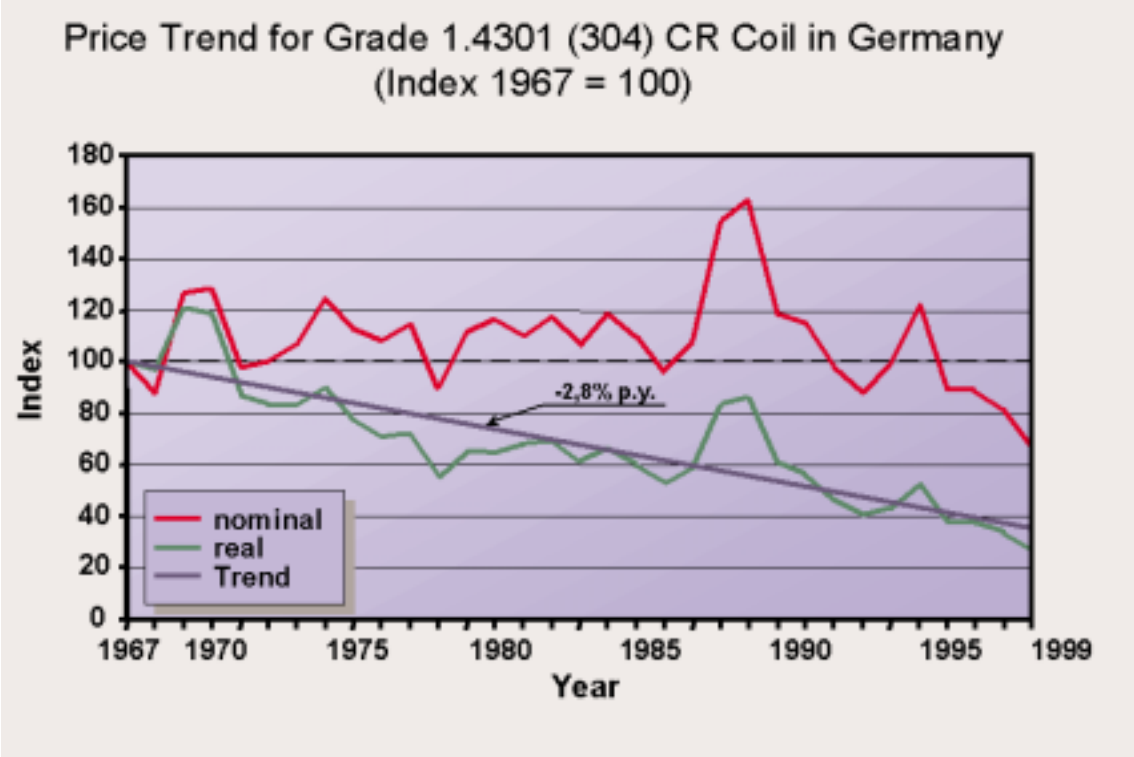
At the end of the 1960s, the introduction of vacuum and argon/oxygen refining of liquid stainless steels meant that it was possible to minimize the level of carbon and to reduce other undesired steel impurities such as sulphur and phosphorus to a minimum; this had a fantastic effect on the cold formability of thin steel sheets and on the reliability of welded joints. The changeover from slab casting to the continuous casting of up to 150 t steel heats in about 1975 was of great importance commercially, but also, and more particularly, produced a striking comparative moderation of steel characteristics as one of the major requirements for the introduction of automated, linked manufacturing processes in the steel processing industry. Today, up to six 150-t steel heats can be continuously cast in sequence and cut into slab bars weighing up to 30 t each: with a slab thickness of about 250 mm, this is then the starting product, for example, for high-gloss steel cold strips only 0.3 mm thick, several thousand metres long and with a coil weight of up to 30 t.

The introduction of the latest generation of 20-roll cold rolling mills at the beginning of the 1990 means that cold rolling of stainless steel strips can be carried out almost completely automatically and unmanned, using the most up-to-date measurement and control systems, with rolling speeds up to 1000 m/min; this can produce a material thickness as small as 0.15 mm, with the most stringent tolerances, excellent flatness and a flawless surface finish.

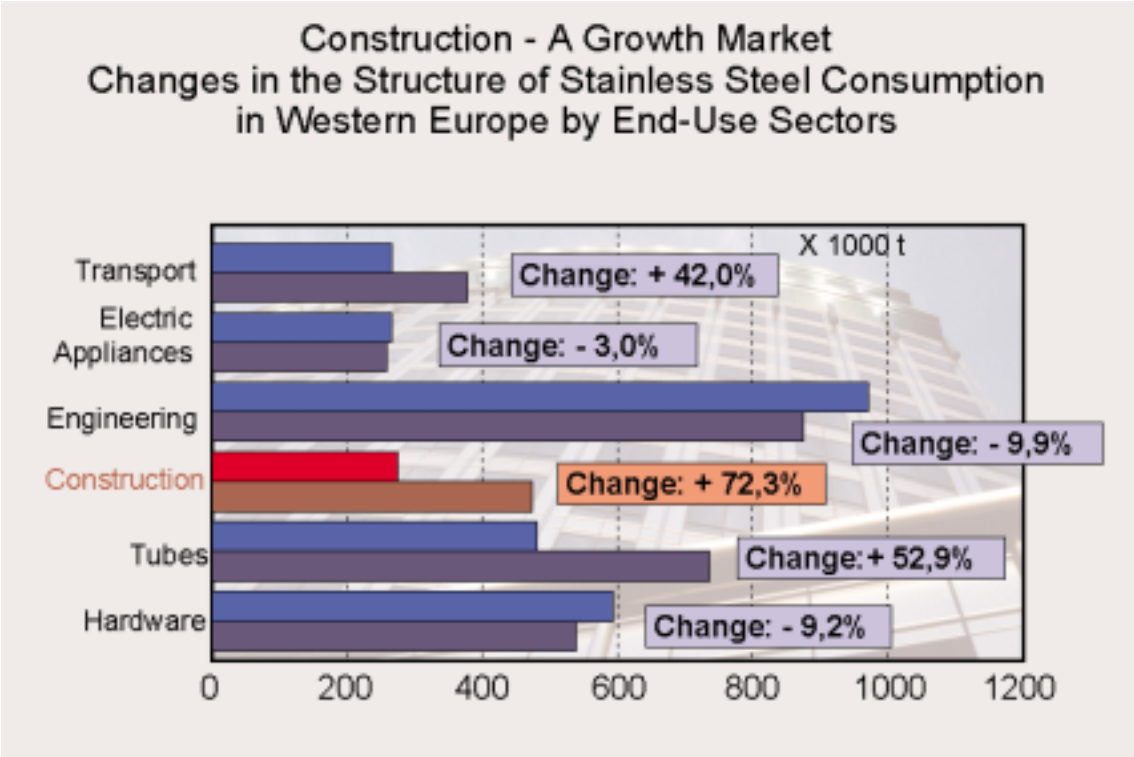
Recent investments in strip treatment lines confirm the trend towards linking the different treatment stages, such as descaling and heat treatment of the hot-rolled high-grade steel strip, cold-rolling, final heat treatment, subsequent skin passing, levelling and trimming of the strip edges with each other in one process. These combination or multi-process lines (MPL) make tough demands on the functional reliability of the linked individual components – on the other hand, they offer the user the chance to produce economically attractive stainless steel products in spite of increasing specific staff and resources costs.

At the moment, we are on the brink of a pioneering process innovation that is about to make its world debut: the introduction of the strip casting of stainless steel. In December 1999, a strip casting plant of this type was given its first trials in Krupp Thyssen Nirosta's Krefeld factory; it had been developed and industrially produced by a consortium of several European steel producers and equipment manufacturers. After the completion of the start-up work in 2002, this system will be working at a capacity of 360,000 t/year producing thin strips only 2-4 mm thick directly from the molten steel and supplying them to cold-rolling plants.

Why has this digression into the technological development of stainless steel production lasted so long? Because I wanted to give you, as users, the security that these technological quantum leaps will continue to have a positive effect on the development of real prices in the long time.

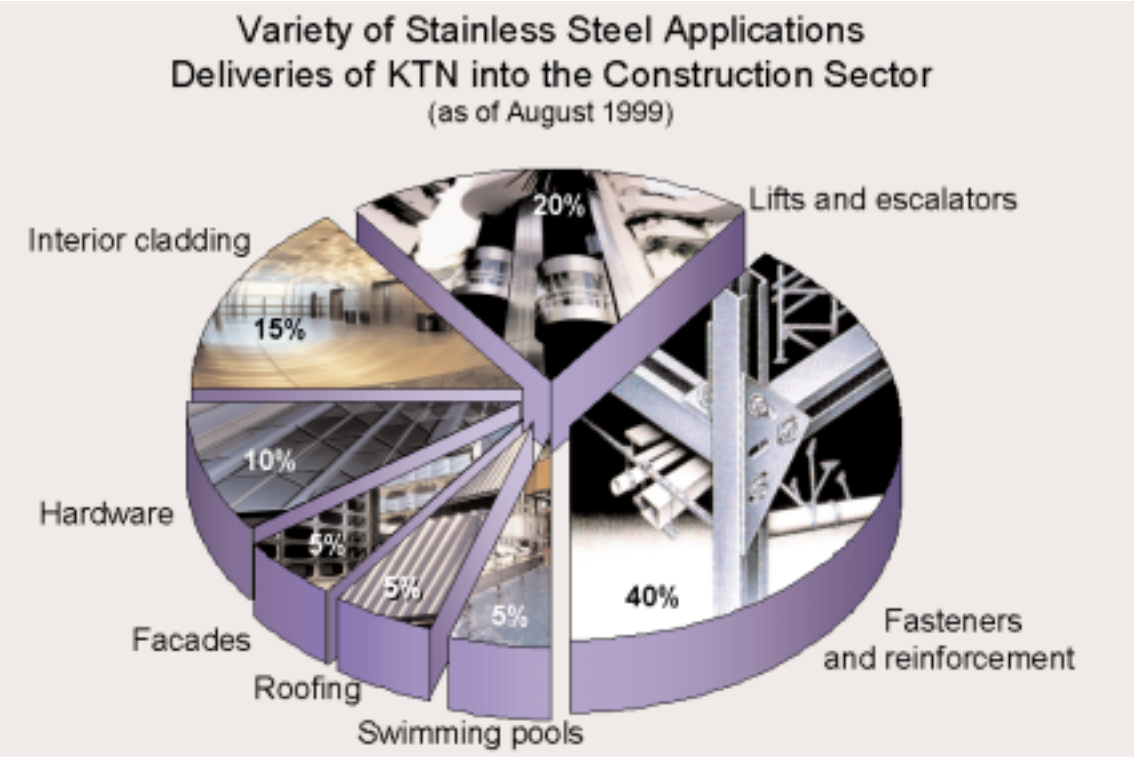


The average real price reduction of 2.8% p.a. shown here is one of the aspects of the steady increase in the growth of stainless steel. The ongoing nickel-based price situation we are seeing this year will not last; the production plants are perfectly aware of the dangers of a negative growth impulse that a high-price phase can trigger. Let us concentrate on the long-term trend.



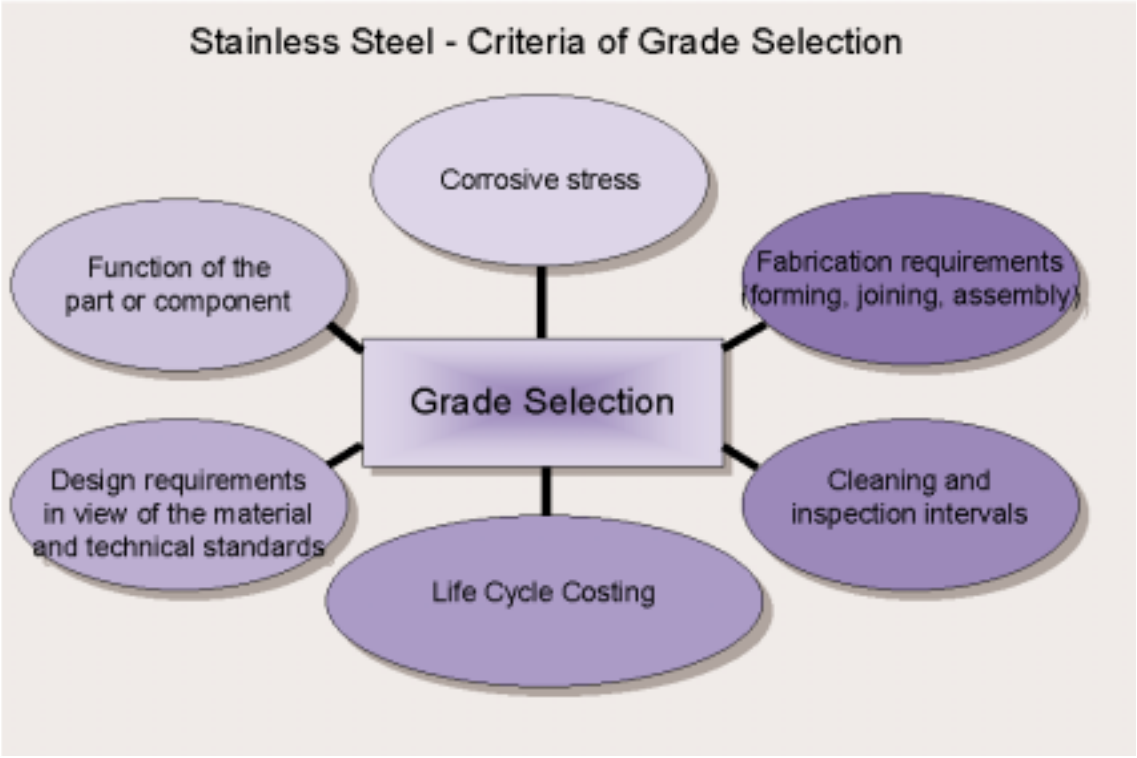
The growth in stainless steel is a real success story, which we want to develop rather than endanger; but the increase in its use in the building industry, and by architects, is something really special. In spite of the problems of definition in this presentation, the growth rate of 72% between 1990 and 1996 in the building trade is higher than in any other sector, with annual growth reaching double digit figures.

In the firm conviction that the use of stainless steel is set to grow even more in this industry, the production plants and processing companies must pay particular attention to this market and to enter into a dialogue with you, ladies and gentlemen, who are the users, so that they can take note of your expectations and turn them into solutions.



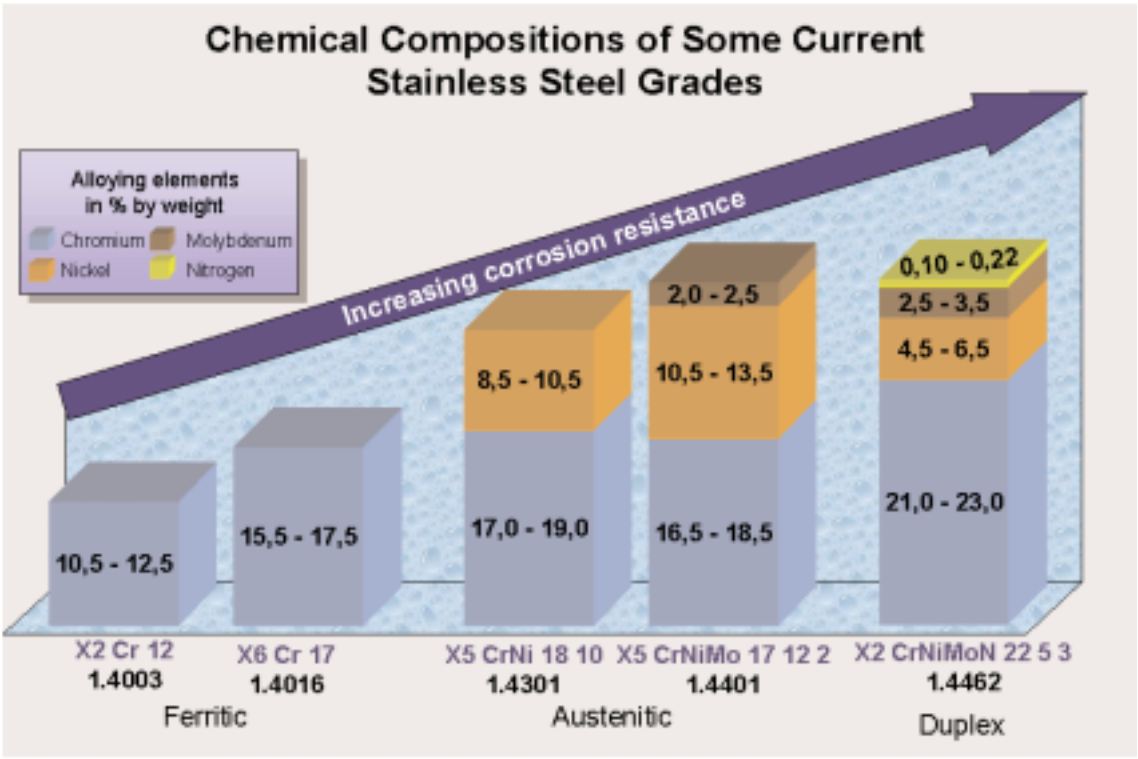
If we want to learn from the market, we must know the market. There are many different possible uses of this material and the components it is used to make, and just as many different requirements that these components have to fulfil. Our goal must be to identify shortcomings where they exist and to eliminate them.

In addition to the architectural and designer masterpieces produced in terms of facade construction and interior design, stainless steel is also being used to an amazingly large extent for less obvious purposes: it provides 40% of fixings and reinforcements, thus generating, with a low visual but highly functional impact, the conditions for a long-lasting, reliable symbiosis between different building materials and making the breakthrough into the world of structural engineering.



The material supplier must therefore be able to do much more than just manufacture materials; he must understand the language of the designer, the architect, the building engineer, in order to select the most suitable material with them, in the full awareness of all the requirements it has to meet and to be able to provide all the necessary advice and knowledge when it comes to further processing.

Life cycle cost considerations are becoming increasingly important, and this could boost the use of stainless steel even more, if, in addition to the admittedly often higher design costs, the reduced repair costs during the period of use are included in the overall usage costs calculation using suitable evaluation procedures. This would clearly show the superior commercial viability of choosing stainless steel. A few years ago, Euro Inox produced life-cycle-costing software. This is currently being redesigned with a particular view to use for building applications, and will soon be available from the Euro Inox Internet address.



As regards the right choice of material to suit the requirements, I would like to give a brief introduction to the basic typology of stainless steel:

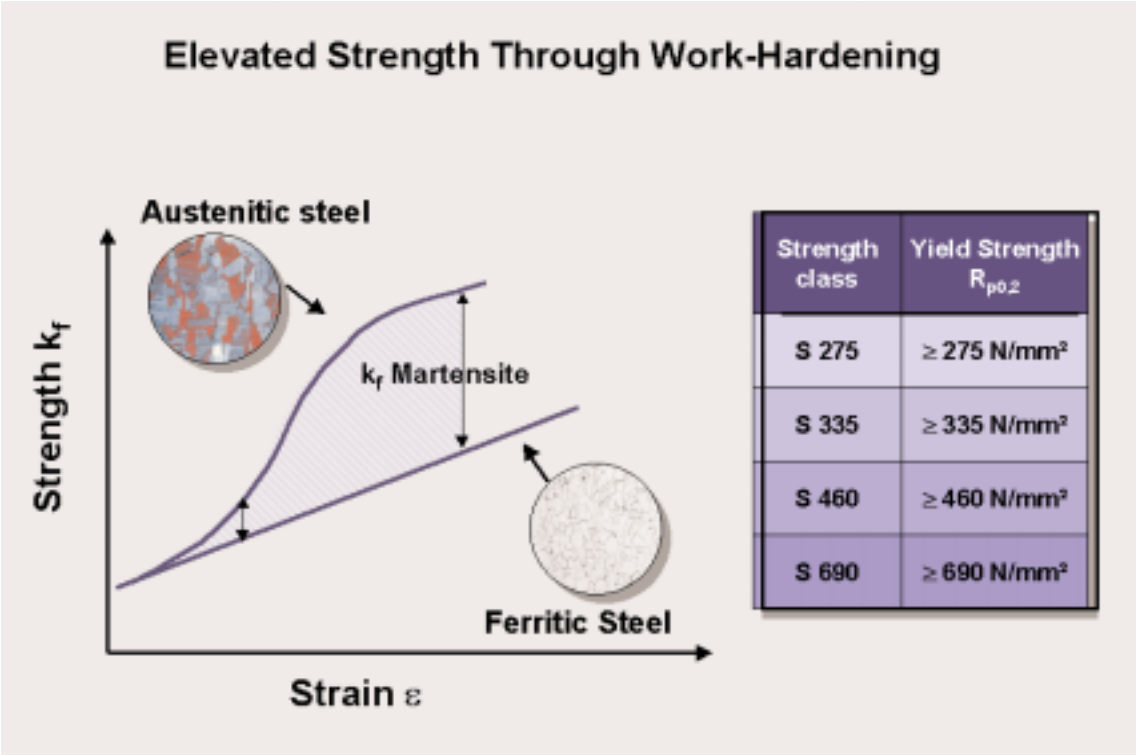
At the bottom end of the corrosion-resistance scale is the structural steel 1.4003. Basically, this is only alloyed with approx. 11% Cr; visually, it is not particularly attractive, but has its part to play because its welded connections are relatively tough for ferritic steels and the material cost is.

Passing over the ferritic 17% Cr steel 1.4016, which is not approved for building purposes in sheet or strip – it can be used as a kitchen or industrial furnishing material – we reach, with the classic austenitic 18-10 CrNi steel 1.4301, the most famous and most frequently used architectural material – used mainly for interior applications.

The addition of approx. 2% molybdenum, in steel 1.4404, produces the most famous stainless steel for outside applications, for example, where a high resistance to chloride and sulphur dioxide is required.

The ferritic-austenitic duplex steel 1.4462 is extremely resistant to corrosion, because of its higher nitrogen content, and is also extremely resistant to corrosion fatigue, making it ideal for use in road tunnels or with sea water.

Amongst and beyond these main representatives of the type, there are also many other stainless steels, which are approved for building use, and which can cope with almost any type of service requirement.



Strength class	Yield Strength $R_{p0.2}$
S 275	≥ 275 N/mm²
S 335	≥ 335 N/mm²
S 460	≥ 460 N/mm²
S 690	≥ 690 N/mm²

A technically useful characteristic of austenitic stainless steels is the cold-forming induced formation of a tough martensitic structural constituent through the lattice transformation of the metastable austenitic structure, e.g. during cold rolling, cold profiling or cold drawing. The yield strength of steels treated in this way increases without any dramatic loss of residual toughness.

Given the range of building products treated in this way in the standardized strength categories S 275-S 690, the building engineer has plenty of opportunity to build lightweight, resilient structures.

It would be "carrying coals to Newcastle" if I were to go through the full range of product forms available on the market today. Let me summarise: Anything is feasible, and yet there are some innovative attempts to expand the product range which I would like to talk about later.

Here, it seems to me that it is the task of the European stainless steel marketing associations to support people looking for suitable suppliers through modern means of communication. I assume that ISER and EURO INOX will be continuing and developing their successful work in this context.

What did I say at the beginning? "What is fascinating is the aesthetic appeal of the surface ..." In addition to the classic, high-gloss polished or brushed surface, stainless steel offers all sorts of opportunities to introduce creative designs – with a wide range of rolled in patterns: linen, squares, frost patterns, to mention just the better known.

Innovative processors have specialized in giving the surfaces supplied from the factories an individual finish for architects and designers, through mechanical or electrical polishing, etching, blasting, galvanic colouring or a combination of these techniques. Anything that can be drawn can be used as a design on stainless steel.

Seven stainless steel columns several metres high, made by the famous light artist Heinz Mack, have decorated the square in front of the Hypothekenbank in Essen since January 2000. The telescopic poles, which taper towards the top and are made from 4 double-walled wings, give the columns a unique rhythmic sequence when viewed by people driving or walking past. Lamps in the bases illuminate the surfaces embossed in 3 different levels of depths. The effect in the evening twilight is of a delicate sliver light fading away upwards. Our company is proud to have realized a uniquely fascinating, embossed relief in the surface of the steel, following the artist's designs.

In spite of the wealth of surfaces supplied to the market by manufacturers and processing firms, we keep on facing new challenges in order to enhance the attractiveness of our fascinating material for the future. We use special pickling and blasting processes, for example, to tone down the outer surface, which is often perceived as having a harsh, metallically hard reflection, for applications for roofs and walls, for example - a surface design that we have christened "Dullskin" and which we will continue to refine.

The rolled in embossing of abraded structures, which has the working name "Polirolled = polished & rolled", seems a very promising way of giving the familiar ground finishes a less rough, and thus less dirt-sensitive, surface structure.

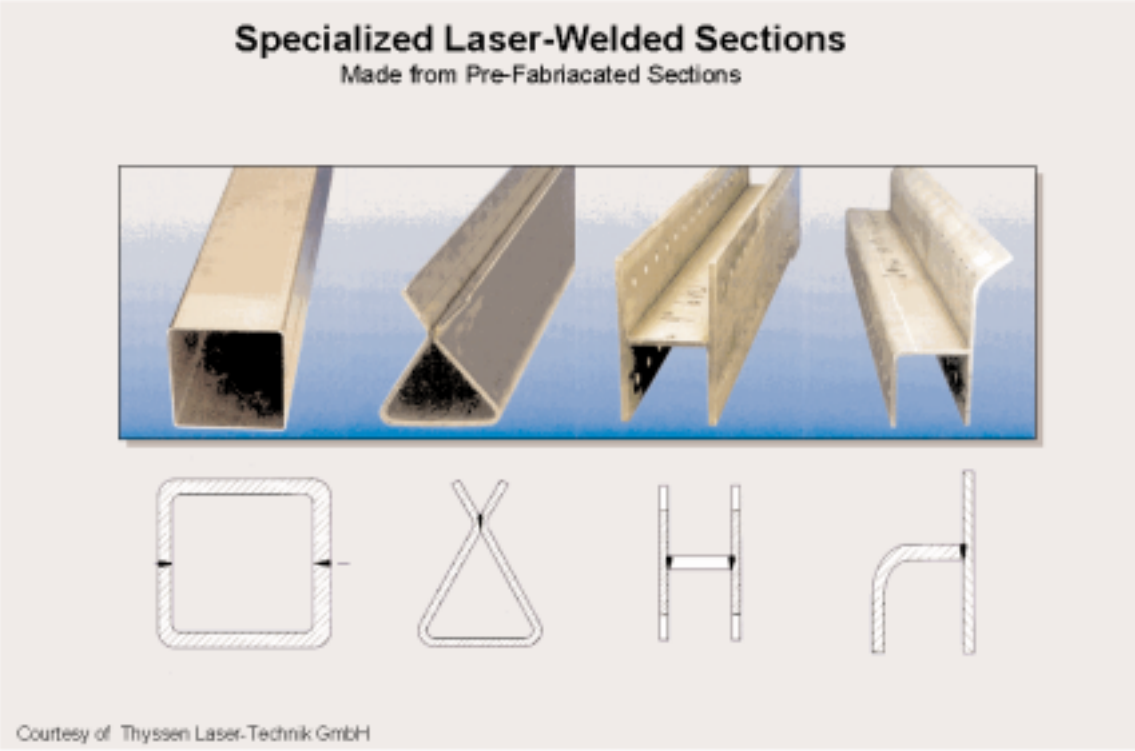
One of the most demanding challenges that stainless steel surface have to meet is still before us: getting rid of sensitivity to fingerprints – a sometimes unattractive phenomenon that appears on smooth high-grade steel surfaces as it does on glass and polished stone. Physicists specialising in surface finishes are working throughout the world on the transfer of the "lotus flower effect", observed in nature, onto technical surfaces – and on providing them with a dirt-repellent, self-cleaning finish.

The coil-coating lines available in integrated steel companies today offer an opportunity to seal the steel surface using suitable organic coatings. Initial successes have been achieved through the application of a permanent transparent protective film known as "Nirosta-Antiprint".

A transparent "Nirosta-Colourprint" finish is also possible. The scratch-resistance and long-term durability of finishes of this type must be improved.

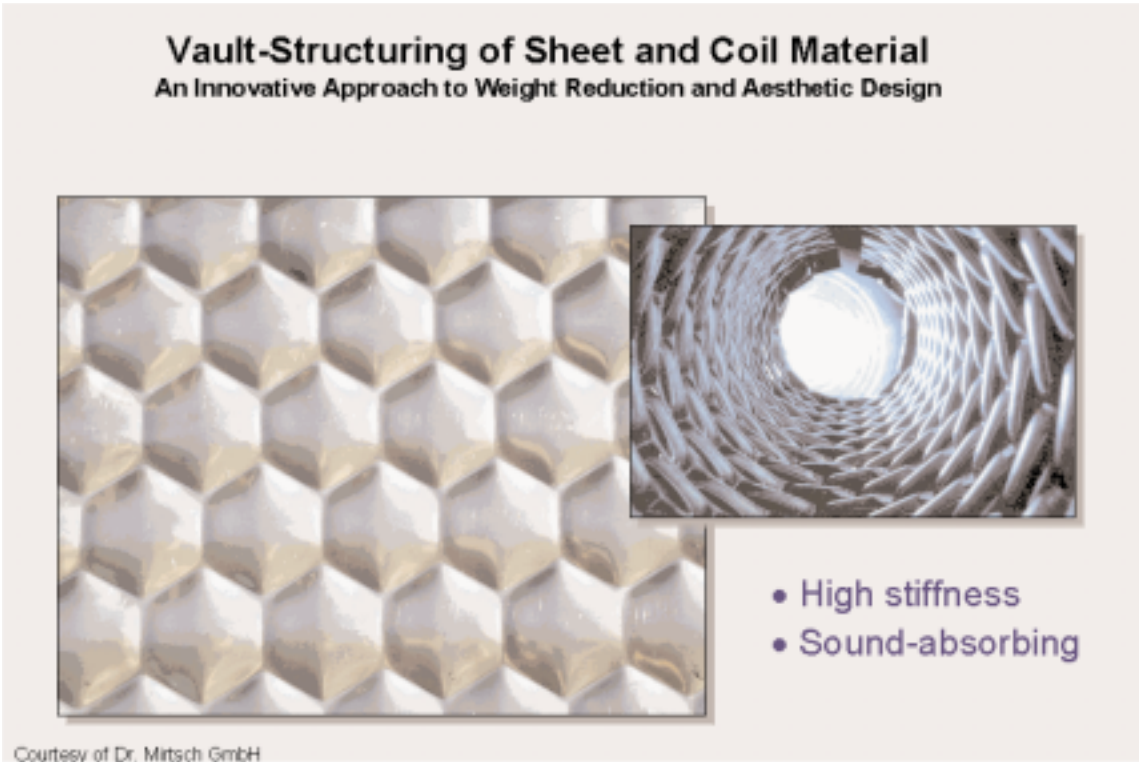
Altogether, as regards the market launch of new surfaces by manufacturers, it can be said that only sufficiently large production batches would justify the financial outlay. The smallest viable production unit would be at least one high-grade steel coil weighing some 20-25 t. Smaller production batches as special orders will continue to come within the domain of the specialist high-performance processing company.

From the wealth of innovative attempts to provide new attractive product forms, let me give just 2 examples from the field of structural applications for stainless steel:



When special sections are needed for unusual design or lightweight building requirements, laser beam welded sections can be produced in all sorts of shapes, which, because of the process used, offer superb weld seam quality and appearance and a high degree of dimensional precision, and which are also more reasonable priced than rolled or hot-pressed profiles.

The "General welding suitability certificate" which is currently applied in Germany will help to ensure that product forms of this type are used without problems, without any time-consuming individual permit procedures.



From the large number of approaches to developing and manufacturing plate-type stiff structural components, I would like to select what I regard as a particularly unusual process: the vault-structuring of steel sheet or strip.

The material is folded in simple machines to form multi-dimensional vault structures, creating an interesting combination of attractive surface finish and high bending strength at low weight; there is none of the material plastification that occurs in traditional forming machines.

The eternally fresh, characteristic use of stainless steel in buildings requires imagination, creativity and innovative power to give expression to the full range of materials, product forms and surfaces in the most fascinating way. And we should therefore take a brief look at the building regulations that create the framework here.

The new building supervisory approval Z-30.3-6, in its most recent version dated 3 August 1999 had led in Germany to a noticeable expansion of approved stainless steel types and strength categories and provided assistance to designers by defining the corrosion resistance classifications.

According to plans issued by the European Commission, it is likely that Part 1.4 of Eurocode III "General dimensioning regulations – Supplementary rules on the use of stainless steels" will be appearing in 2003 at the latest as an EN. National implementation regulations should then be appearing 2 years later at the most, as EN 1993-1-4.

The German Minister of Transport (Public Works Division) has decide, in agreement with the French Minister of Transport, that bridge building will be converted completely to Eurocodes in the year 2005.

In the private building sector, the co-existence period will start in 2005; after a further 2 years maximum, all national standards affected by the Eurocode must will have to be withdrawn.

Euro Inox will undertake to convert the often unwieldy Eurocode into a user-friendly high-grade stainless steel manual, so that it can answer all the relevant questions clearly and in one go.

I must bring my presentation to a close. "Stainless steel – a material for architectural visions." I have taken you on a brief tour of the material world and of our visions – turning these architectural visions into reality will be our major concern for the rest of today. Our material is more than a facade – it is the hallmark of a design concept like no other material is, and embodies the idea of a unique design. The stability of its values is clear; the surface is a mirror of the light that immerses a structure in a host of multifaceted views.

Interiors – planned functionally and created with elegance – become spacious and attractive when stainless steel is used, whether it is used alone or in a dialogue with other high-quality building materials.

"And they last practically forever". An icon in stainless steel should prove this clearly: The hood of the Chrysler Building – which caused a furore when it was erected in Manhattan in 1929 – will continue to fascinate generations to come over and over again.