HISTAR®
Innovative high strength steels for economical steel structures
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Hot rolled sections in sustainable construction

The preservation of natural resources in our industrialized societies has become a priority in the creation of the built environment. Consequently, the industrialized building concepts have to comply on one hand with changing economical parameters like the incorporation of life cycle analyses in the design of buildings, on the other hand with technological changes for considering at an equal level sustainability goals with respect to the environment, economy and society.

These three sustainability goals are in nature:

- ecological
- economical
- socio-cultural

They are both interdependent as well as ambivalent and they must provide a coherent response to complex questions for insuring to the future generations a built environment in which it is worth living.

Sustainable construction using hot rolled steel sections is fully consistent with the various aspects of the three sustainability goals.

- Ecological aspects of sustainability

The main ecological goals aim at using building materials that are safe from health and environmental points of view, at reducing building waste when dismantling buildings at the end of their useful life, and at preserving as best as possible the energy content in the building materials, thus maintaining their ideal efficiency. Here, the structural steels offer high material efficiency and the hot rolled sections constitute the most recycled building material in the world. In the modern electric arc furnace (EAF) route, steel is produced using 100% scrap as a raw material (upcycling). Also, used steel elements can be deployed for further use in renovation and refurbishment of existing buildings. In addition, the EAF technology of steel allows for significant reductions of noise, particle- and CO₂-emissions as well as water and primary energy consumption in the production mills.

- Economical aspects of sustainability

Here, the investors are mainly concerned with the reduction of investment costs, the optimization of operational costs and the achievement the longest possible service life in combination with high flexibility in use of the building. Hot rolled sections in structural steel allow architects and designers to easily achieve the requirements of the investors by combining high quality, functionality, aesthetics, low weight and fast construction time. Recovered steel can be recycled indefinitely. Assuming an appropriate design, whole structures or their individual steel elements can be re-used after dismantling of the original building and offer so significant economical life-cycle potential.

- Socio-cultural aspects of sustainability

This aspect allows the architect to reconcile his own aesthetic demands for a building with the social expectations of its surrounding environment. Again, thanks to the prefabrication construction system, hot rolled steel sections provide the user with transparent and lean structures combined with robustness and safety. The inhabitants and their social environment live in a clean, uncontaminated surrounding as steel in structures does not release any harmful substances into the environment and represents therefore no danger to living beings.

The aim of this brochure is to guide the reader towards choosing the appropriate steels and using their full potential, thus creating the best conditions for a contemporary, economical, ecological and consistent sustainable construction.
1. Introduction

With the development of the HISTAR steels, ArcelorMittal has succeeded to create structural steels combining high yield strength with excellent toughness at low temperatures and outstanding weldability. These material properties were considered incompatible until now.

This development was made possible by the innovative “in line” Quenching and Self-Tempering (QST) process, developed by the Commercial Sections division of ArcelorMittal in cooperation with the Centre de Recherches Métallurgiques in Liège.

The QST process enables the cost-effective production of high-strength steels. HISTAR steels are in full compliance with European and national standards.

Hot rolled H-beams in HISTAR grades enable the construction of innovative and competitive structures. Engineers take full advantage of the excellent HISTAR properties when designing gravity columns of high-rise buildings, long-span trusses and offshore structures. Furthermore, the new steels are recommended in case of stress governed as well as seismic design.

With HISTAR, ArcelorMittal satisfies the needs of the designers for light and economical structures which fulfil at the same time the criteria of safety and sustainability.
2. Characteristics of the HISTAR® steels

1. Product Description

HISTAR steels are structural grades with a low alloy content, combining high strength, good toughness and superior weldability. HISTAR grades are available with minimum yield strengths of 355 or 460 MPa.

When compared to standard structural steels, HISTAR grades feature improved guaranteed mechanical characteristics over the whole range of product thicknesses (Figure 1). In order to best suit the different applications, HISTAR grades are available with guaranteed toughnesses down to -20°C and down to -50°C.

HISTAR steels are delivered in the thermomechanically rolled condition and comply with the requirements of the European standards EN 10025-4:2004 for weldable fine grain structural steels and EN 10225:2001 for weldable structural steels for fixed offshore structures. They also comply with other national standards like ASTM A 913-07 and JIS G 3106:2004. Table 1 shows a comparison, based on yield strength, between HISTAR and other standard structural steel grades. HISTAR grades are compatible with the requirements of the Eurocodes for the design of steel structures and composite steel-concrete structures.

The HISTAR grades for offshore applications offer the following additional features:

- improved deformation properties in through thickness direction with respect to the resistance to lamellar tearing (Z qualities).
- notch impact properties in transverse direction.
- maximum ratio between yield strength and tensile strength.

Different HISTAR grades are available in the market:

**for general construction:**
- HISTAR 355 fulfils the requirements of S 355 M–EN 10025-4:2004
- HISTAR 355 L fulfils the requirements of S 355 ML–EN 10025-4:2004
- HISTAR 460 fulfils the requirements of S 460 M–EN 10025-4:2004
- HISTAR 460 L fulfils the requirements of S 460 ML–EN 10025-4:2004

**for offshore applications:**
- HISTAR 355 TZ OS fulfils the requirements of S 355 G11+M–EN 10225:2001
- HISTAR 355 TZK OS fulfils the requirements of S 355 G12+M–EN 10225:2001
- HISTAR 460 TZ OS fulfils the requirements of S 460 G3+M–EN 10225:2001
- HISTAR 460 TZK OS fulfils the requirements of S 460 G4+M–EN 10225:2001

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![Figure 1: Minimum yield strength of HISTAR steels and EN 10025-4:2004 steel grades according to the material thickness](image-url)
Table 1: Comparison table for HISTAR grades

<table>
<thead>
<tr>
<th>HISTAR Yield strength (MPa)</th>
<th>Standards</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>European and national standards</td>
<td>Previous standards</td>
</tr>
<tr>
<td>355</td>
<td>S 355</td>
<td>S 355</td>
</tr>
<tr>
<td>460</td>
<td>S 460</td>
<td>S 450</td>
</tr>
</tbody>
</table>

2. Chemical composition and mechanical properties

The chemical composition and the mechanical properties of the HISTAR grades are given in Table 2 and 3 for general construction and in Table 4 and 5 for offshore applications. (pages 8-9)

3. Types of sections

HISTAR grades are available for HE-beams ≥ 260 mm and IPE beams ≥ 500 mm. The corresponding ASTM A6 and the BS 4 shapes are also available.

The maximum flange thickness is:
- 125 mm for HISTAR 355 / 460
- 63 mm for HISTAR 355 L / 460 L
- 40 mm for HISTAR Offshore grades (sections with flange thickness > 40 mm are subject to agreement).

Additional information are given in the sales programme for “Beams, Channels and Merchant Bars”.
## 2. Characteristics of the HISTAR® Steels

### Table 2: Chemical composition of HISTAR steel grades for general applications

<table>
<thead>
<tr>
<th>Grades</th>
<th>Chemical composition</th>
<th>Nominal thickness [mm]</th>
<th>CEV (^{(1)}) max.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ladle analysis [%]</td>
<td>≤ 63</td>
<td>&gt; 63</td>
</tr>
<tr>
<td>HISTAR 355</td>
<td>0.12</td>
<td>1.60</td>
<td>0.30</td>
</tr>
<tr>
<td>HISTAR 355 L</td>
<td>0.12</td>
<td>1.60</td>
<td>0.30</td>
</tr>
<tr>
<td>HISTAR 460</td>
<td>0.12</td>
<td>1.70</td>
<td>0.30</td>
</tr>
<tr>
<td>HISTAR 460 L</td>
<td>0.12</td>
<td>1.70</td>
<td>0.30</td>
</tr>
</tbody>
</table>

\(^{(1)}\) CEV = C + Mn/6 + (Cr + Mo + V)/5 + (Cu + Ni)/15

\(^{(2)}\) If sufficient nitrogen binding elements are present, the minimum aluminium requirement does not apply.

\(^{(3)}\) Upon agreement: Si 0.14 - 0.25 % and P ≤ 0.035% max. for capability of forming a zinc layer during hot-dip galvanisation.

### Table 3: Mechanical properties of HISTAR steel grades for general applications

<table>
<thead>
<tr>
<th>Grades</th>
<th>Mechanical properties</th>
<th>Charpy V-notch impact test (^{(1)})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tensile test</td>
<td>Temperature</td>
</tr>
<tr>
<td></td>
<td>Min. yield strength (R_y) [MPa]</td>
<td>Tensile strength (R_m) [MPa]</td>
</tr>
<tr>
<td></td>
<td>Nominal thickness [mm]</td>
<td>≤ 63</td>
</tr>
<tr>
<td>HISTAR 355</td>
<td>355</td>
<td>355</td>
</tr>
<tr>
<td>HISTAR 355 L</td>
<td>355</td>
<td>-</td>
</tr>
<tr>
<td>HISTAR 460</td>
<td>460</td>
<td>450</td>
</tr>
<tr>
<td>HISTAR 460 L</td>
<td>460</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^{(1)}\) Mean value of three tests for full size specimens with no single value less than 70 % of the guaranteed average value. The provisions according to EN 10025:2004 are applicable.
2. Characteristics of the HISTAR® Steels

### Table 4: Chemical composition of HISTAR steel grades for offshore applications

<table>
<thead>
<tr>
<th>Grades</th>
<th>Chemical composition</th>
<th>Ladle analysis [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>HISTAR 355 TZ OFFSHORE</td>
<td>0.12</td>
<td>1.60</td>
</tr>
<tr>
<td>HISTAR 355 TZK OFFSHORE</td>
<td>0.12</td>
<td>1.60</td>
</tr>
<tr>
<td>HISTAR 460 TZ OFFSHORE</td>
<td>0.12</td>
<td>1.70</td>
</tr>
<tr>
<td>HISTAR 460 TZK OFFSHORE</td>
<td>0.12</td>
<td>1.70</td>
</tr>
</tbody>
</table>

1) CEV = C + Mn/6 + (Cr + Mo + V/5 + (Cu + Ni)/15
2) When other N-binding elements are used, the minimum Al value does not apply.
3) Upon agreement: Si = 0.14 - 0.25 % and P ≤ 0.035% max. for capability of forming a zinc layer during hot-dip galvanisation.

### Table 5: Mechanical properties of HISTAR steel grades for offshore applications

<table>
<thead>
<tr>
<th>Grades</th>
<th>Mechanical properties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tensile test</td>
</tr>
<tr>
<td></td>
<td>Min. yield strength $R_p$ [MPa]</td>
</tr>
<tr>
<td>Nominal thickness (mm)</td>
<td>16</td>
</tr>
<tr>
<td>HISTAR 355 TZ OFFSHORE</td>
<td>355</td>
</tr>
<tr>
<td>HISTAR 355 TZK OFFSHORE</td>
<td>355</td>
</tr>
<tr>
<td>HISTAR 460 TZ OFFSHORE</td>
<td>460</td>
</tr>
<tr>
<td>HISTAR 460 TZK OFFSHORE</td>
<td>460</td>
</tr>
</tbody>
</table>

1) Through thickness testing upon agreement. Mean value of 3 tests. Only for $t > 15$ mm.
2) Mean value of three tests for full size specimens with no single value less than 70% of the guaranteed average value. The provisions according to EN 10225: 2001 are applicable.
3) Tested upon agreement.
4) For thickness ≤ 25 mm, Charpy V test at -20°C.
3. Weight reduction of steel structures through the use of HISTAR® steels
High strength HISTAR grades allow, in comparison with conventional structural steels, to reduce the weight and material costs of steel structures, and to cut welding and assembly time (see Figures 2, 3 and 4).

**Figure 2:** Economical use of HISTAR steel in columns

**Figure 3:** Economical use of HISTAR steel in heavy columns

**Figure 4:** Influence of the slenderness on the load carrying capacity of the columns in HISTAR and conventional steels
In case of bending, the required cross section and fabrication cost can be reduced by using beams in HISTAR grades (see Figure 6).

HISTAR grades develop their full potential in the design of tension members in trusses. Here, they not only allow to save material costs by taking full advantage of the high yield strength. The reduction of the dead load of the truss leads to the design of even thinner sections, resulting in additional savings in fabrication costs (see Figure 7).

Due to the high yield strength of HISTAR beams, it is possible to substitute complicated and expensive built-up sections by economical hot rolled beams (see Figure 5).
4. Fabrication guidelines

1. General

The general recommendations given in this chapter shall be observed to ensure the successful fabrication, welding, and heat treatment of the fine-grained high-strength HISTAR 355 and HISTAR 460 steels for structural and offshore applications.

For aspects not covered within these guidelines, it is recommended to ask the advice of the Commercial Sections division of ArcelorMittal.

2. Machining

HISTAR 355/460 beams can be machined under the same conditions as structural steels featuring the same level of tensile strength. Tool wear from drilling and cutting of beams in HISTAR grades is similar to the one of beams in structural grades of the same level of strength.

3. Flame cutting

HISTAR 355/460 beams can be cut with a torch, using a process normally applied to structural steels featuring the same level of tensile strength. No preheating is required when flame cutting is performed at ambient temperatures > 0°C.

4. Welding

HISTAR steels offer a good weldability for manual and automatic processes, provided the general rules for welding are respected. Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW), Flux-Cored Arc Welding (FCAW), and Submerged Arc Welding (SAW) are processes successfully used to weld HISTAR 355 and 460 grades.

Flame cut groove surfaces have to be descaled by grinding before welding. HISTAR 355 / 460 and conventional structural grades can be combined by welding. For these cases the welding conditions of the conventional grade have to be integrated in the welding procedure.

4.1 Preheat temperatures

The preheat temperature for avoiding cold cracking represents the lowest temperature before starting the first run and below which the weld region shall not fall during welding.

Thanks to the low carbon equivalent values of the HISTAR grades (see figure 8), it is generally not necessary to preheat, as long as:

- the energy supply ranges between 10 and 60 kJ/cm,
- the temperature of the product is > 0°C,
- electrodes with low hydrogen content and low carbon equivalent are used.

No preheat conditions for HISTAR grades:

- For $R_e < 460$: $H_2 \leq 10$ ml/100g
- For $R_e \geq 460$: $H_2 \leq 5$ ml/100g
- $E > 10$ kJ/cm

$$CEV(\%) = C + \frac{Mn}{6} + \frac{(Cr+Mo+V)}{5} + \frac{(Cu+Ni)}{15}$$

Figure 8: Preheating temperatures for conventional structural and HISTAR grades (acc. to EN 1011-2:2001/method A)
Recommendations for the preheating temperature of fine grain steels are given in EN 1011–2:2001 in function of the carbon equivalent, the thickness of the product, the hydrogen content of welding consumables and the heat input. These recommendations apply to normal fabrication restraint conditions and welding of parent metal at temperatures > 0°C.

From these recommendations and specific trials on HISTAR 355 and HISTAR 460 grades, the following preheating temperatures have been deduced:

HISTAR 355: no preheating required over the entire thickness range with:
- diffusible hydrogen content of deposited metal ≤ 10 ml/100g
- heat input values ≥ 10 kJ/cm

HISTAR 460: no preheating required over the entire thickness range with:
- Diffusible hydrogen content of deposited metal ≤ 5 ml/100g
- heat input values ≥ 10 kJ/cm
HISTAR 460 may also be welded with consumables containing hydrogen levels between 5 and 10 ml/100g. In this case, a slight preheating is advised when combined with thick sections at a low range of heat input.

Table 6 indicates the preheating requirements applicable for the HISTAR 460 grade in function of the thickness, heat input and hydrogen content of the weld consumables.

Some preheating may be required for ambient temperatures < 0 °C, electrodes with high hydrogen content, high restraint conditions or low heat input welds (such as repair welds, tack welds or single pass welds on thick material). In case of special applications, the fabricator may apply a more conservative preheating procedure. In any case, preheating is not detrimental to the quality of the HISTAR grades.

Drying of the groove area is recommended before carrying out welding or if the surface of the beam is wet.

4.2 Welding consumables

The filler metal has to be selected in order to ensure the intended mechanical properties of the weld joint. The consumable should be chosen according to the following criteria:

- the mechanical properties of the weld metal shall comply with the requirements of the HISTAR grade, in particular the impact energy,
- matching or slight “overmatching” of the tensile properties in comparison with the base metal is common welding practice,
- in order to use the “no preheat” procedure, the diffusible hydrogen content in the deposited weld metal must be low, i.e. \( H_2 \leq 10\text{ml/100g} \) for HISTAR 355 and \( H_2 \leq 5\text{ml/100g} \) for HISTAR 460,
- basic covered electrodes and fluxes are to be dried before use for 2 hours at 300 °C and stored at 150 °C in a drying oven and/or a quiver. When using dry electrodes, only the storage at 150 °C is required. The recommendations of the manufacturer shall be followed,
- as for the welding of conventional structural steels, electrodes containing nickel are recommended in case of high toughness requirements at low temperature (e.g. bridges, offshore).

Table 7 summarises the information allowing a suitable choice of the welding consumables: tensile and impact properties of the HISTAR grades as well as the standards for the classification of the welding consumables for the various welding processes. Typical examples for choosing the welding consumables are included in the table. Other choices may also be adequate. Advice on commercial designations is available upon request and may be provided by the welding consumable producers.

The hydrogen content of the weld consumables is indicated in the standard designation as H5 or H10 respectively for contents lower than 5 or 10 ml/100g. No hydrogen is present in the weld consumables for the flux free welding processes (GMAW, MAG).

4.3 Weld bevel preparation

The bevel preparation can be done by oxy-cutting, milling, plasma or waterjet cutting.

Bevels for V or half V joints are possible without restriction.

For other bevel types (K or X joints) in material thicknesses greater than 63 mm, it is recommended to locate the weld root at about a third up to a quarter of the material thickness.

5. Stress relieving

A stress relief post weld heat treatment (PWHT) may be necessary when the layout of the structure and/or the expected stress condition after welding requires a reduction of the residual stresses.

Stress relieving of HISTAR steel grades is performed at temperatures between 530 °C and 580 °C. The holding time should be 2 minutes per mm of product thickness, but not less than 30 minutes and not more than 90 minutes.

### Table 6: Preheating requirements for HISTAR 460

<table>
<thead>
<tr>
<th>Thickness [mm]</th>
<th>Hydrogen content of consumables [ml/100 g]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤ 5</td>
</tr>
<tr>
<td>≤25</td>
<td>≤ 5</td>
</tr>
<tr>
<td>&gt; 25</td>
<td>≤ 10</td>
</tr>
<tr>
<td>Heat input [kJ/cm]</td>
<td>Heat input [kJ/cm]</td>
</tr>
<tr>
<td>10–15</td>
<td>15–60</td>
</tr>
<tr>
<td>No preheat</td>
<td>No preheat</td>
</tr>
<tr>
<td>100 °C</td>
<td>No preheat</td>
</tr>
</tbody>
</table>

The hydrogen content of the weld consumables is indicated in the standard designation as H5 or H10 respectively for contents lower than 5 or 10 ml/100g. No hydrogen is present in the weld consumables for the flux free welding processes (GMAW, MAG).
6. Flame straightening

Flame straightening is defined as a fast and local heating in order to eliminate deformations or to give to a structural member a required shape. HISTAR 355/460 grades can be flame straightened following the procedures usually applied to fine grain steels. The flame straightening temperature may go up to 700 °C in case of a local short heating over the entire product thickness. For local superficial heating of the surface only, the flame straightening temperature may go up to 900 °C.

In order to improve the efficiency of the flame straightening process, restrain forces should be applied to the structural element through calibrated jacks or other suitable devices. In the areas to be flame straightened, the stresses from the restraining forces shall be less than the yield stress of the steel at elevated temperature.

7. Hot forming

The operations of hot forming and normalizing at temperatures higher than those of the stress relieving treatment are not suited for the HISTAR steels.

8. Cold forming

The cold forming behaviour of the HISTAR steels is comparable to the one of conventional structural steels of the same range of tensile strength. The usual cold deformation rules apply. In particular, it is recommended to control and limit the degree of cold deformation. Cold forming modifies the mechanical properties of steel; they should remain compatible with the intended use of the structure.

9. Galvanising

Upon agreement, HISTAR grades are delivered with a silicon content ranging between 0.14 % and 0.25 % and are as such capable of forming a zinc layer during hot dip galvanising. Fabrication recommendations for steel elements to be galvanized must be followed. More detailed information on this topic are given in the brochure “Corrosion protection of rolled steel sections using hot dip galvanisation” (available upon request).

10. Beam Finishing

To save time and costs to the customer, the structural shapes from ArcelorMittal can be delivered with processing like cold sawing, drilling, coping, straightening, cambering, weld-edge bevelling, welding, and surface coating.
5. Technical delivery conditions
1. Rolling tolerances

Tolerances on dimensions and weight of beams in HISTAR grades and in structural steels are identical. They are given in the sales catalogue "Beams, Channels and Merchant Bars".

2. Mechanical testing

For the structural HISTAR grades, tensile test and Charpy V-notch impact test are performed in accordance with EN 10025-1:2004. Supplementary tests are possible upon agreement at an extra.

The frequency of mechanical testing for the HISTAR Offshore grades is in accordance with EN 10225:2001, i.e. once per 40 t or part thereof. The following tests are performed: one tensile test and one set of three Charpy V–Notch impact tests. Position and orientation of samples for these tests are in accordance with EN 10225:2001. Supplementary tests such as through thickness tensile tests according to EN 10164:2004 and impact tests in transverse direction can be performed upon agreement at an extra.

If other tests, such as weldability evaluation tests, are requested, this has to be agreed upon.

3. Ultrasonic testing

Ultrasonic testing is carried out upon agreement at an extra. The procedure for this test must be agreed between the purchaser and the manufacturer.

In case of order following EN 10164:2004, ultrasonic testing is performed in accordance with EN 10306:2001 class 2.3.

4. Certification

The type of certification shall be specified at the time of order.

5. Surface conditioning

HISTAR beams are delivered in standard ex-mill condition with surface quality in accordance with EN 10163–3:2004, Class C, Subclass 1. Other conditions are possible upon agreement.

Material can be supplied shot–blasted with or without coating upon agreement at an extra. Procedures have to be agreed upon between the purchaser and the manufacturer. Shot–blasted material with or without coating can be supplied with surface condition in accordance with EN 10163–3:2004, Class D, upon agreement at an extra.
Technical Advisory

We are happy to provide free technical advice to optimise the use of our products and solutions in your projects and to answer your questions about the use of sections and merchant bars. This technical advice covers the design of structural elements, construction details, surface protection, fire safety, metallurgy and welding.

Our specialists are ready to support your initiatives anywhere in the world.

To facilitate the design of your projects, we also offer software and technical documentation that you can consult or download from our website:

www.arcelormittal.com/sections

Finishing

As a complement to the technical capacities of our partners, we are equipped with high-performance finishing tools and offer a wide range of services, such as:

- drilling
- flame cutting
- T cut-outs
- notching
- cambering
- curving
- straightening
- cold sawing to exact length
- welding and fitting of studs
- shot and sand blasting
- surface treatment

Building & Construction Support

At ArcelorMittal we also have a team of multi-product professionals specialising in the construction market: the Building and Construction Support (BCS) division.

A complete range of products and solutions dedicated to construction in all its forms: structures, façades, roofing, etc. is available from the website

www.constructalia.com
Although every care has been taken during the production of this brochure, we regret that we cannot accept any liability in respect of any incorrect information it may contain or any damages which may arise through the misinterpretation of its contents.

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