Industeel® S355G10+N: a weldable normalized structural steel for large offshore structures with excellent toughness and weldability

Industeel® S355G10+N is a normalized structural steel plate grade with a nominal minimum yield strength of 325 MPa* dedicated to large offshore structures in the North Sea and similar environments. Thanks to the application of Option 18 of EN10225, the weldability of the steel is prequalified with a documentary file that has been reviewed by DNV-GL and Lloyd's Register, making its implementation easier. Its extreme purity with very low sulphur and phosphorus contents, as well as its adapted chemical analysis, makes Industeel® S355G10+N easy to cut, shape and weld, and provides excellent impact toughness and CTOD properties in the very large sizes available. Industeel® S355G10+N is elaborated through Electric Arc Furnace (EAF) melting of selected scraps with fine grain practice, vacuum treatment and ingot casting to provide the necessary characteristics of the material. The steel is rolled in plates with a quarto mill and finished using a separate normalizing heat treatment.

* 1 MPa = 1 N/mm²

**STANDARD**

EN10225:2009 S355G10+N – plates (to 150 mm thickness per the standard, and above)

Industeel® S355G10+N has been qualified to the following requirements of EN10225:2009
Option 12 (strain-ageing testing)
Option 13 (through-thickness testing)
Option 18 (Weldability testing)

This prequalification has been reviewed and approved by DNV-GL and Lloyd's Register. The grade can be delivered according to NORSOK M-120 Ed. 5 datasheet MDS-Y20 Rev.5 and at thicknesses above the maximum defined in the standard.

**CHEMICAL ANALYSIS – WEIGHT %, MAXIMUM UNLESS A RANGE IS INDICATED**

<table>
<thead>
<tr>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Cr</th>
<th>Mo</th>
<th>Ni</th>
<th>Al</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.12</td>
<td>0.15</td>
<td>0.55</td>
<td>0.008</td>
<td>0.002</td>
<td>0.20</td>
<td>0.08</td>
<td>0.70</td>
<td>0.015</td>
<td>0.050</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N</th>
<th>Nb</th>
<th>Ti</th>
<th>V</th>
<th>B</th>
<th>Nb+V</th>
<th>Nb+V+Ti</th>
<th>CEV</th>
<th>Pcm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.010</td>
<td>0.030</td>
<td>0.025</td>
<td>0.060</td>
<td>0.0005</td>
<td>0.06</td>
<td>0.08</td>
<td>0.43</td>
<td>0.22</td>
</tr>
</tbody>
</table>

CEV = C + Mn/6 + (Cr+Mo+V)/5 + (Cu+Ni)/15
Pcm = C + Si/30 + (Mn+Cu+Cr)/20 + Ni/60 + Mo/15 + V/10 + 5 B

Industeel® Trademark - Industeel® S355G10+N - 12/2018
The steel is manufactured through Electric Arc Furnace (EAF) melting of selected scraps with fine grain practice, vacuum treatment and ingot casting to provide the necessary characteristics of the material.

**Sizes**

- Thickness range.................80mm to 255mm
- Maximum unit weight...........60 tonnes
- Maximum width..................4350mm
- Maximum length...............19000mm

**Heat treatment conditions**

Heat treatment...............normalizing of plates at 900°C
Simulated PWHT...........on request on test coupon; nominal 580°C

**Material condition**

- Edges....................................oxycut
- Surface condition............EN10163-2 Class B Sub-class 3, ground
- Internal soundness............ultrasonic testing according to EN10160 S1/E2

Other delivery conditions can be agreed on request
**FORMING, CUTTING & MACHINING**

**Industeel® S355G10+N** can be processed with the parameters generally applied for mild steels. Please enquire for advice if requested.

**WELDING**

The weldability of **Industeel® S355G10+N** is excellent thanks to its balanced chemical composition. The weldability has been prequalified according to EN10225:2009 annexes E, F and G according to Option 18: Weldability testing according to annex E

Cross weld tensile tests and Charpy V notch impact tests at -40°C fulfill the requirements of the standard.

Eighteen 250mm thick CTOD tests have also been performed to check NORSOK MDS-Y20 requirements at -10°C.

**Bead on plate tests (BOP) according to annex F**

Maximum hardness is below the required 325HV10

**Controlled Thermal Severity test (CTS) according to annex G**

No cracking has been observed after preheating at 50°C.

**Welding processes**

Conventional fusion welding methods can be used, such as submerged arc welding (SAW), flux cored wire arc welding (FCAW), metal cored arc welding (MCAW), shielded metal arc welding (SMAW), GMAW and GTAW.

Preheating at 125°C is recommended and interpass temperature should be limited to a maximum of 250°C. A maximum heat input of 3.5kJ/mm should be observed to achieve good properties in the weld metal.

A Post Weld Heat Treatment (PWHT) at 580°C +/-10°C for 1 hour per 25mm thickness is appropriate.

**Welding consumables**

Fluxes should be re-dried at 300-350°C for minimum 2 hours and stored at 150°C until used.

<table>
<thead>
<tr>
<th>Standard</th>
<th>SMAW</th>
<th>GMAW</th>
<th>FCAW</th>
<th>SAW</th>
</tr>
</thead>
</table>
| AWS      | AWS A5.1 E7018-G H4R  
AWS A5.5 E8018-C3 H4R | AWS 5.28  
ER80S-Ni1 | AWS A5.36  
E71T5-M21P8-G-H4  
E8xT1x-M21P8-Ni1-H4 | AWS A5.17  
F7A8-EH12K  
F7P8-EH12K |
| EN       | EN ISO 2560-A  
E 42 4 B 3 2 H5  
E46 6 1Ni B 4 2 H5 | EN ISO 14341-A  
G 46 6 M21 3Ni1 | EN ISO 17632-A  
T 42 6 2 B M 1 H5  
T46 6 1Ni x M 1 H5 | EN ISO 14171-A  
S46 6 FB S3Si |

**APPLICATIONS**

**Industeel® S355G10+N** is designed for use in thick and very thick parts of large offshore structures.

---

**YOUR CONTACTS**

**Perrine LAVALLEY**  
Tel. +33 3 85 80 52 56  
perrine.lavalley@arcelormittal.com

**Industeel France**  
Châteauneuf plant  
BP 368 Châteauneuf  
42803 RIVE-DE-GIER Cedex

[https://industeel.arcelormittal.com](https://industeel.arcelormittal.com)

---

**Note:** This technical data and information represents our best knowledge at the time of printing. However, it may be subject to some slight variations due to our ongoing research program on offshore steel grades. We therefore suggest that information be verified at time of enquiry or order. Furthermore, in service, real conditions are specific for each application. The data presented here is only for the purpose of description, and may only be considered as guarantees when our company has given written formal approval. All information in this brochure is for the purpose of information only. Industeel reserves the right to change its product range at any time without prior notice. All Industeel facilities are ISO 9001, ISO 14001 and OHSAS 18001 certified. © Industeel 2017