Spirally welded steel pipes
Company profile
ArcelorMittal is the world’s number one steel company, present in more than 60 countries. It has led the consolidation of the world steel industry and today ranks as the only truly global steelmaker. ArcelorMittal is the leader in all major global markets, including automotive, construction, household appliances and packaging. The Group leads in R&D and technology, holds sizeable captive supplies of raw materials and operates extensive distribution networks.

Its industrial presence in Europe, Asia, Africa and America gives the Group exposure to all the key steel markets, from emerging to mature. ArcelorMittal will be looking to develop positions in the high-growth Chinese and Indian markets.

ArcelorMittal is listed on the stock exchanges of Paris, Amsterdam, New York, Brussels, Luxembourg and on the Spanish stock exchanges of Barcelona, Bilbao, Madrid and Valencia.

Projects Europe
Projects Europe offers complete and customized steel solutions serving three markets:
- Foundation Solutions
- Oil & Gas
- Steel Construction

Projects Europe can be involved from the early stage with an advising role towards the investor; ensuring the best and most efficient steel solution. From planning till the actual construction, Projects Europe is your steel ally who goes beyond.

Foundation Solutions
Projects Europe offers foundation solutions for the construction of quays, harbours, locks, breakwaters and to reinforce the banks of rivers or canals. Other applications involve the protection of excavations underwater or on land, and excavation works for bridge abutments, retaining walls and underground car parks.

With the possibility to make pipes up to 3,000mm diameter, 53m long (without circumferential welds) and 25mm thick, we have a unique position in the world.

Our worldwide presence with stocks of sheet piles, H-bearing piles and pipe piles makes us the preferred partner for our customers to offer tailor-made solutions. The complete range of products goes from hot rolled sheet piles and H-profiles to cold formed sheet piles and foundation pipes.

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Production range
Our strong points are:
- Production is 100% controlled and certified with delivery of 3.1 certificates according EN 10204 - 2004.
- Pipes can be produced with diameters up to 3000mm and wall thicknesses up to 25mm.
- We can provide pipes in all requested steel grades due to our worldwide network of coil producers.
- Pipes can be produced with lengths up to 53m without circumferential weld. Longer tubes can be achieved by welding.
- There is a coating facility present on our production site.
- Several specialized welding facilities are placed in line with the spiral mill for executing specific works like welding clutches or other steel parts and making butt welds.
Production process of spirally welded pipes
Production Process of Spirally Welded Pipes

de-coiling
levelling and centring
cutting
edge cutting
bevelling
main drive
three-roll forming
inside welding
transversal bevelling and transversal welding
centring
outside welding
US testing weld seam
plasma cutting
pipe body testing
The welding process
The Welding Process

The welding of the spirally welded pipes is based on the Double-Sided Submerged Arc Welding (DSAW) process.

The principle

Arc welding works by using electric current to produce an electric arc in a gas environment. The arc's heat brings the metal to fusion point. A key question is how to increase both the concentration and energy intensity of the arc.

DSAW's better penetration makes it possible to achieve higher weld travel speeds without impairing quality, thus improving productivity and lowering costs.

Multi arc welding

The Spiral Mill of ArcelorMittal Projects combines the advantages of DC and AC arc combinations.

Both on the inside and the outside the multi arc principle is used. The first welding pass is done by using a DC arc. Herewith a large and concentrated penetration can be achieved. The second pass is done by using an AC arc. Herewith better deposition rates can be achieved.

The result of the multi arc welding on both sides of the coil is a full penetration weld of a very high quality produced in a cost effective way.

The flexibility of the mill is very high because of the use of this system. A large range of coil thicknesses (between 10 and 25mm) can be transformed in spirally welded pipes in an economic way by choosing the right parameters.

Inside weld: triple arc welding

1/ DC-torch for deep-penetration weld
2/ AC-torch for filling weld
3/ AC-torch for finishing weld

Outside weld: tandem arc welding

1/ DC-torch for deep-penetration weld
2/ AC-torch for finishing weld
Technical delivery conditions

Technical Delivery Conditions
Pipes for construction purposes are normally produced according to EN 10219 or API 5L-PSL1. The EN 10219 is a European standard giving technical delivery conditions for cold formed, welded pipes for construction works. The API 5L is drawn by the American Petroleum Institute in order to provide standards for pipes suitable for use in conveying gas, water and oil.

Steel grades
Steel grades are built up by symbols and numbers showing the requested properties of the steel.

• An example of a steel grade according to EN 10219:
  S355J0H
  With: EN 10219: the European standard
  S: structural steel
  355: minimum yield strength [N/mm²]
  J0: minimum impact energy value of 27 J at 0°C for Charpy testing, others are JR (27 J at 20°C) and J2 (27 J at -20°C)
  N or M: normalised rolling or thermomechanical rolling of the feedstock material (coils). Both are rolling processes in which the final deformation is carried out in a certain temperature range. When a minimum impact energy value is specified at a temperature of −50°C, the letter L is added to N or M.
  H: hollow sections

• An example of a steel grade according to API 5L-PSL1:
  X52
  With: API 5L: the standard of the American Petroleum Institute
  52: 52000 pounds per square inch = 359 N/mm². This is the yield strength.
### Mechanical properties

<table>
<thead>
<tr>
<th>Steel grade according to EN 10219-1</th>
<th>Minimum yield strength $R_{eH}$ (Ts≤16mm)</th>
<th>Minimum yield strength $R_{eH}$ (16&lt;T≤40mm)</th>
<th>Minimum ultimate tensile strength $R_{m}$ (3≤T≤40mm)</th>
<th>Minimum elongation $A_{s}$ (T≤40mm)</th>
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</thead>
<tbody>
<tr>
<td>S235JRH</td>
<td>235</td>
<td>225</td>
<td>340–470</td>
<td>24</td>
</tr>
<tr>
<td>S275J0H/J2H</td>
<td>275</td>
<td>265</td>
<td>410–560</td>
<td>20</td>
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<tr>
<td>S355J0H/J2H</td>
<td>355</td>
<td>345</td>
<td>490–630</td>
<td>20</td>
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<tr>
<td>S420MH</td>
<td>420</td>
<td>400</td>
<td>500–660</td>
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<td>S460MH</td>
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<td>530–720</td>
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<table>
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<tr>
<th>Steel grade according to API 5L, PSL1</th>
<th>Minimum yield strength $R_{eH}$</th>
<th>Minimum ultimate tensile strength $R_{m}$</th>
<th>Minimum elongation $A_{s}$</th>
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<tr>
<td>X42</td>
<td>290</td>
<td>415</td>
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</tr>
<tr>
<td>X46</td>
<td>320</td>
<td>435</td>
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<tr>
<td>X52</td>
<td>360</td>
<td>460</td>
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</tr>
<tr>
<td>X56</td>
<td>390</td>
<td>490</td>
<td>19</td>
</tr>
<tr>
<td>X60</td>
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<td>X65</td>
<td>450</td>
<td>535</td>
<td>18</td>
</tr>
<tr>
<td>X70</td>
<td>485</td>
<td>570</td>
<td>17</td>
</tr>
</tbody>
</table>

1) PSL: Product specification level
2) T: Thickness
3) Depends on tensile test piece cross-sectional area

### Chemical properties

<table>
<thead>
<tr>
<th>Steel grade according to EN 10219-1</th>
<th>C max.</th>
<th>Mn max.</th>
<th>P max.</th>
<th>S max.</th>
<th>Si max.</th>
<th>N max.</th>
<th>CEV max. (d≤40mm)</th>
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<tbody>
<tr>
<td>S235JRH</td>
<td>0.17</td>
<td>1.40</td>
<td>0.045</td>
<td>0.045</td>
<td>-</td>
<td>0.009</td>
<td>0.15</td>
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<tr>
<td>S275J0H/J2H</td>
<td>0.20</td>
<td>1.50</td>
<td>0.040</td>
<td>0.040</td>
<td>-</td>
<td>0.009</td>
<td>0.40</td>
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<tr>
<td>S355J0H/J2H</td>
<td>0.22</td>
<td>1.60</td>
<td>0.040</td>
<td>0.040</td>
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<td>0.009</td>
<td>0.45</td>
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<td>S420MH</td>
<td>0.16</td>
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<td>0.035</td>
<td>0.030</td>
<td>0.50</td>
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<td>0.025</td>
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<table>
<thead>
<tr>
<th>Steel grade according to API 5L, PSL1</th>
<th>C1) max.</th>
<th>Mn1) max.</th>
<th>P max.</th>
<th>S max.</th>
<th>Ti+V+Nb max.</th>
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<tr>
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<td>1.20</td>
<td>0.030</td>
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<td>X42</td>
<td>0.26</td>
<td>1.30</td>
<td>0.030</td>
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<td>X46</td>
<td>0.26</td>
<td>1.40</td>
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<td>X52</td>
<td>0.26</td>
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<td>X70</td>
<td>0.26</td>
<td>1.65</td>
<td>0.030</td>
<td>0.15</td>
<td></td>
</tr>
</tbody>
</table>

1) According to API 5L: For each reduction of 0.01% below the specified maximum carbon content, an increase of 0.05% above the specified maximum manganese content is permissible, up to a maximum of 1.50% for grade X42 to X52, 1.65% for X56 to X65 and 2.00% for X70.
2) Unless otherwise agreed, the sum of the niobium and vanadium contents shall be ≤ 0.06%.
3) Unless otherwise agreed.

### Geometric tolerances

<table>
<thead>
<tr>
<th>Standard</th>
<th>Outside diameter D</th>
<th>Wall thickness T</th>
<th>Straightness</th>
<th>Out-of-roundness</th>
<th>Mass</th>
<th>Maximum weld bead height1)</th>
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<tbody>
<tr>
<td>EN 10219-2</td>
<td>+/- 1% max. +/- 10.0 mm</td>
<td>+/- 10% max. +/- 2.0 mm</td>
<td>0.20% of total length</td>
<td>+/- 2%</td>
<td>+/- 6%</td>
<td>T ≤ 14.2 mm: 3.5 mm T &gt; 14.2 mm: 4.8 mm</td>
</tr>
<tr>
<td>API 5L ISO 3183</td>
<td>≤ 1422 mm</td>
<td>&lt; 15.0 mm: +/- 10% &gt; 15.0 mm: +/- 15 mm</td>
<td>0.20% of total length</td>
<td>D ≤ 75 D &lt; 1422 mm</td>
<td>+/- 1.5% ≤ 15.0 mm Else</td>
<td>+10% - 3.5%</td>
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<tr>
<td></td>
<td>&gt; 1422 mm as agreed</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

1) Tolerance on height of internal and external weld bead for submerged arc welded hollow sections.
Combined walls

A combined wall is the retaining wall solution when a high horizontal or vertical bearing capacity is required. A combined wall combines pipes (primary elements) with intermediate sheet piles (secondary elements).

Structurally the pipes fulfil two functions:
- as retaining elements for horizontal loads from soil and water pressures
- as bearing piles for vertical loads

The intermediate sheet piles transfer horizontal loads to the pipes. Intermediate sheet piles can be shorter than the pipes. The table below gives only a part of the possibilities with combined walls. All kinds of combinations are possible, so tailor-made solutions can be delivered.

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>Thickness (mm)</th>
<th>M60% (kg/m²)</th>
<th>M100% (kg/m²)</th>
<th>I (cm²/m)</th>
<th>W (cm³/m)</th>
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<td>138</td>
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<td>203</td>
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<td>914</td>
<td>10</td>
<td>140</td>
<td>167</td>
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<td>3,279</td>
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<td>14</td>
<td>180</td>
<td>207</td>
<td>199,625</td>
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<td>426</td>
<td>5,343,522</td>
<td>35,623</td>
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</table>
With:

Diameter: Outside diameter of pipe [mm]
Thickness: Wall thickness of pipe [mm]
M60%: Mass of combined wall with a length of the intermediate sheet piles equal to 60% of the length of the pipes [kg/m²]
M100%: Mass of combined wall with a length of the intermediate sheet piles equal to the length of the pipes [kg/m²]
I: Moment of inertia of combined wall [cm⁴/m]
W: Section modulus of combined wall [cm³/m]

The weight of the interlocks welded on the pipes is neglected.

The following formulas can be helpful for the design of combined walls:

\[
I_{\text{prim}} = \frac{\pi \cdot (D^4 - (D - 2t)^4)}{64} \\
W_{\text{prim}} = \frac{I_{\text{prim}}}{0.5 \cdot D} \\
I = \frac{I_{\text{prim}} + I_{\text{sec}}}{b} \\
W = \frac{I}{0.5 \cdot D} \\
\sigma = \frac{M}{W}
\]

With:

t: Wall thickness [cm]
W_{\text{prim}}: Section modulus of the pipe [cm³]
I_{\text{prim}}: Moment of inertia of the pipe [cm⁴]
I_{\text{sec}}: Moment of inertia of sheet piles [cm⁴]
b: System width [m]: pipe diameter [m] + width of sheet piles [m] + 0.05m (interlocks)
D: Outside pipe diameter [cm]
\sigma: Maximum steel stress due to bending moment [N/mm²]
M: Bending moment [Nm]

Calculation sheets can be found on our website (www.arcelorprojects.nl).

The diameter and thickness of the pipes, the intermediate sheet piles and the steel grade determine the strength of a combined wall. Varying these parameters leads to an optimized solution.

Soil conditions, installation lengths and durability demands may lead to design restrictions for pipe dimensions and intermediate sheet piles.

The advantages of AZ sheet piles in combined walls are:

- Load–displacement behaviour is far better than that of double and triple U–piles, so settlements are less.
- High soil and water pressures are increasingly transferred to the pipe as normal tensile stresses (membrane effect).
- Because of their geometry, AZ intermediate sheet piles are coping better with driving deviations of the pipes than U–piles, because of the triple hinge system.
- Larssen–type interlocks contribute to the high performance of AZ intermediate sheet piles.
- In tests is measured that AZ intermediate sheet piles can resist very high ultimate loads, for example up to 57m hydraulic head for an AZ 18 (S 430 GP).

There are two standard solutions to connect sheet piles with pipes: with C6 interlocks or with C9 interlocks.

Advantages C6:
- Less weight than C9, therefore more economical
- Easy to weld

Advantages C9:
- Fixed interlock opening
Coating

The classical protection for steel tubes is surface coating. The European standard EN ISO 12944 deals with protection by paint systems and its various parts cover all the features that are important in achieving adequate corrosion protection.

In certain situations where there is no oxygen (deep below surface level) steel tubes may not corrode. When water and oxygen are both available, corrosion takes place by an electrochemical process. Coating systems are used to protect against corrosion as well as for decoration, but before a coating system is applied it is essential that the steel surface is properly blasted.

Surface Preparation
The most commonly used preparation grades are, according to the ISO 8501-1 standard:
- ISO Sa 2.5: very thorough blast cleaning
- ISO Sa 3: blast cleaning to visually clean steel
Coating Systems
In the following, some paint systems are proposed for different environments according to the classification of EN ISO 12944.

Atmospheric exposure
Steel tubes can be partly exposed to the atmosphere, for example when used as pillars for bridges or in permanent retaining combiwalls. In such applications, polyurethane finishes provide an aesthetical and functional look. They combine gloss and color retention and are easy to apply and maintain.

Proposal (EN ISO 12944 - table A4, corrosivity category C4)
- Zinc silicate epoxy primer (50µm)
- Recoatable epoxy intermediate coating (140µm)
- Aliphatic polyurethane topcoat (40µm)
Nominal dry film thickness of the system: 230µm

Freshwater immersion
Freshwater immersion is usually less corrosive than in marine conditions, but there can be aesthetic considerations. For convenience here, a system has been chosen which is capable of performing well both above and below water.

Proposal (EN ISO 12944 - table A8, corrosivity category Im 1)
- 2 coats of polyamide cured epoxy coating (150 + 150µm)
Nominal dry film thickness of the system: 300µm

Seawater immersion
Structures continuously or partially immersed in seawater require careful attention. For long-term performance in immersion there should be no compromise on quality. The application must be properly carried out and inspected and, of course, the coating system must be of high quality.

Proposal 1 (EN ISO 12944 – table A8, corrosivity category Im 2)
- Polyamide cured epoxy primer (50µm)
- 2 coats of polyamide cured coaltar epoxy coating (200 + 200µm)
Nominal dry film thickness of the system: 450µm

Proposal 2 (EN ISO 12944 – table A8, corrosivity category Im 2)
- Polyamide cured epoxy primer (50µm)
- Glassflake reinforced polyamide cured epoxy coating (400µm)
Nominal dry film thickness of the system: 450µm

All coating systems can be provided by ArcelorMittal Projects for its entire production range.
Logistics and services

Logistic Process
ArcelorMittal Projects deals with the all logistics starting with the acceptance and storage of base materials until tailor-made deliveries on the job site worldwide.

An experienced team is at our clients service to arrange road, rail or water transport all over the world, all additional activities such as loading and unloading facilities, custom clearance, local taxes etc. included.

Transport by truck
ArcelorMittal Projects has a close cooperation with specialized companies to ensure in-time deliveries with lengths up to 40m.

Transport by rail
Delivery of lengths up to 32m can be done in most European countries.
For longer items a specific study needs to be done before executing.

Transport over water
Both our site in Dintelmond and Moerdijk are directly connected to deep water in the port of Rotterdam area.
The loading berths are equipped with cranes with lifting capacities over 120 tons. Herewith long and heavy pipes can be transported directly after production to our clients without additional trans- shipments.

Delivery Conditions
All deliveries made by ArcelorMittal Projects are in accordance with Incoterms 2000.
Below you will find some examples of these terms:

All modes of transport
- EXW Ex Works (named place)
- FCA Free Carrier (named place)
- CPT Carriage Paid To (named place of destination)
- CIP Carriage and Insurance Paid to (named place of destination)
- DAF Delivered At Frontier (named place)
- DDU Delivered Duty Unpaid (named place of destination)
- DDP Delivered Duty Paid (named place of destination)

Sea and inland waterway transport
- FAS Free Alongside Ship (named port of shipment)
- FOB Free On Board (named port of shipment)
- CFR Cost and Freight (named port of destination)
- CIF Cost; Insurance and Freight (named port of destination)
- DES Delivered Ex Ship (named port of destination)
- DEQ Delivered Ex Quay (named port of destination)

ArcelorMittal Projects can arrange all necessary export documents such as EX1, EUR1, certificates of origin, etc.
Services

ArcelorMittal Projects delivers the entire range of steel foundation products to its customers, and offers a total solution to its customers in civil engineering.

In order to do so, ArcelorMittal Projects relies on 3 pillars:

1. Extensive product range:
   - Spirally welded pipe mill: unique state-of-the-art pipe producing mill with production specifications ranging from:
     - 10-25mm thickness,
     - 863mm-3000mm diameter,
     - Steel grades up to X70
     - Capacity to produce pipes up to 53m length without circumferential weld.
   - Large stock of steel pipes:
     - Newly produced, high quality pipes from overrollings, mainly meant for gas transportation or water transmission pipelines.
     - Used pipes, formerly used as water or gas pipeline.
   - Other pipes: if the customer’s requirement is beyond our production range, we will rely on our worldwide network of pipe producers, in order to find a technically and economically optimized solution for our customers.

2. Fabrication of end products:
   Because all our fabrication halls have direct access to deep water, we are able to deliver end products up to 120 ton per piece.
   Our services are:
   - Construction of: piles for combiwalls (welding of clutches and welding pipes to required lengths), box piles, special sheet piles, MV piles, walings and struts for supporting sheet pile walls...
   - Sealing of interlocks with: Beltan, Roxan or by welding.
   - Coating: when end products need to be treated we can provide all requirements.

3. Technical support
   With our team of engineers we are able to find the most suitable solution for our customers projects by providing: feasibility studies, dimensioning of entire structures, elaboration of anchorage or strutting systems, calculation of vertical load-bearing capacity...
   We can also provide driving plans.
Quality Control

1. Certification
Projects Europe has been certified for many years for the production of spirally welded steel pipes. Our production facility is certified to produce spirally welded pipes according to customer requirements e.g. EN 10219. Projects Europe has the right to issue 3.1. certificates with their products. 3.2. certificates can be issued when the production is controlled by a notified third party.

2. The quality process
Our quality management system is certified according to EN ISO 9001-2008 (Lloyds Register Quality Assurance) to ensure a completely controlled process from purchasing the coils until delivery of the final goods to our clients. Furthermore, we hold a certification to produce under the CE MARK and the German DIN 18800 – 7 (Grosser Eignungs Nachweis).

Being a certified mill for spirally welded steel pipes the following quality conditions are guaranteed:
- Internal procedures for production of spirally welded pipes, and implementation of them in the production process
- Conformity of our procedures to EN 10219 and API standards
- Methodology for testing and inspection in order to deliver quality products:
  • Purchase of base material with certificates of conformity as per the clients detail
  • Welding procedures and welders qualifications
  • Control on dimensioning
  • Visual inspection
  • Non-destructive inspection: the welds are 100% US tested
- Methodology for storage of end products
- Methodology for transport
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