2205 - Wet Corrosion Resistant Welded Stainless Tubular Products

Characteristics

2205 is a Molybdenum and Nitrogen alloyed duplex (austenitic-ferritic) stainless steel with low Carbon content.

Characteristic properties:

- High mechanical strength
- Good weldability
- Good corrosion resistance
- High resistance to Stress Corrosion Cracking (SCC)
- Good machinability
- Very good wear and abrasive resistance
- Low thermal expansion

Dimensions

2205 is manufactured in most common standard sizes within Outokumpu Stainless Tubular Products product range.

Pipe

OD: 17,2-1219 mm
Wall thickness: 1.0-25,4 mm
Lengths up to: 12 m

Pipe stock

ANSI NPS 2-4" Sch 10S, ASTM A790
ANSI NPS 6-18"
Sch 10S ASTM A928 cl 3

Heat exchanger tubes

OD: 18-51 mm
Wall thickness: 1.0-2.11 mm
Lengths up to: 14 m

Executions

Pipe

With or without filler metal
Not annealed but pickled
Solution annealed and pickled
With- or without cold worked weld
Bevelled ends according to standards

Heat exchanger tubes

Cold worked weld
Solution annealed and pickled

Corrosion resistance

Pitting corrosion tests according to ASTM G48 with requirements in line with ASTM A923 are made on request. For details see Outokumpu brochure about Duplex Stainless Steels, and Outokumpu Stainless Tubular Products brochure about Chloride resistant grades, or use our website.

Weld factor

The joint coefficient (z used in EN standards) or Basic quality factor (E_j, used in ASME standards) is used for calculation of the wall thickness for welded tubes. The type of welding process, amount and type of NDT decide the factor.

Ferrite content

Outokumpu Stainless Tubular Products aims at the following ranges in order to keep the mechanical properties and corrosion resistance within specified limits.

Base metal	35-65 %
Weld without filler metal	35-65 %
Weld with filler metal	25-60 %

The ferrite content is not a property, but a way to check that the welding and heat treatment have been properly done.
Small deviations may lead to an extra check of the material properties.The general opinion is that a too high ferrite content, i.e., > 70% decreases the toughness and pitting resistance, and a too low ferrite content, i.e., < 25% decreases the SCC-resistance.

Inspection standards

Europe

EN 10217-7 Welded SS tubes for pressure purposes.
EN 10296-2 Welded SS tubes for general purposes.
EN 10253-4: Butt-welding pipe fittings. Wrought austenitic and austenitic-ferritic (duplex) stainless steels with specific inspection requirements.
prEN 10253-3: Butt-welding pipe fittings. Wrought austenitic and austenitic-ferritic (duplex) stainless steels without specific inspection requirements.

USA

ASTM A 789 Welded and seamless F/A SS heat exchanger tubes.
ASTM A 790 Welded and seamless F/A SS pipe.
ASTM A 928 F/A SS pipe fusion welded with filler metal.
ASTM A 815 Wrought ferritic, duplex, martensitic stainless steel piping fittings.

Weld factor

Type of weld process and NDT	EN 13480-3		ASME B31		
	EN 10217-7	EN 10296-2	A 789	A 790	A 928
EFW, 100% ET	1.0	1.0*	0.8	0.8	0.8
EFW, 100% RT	1.0	1.0*	1.0	1.0	1.0
EFW, spot RT	n.a.	0.85*	n.a.	n.a.	0.9
EFW, double butt	n.a.	0.7	0.85	0.85	0.85
EFW, single butt	n.a.	0.7	0.8	0.8	n.a.

EFW= Electric Fusion Welded ET= Eddy Current Test RT= Radiographic Test * If manufactured and tested according to EN 10217-7

Chemical composition, %

Typical values

Outokumpu	EN	ASME/UNS	C	Cr	Ni	Mo	N	PRE*
LDX 2101®	1.4162	S32101	0.03	21.5	1.5	0.3	0.22	26
4301	1.4301	304	0.04	18.1	8.1	-	-	18
4401	1.4401	316	0.04	17.2	10.1	2.1	-	24
2304	1.4362	S32304	0.02	23	4.8	0.3	0.10	26
2205	1.4462	S31803	0.02	22	5.7	3.1	0.17	35
2507	1.4410	S32750	0.02	25	7	4	0.27	43

* PRE = %Cr + 3.3%Mo + 16%N (A ranking index against pitting corrision)

Pressure vessel approvals

Europe
The Pressure Equipment Directive PED regulates the use of welded SS pipe in most European countries. Outokumpu Stainless Tubular Products fulfils the Directive, and is an approved manufacturer of welded duplex stainless steel tubes and fittings.

USA
Pressure vessel regulations are authorized to ASME. ASME Section II, Part D Table 2A, shows design values for tube and pipe. ASME B31.1 Power Piping and ASME B31.3 Process Piping state design for approved pipe material.

Norway
NORSOK is a Norwegian standard that regulates the use of materials in some offshore applications. Outokumpu Stainless Tubular Products is an approved manufacturer of duplex UNS S31803 and UNS S32205 pipe and fittings based on NORSOK requirements.

Other approvals

NACE MR 0175-00 allows max hardness 28 HRC for UNS S31803.

Fabrication

Welding
Recommended welding methods for tubular products are GTAW, PAW and MMA. Filler metal of type Avesta 2205-PW, Sandvik 22.9.3LR or similar should be used. Welding without filler metal not followed by post weld heat treatment, will reduce the corrosion resistance of the weld and is therefore not recommended. The base of the shielding and welding gases should consist of pure Ar with additions of 2-3% Nitrogen in order to get optimal corrosion resistance.

Cold forming
Since the yield strength is about twice that of standard austenitic grades, a higher initial force is necessary in operations such as bending or expanding tubes into tube sheets. The spring back effect is also more pronounced.

Hot forming
2205 is like all duplex grades much softer at higher temperatures than austenitic standard grades. Forming at temperatures in the range 1000-1100°C does not require any post heat treatment, if the operation is followed by a reasonable fast cooling, (>500°C/min).

Heat treatment
1020-1100°C followed by rapid cooling to at least 700°C. At temperatures between 900-800°C, intermetallic phases that impair the properties will form within 5-10 minutes.

Applications

- Chloride containing environments
- Heat exchanger tubes
- Oil and gas pipe
- Pipe systems within
  - Pulp & Paper
  - Chemical and Petrochemical
  - Chemical tankers

Design

The allowable design values are about twice those for standard austenitic steels. This means that the possibility of designing thinner walls can save cost.

Design

Temp	EN 10217-7 min $R_{p0.2}$	EN 10217-7 Design stress (EN 13480-3 see 5.2.1-1)	ASME Temperature		B31.3 -2006	
°C	Mpa	Mpa	°F	°C	ksi	Mpa
50	415	277	100	38	30.0	207
100	360	240	200	93	30.0	207
150	335	223	300	149	28.9	199
200	310	207	400	204	27.9	192
280	295	197	500	260	27.2	188
			600	316	26.9	186

	Minimum average absorbed energy KV (EN 10217-7) J	
Temperature °C	-40	+20
Base metal	40	90

Mechanical properties (At Ambient temperature)

	Min values acc. to EN 10088									ASTM min values		
	$R_{p0.2}$, MPa			R_m, MPa			A_{80} %			$R_{p0.2}$, MPa	R_m, MPa	A_5 %
Outokumpu	P	H	C	P	H	C	P	H	C			
LDX 2101®	450	480	530*	650	680	700*	30	30	30*	530 (t≤6.35)/ 450 (>6.35)	700 (t≤6.35)/ 650 (>6.35)	30
4301	210	210	230	520	520	540	45	45	45	205	515	40
4401	220	220	240	520	530	530	45	40	40	205	515	40
2304	400	400	450	630	650	650	25	20	20	400	600	25
2205	460	460	500	640	700	700	25	25	20	450	655	25
2507	530	530	550	730	750	750	20	20	20	550	795	15

* LDX 2101® not yet included in EN10088 P = Hot rolled plate H= Hot rolled strip C= Cold rolled coil and strip

Physical properties

Outokumpu	Density, g/cm³	Modulus of elasticity, GPa	Poisson´s ratio $\nu = -\varepsilon_{trans}/\varepsilon_{longitudinal}$	Average linear expansion at RT - 100 °C x10⁻⁶/ °C
LDX 2101®	7.8	200	0.3	13.0
4301	7.9	200	0.3	16.0
4401	8.0	200	0.3	16.0
2304	7.8	200	0.3	13.0
2205	7.8	200	0.3	13.0
2507	7.8	200	0.3	13.0

Outokumpu is a global leader in stainless steel. Our vision is to be the undisputed number one in stainless, with success based on operational excellence. Customers in a wide range of industries use our stainless steel and services worldwide. Being fully recyclable, maintenance-free, as well as very strong and durable material, stainless steel is one of the key building blocks for sustainable future.

What makes Outokumpu special is total customer focus – all the way, from R&D to delivery. You have the idea. We offer the world's best stainless steel, technical know-how and support. We activate your ideas.

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www.outokumpu.com

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