

# LDX 2101<sup>®</sup> Comparative for Construction

## LDX 2101<sup>®</sup> Summary/Overview

Outokumpu	EN	UNS
LDX 2101 <sup>®</sup>	1.4162	S32101

For civil engineering and construction projects, the use of standard grades of stainless steel had their attractions: superb corrosion resistance and low maintenance and life-cycle costs. But the price volatility of the high nickel content of standard stainless steel grades often made them prohibitively expensive.

To address this, Outokumpu introduced a new grade: lean duplex LDX 2101<sup>®</sup>, which contains one-fifth the nickel content (1.5% nickel) as that of ASTM 316L, but with nearly twice the strength and comparable pitting corrosion resistance — at a lower cost. LDX 2101<sup>®</sup> is also an equally

strong grade as 2205, with more than sufficient corrosion resistance in the annealed and pickled condition and also at a lower cost, containing one-third the nickel of 2205 — making LDX 2101<sup>®</sup> a practical and economical choice for rebar.

## Using LDX 2101<sup>®</sup> as Stainless Steel Reinforcement Bar

For the first time, LDX 2101<sup>®</sup> is being used as concrete reinforcing bar — on the Gateway Bridge in Queensland, Australia. LDX 2101<sup>®</sup> is specified for the most crucial bridge structures: the splash zones of the main river pylons. Outokumpu's in-house research metallurgists made extensive corrosion tests on LDX 2101<sup>®</sup> rebar in the event that concrete is permeated by seawater reported in 2005 NACE paper number 05260. (See fig. 1.) The results proved that LDX 2101<sup>®</sup> withstands such a high-corrosion environment. For additional proof, a trial rebar coil was sent to Atlas Specialty Metals in Melbourne, Australia for further processing to confirm that LDX 2101<sup>®</sup> in coil could be easily straightened. As a result of the research and tests, the Gateway Bridge is now under construction with LDX 2101<sup>®</sup> rebar.

## Properties of LDX 2101<sup>®</sup>

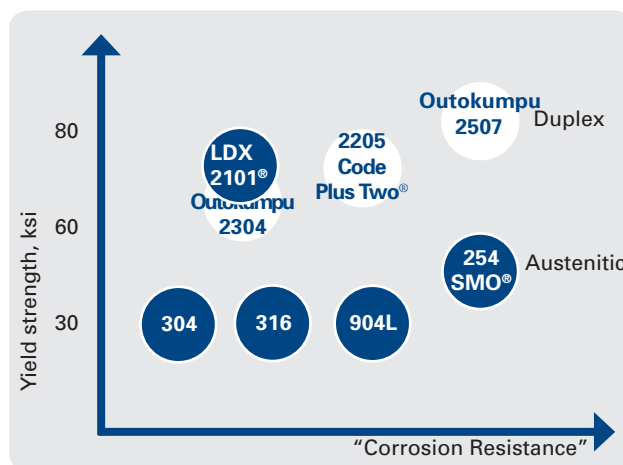


Table 1

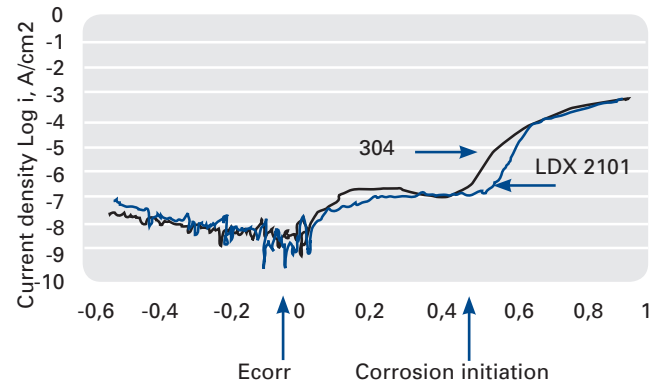
Steel Grade	Typical composition, %							Microstructure
	Cr	Ni	Mo	C	N	MN	PREN*	
304	18.1	8.3	—	0.04	—	—	18	Austenitic
316	17.2	10.2	2.1	0.04	—	—	24	Austenitic
<b>LDX 2101<sup>®</sup></b>	<b>21.5</b>	<b>1.5</b>	<b>0.3</b>	<b>0.03</b>	<b>0.22</b>	<b>5</b>	<b>26</b>	<b>Lean Duplex</b>
Outokumpu 2304	23	4.8	0.3	0.02	0.10	—	26	Lean Duplex
2205 Code Plus Two <sup>®</sup>	22	5.7	3.1	0.02	0.17	—	35	Duplex
Outokumpu 2507	25	7	4	0.02	0.27	—	42	Super Duplex

\*PREN= %Cr+3.3x%Mo+16x%N

**Materials - Mechanical Properties**

**Table 2**

Steel Grade ASTM	ASTM, min values		
	Yield, ksi	Tensile, ksi	Elongation [%]
304L	30	75	40
316L	25	70	40
LDX 2101®	≥3/16"	65	94
	<3/16"	77	101
Outokumpu 2304	58	87	25
2205 Code Plus Two®	65	95	25
Outokumpu 2507	80	116	15

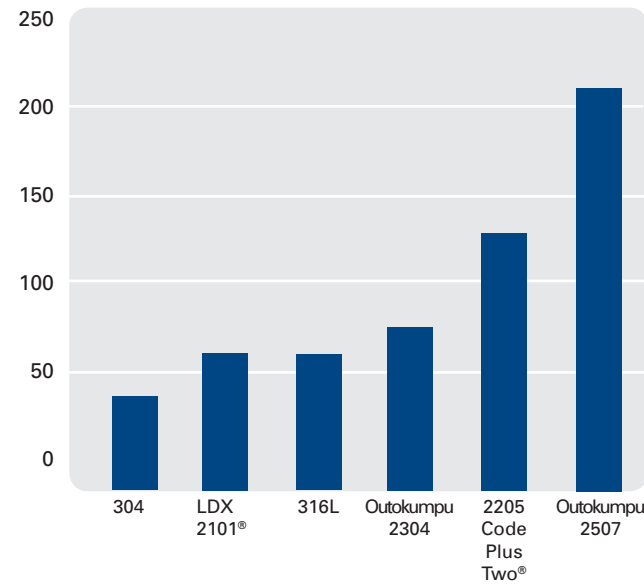


**Fig. 1** Polarization measurements of rebars in a pore solution containing 42g/L Cl<sup>-</sup>. Reference NACE paper number 05260

**Stainless Performance Advantages of LDX 2101® Reinforcement Bar**

- Excellent corrosion resistance ensuring maximum durability
- Reduced maintenance and unscheduled repairs
- Reduced concrete cover and greater crack widths allowed
- Eliminates the need for expensive bridge deck surface treatments
- LDX 2101® has ductility and strength superior to carbon steel
- All the above result in reduced total life-cycle costs
- Can be connected to carbon steel without risk of galvanic corrosion

CPT, [°F]



**Fig. 2** Typical CPT values in 1M NaCl for tested stainless steels tested in ground conditions according to ASTM G150.

**Fatigue**

The high tensile strength of duplex steels also implies high fatigue strength. Table 3 shows the result of pulsating tensile fatigue tests (R=0.1) in air at room temperature. The fatigue strength has been evaluated at 2 million cycles and probability of rupture is 50%. Since the test was made using round polished test bars from hot rolled plate, correction factors for surface roughness, notches, welds, etc. are required in accordance with classical theory relating to fatigue failure. As shown by the table, the fatigue strength of the duplex steels corresponds approximately to the yield strength of the material.

**Contact Us**

For more information on LDX 2101 reinforcement bar or Outokumpu's other grades of stainless reinforcement bar, please go to our web site, [www.outokumpu.com/stainless/na](http://www.outokumpu.com/stainless/na), or call 888-458-4600.

**Fatigue, pulsative test**

**Table 3**

Minimum value	LDX 2101®		2205 Code Plus Two®		316L	
	MPa	KSI	MPa	KSI	MPa	KSI
Yield Strength 0.2%	478	69	497	72	280	40
Tensile Strength	696	100	767	111	578	83
Fatigue Strength	500	72	510	73	360	52

Standard deviation of fatigue strength, for the entire population ~ 30 MPa/5 KSI

**Uniform Corrosion Results**

**Table 4**

Test solution	Conc, wt%	Critical temperature °F (°C)		
		316L	304	S32101
<b>Hydrochloric Acid</b>				
HCl	0.2	>bp	>bp	>bp
HCl	1.0	86(30)	86(30)p	140(55)
HCl+FeCl <sub>3</sub>	1.0HCl + 0.3FECl <sub>3</sub>	25p	20p	20
<b>Sulfuric Acid</b>				
H <sub>2</sub> SO <sub>4</sub>	10	122(50)	N.T.	167(75)
	60	<59(<15)	N.T.	<86(<30)
	96.4	113(45)	N.T.	86(30)
<b>Phosphoric Acid</b>				
H <sub>3</sub> PO <sub>4</sub>	85	203(95)	176(80)	214(100)
<b>Nitric Acid</b>				
HNO <sub>3</sub>	10	>bp	>bp	>bp
	65	214(100)	214(100)	221(105)
<b>Organic Acids</b>				
Acetic acid CH <sub>3</sub> COOH	80	>bp	214(100)	>bp
Acetic acid+ acetic anhydride CH <sub>3</sub> COOH+ (CH <sub>3</sub> CO) <sub>2</sub> O	50+50	248(120)	<bp	221(105)
Formic acid HCOOH	50	104(40)	<50(<10)	203(95)
<b>Sodium Hydroxide</b>				
NaOH	50	194(90)	185(85)	185(85)

N.T.= Not Tested      bp.= Boiling Point      p.= Pitting Corrosion

For further information concerning corrosion in other media, contact your local Outokumpu Sales Representative.

# Working towards forever.

We work with our customers and partners to create long lasting solutions for the tools of modern life and the world's most critical problems: clean energy, clean water and efficient infrastructure. Because we believe in a world that lasts forever.

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