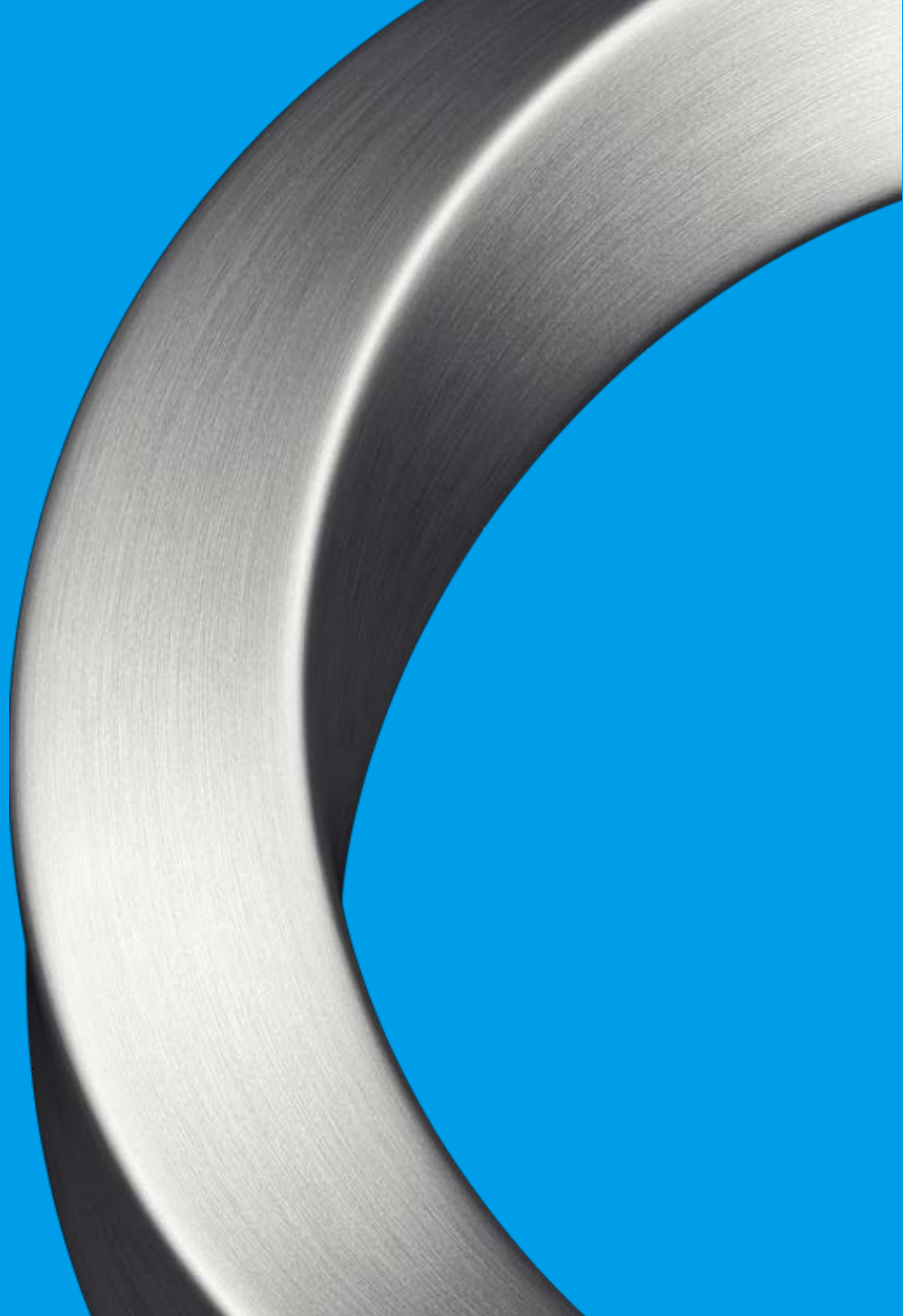
Material Selection

Andrew Backhouse
Technical Manager
Outokumpu Stainless, Sheffield

outokumpu



Material Selection

1. Some strategies & tools for selecting stainless steel grades

2. What's right and what's wrong with 304L & 316L ?

3. Some (newer) alternatives to the common stainless steel grades:-

    Cost effective alternatives to 304L & 316L

    Duplex stainless steels

outokumpu

Versatile Stainless

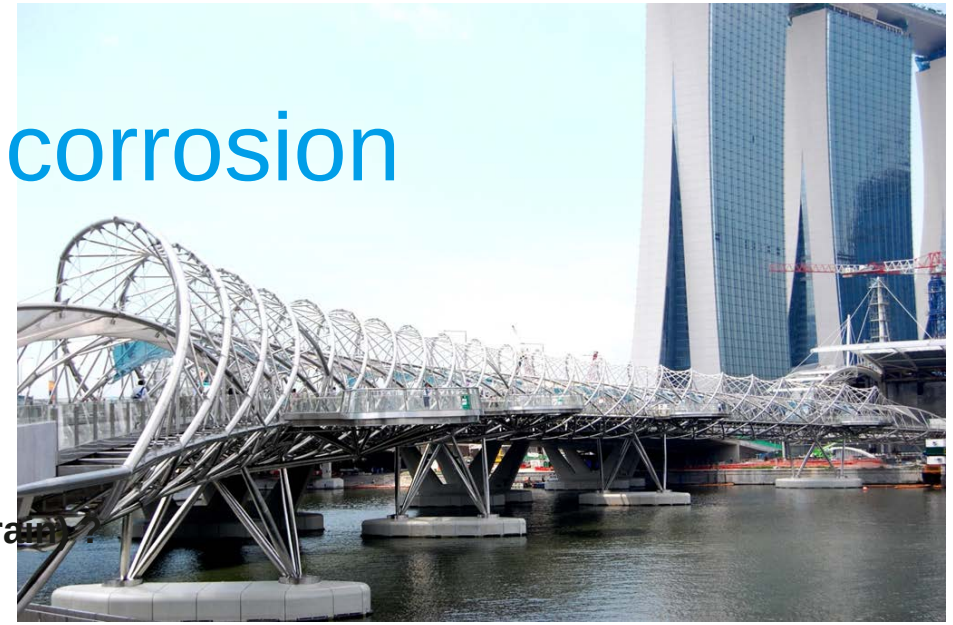
.....sometimes under extreme conditions.....

Familiar.....

And at the coldest place on Earth.....

Hospital MRI full body scanner, operates continuously for 10 years at minus 267°C

Stainless steel fights corrosion



Real environments often complex

Inside a building or external?

Where in the world? Near the coast?
Sheltered or exposed to the atmosphere (any ra
Near a road? (Any winter de-icing salt?)

Process Plant :
Operating conditions & practices
What chemicals, including “water”?
Concentration & temperature? Fluctuations? Injection poi
Condensation? Very hot (furnaces?) Very cold (cryogenic
Conditions during down time – planned/unplanned

Cleaning frequency, chemicals used and practices

Material Selection: A pre-emptive strike against a corrosion failure

outokumpu

What is Failure? It depends…..

outokumpu

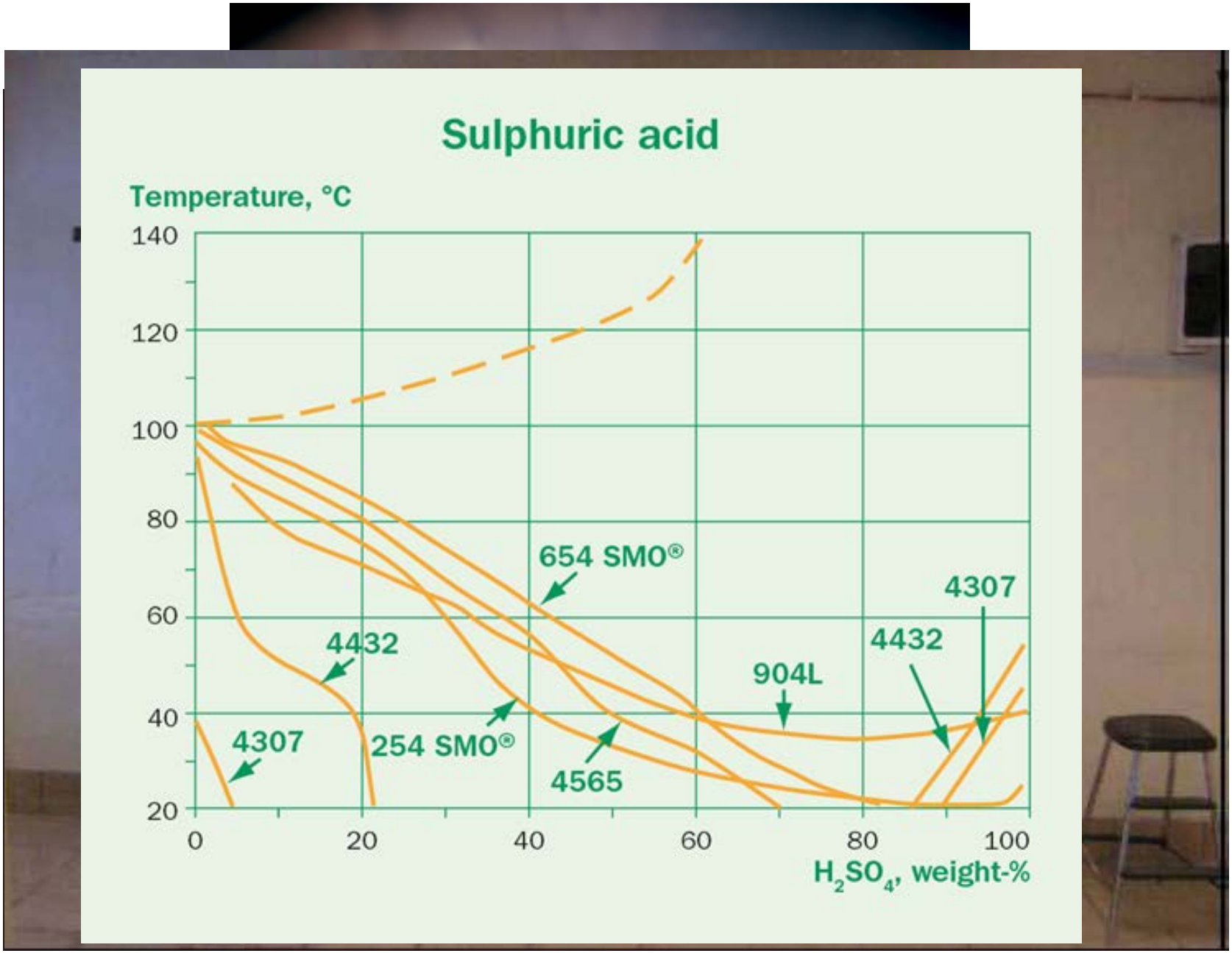
Stainless steel fights corrosion

Real environments are often complicated.

USE:

1. Direct experience of stainless steels used in the actual, or similar, installations
2. Long-term in–situ testing of samples of different grades
3. Results of lab tests performed in similar liquors to the actual use.
4. Short-term accelerated standard laboratory tests to rank different grades

outokumpu


Sulphuric acid
Temperature, °C
140
120
100
80
60
40
20
0
20
40
60
80
100
H_2SO_4, weight-%
654 SMO®
4307
4432
904L
4432
4307
254 SMO®
4565

Public information for Material Selection

- www.outokumpu.com
  - ISO-corrosion diagrams for st/steels in contact with different chemicals
  - Case studies
- www.imoa.info/molybdenum-uses/molybdenum-grade-stainless-steels/architecture/stainless-steel-selection-system.php
  - IMOA (International Molybdenum Association)
  - Free material selection software/tool for external environments
- www.stainlessconstruction.com (st/steels in the built environemnt, SCI)
- www.bssa.org.uk
  - Short technical articles and links to longer publications
- www.euro-inox.org and www.worldstainless.org
  - brochures and case studies

Materials Selection - Not only about corrosion resistance

- Most common attributes required :
  - Corrosion Performance
  - Mechanical Performance
    - strength, toughness…
- Often…..
  - Ease of fabrication – ductility, formability, weldability
  - Surface appearance (hygiene / aesthetics)
- Sometimes…..
  - Physical properties - magnetic, conductivity, thermal expansion coefficient
  - …….,cryogenic properties
  - ……high temperature oxidation, microstructural stability, creep..
- Competitive final product
  - Functionality at lowest overall cost
  - Availability of materials

outokumpu

What's wrong with using 304L & 316L ?

- The most widely used stainless steels for good reasons:
  - Readily available
  - Wide range of surface finishes
  - Properties well characterized and understood
  - Sufficient corrosion resistance in moderately aggressive environments
  - Highly formable, tight bends and deep pressings possible
  - Easily welded
  - Useful at wide temperature range from cryogenic to elevated temperature service

Downsides:

- Poor resistance to stress corrosion cracking (>50°C in chloride environments)
- Insufficient corrosion resistance in very aggressive environments
- Relatively low strength, soft steels in the common supply conditions (2B, 1D)
- High cost & fluctuating cost mainly due to 8 – 10% nickel content

outokumpu

Minimise Cost

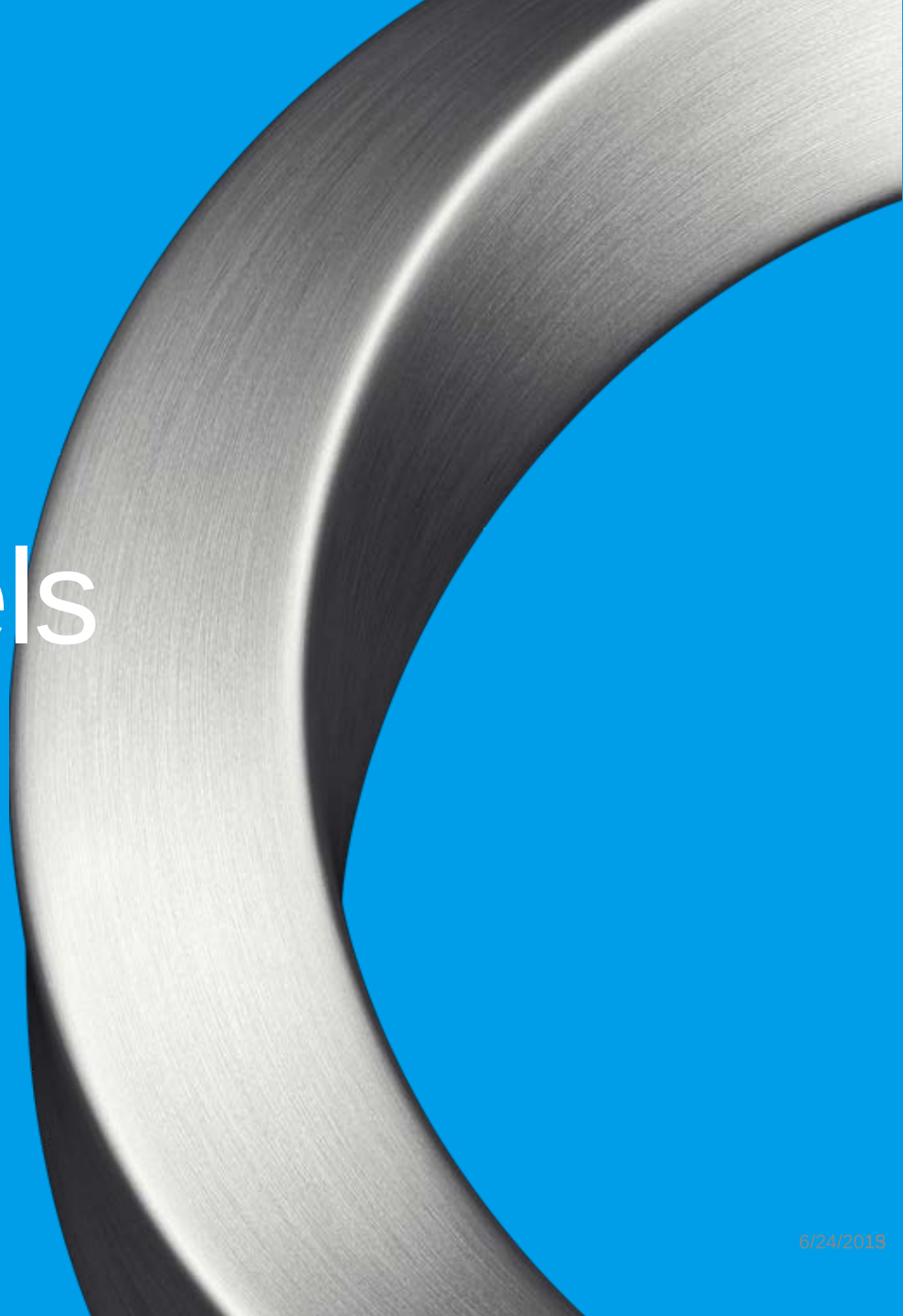
Different strategies:

- Use higher strength material to reduce thickness and lower material usage
- Reduce plate thickness and reduce number of welding passes (and reduce quantity of welding wire required)
- Look for lowest overall alloy content, consistent with achieving the level of corrosion resistance and other performance characteristics required

Some newer & alternative material selections to the common stainless steels

outokumpu

The Duplex Stainless Steels



outokumpu

Why Duplex? Duplex?

High Strength - use thinner section plate, save cost

Good to excellent corrosion resistance

Excellent resistance to Stress Corrosion Cracking

Readily weldable in all section sizes

More stable price

Why Not

Unsuitable for cryogenic use

Unsuitable for service above approx 300°C

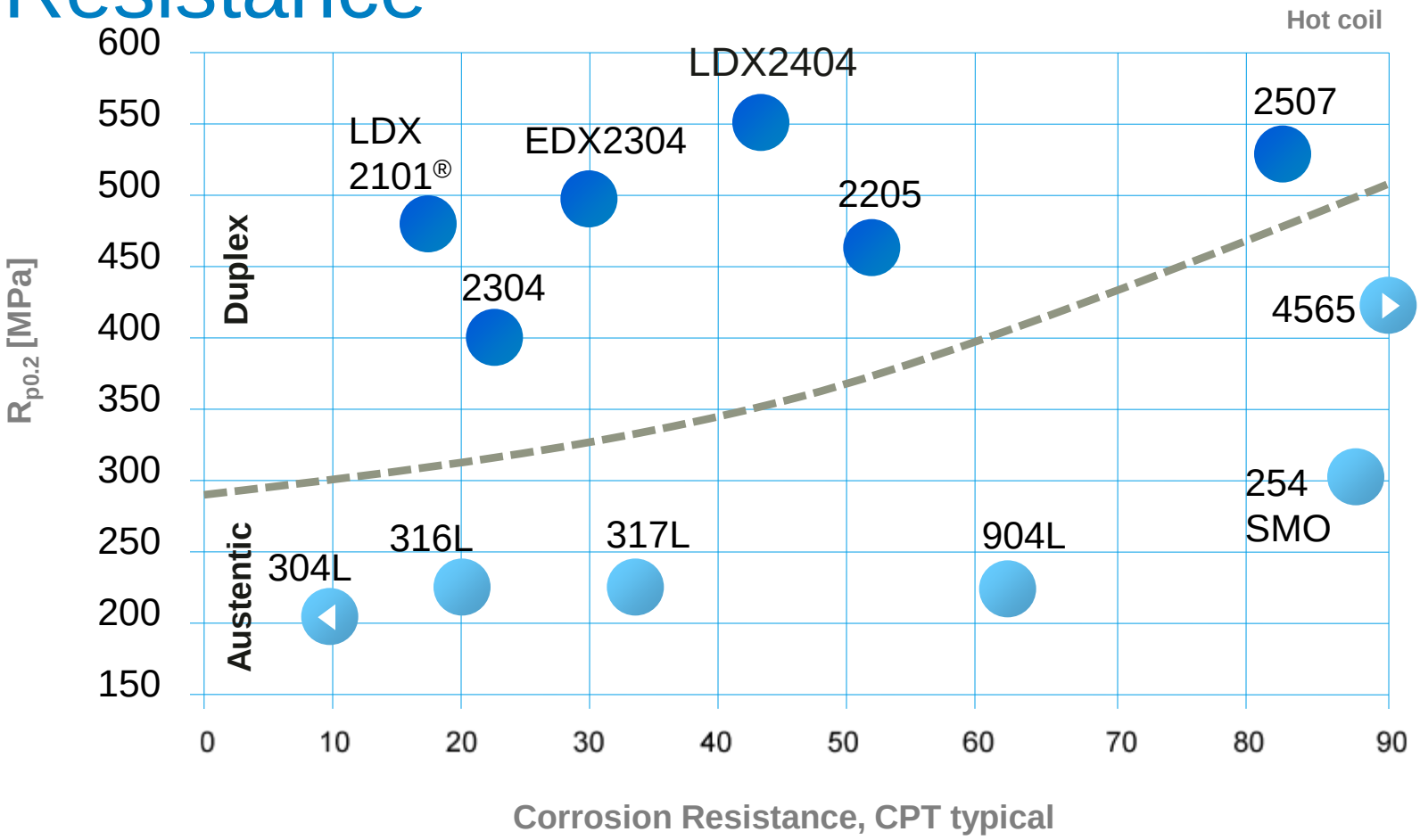
Reduced stretch-formability (cf 304, 316)

High strength means more power required to bend (for given thickness)

Fewer surface finishes available, less widely stocked

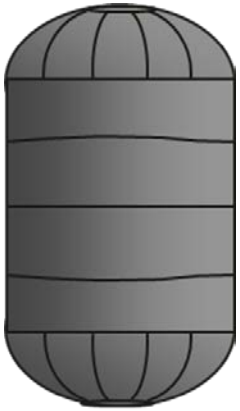
outokumpu

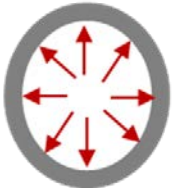
Positioning of Duplex and Austenitic grades Strength vs Corrosion Resistance



outokumpu

Duplex Stainless





outokumpu

Alternative to 304L:

1.4622

1.4622 - Alternative to 304L?

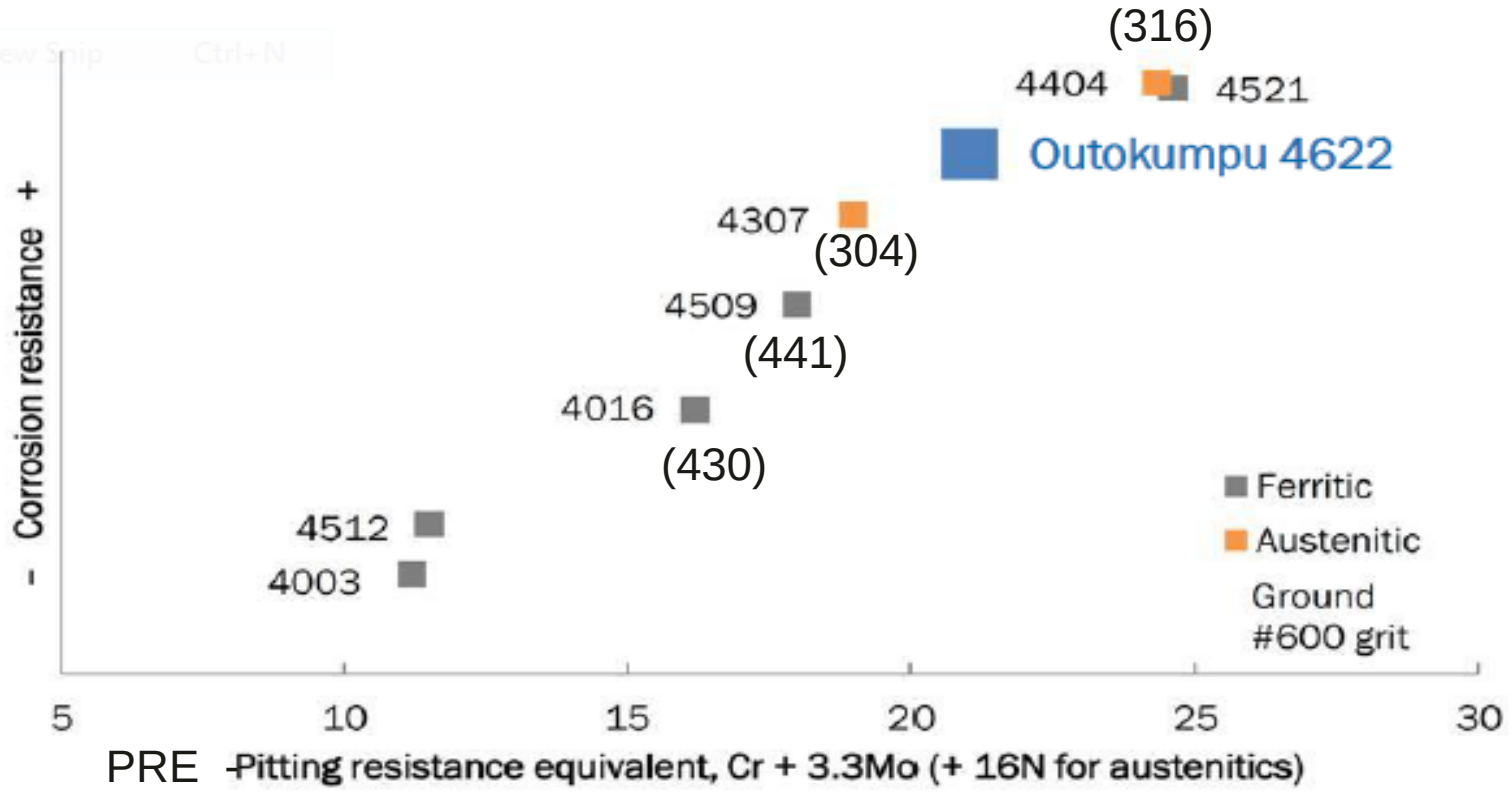
Common Name	EN	ASTM/UNS	C	N	Cr	Ni	Mo	Other
4622	**1.4622**	**S44330**	**0.02**		**21**			**Ti, Nb, Cu**
304L	1.4307	304L	0.02		18.1	8.1		
316L	1.4404	316L	0.02		17.1	10.1	2.1	

Pitting Resistance Equivalent = %Cr + 3.3x%Mo + 16x%Nitrogen

1.4622 not yet listed in EN10088

outokumpu

Pitting Corrosion Resistance



outokumpu

Pitting potential, 0.2M NaCl

Cyclic Salt Spray Test

- Same Test Cabinet, aggressive test using cyclic wet/dry salt spray conditions

4622 before test

4622 after 7 days

Typical 304L after 7 days

outokumpu

1.4622 ferritic stainless steel

Why Use 1.4622 ?

Significantly lower cost

Weldability good up to approx 3 - 4 mm thick sheet

Very good deep drawability,

Similar bending ability to S355 carbon steel.

Example applications:

Catering equipment, tables, shelves, panels for enclosures, cupboards, doors etc

“light fabrications”

Why not use 1.4622, stick with 304L ?

Risk of weld embrittlement above around 4mm thick

Unsuitable for cryogenic applications

Embrittlement at approx 475 °C in service

Lower stretching ability

Magnetic

New steel, not widely stocked.

Not yet formally adopted in EN standards; available in ASTM A240

outokumpu

1.4622 application example

RESPETRA rescue chamber by HEAT-IT Oy saves lives in several mines and underground building sites in Europe

outokumpu

Indication of Alloy Surcharge – price stability

outokumpu

Monthly Alloy Surcharges for Flat products

2015

Steel designations GBP Currency / tonne

Outokumpu	EN	ASTM	Jan.	Feb.	Mar.	Apr.	May
Core							
Core 4622	1.4622		561	564	544	532	551
Core 304L/4307	1.4307	304L	1050	1007	990	954	926

Lower overall cost of 1.4622 with better price stability

Note: Base price of 1.4622 slightly higher than 304L

outokumpu

316plus / 1.4420

An new alternative to 316L

outokumpu

316plus /1.4420 Typical Composition & Mechanical Properties

Name	EN	Carbon	Nitrogen	Cr	Ni	Mo
316plus	**1.4420**	**0.02**	**0.2**	**20.3**	**8.6**	**0.7**
316L	1.4404	0.02		17.1	10.1	2.1
304L	1.4307	0.02		18.1	8.1	

Name	EN	Rp 0.2 Mpa	Rm MPa	Elongation A80%
316plus	**1.4420**	**385**	**725**	**43**
316L	1.4404	290	600	53
304L	1.4307	285	620	55

outokumpu

1.4420 not yet listed in EN10088

Cyclic Salt Spray Test

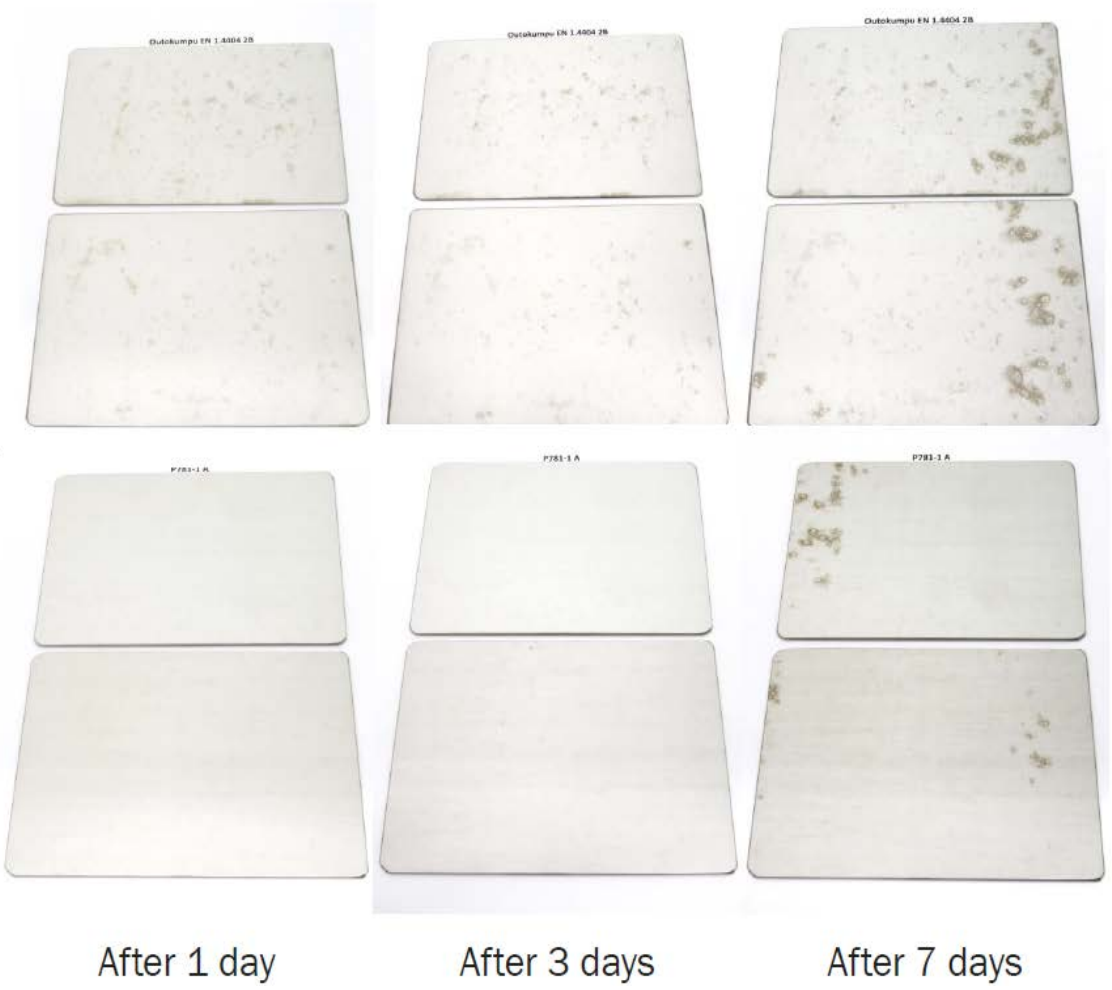
316L

Austenitic
1.4404
17Cr 10Ni 2Mo
2B finish

316plus

Austenitic
EN 1.4420
X2CrNiMoN20-8-1
2B finish

Test conditions:
5% NaCl, 5 min spraying
55 min drying at 35 °C,
humidity 70 %



After 1 day | After 3 days | After 7 days

1.4420 316plus austenitic stainless steel

Why Use 1.4420 316plus ?

Lower cost

Weldability good at all thicknesses, similar to 316L

Slightly Higher strength – possibility to reduce thickness

Similar or slightly better corrosion resistance to 316L

Example applications:

Most current uses of 316L

Why not use 1.4420 316plus, stick with 316L ?

Slightly higher bending forces needed

Slightly reduced stretchforming , ability

New steel, produced to order, not widely stocked.

Not yet formally adopted in EN standards; available in ASTM A240

outokumpu

1.4420 / 316^{plus} applications

outokumpu

316L vs 1.4420 Alloy Surcharges

outokumpu

Monthly Alloy Surcharges for Flat products

2015

Steel designations GBP Currency / tonne

Outokumpu	EN	ASTM	Jan.	Feb.	Mar.	Apr.	May
Supra							
Supra 316L/4404	1.4404	316L	1526	1474	1439	1371	1347
Supra 316plus	1.4420		1298	1246	1224	1178	1150

- Fabrication:
  - Similar to 316L
  - 316^{plus} slightly higher strength & slightly lower ductility
  - Similar welding parameters

- **Product Range Sheet & Coil & Plate**
- **Up to 1500mm wide**
- **Thickness**
  - **Hot rolled 3.5 – 8mm**
  - **Cold Rolled 0.7 – 5mm**

outokumpu

Summary

- Material selection involves thinking about a wide range of technical properties, as well as practical aspects such as cost and availability.
  - Short term lab testing can help with some aspects of material selection, but..
  - Long term experience/long term tests are the best assessment method

- 304L & 316L are widely used for good reasons

- For specific applications there can be significant advantages to alternative steels

outokumpu

Contact Details

Andrew Backhouse

Technical Manager

Outokumpu Stainless Ltd, Sheffield

0114 2613879

Andy.backhouse@outokumpu.com

outokumpu