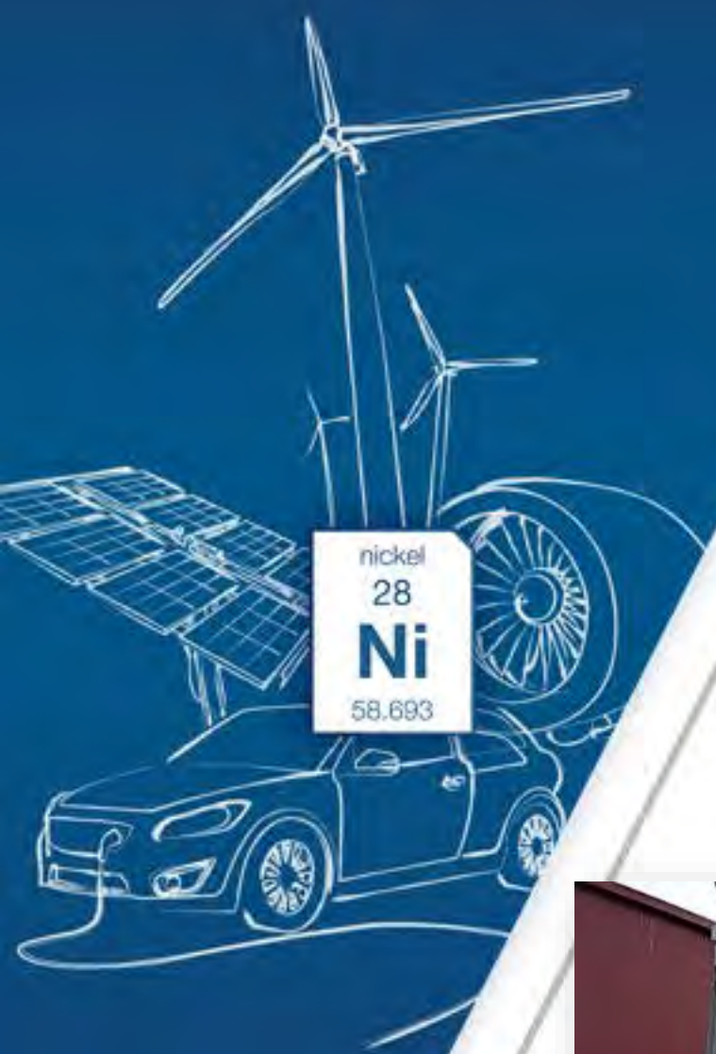

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knowledge for a brighter future

Guidelines and Application of Stainless Steels in Water and Wastewater Treatment Environments

Presenter Carol Powell
Southern Water, July 2018

Reasons for choosing stainless steel

- Low corrosion rates

Opus International Consultants

- No coating required
- Does not contaminate water

Reasons for choosing stainless steel

- Strong and ductile
- Ease of fabrication
- Lightweight and easy to transport

Opus International Consultants

Light weight air line

Design modifications easily implemented on site.

And mistakes fixed

Opus International Consultants

Complex shapes-versatile

Opus International Consultants

Reasons for choosing stainless steel

- Withstands high flow rate
- Low life cycle costs
- Recyclable

Opus International Consultants

Issues

- Selecting right grade for the environment
- Design to avoid localised corrosion
- Correct fabrication practices
- Avoid galvanic corrosion on dissimilar metals

Opus International Consultants

In the atmosphere..

- Rural areas-304L
- Coastal areas-316L
- Occasional wash down to remove deposits

- Areas where chlorine vapours collect
- Wash down or vent
- Higher grade

Plant fixtures

Ladders and fixings

Walkways

Water handling systems

Selecting the correct grade of stainless steel - the important parameters are:

- chloride level
- chemicals used in treatment
- pH
- flow rate of water
- presence of oxidant
- Hydrogen sulphide

Water Treatment and Distribution

Property	Treatment Plant	Distribution System
Turbidity	Particulates	Clean
pH	6-8.5	7-8.5
Oxygen	Low to saturated	Saturated
Oxidants	O_3,Cl_2,ClO_2, $KMnO_4$	Low oxidant residual
Fe+Mn	precipitated	Very low
Chemicals	e.g.$FeSO_4$,$FeCl_3$	None

Grade selection guidelines for immersed conditions

Chloride content of the water is most important parameter

Practical experience and tests show crevice corrosion is unlikely at pH > 6 and ambient temperature when:

Chloride level	Suitable grades
<200 ppm	304L
< 1000 ppm	316L
<3600 ppm	duplex 2205,
>3600 ppm and seawater	6% Mo superaustenitic, 25%Cr superduplex

Aeration Piping-UK

Stainless steels are very suitable for these conditions

Slide Gates

316 stainless steel

316Ti Pipework in Water Works, Germany

Lightweight

Welded and flanged construction

Connections

- If flanged joints are used, ensure gaskets are:
- Non-porous
- Chloride-free
- Do not contain graphite

- If joints are welded:
- Cleanliness is most important – no oil, grease, dirt
- GTAW (TIG) is preferred
- Use an argon shield
- Ensure full weld penetration – no crevices
- Inert gas purge in the bore
- to minimise heat tint
- Remove external heat tint
- – pickle or polish

Flow rates

- Preferred minimum velocities to avoid sediment build up:
-Clean water greater than 0.5m/s
-Dirtier waters greater than 1m/s
- Avoid dead legs
- Slope pipes
- Can withstand flow rates of 40m/s

Piping gallery in water treatment plant, New Zealand

Hydrotesting Guidelines

*Remove weld heat tint

*Use clean treated water e.g potable water

*Avoid prolonged, stagnant conditions after testing

*Drain away water after testing, keep circulating or put straight into service

304L *MIEX* plant removes dissolved organic carbon (DOC) from raw water

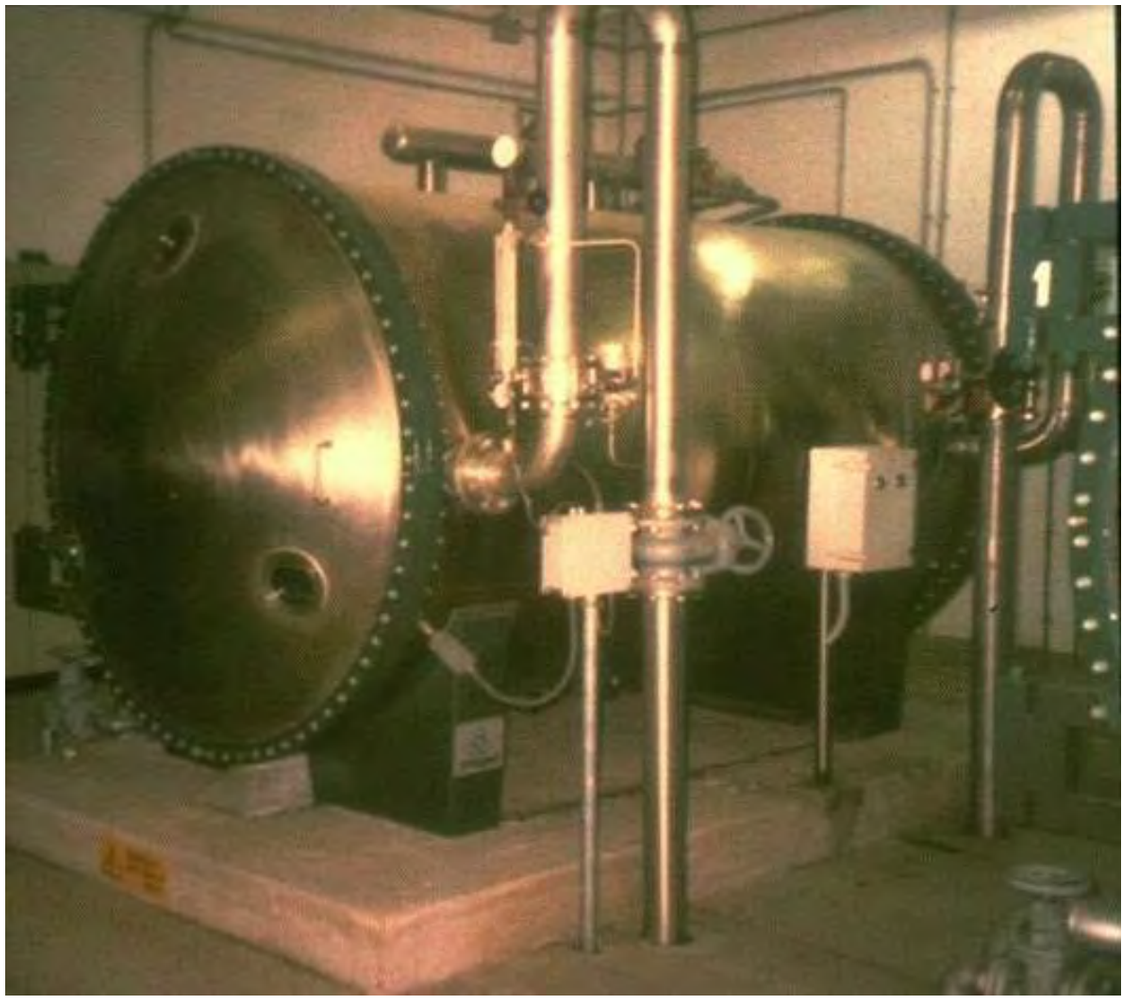
Granulated Activated Carbon Tanks

Italy

Oxidants

Examples:-

Chlorine, ozone, chlorine dioxide, potassium permanganate



Ozone Generator

316L Chlorine/Ozone Mixing Towers-USA

Chlorine Guidelines
(not to be confused with chloride!)

- 304L suitable for chlorine levels up to 2ppm
- 316L suitable for chlorine levels up to 5ppm
- Short term dosing, say 25ppm, for sterilisation purposes of 24 hours acceptable if effectively flushed through afterwards.

Chlorine

Care required to avoid concentration effects:-

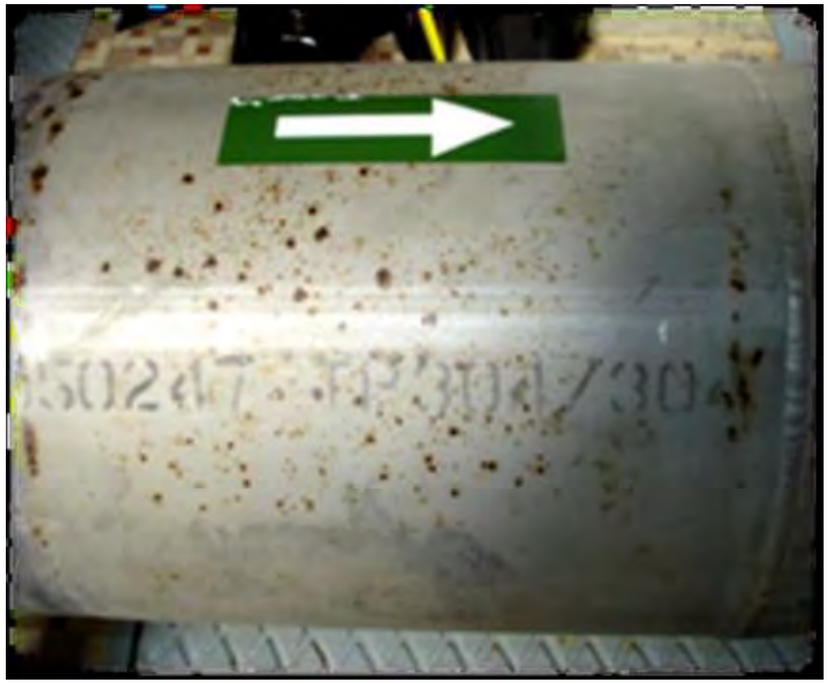
- Injection areas
- Excessive Dosing
- Chlorine Vapours

Buildup of chlorides over time on the wall of a tank in the vapour space

Chloride Cl^- concentration

Results of a Japanese study

Corrosion due to chlorine vapour in confined space



Surface pitting corrosion on pipe carrying cold water

Avoided by venting or regular wash downs or higher grade alloy

Desalination

- Stainless steel is used extensively in both reverse osmosis and thermal processes

High pressure piping in RO plant, frequently 6% Mo stainless steel

Singapore

Thames Gateway Water Treatment Works

Lamella clarifier filters supported by 78 Duplex 2205 supporting beams

Design led to weight saving and ease of transport

Wastewater treatment plant applications

Screens
Grit removers
Scrapers
Slide gates
Aeration piping
Pumps and valves
Sludge transfer piping
Tanks
Digester gas piping
Weirs
Ozone generators and piping
Ultraviolet equipment
Chemical treatment lines
Ducting
Backwash systems
Distributors

North Shore Waste Water Treatment Plant
Auckland, New Zealand

Careful Handling

H Butting, Germany

Large longitudinally welded pipes for sewage plant in Greece

Good fabrication improves long term performance

Ex CDA La Rochelle.

Pipe systems after assembly in a WWT plant.

Lack of heat tint removal

Immersed Conditions
Which stainless….?

- Main grades used are 304L and 316L
- Grade primarily defined by chloride level of effluent- similar to water treatment guidelines

Duplex 2205 Biogas transfer piping at waste water treatment plant in New Zealand

Settlement Tank, New Zealand

Ex L. Boulton NewZealand

Screens

Type 304 Multi-rake Bar Screens-Meadowhead STW Scotland

ex Hans Huber , Germany

Shipped in sections and reassembled on site through roof of building

Microstrainers

ex Hans Huber, Germany

Used for the removal of finely suspended solids from the secondary clarifiers effluent

Piping:External Environment

- Open atmosphere
- Moist environment with hydrogen sulphide
- Activated sludge with chlorides, sulphates and other chemicals

Piping:Internal Environments

- Warm air and moisture
- Moist digester gases
- Sludge with chlorides, sulphates, hydrogen sulphide and other gases

BAFF reactor cell pipework. Upper manifold-process air (2205)
Lower manifold- air scour (2205). 4 lower pipes are the inlets 316. Unconnected vertical lines are recycle lines-all 316

Aeration

304 stainless steel piping
after cleaning out basin, USA

Ex Centrolnox

Two stainless steel containers
with aeration tanks.

Transfer piping

Germany

Italy

Piping system below sand filter basins in sewage treatment plant in Sweden

Ex Outokumpu

Thickened sludge 30% discharge line, 60 bar rating

Flow rates

- Preferred velocities to avoid sediment build up:

-Clean water greater than 0.5m/s

-Dirtier waters greater than 1m/s

-Wet sludges greater than 0.6m/s

- Avoid dead legs
- Access points for flushing out
- Slope pipes

Ease of Assembly

Skid-mounted stainless steel pipework assembly

Stainless steel pipework in package plant

Membrane Boxes

ex CentroInox, Milan

Hydrogen sulphide….

- Moist hydrogen sulphide generally has minimal effect on stainless steels
- If in closed systems, moist hydrogen sulphide, chlorides and high temperatures, or sulphurous acid formed- alloy 2205
  or 904L (25Ni-20Cr-4.5Mo-Cu)

Digester Dome-Italy

Economic benefit - Life Cycle Costing (LCC)

Odour control ducting

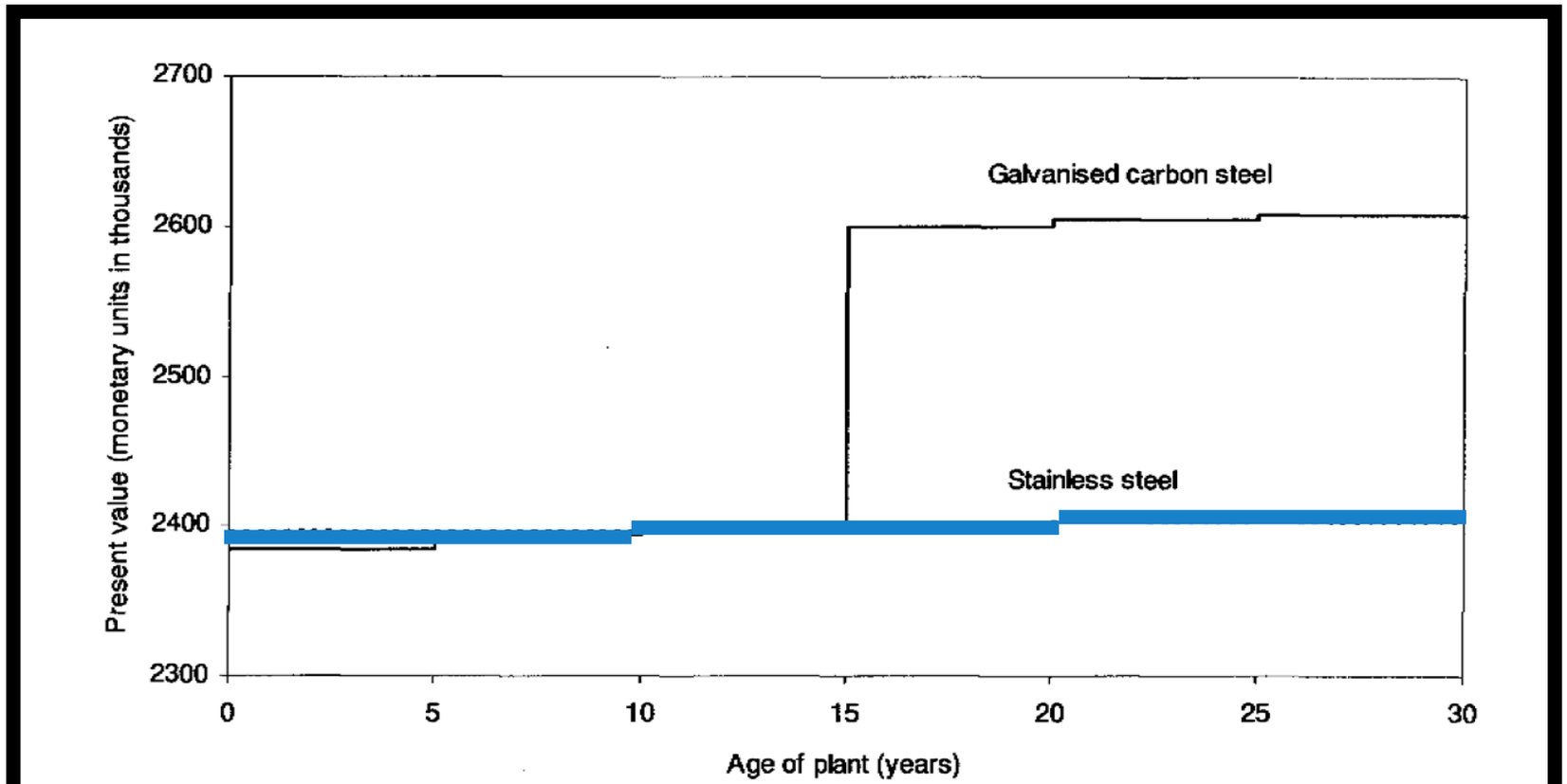


Figure 7 *Life cycle cost comparison for ductwork to remove odorous fumes in a sewage inlet works*

Ultraviolet Treatment of Wastewater

The upper structure is in 304L and the wetted surfaces are 316L

Ex Trojan, USA

Couplings and clamps

Stainless steel is widely used for couplings, tapping sleeves, spacers and restraining and repair clamps

Soils

Corrosion unlikely if :

- pH>4.5
- Resistivity >2000 ohm.cm
- Good drainage and clean backfill

If risk of corrosion:

- Upgrade alloy
- Wrap, encasement or cathodic protection

Manufacturer of Flexible and Jack pipe couplings

Coupling Type	Soil Conditions			
	Inland	Coastal		
		Non-Tidal zone	Tidal Zone	Extremely Aggressive
	Cl^- <1000ppm	Cl^- <2000ppm		
Jacking Pipe	316L	316L	2205	6Mo super-austenitic
Flexible Coupling	304	316	304 wrapped in waterproof tape	316 wrapped in waterproof tape

Soils

TABLE 1 **SPECIFIC GRADE RECOMMENDATIONS**

Resistivity Ω.cm	Chloride ion concentration (ppm)			
	200	1000	2000	15,000
>5000	304/304L			
2000-5000	316/316L/2304		2205	Super duplex
1000-2000	2205		Super duplex	
<1000	Super duplex			

Source: ArcelorMittal.

GUIDELINE SUMMARY

- Choose stainless steel grade appropriate for chloride and oxidant levels
- Maintain flowing conditions where possible.
- Good fabrication practices.
- Drain water after hydrotesting
- Avoid excessive dosing of chlorine.
- Vent or regularly wash down areas where moist chlorine vapours can collect

A shining example after 25 years!

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Presenter Carol Powell

Thanks for your attention

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