Instructions on alloy selection for waters and waste water treatment applications

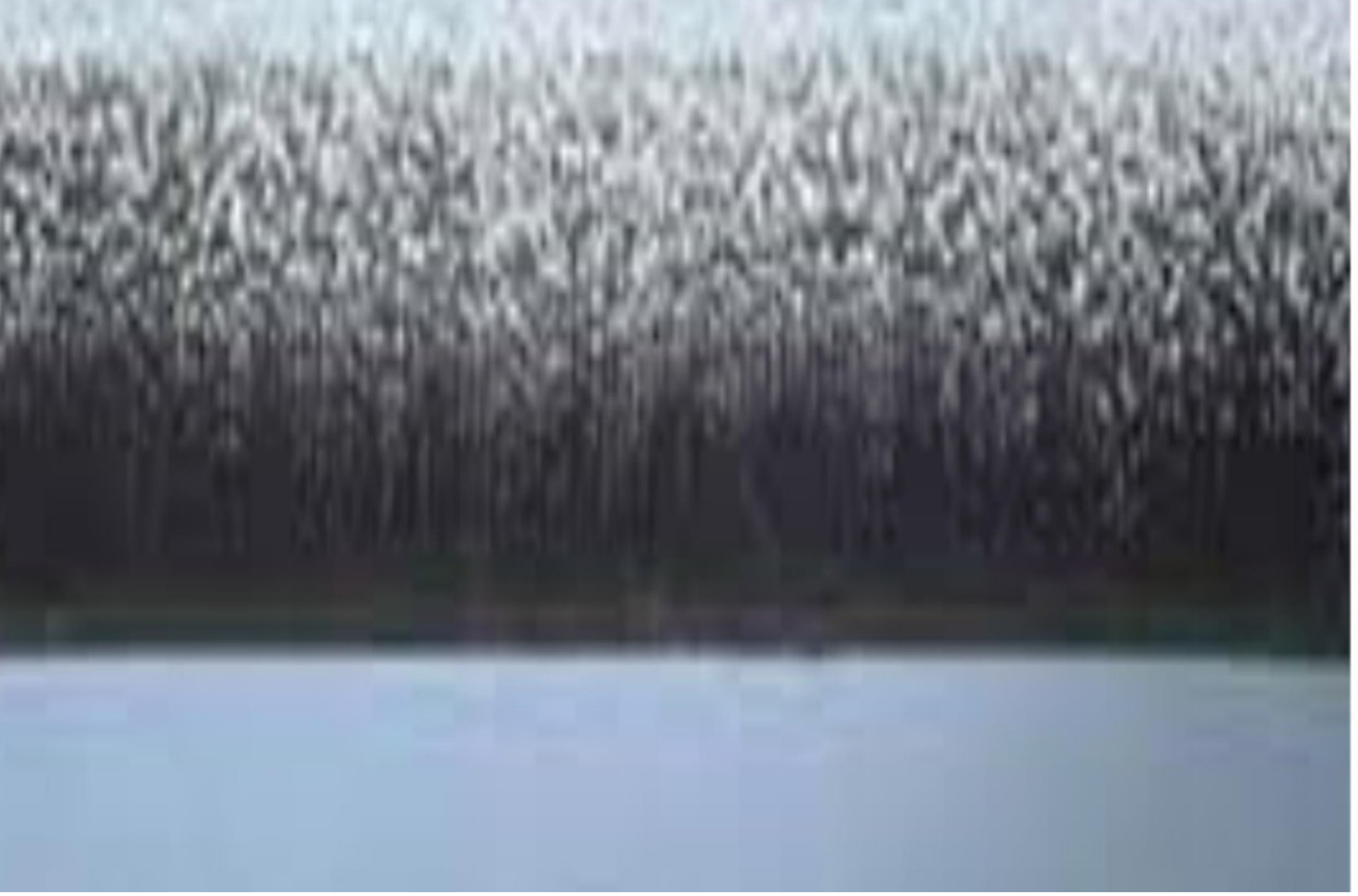
The most essential factors to obtain the adequate functionality are-

1. Select the suitable grade for chloride% of water
2. Prevent crevice corrosion when possible by suitable design
3. Follow suitable fabrication procedure, specifically eliminating weld heat tint
4. Drain quickly after hydro testing

Waters

Stainless steels are resistant to corrosion when subjected to water based media. But they can be sensitive to localized corrosion in the specific conditions that designers and users must identify and control. This corrosion, if occurs in water conditions, is often localized as pits or in creviced regions. Suitable design and fabrication can prevent corrosion however it requires to be combined with specific alloy choice.

Pitting and crevice attack needs the availability of chlorides and for a common chloride % high alloyed steels are excellently resistant to chloride corrosion. Normally, higher chromium, molybdenum and nitrogen concentrations in steel offer better corrosion resistance. Still there are also other aspects that have an influence on corrosion rate in waters such as chloride content is a crucial factor for choice of a suitable grade and is easily assessable. The crevice corrosion occurs at smaller chloride concentrations and temperatures than pitting, it is often the parameter utilized to guide choice. The instructions in the following table depend on the lab tests and service experience over several years.



Suitability of Stainless Steels in Waters

Chlorides content ppm	Suitable Stainless Steel Grade
Below 200ppm	304L, 316L
200-1000ppm	316L,duplex alloy 2205
1000-3,600 ppm	Duplex alloy 2205 6% Mo super-austenitic, super-duplex
Above 3,600ppm	6% Mo super-austenitic, super-duplex
15,000 – 26,000 ppm(seawater)	6% Mo super-austenitic, super-duplex

For chloride levels shown in the above table, crevice attack is small at pH values more than 6 and ambient temperature limits that normally occur in the most of industrial water conditions. Although, where the conditions are intense, for example extremely crevices conditions, smaller pH values, higher temperatures, small flow rates and other conditions, where the risk of local concentration of higher chloride levels or simply on basis of conservatism, stainless steel 304l can be chosen for chloride values up to 50ppm and stainless steel 316l for the higher chloride values about 250ppm. Otherwise if the stainless steel is cathodically secured, the waters are de-aerated or there is only the transient exposure to these chloride magnitudes then the needs as stated in the above table can be relaxed.

The machining grades of stainless steel consist of high levels of non-metallic stringers that considerably decrease their pitting resistance in waters. Hence, free-cutting high sulphur or selenium bearing grades for example alloy 303 and 303Se should not be utilized.

<u>Chemical inclusions</u>

Care should be taken while including chlorine compounds to different process streams. Serious factors should be considered to confirm that chlorine and severe chemicals, for example ferric chloride are included centrally into the stream for appropriate dispersion. The concentrated forms of these chemicals directed at or down the side of stainless steel piping or device can cause localized corrosion.

Bacterial control and management is obtained by chlorine dosage. 316l SS offers good performance and inclusions of molybdenum in this alloy offer higher pitting and crevice corrosion resistance than grade SS 304l counterparts. The data to understand the satisfactory chlorine levels is limited however that available for unused waters refer to 2 ppm for steel grade 304l and 5ppm for grade 316L. Although stainless steel can stand suitably larger levels of chlorine for small periods of time as would be the condition while disinfection treatments such as AWWA standards C651/652 where 25 to 50 ppm chlorine, are conducted for 24 to 48 hours. it is essential although that these levels are well flushed by the system quickly after treatment.

<u>Flow & Stagnation</u>

Stainless steels do not suffer from erosion corrosion and can function at high flow rates, about to 40 m/s without cracking of the surface layer. The flow rates of larger than 1 m/s are recommended in raw waters and higher than 0.6m/s in cleaner, processed waters to prevent accumulation of deposit.

Quick removal of sluggish water after hydrotesting needs specific attention. It is essential to drain and dry stainless steel systems after hydrotesting, if the system is not going into operation directly. In case if this is not feasible, retaining regular draining or water redistribution of the system is a suitable step. Potable waters, steam condensates or filtered waters must be utilized for hydrotesting instead the raw waters.

These procedures eliminate prolong stagnant condition that normally can develop accumulation of specific unsuitable kinds of bacteria as biomounds and tubercels that can lead to microbiologically influenced corrosion. The bacteria resulting in MIC attack more tends to settle in the weld areas where heat tint are not cleaned. Hence suitable fabrication methods that eradicate or prevent heat tint also significantly enhance corrosion resistance.

Galvanic conduct –

It is usually essential to utilize several different alloys to build a processing unit or system and the galvanic suitability of these materials should be taken into account. The galvanic corrosion may occur where two different materials come in contact in a common electrolyte for example, rain, fresh and processed water, waste water etc producing a galvanic corrosion cell. The supply of electricity between the two alloys, causes corrosion of the less inert material more quickly than it occurs if they do not come in contact.

Determining the corrosion rates can be complex by area ratios of metals, temperature, surface layers and electrical conductivity of the electrolyte that are not always easy to precisely determine. The Galvanic series is used to determine which alloy is least inert in a metal group however these are normally based on marine water treated as electrolyte.
Order of resistant metals & alloys as anode for fresh water is- Magnesium, Zinc, Aluminum, Carbon steel & cast iron, copper alloys, stainless steel, graphite.

Cathodic action- most noble
The larger the potential difference or more simply the vertical distance among two metals in the series, higher the driving force for corrosion. The stainless steels are inert alloys in the ranking and these are a secured part of the combination.
When the stainless steel is active and passive layer is damaged or eliminated by localized corrosion, its position in the series can be altered to between copper alloys and carbon steel and hence become less inert.

Practically, galvanic corrosion is relevant while the process of welding of stainless steel and carbon or low alloy steels. The risk of deep corrosion is higher if the stainless steel region is larger as compared to the steel, for instance, galvanized or steel fasteners in a stainless steel flange.

Procedures to prevent galvanic corrosion-

1. Design to assure that more noble region is smaller as compare to less noble region
2. Joint insulation such as insulating gasket, sleeves & washers, paint and tapes
3. Using isolation spools
4. Cathodic security
5. Joint area coating confirms sufficient coverage on any side, if this is tough, paint only the more noble metal. If the less noble material solely is secured, then corrosion at any coating flaws will be intense.
6. Galvanic attack is also a basis of significance of selecting a weld consumable which is at noble as the base metal.

In the natural waters opposite to marine water, copper base alloys are suitable with stainless steel unless excessive stainless steel to copper region ratio lies for instance, copper alloy valves can be utilized in the stainless steel pipes. Although, steel, zinc and aluminium are considerably less noble than stainless steel and normally must be insulated from stainless steel.

Need for waste water treatment

Waste water treatment includes the process of discarding contaminants from waste water to make it able for regular use similar to fresh water. It is produced by residences, institutions, hospitals and commercial and industrial houses. It also consists of storm runoff, some consider rainwater is perfectly clean however between initial rain fall and moving to sewers it possesses several toxic materials that lie in areas for example roof tops, parking lots and streets. The treatment units decrease pollutants in wastewater back to a level nature can hold. There are several phases that occur across this procedure. Heanjia Super-Metals supplies pipes and other material forms for dealing with the various waste water treatment units, our material is suitable because of the tight tolerances.

<u>Stainless steel installation in waste water treatment system</u>

Waste water treatment units choose stainless steel for providing durable and corrosion resistant performance while becoming very economical. While constructing, managing and operating a waste water treatment system, there are several factors need to take into account. Consider which materials to utilize for the aeration pipes, valves, containers and transfer pipes. Choose materials for machinery that must be corrosion resistant without affecting the water quality. Stainless steel is the only metal that meet these criteria while keeping the low maintenance and repair cost. Stainless steel grades 304l and 316l are the proven grades for use in waste water treatment procedures and water filtering systems. Other materials were used traditionally but they didn’t provide adequate performance as provided by these steel grades. For example, HDPE is a popular material that occurs in plastics across the United States. It contains a chemical resistance feature equivalent to the steel. Although, it decomposes when subjected to light, it is a difficult and pricey issue to face in the waste and water treatment industries.

Moreover, these two grades 304l and 316l do not have a complication of thinning while in use. It is essential factor while making the pieces. It offers selection options. You are no longer limited to intense materials. Rather, select thin, lightweight parts and keep eye on determining that they are built from strong stainless steel grades that comprise low upkeep expenditures across its complete long operation life.

The proper selection and fabrication of stainless steels offers low maintenance and prolong manufacturing solutions for waste water system configurations. The stainless steels are completely recyclable. Meanwhile their outstanding corrosion resistance properties have been popular over the several years, recently their mechanical properties have also been considered by the metallurgists. The steel's design offers thinner wall thickness to be utilized that offers cut down in weight and investment needs. Moreover increase in strength may be obtained through cold deformation of austenitic stainless steels to offer more economical performance. Austenitic stainless steels are easily formable on the operation place as their great ductility enables them to be easily formed. Moreover, life cycle costs are considered that make stainless steel a more appealing material.

Generally, using stainless steel 316l is preferred for water pipes and underwater structures, on the other hand stainless steel 304l is used as a material for several applications above the water line. It is based on the corrosion resistance and capital factors. The duplex stainless steel grades in the solution annealed form, provide a blend of greater corrosion resistance as well as strength. Therefore they can be used in submerged as well as above water operations that need big components to be transported so lightweight structure is beneficial.

Group (type)	Designation EN 10088		Chemistry %				
	Name	Nr.	Cr	Ni	Mo	Cmax	Others
SS 304 (1)	X5Cri18-10	1.4301	17.5 to 19.5	8 to 10.5		0.07	N – 0.11
	X2CrNi18-9	1.4307	17.5 to 19.5	8 to 10.5		0.03	
	X2CrNi19-11	1.4306	18 to 20	10 to 12		0.03	
	X6CrNITi18-10	1.4541	17 to 19	9 to 12		0.08	Ti 5xC-0.70
316 (2)	X5CrNiMo17-12-2	1.4401	16.5 to 18.5	10 to 13	2 to 2.5	0.07	N -0.11
	X2CrNiMo17-12-2	1.4404		10 to 13		0.03	

	X6CrNiMoTi17-12-2	1.4571		10.5 to 13.5		0.08	Ti-5xC-0.70
Stainless steels for waste water installations with special needs							
3	X2CrNiMo18-14-3	1.4435	17 to 19	12.5 to 15	2.5 to 3	0.03	N 0.11
4	X2CrNiMoN22-5-3	1.4462	21 to 23	4.5 to 6.5	2.5 to 3.5	0.03	N 0.10 to 0.22
	X2CrNiMo17-13-5	1.4439	16.5 to 18.5	12.5 to 14.5	4 to 5	0.03	N 0.12 to 0.22
5	X1CrNiMoCuN20-18-7	1.4547	19.5 to 20.5	17.5 to 18.5	6 to 7	0.02	N 0.18 to 0.25, Cu 0.5 to 1
	X1NiCrMoCuN25-20-7	1.4529	19 to 21	24 to 26	6 to 7	0.02	N 0.15 to 0.25, Cu 0.5 to 1.5

Types of stainless steels

Considering the vast range of stainless steels, a variety of materials are usually taken in to account for applications of waste water treatment units. First and second group include austenitic grades SS 304 and 316 that contain up to 18% chromium and 10% nickel, grade 316 consists of 2 to 2.5% molybdenum. The corrosion resistance of these grades is because of main alloying agents. They also comprise of nominal magnitudes of carbon. If not limited to stabilizing agents such as titanium, carbon may cause intergranular attack subsequent to welding of the massive parts. Hence titanium is added to stabilize them. Although, advanced steel production procedure prefers to keep carbon % small to eliminate the need of stabilization. These low carbon grades are such as SS 316l.

SS 304l and 316l are internationally preferred grades that are readily available and easily weldable. These are widely considered for operation in the waste water systems in the severe conditions. The duplex stainless steels are austenitic-ferritic steel grades of special interest for providing enhanced corrosion resistance as well as high proof stress.

Need of stainless steels

Resistance to corrosion in waste water and products utilized for the processing of water are the main need that has been met by stainless steels. The materials included in the ingress waste water are chlorides that are the main concern, after then inclusions occurred while the water processing that cause oxidation and flocculation. Chloride that can be included as a sanitizer is itself a strong oxidizing agent. Resistance to corrosion in the surrounding environments should also be taken into account such as gas products that may produce while waste water treatment. Suitability with other materials of production may need attention and corrosion resistance to the nearby soil for underground structures. The mechanical forces may not be merely static even also dynamic for example aeration pipes. Finally the erosion resistance may also be demanded for the solid materials carried by the water.

Corrosion resistance in water

Corrosion is the essential factor for steel grades, it is not a material characteristic, but it occurs due to contact between the material and surrounding media at the material's surface. Hence besides of vigilant consideration of the attacking nature of water and the suitable selection of construction material, the entire manufacturing, fabrication and joining processes must be taken into account as they have an impact on the surface quality. The general corrosion resistance of stainless steel grades can be specified as:

1. The steel grades as stated earlier are resistant to uniform corrosion in potable water and liquids of equivalent composition, surface water mixed seawaters and hence typically in waste water. Besides of possible accumulation of dirt, the metallic bright surface of steels will be maintained while application. Resistance to uniform corrosion is not affected by inclusion of acids of pH below 4 and hence is not a problem with stainless steels.
2. Intergranular attack can be prevented while the welding of massive components of thickness above 6mm or diameter above 20mm, steel grades are utilized consisting of carbon up to 0.03%.
3. Stress corrosion cracking (SCC) of austenitic stainless steels in the chloride based waters is typically noticed at temperatures above 50 to 60oC. Duplex stainless steel grade 2205 is even slightly sensitive. Fabrication is perfectly performed to prevent sensitivity and vast cold forming, stress corrosion cracking of stainless steels in the waste water installation is usually not a problem.
4. Besides of above kinds of corrosion, there are two kinds of decays that need special consideration with stainless steel in water conditions – pitting corrosion and crevice corrosion. These kinds of corrosion basically occur in the presence of chloride. It has to be balanced by choosing a suitable stainless steel grade and factors.
5. Microbiologically influenced corrosion or MIC that takes place particularly in or near the welded regions, has a small incidence in waste water configurations. The specific factor in preventing MIC is complete elimination of heat tint scale affected welding. It is perfectly done by dipped pickling, however other sources are also available.

<u>Influence of Chemistry</u>

The corrosion resistance properties of stainless steel to pitting and crevice attack in chloride mixed waters is a function of their chemistry and enhances with pitting resistance equivalent number (PREn). This connection works for uniform materials in the as-delivered form. Definitely the molybdenum material is of great significance as it has a factor of 3.3. Nitrogen is essential as well. Value of 16 is considered for duplex stainless steels and 30 for excess stainless steel grades. Nitrogen has minor effect on steel grades. The general instructions for adequate choice of stainless steels in chloride based waters apply-

1. Stainless steel grades 304l and 316l are fit for use with potable and industrial waters with medium chloride magnitude. Duplex stainless steel grades are the suitable selection for potable and industrial waters with increased chloride %. For use in brackish water and marine water, grades for 4^{th} and 5^{th} groups should be chosen.
2. Titanium stabilized steel types 1.4541 and 1.4571 are said to attain lower resistance to pitting corrosion as compare to other grades in the same groups. Titanium in stainless steel grades may improve the pitting corrosion.
3. The so named free machining types consist of high sulphur magnitude, type 1.4305 are not adequate for regular water handling since the presence of sulphide in the composition causes to decrease the resistance to pitting attack.

<u>Influence of water composition</u>

<u>Chloride ions</u>

It is evident from the earlier statements that while choosing the stainless steels for operations in waters and waste waters, chloride content of water is the highly influencing factor. The permitted higher concentration limits are based on the pH value, temperature, limit to which other oxidizing agents occur and other materials dissolved in water for example nitrates and sulfates and more are chlorates, acetate ions etc.

Due to availability of other ions, the permitted chloride content % in potable and fresh waters will be more than in the pure water. The temperature limits in many waters will generally be smaller if the chloride % is higher and for crevice corrosion, crevice shape is also essential. Tight crevices are critical and may occur among metals and plastics and under sediments introduced by water from external or under accumulation of corrosion materials.

With experience of several years with grade 304 shows that it performs adequately in handling waters containing chloride ions below 200mg/l. It offers slightly acceptable performance if chloride content is between 200 to 1000mh/l and their complete use would base on other factors for example high content of other anions, the nature of crevices occur etc, and the feasibility of toleration to some extent of crevice corrosion in the operation. Although, stainless steel from 2nd group is recommended for crucial applications including chloride % above 200mg/l and various deleterious factors for example small sulphate concentration and tight crevices with around 1000mg/l chlorides.

Latest waste water based studies state that grade 316l is preferred over 304l for application in conditions including chlorides of content above 200 mg/l. The practical experience with potable waters state that stainless steel 304 can handle potable water with chloride magnitudes about 200mg/l. Following the European standard EN 12502-4, molybdenum free ferritic-austenitic stainless steel grades offer high sensitivity to pitting attack in cold water with chloride concentrations above 6mmol/l or 200mh/l however in warm water this limit is decreased to 1.5 mmol/l or 50mg/l.
But with molybdenum free steel grades, crevice attack also may take place in cold water at the chloride % specifically smaller than 200mg/l. The crevices must be tight depending on the design or below sediments, for crevice attack to occur. Following the rule, crevice gaps above 0.5mm are not significant but the crevice depth should be considered. The procedure of connection is an important factor in finding the risk of crevice attack. Using the press fittings, stainless steels from the 1st group are not fully resistant to crevice attack in the limit of chloride contents occurred allowed in potable water by drinking water up to 250mg/l. It is essential to use steel grades from second group (SS 316) that are applicable in chloride limits about 500mg/l as shown for environment for example in drinking water system configuration.

Hydrogen Sulphide

Hydrogen sulphide gas can add to the general corrosion that takes attacks on copper alloys, aluminium alloys and hot dipped galvanized steel, coated or uncoated steel in waste water treatment processing systems. Unlikely, the general corrosion rates of stainless steel 304l and stainless steel 316l in the atmosphere and in closed units for example pipes, where wet hydrogen sulphide is available are nominal at the almost ambient temperatures. Although in closed units there may be tendency for localized corrosion attack to take place in stainless steel 316l and 304l if damped hydrogen sulphide and chlorides occur together at the high temperatures. The acidic nature of waste waters may increase so that they become more attacking if condensates consisting of dissolved sulphur dioxide are produced, creating sulphurous acid. These extremely corrosive conditions may need austenitic stainless steels with higher molybdenum content such as SS 904l or duplex steel grades such as 2205 grade should be considered as construction material.

Other materials dissolved in or included to water

Besides of chlorides, other materials are also present that may worsen the corrosive action of water. The presence of halides in addition of chlorides should be determined such as bromides or iodides. Another essential aspect is the magnitude of oxidizing agents because the pitting attack increases with the higher oxidizing potential of water. Chlorine is a powerful oxidizing agent. The stainless steel grades normally prevent the chloride attack at concentrations generally occurred in waste water processing systems. If chlorine concentration is about 2 mg/l in fresh water, attack on stainless steel grades 304 and 316 doesn't occur. Constant use of steel in 3 to 5mg/l residual chlorine in chlorinated fresh waters causes crevice attack of grade 304/304l higher than grade 316l. So grade 316l would be a more suitable selection in these applications.

Ozone is a popular alternative oxidizing agent that can be utilized separately or in combination with chlorine. Ozonation has got attention in the recent period. It is a strong oxidant with controlled retention life. It doesn't develop ions or compounds that are severe to stainless steel. Although a fine filter recommended to eradicate sediment from the cooling water prior it enters the generator, prevents accumulation on the alloy tubing. Stainless steel 316l grade is utilized in ozone production and for dealing with the ozonated water streams. Steel grade 316 is a recommended building material for ozone generators.

Ferric chloride is generally utilized for flocculation in the waste water treatment units. SS304 and SS316 grades may be attacked by both pitting and crevice corrosion when concentration is extremely high for alloys, referring to the availability of 250 to 300 mg/l ferric chloride in triggered sludge resulting attack. Inclusions require to be well combined and diluted with the waste water upstream of stainless steel to prevent exposure to deleterious concentration. Ferrous sulphate is another chemical that is commonly included in the waste water treatment units however experience received till now states that the attack rate for steel grades in the acid free ferrous sulphate conditions will be ignorable.

Waste water system structure

To receive a great corrosion resistance in water conditions, the design should be like that to offer complete realistic flow however limited flow up to 1m/s to decrease the inception of pitting and to reduce the accumulation of sediments. Moreover it is essential to prevent crevice attack at the maximum rate. If crevices are unpreventable, they must be made with the maximum width. The metal and metal crevices are normally less significant than metal and plastic crevice. A great risk of attack by crevices can be controlled by choosing the highly corrosion resistant metals such as stainless steel 316 grades rather 304. The horizontal pipes must be inclined adequately for easy drainage. For handling sludges, it is essential to prevent any dead legs and pockets to eliminate accumulation of sludge.

While connecting pipes through flanges or fittings, it is essential to choose the gasket and sealing material that do not liberate chlorides. Corrosion due to chlorine/ chlorine based conditions or vapors must also be prevented. Insulating the materials is not preferred to achieve chloride concentration above 0.05%. Acoustic damping parts of fixing elements for piping structures should be isolated from water soluble chlorides.

<u>Operation environments</u>

Hydrostating testing of pipes and tubes shows a common method of checking the reliability of structures after manufacturing. Although it is important to drain and dry drain stainless steel systems subsequent testing if the apparatus is not needed to be implanted in the operation directly. It is specifically crucial if raw waters are taken for inspection where bacteria and water stream deposit can accumulate when the left sluggish and starts under-accumulated corrosion in the welded regions. Filtered water or potable water hence should be utilized for inspection. In case of impossible draining, regular wash out of a unit should minimize the critical issues until it is installed for operation.

The temperature effect is also of significance. Generally pitting and crevice attack resistance reduces with increase in temperature. Although if the oxidizing agent content reduces with increase in temperature, and apparatus is pressure free, the effect of temperature on pitting attack would be nominal.

The water flow speed is also an essential factor, following the rule, in water running with adequate velocity, corrosion resistance is comparatively high however the pitting attack may begin in sluggish waters. Slowly running water may enable accumulation of sediments beneath which crevice attack may take place. Water with sludges must run at a rate of 0.6 m per sec to prevent sediment accumulation. Suitable counter measures include cleaning and draining of the system periodically.

Further humid hydrogen sulphide and chloride included vapors may be found in waste water treatment units. However a nominal corrosion is found on SS 304 and SS 316 in moist hydrogen sulphide, it is also stated that both grades may suffer from corrosion if extensive magnitudes of humid hydrogen sulphide are increasing in the waste water structure. This attack may be because of the power depolarizing action of the hydrogen sulphide that results in pitting corrosion. The perfect treatment is allowing suitable ventilation. The steel grades also attain surface corrosion and pitting in conditions where damped chlorine vapors can deposit and finally concentrate. Suitable ventilation or water draining and cleaning periodically are important in these operation environments.

When produced or finished to required standards, grades 304l and 316l can maintain their bright look in environmental exposure for several years specifically when any surface accumulations that develop are eliminated by regular cleaning. In seawater and chloride based or industrial contaminated conditions, stainless steel 316l is recommended for providing prolong life as well as architectural look. In surrounded plant conditions where wet chlorine vapors gather and concentrate, acid condensates can start to stain and pit stainless steel. Again, suitable venting or periodic cleaning is suggested in the pipe networks and other regions where chlorine gases can congregate. Although, where it is not feasible, an enhanced grade Duplex stainless steel 2205 may be used.

Atmospheric corrosion resistance

The external environments may vary widely. Particles consisting of carbon and sulfur dioxide produce the intensive materials in the atmosphere and industrial conditions. The chloride aerosols are the essential aggressive materials near coastlines that are very far from the ocean under the unsuitable winds. Comparatively, rural areas far from ocean are not aggressive. Stainless steel grades 304 are the most suitable material for use in rural conditions far from sea considering its cost and corrosion resistance properties. Grades 316/316l are valid for locations close to sea and in town conditions. In the industrial conditions and near the sea, the grades of group 4 become important in the unsuitable environments of high moisture, temperature and intense contaminants.

<u>Soil</u>

Soil sensitivity towards stainless steels is based on several factors the more crucial are soil resistivity, pH, chloride percentage and soil drainage. The chlorides are influenced by location, the more severe are coastal regions or near salted regions for deicing. The choice of bedding can support in drainage from pipes, particularly in severe acidic or high chloride soils.

The coating security, cathodic security or both are usually recommended for stainless steel 300 series in environments where resistivity is lower than 2,000 ohm cm and pH is lower than 4.5 and drainage is inadequate. At the resistivities about 2000 to 5000 ohm.cm, stainless steels may need security or preference should be given to higher alloys if the chloride concentration is high or soil acidity is an issue.

<u>Stainless steel selection following soil environments</u>

Steel Grades	Soil environments
SS 304l	Chlorides below 500 ppm, Resistivity above 1000 ohm.cm
SS 316L	pH above 4.5, chloride below 1,500 ppm, resistivity above 1,000 ohm.cm, pH above 4.5
Super duplex,	Chloride below 6,000 ppm, resistivity above 500 phm.cm
Super austenitic	pH above 4.5

Different soils have different corrosive natures on the base of chloride concentration, pH value and resistivity. Stainless steel grades offer quality performance in the different soil types. The selection factors prefer using type 304/304l for use in soils with chloride concentration below 500 ppm and resistivity higher than 1000 ohm.cm. Type 316l can be used for chloride concentration below 1500 ppm and resistivity higher than 1000 ohm.cm and duplex steel grades are chosen for chloride concentrations below 6000 ppm and resistivity above 500 ohm.cm. These selections are valid for pH above 4.5, in unavailability of stray currents and presence or absence of coating or cathodic protection.

Mechanical Characteristics

Few essential mechanical characteristics of stainless steel grades are given in the following table:

Group	EN Number	0.2% Proof stress Rp 0.2 N/mm2 (least)	Tensile strength Rm, N/mm2 (least)	Elongation A% (least)
1	1.4301	230	540	45
	1.4306	220	520	45
	1.4307	220	520	45
	1.4541	220	520	40
	1.4401	240	530	40
	1.4404	240	530	40

2	1.4571	240	540	40
3	1.4435	240	550	40
4	1.4462	500	700	20
	1.4439	290	580	35

Cold rolled steel strip of thickness 8mm in the solution annealed condition has been chosen as an example. Using this product form, sheets are cut for producing tanks and containers and in producing the longitudinally welded tubes that are utilized in the waste water installations.

The high ductility of austenitic stainless steels takes special attention as it is much better than the general structural steels with elongations to fracture of minimum 40% for stainless steels of 1st and 2nd groups. Due to high ductility, austenitic steels are easily formable on the operation place and easily adept even to the non-uniformity of concrete configurations. Therefore austenitic stainless steels can be easily handled and repaired as compare to aluminum or galvanized steel.

Suitable strain hardening potential that is related with high ductility is another special attribute of austenitic steels. This property offers to increase 0.2% proof stress by cold forming procedure following the product kind such as through drawing or cold rolling. Thin sheets of austenitic steel types 1.4301/1.4571 that are strain hardened by cold rolling to large proof stress can be utilized for big tanks and containers. It permits cut in weight and related cost while providing guaranteed constant structure stability. For example using as waste water processing containers for different kinds in breweries. The additional strength received from cold forming processes can be implemented to decrease wall thickness. But to take this advantage connection procedure should be any except welding because welding results in the localized softening of metal.

Some pipe structures for example aeration pipes experience vibration while operation, for this, the permitted design stress is received from the fatigue endurance limit that is lower than 0.2% proof stress. However the grades 304l and 316l stainless steels attain outstanding fatigue strength, it is essential in design to combine smoothly areas like transition joints and where the structure materials meet because these regions are the weakest locations of the structure where vibration pressure may accumulate.

Uses of stainless steels in waste water structures

The stainless steel applications in waste water installations are extensive where steel is commonly used in tubing and pipe structures for aeration. The containers are constructed from the work hardened stainless steel sheet, the settlement apparatus for round and rectangular containers like submerged apparatus and weirs of clarifiers are made beneficially from stainless steel grades. The machinery for waste water treatment is widely made from steel for screening, washing, compacting, dewatering of screening, grease and oil refining, thickening and de-watering of the different kinds of sludge, sieve filtration are only a few. Stainless steel grades are also used as construction materials for primary materials such as climbing structures, stairs, ladders, rails, hand rail, manhole cover, architectural apparatus and roofing.

If there are no specific factors for water quality or conditions, using type 316l stainless steel may act as a practical standard material for constructing waste water and underwater pipes. For many of above stated applications, steel grade 304l is also a suitable material for providing both corrosion resistant and cost – effective services. The high strength duplex grades and strain hardened austenitic types for lightweight structures can also be chosen for providing more cut down in cost as less material weight required.

Life cycle cost study

Stainless steel is a significant building material however the galvanized steel parts are usually available at the cheaper price. But if maintenance and repair cost is considered for the system life, stainless steel proves to become more economical selection. The most essential factor is corrosion resistance of stainless steel for prolong service. This factor is also beneficial in cut down the cleaning and maintenance cost. After the prolong service, stainless steel materials are completely recyclable.

Studies state that galvanized steel manhole covers are usually 20% cheaper than the same constructed of SS 304. But because of larger maintenance costs for the galvanized steel, the manhole cover constructed from the stainless steel offers 24% reduced cost considering the complete life cycle cost for around 25 years.

When desired service lifetimes are varied, the whole cost needs to be calculated as total cost per year for comparison. In 1998 a study was conducted on waste water thin screen. If it is constructed of galvanized steel, the investment capital would be lower by 15 % from that constructed of stainless steel. But the overall service was 12 years. Oppositely, the identical screen made from type 304l would have a much better service for 18 years. As a result the latter screen is found cheaper than that made from galvanized steel. The similar cost relations were also found for sludge thickening press.

Type 316 stainless steel is used in ducting to vent hydrogen sulfide from a treatment unit in North West of England. Fine sections and scarce coating refer that the initial cost difference between stainless steel and coated steel was not as outstanding as first anticipated. The net costs were identical after around five years when initial main maintenance schedule was designed. It was because finishing in site was not required and there was a sizeable cost benefit after 15 years when replacement of the coated steel would be expected.

<u>Beneficial factors of cut down in cost</u>

In the pipe industry, the wall thickness of stainless steel tubes may be chosen more suitably for the design pressure instead galvanized tubes is minimum 4.5 mm however in many cases just 6.3mm is made.

More cost saving can be obtained if using the complete potential of stainless steel has to provide with respect to flow speed. The maximum permissible value of 30 m/s can permit smaller pipe diameters allowing to decrease weight as well as cost unlike to other materials.