Water Quality Parameters Background Information

Parameter	**Alkalinity**
Description	Alkalinity measures the buffering capacity of water and its ability to neutralize acids. Alkalinity is a good indicator of the total dissolved inorganic carbon (bicarbonate and carbonate anions) present. Alkalinity is a measure of how easily the pH of the water can be changed. Hence it is considered to be a mitigating influence with regards to extreme pH levels. Water with a high alkalinity is more likely to be scale-forming even at a relatively low pH. In contrast, low alkalinity waters lack the buffering capacity to deal with acids, so they can easily become more acidic and corrosive. High alkalinity is preferred as it helps control pH changes which reduces corrosion.
Interactions	Alkalinity is dependent on the concentrations of all acidic and basic species present, and as such is governed by the full chemical composition of the water as well as physical parameters, such as the temperature and electrical conductivity
Measurement	The criteria are given in terms of the total alkalinity concentration, expressed as mg $CaCO_3$/l
Adverse Effects	Scaling

Parameter	Calcium
Description	Calcium is an element that belongs to the alkaline earth metals. It is an element that exists as a double positively charged ion (Ca^{2+}). It is not found uncombined in nature, but occurs abundantly as limestone (calcium carbonate), gypsum (calcium sulfate), fluorite (calcium fluoride) and apatite (calcium chloro- or fluoro-phosphate). Calcium is an element that occurs naturally at varying concentration in most water and, together with magnesium elements they are two of the main components of water hardness. Soft water has low concentrations of calcium, whereas hard water has a high concentration of calcium. Calcium contributes to significantly to scaling especially in terms of calcium carbonates as this is one of the main components of scale that is commonly encountered in chemical and related industries. The calcium carbonate scale often grows extensively on equipment and parts, causing major operational difficulties. Calcium is a very essential element/mineral for all living organisms and certain metabolic process, and it is also a vital constituent of bone on mammalian skeletons.
Interactions	The precipitation potential of calcium is dependent on the action of other water quality constituents such as the associated cations, the pH and the sulphate concentration.
Measurement	mg/l
Adverse Effects	Scaling

Parameter	Chloride
Description	Chloride is the anion of the element chlorine, which does not occur in nature but is found only as chloride. The chlorides of sodium, potassium, calcium and magnesium are all highly soluble in water. Chloride is of concern in water supplies because elevated concentrations accelerate the corrosion rate of metals and shorten the lifetime of equipment and structures.
Interactions	The taste threshold and the corrosion acceleration threshold of chloride are dependent on the action of other water quality constituents such as the associated cations, the pH and the calcium carbonate concentration.
Measurement	The criteria are given in terms of dissolved chloride concentration, in units of mg Cl. The reference method for determination of dissolved chloride is usually by means of the ferricyanide method and colorimetry.
Adverse Effects	Chlorides are found to be the most aggressive ion regarding corrosion, specifically in the case of crevice and pitting corrosion.

Parameter	Dissolved Oxygen
Description	Dissolved oxygen refers to the level of free, non-compound oxygen present in water.
Interactions	The dissolved oxygen concentration of water is strongly affected by the presence of oxidizable matter and as such is affected by the dissolved organic carbon (DOC), biological oxygen demand (BOD) and organic nitrogen concentrations. Other factors that affect the dissolved organic oxygen concentration are temperature and pressure. Dissolved oxygen can destroy the protective hydrogen film that can form of many metals and oxidize dissolved ions into insoluble forms hence increasing the risk of corrosion.
Measurement	mg/l
Adverse Effects	Corrosion

Parameter	**Electrical Conductivity**
Description	Conductivity is a measure of water's capability to pass electrical flow. This ability is directly related to the concentration of ions in the water. These conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulphides and carbonate compounds. Compounds that dissolve into ions are also known as electrolytes. The more ions that are present, the higher the conductivity of water. Likewise, the fewer ions that are in the water, the less conductive it is. Distilled or deionized water can act as an insulator due to its very low (if not negligible) conductivity value. Sea water, on the other hand, has a very high conductivity.
Interactions	In most waters nearly all the electrical conductivity (EC) is due to the major cations (calcium, magnesium, sodium, potassium and nitrate) and anions (carbonate, bicarbonate, chloride and sulphate). In acidic or basic waters the proton (H) or hydroxyl ion (OH) contribute extensively to the + - EC. Most organic compounds dissolved in water do not dissociate into ions, consequently they do not affect the EC
Measurement	mS/m
Adverse Effects	Scaling

Parameter	Hardness
Description	Hardness refers to the concentration of dissolved calcium and magnesium in the water. Hard water has a high concentration of calcium and magnesium, which has a tendency to result in scaling. Consequently, this makes this water less corrosive due to the tendency to form protective films in the pipe. However, this is dependent on the alkalinity and pH. Soft water has a lower concentration of calcium and magnesium and thus is often more corrosive than hard water. Typically, water is considered soft if the total hardness is less than 50mg/l CaCO3 while values greater than 150 mg/l $CaCO_3$ are considered hard water. Galvanized piping, like steel and cast-iron piping, tends to experience its best performance in hard water compared to soft water due to scale formation. However, hard water is not always the most beneficial as in cases whereby copper piping is used, pitting corrosion in typically observed and occurs at low temperatures. However, if the hardness in the water is primarily non-carbonate, the chlorate and sulphate ions will tend to keep the calcium in solution and will prevent scale formation. Excessive scale formation is also not preferable as high amounts of scale deposition on the surface will limit the heat transfer efficiency of certain equipment.
Interactions	Hardness is a complex property of water and is governed by the concentrations of calcium, magnesium and other polyvalent cations.
Measurement	Total hardness is expressed as mg $CaCO_3$/l. Total hardness is calculated from the concentrations of calcium and magnesium as given below- Total hardness (mg $CaCO_3$/l) = 2.497 x [mg Ca/l] + 4.118 x [mg Mg/l]
Adverse Effects	Scaling and corrosion

Parameter	Magnesium
Description	Magnesium is typically found in water as $Mg^{2}+$ and can also be found as $MgOH^{+}$(aq) and $Mg(OH)_2$ (aq). Its occurrence is due to dissolution of rocks, presence of chemical. Similarly to calcium, magnesium is a contributor to scale formation. Magnesium contributes to significantly to scaling especially in terms of magnesium silicate scaling. The formation of magnesium carbonate scale is influenced by many factors such as the concentration of solution, pH value, temperature, pressures, and ionic strength. Magnesium hydroxide scale forms according to the hardness of the water.
Interactions	The precipitation potential of magnesium is dependent on the action of other water quality constituents such as the associated cations, the pH and the silica concentration.
Measurement	mg/l
Adverse Effects	Scaling

Parameter	**pH**
Description	pH is a major contributing factor to metal corrosion and release. The pH can have an effect on multiple factors that range from the rate of dissolution, the solubility and protectiveness of different films and scales, to the appearance and morphology of the corrosion observed. Low pH values (<4) tend to have a higher corrosion rate. At low pH values, acids release hydrogen ions, which oxidize the metals in pipes, accelerating corrosion. At pH values less than 5, rapid corrosion of iron, copper, and lead may occur. At more alkaline pH values greater than 9, corrosion of these metals is typically reduced due to the formation of protective films. However, at higher alkaline pH values, scale formation and the efficiency of certain corrosion inhibitors can be hindered and hence corrosion may increase again.
Interactions	The pH of natural waters is influenced by various factors and processes, including temperature, discharge of effluents, acid mine drainage, acidic precipitation, runoff, microbial activity and decay processes
Measurement	pH units
Adverse Effects	Corrosion

Parameter	**Silica**
Description	Silica deposits are glass-like coatings that can form almost invisible deposits on metal surfaces. The solubility of silica increases with higher temperatures and pH. Consequently, this occurs in opposite operating regimes to $CaCO_3$ scale formation. Once formed it is difficult to remove even with aggressive acid cleaners. The solubility of silica in steam increases with an increase in temperature. Thus, the solubility of silica increases as steam is superheated. In boiler water systems, as steam is cooled by expansion through the turbine, silica solubility is reduced and deposits are formed, usually in cases where the steam temperature is below that of the boiler water. To minimize this problem and prevent silica scale from forming, the concentration of silica in the steam must be controlled.
Interactions	The solubility of silica is governed by pH and the concentrations of available cations.
Measurement	mg/l
Adverse Effects	Scaling

Parameter	Sulphate
Description	Sulphate is a common constituent of water and arises from the dissolution of mineral sulphates in soil and rock, particularly calcium sulphate (gypsum) and other partially soluble sulphate minerals. Sulphate (SO_4^+) is the oxy-anion of sulphur in the VI oxidation state and forms salts with various cations. Since most sulphates are soluble in water, and calcium sulphate relatively soluble, sulphates when added to water tend to accumulate to progressively increasing concentrations. Sulphates can be removed or added to water by ion exchange processes, and microbiological reduction or oxidation can interconvert sulphur and sulphate. Sulphate and is used commercially in the manufacture of numerous products including chemicals, dyes, glass, paper, soaps, textiles, fungicides and insecticides. Sulphate, including sulphuric acid, is also used in mining, pulping, and the metal and plating industries. Barium sulphate is used as a lubricant in drilling rigs for groundwater supply. In the water industry, aluminium sulphate (alum) is used as a flocculant in water treatment, and copper sulphate is used for the control of blue-green algae (cyanobacteria) in water storages. Under anoxic conditions, the reduction of sulphate to sulphide by sulphate-reducing bacteria can result in unpleasant taste and odour due to the release of hydrogen sulphide and can increase corrosion in pipes.
Interactions	Sulphates are to a large extent governed by the nature of the associated cations, of which calcium and sodium are the important in terms of industrial water uses. Solubility of gypsum increases with decreasing pH and decreasing temperature.
Measurement	The criteria are given in terms of the dissolved sulphate concentration in, units of mg SO_4^+. Dissolved sulphate is normally measured turbidimetrically on precipitation as insoluble barium sulphate. This is the reference method. If other methods are used to measure sulphate, their characteristics relative to the reference methods given should be known.
Adverse Effects	Scaling, Taste effects, Corrosion

Parameter	Suspended Solids
Description	Suspended solids (SS) consist of inorganic and organic matter which includes silt, sand, clay, particles or any type of suspended matter. Particulate fouling occurs due to a high suspended solids in the feed which results in deposition of these suspended solids in the process streams due to gravity settling as well as other deposition mechanisms.
Interactions	Suspended solids give rise to turbidity in water. The relationship between the amount of suspended solids and turbidity measurement is, however, dependent on the nature and particle size distribution of the suspended matter. A
Measurement	The criteria for the suspended solids concentration are given in units of mg/l. Suspended solids are measured as the mass of material retained on a glass fiber filter after drying at 103°C to 105°C. Settleable solids are determined by difference after a one-hour settling period followed by determination of the suspended solids in the supernatant.
Adverse Effects	Fouling

Parameter	Total Dissolved Solids
Description	Total dissolved solids (TDS) consist of inorganic salts and small amounts of organic matter that are dissolved in water. Clay particles, colloidal iron and manganese oxides and silica, fine enough to pass through a 0.45 micron filter membrane can also contribute to total dissolved solids. Total dissolved solids comprise: sodium, potassium, calcium, magnesium, chloride, sulfate, bicarbonate, carbonate, silica, organic matter, fluoride, iron, manganese, nitrate, nitrite and phosphates.
Interactions	Since TDS concentration in water is a measure of the total amount of inorganic salt dissolved in water, it is also closely related to properties such as the Total Hardness of the water and the corrosion and scaling potential.
Measurement	mg/l
Adverse Effects	Corrosion and scaling