Wastewater Treatment

Primary function of the wastewater treatment system used in industrial facilities is to remove or reduce the high level contaminants in the waste stream from being discharged to local sewer systems or the environment.

Local, state and federal government have imposed regulations on the waste discharge of industries. Such regulations come of the Clean Water Act passed by the federal government; most local and state governments adopt these laws and may impose separate regulations. Noncompliance to local, state and federal regulations can result in series financial or legal consequences. The following Table shows approximate effluent regulations for a can manufacturing facility.

Pollutant	Maximum for any 1-day		Maximum for monthly average	
	g (lbs.) / 1,000,000 cans manufactured**			
Chromium (Cr)	94.60	(0.209)	38.70	(0.085)
Zinc (Zn)	313.90	(0.692)	131.15	(0.289)
Aluminum (Al)	1382.45	(3.048)	688.00	(1.517)
Fluoride (F)	12792.50	(28.203)	5676.00	(12.514)
Phosphate as P total	3590.50	(7.916)	1468.45	(3.237)
TSS	8815.00	(19.434)	4192.50	(9.243)
Oil & Grease Total	4300.00	(9.480)	25800.00	(5.688)
pH	7.0 to 10.0 at all times		7.0 to 10.0 at all times	

** Information gathered from Environmental Protection Agency 40 CFR Ch.1 (7-1-87 Edition)

Typically waste streams that are treated in a industrial facility will come from the ferrous or nonferrous washing processes.

Other areas could include the coolant sump, floor sump in wastewater treatment area and deionized or RO water regeneration waste. These processes consist of acids, bases, organic constituents and inorganic components. Organics found in the waste stream include greases, oils, (hydraulic, gear lubes, soluble lubes from coolant system) surfactants, and possibly solvents and defoamers. Inorganic components include copper, chromium, manganese, zinc and phosphorus among other mineral matter.

Other important differentiating traits of wastewater are that of the physical nature. Characteristics that typically define wastewater are temperature, odor, and color, Total Solids (TS), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

Total Solids is the sum of Total Suspended Solids (TSS) and Total Dissolved Solids (TDS). In water analysis these quantities are determined gravimetrically by drying a sample and weighing the residue.

TSS could include, grit, dirt and sand that can be captured by filtration of a 0.45-micron filter. TDS are solids that pass through a 0.45-micron filter, such as metal ions (an electrically charged atom or group of atoms bonded together).

BOD is a measure of organic material contamination in water, specified in mg/L. BOD is the amount of dissolved oxygen required for the biochemical decomposition of organic compounds and the oxidation of certain inorganic materials (e.g., iron, sulfates). Typically the test for BOD is conducted over a five-day period.

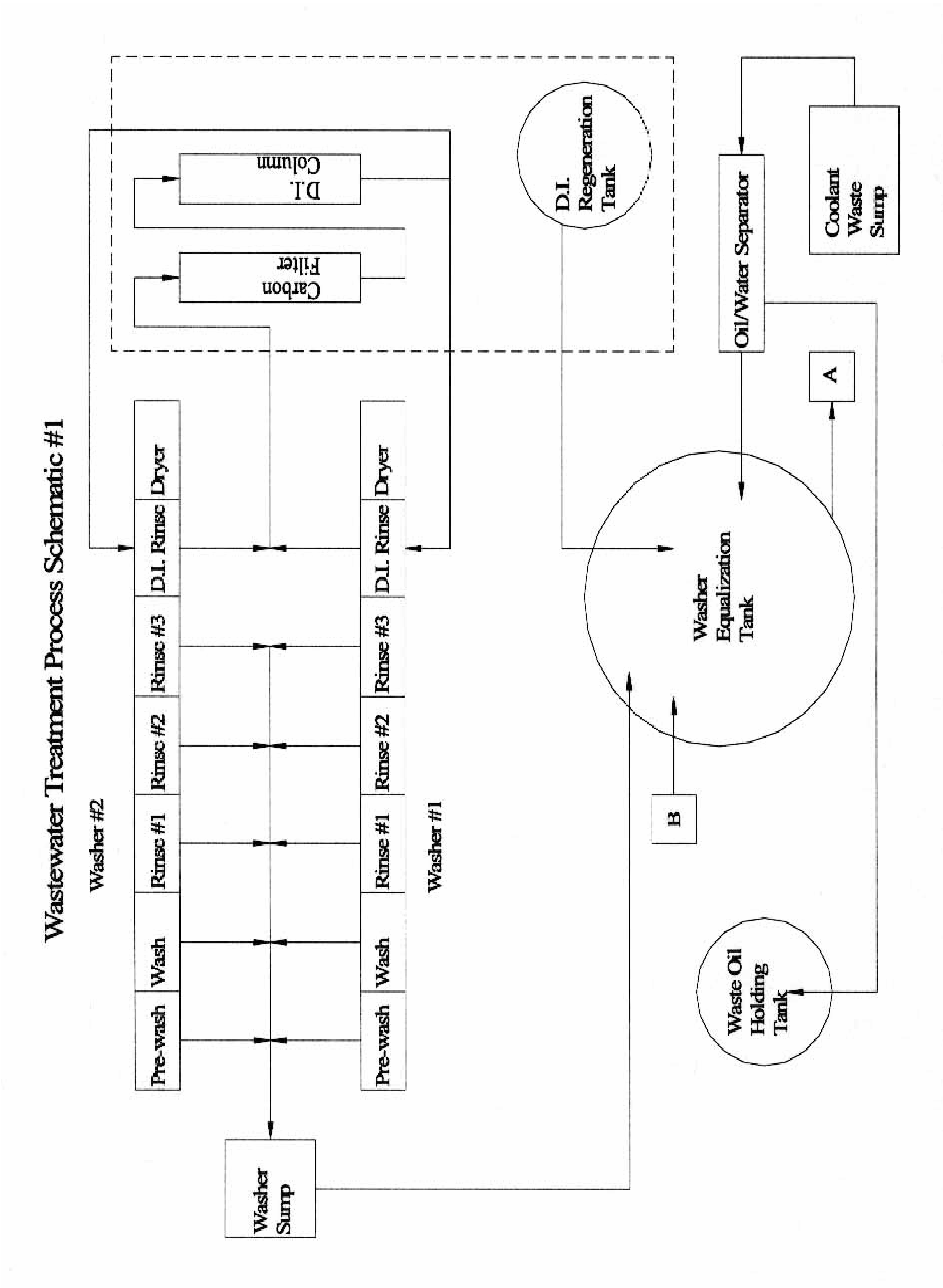
COD is another measure of organic material contamination in water specified in mg/L. COD is the amount of dissolved oxygen required to cause chemical oxidation of the organic material in water.

Both BOD and COD are key indicators of the environmental health of a surface water supply. They are commonly used in wastewater treatment.

Treatment Process

Typically for the wastewater treatment process a number of tanks and equipment will be employed. The wastewater treatment process will normally be referred to as a batch or continuous process. The majority of the industrial facilites will use a continuous process. A continuous process is equipped with several tanks or segmented compartments to accommodate the separate functions of equalization, acidification, oil break, and pH adjustment, flocculation and sludge consolidation. Continuous process is considered when high flows are anticipated.

The wastewater treatment in a industrial facility starts with the collection of wastewater. The wastewater is collected from the washer sump, where wastewater is overflowed from the various washer stages. The water from the washer sump is pumped to the washer equalization tank. Another collection point is the coolant waste sump. From here the effluent is pumped through an oil/water separator (coalescer). Unemulsified oils are separated and sent to a waste oil holding tank. The coalescer effluent is sent to the washer equalization tank, reference to Schematic #1.



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Wastewater Equipment

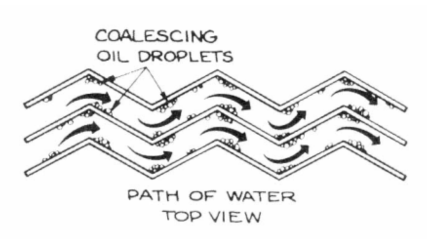
The Washer Equalization tank is usually a large tank, large enough to allow an equalization time for the wastewater. During this time the wastewater will have time to allow for pH equalization and to allow for oils to split. These oils will be over-flowed or pumped off when the oil level reaches a predetermined depth. From the equalization tank the wastewater is pumped to the treatment chambers.

There are a number of steps in the treatment of the wastewater before the solids separation; treatment starts with the influent pumped from the equalization tank, reference to Schematic #2.

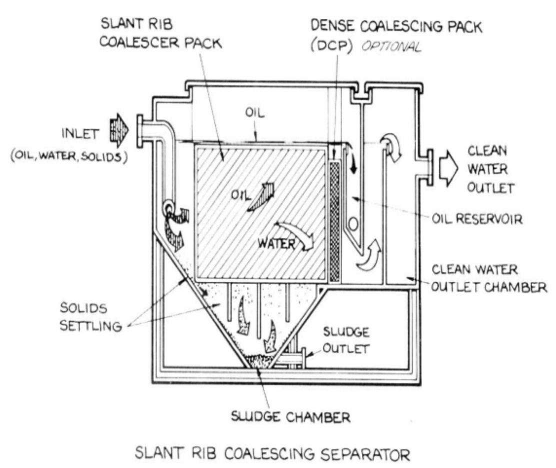
1. Oil Water Separator (Coalescer)
2. Acidification
3. Oil Break
4. Neutralization
5. Flocculation

Oil Water Separator (Drawing #2)

When certain materials are placed in the wastewater flow, removal efficiencies of oil increase due to impingement on their surfaces. Plastic media is particularly effective because of its oleophilic (oil attracting) characteristics. As fine oil droplets impinge upon or pass close to the plastic surface, Drawing #1, they are attracted to it and adhere. Additional droplets continue to be attracted and coalesce or merge with previous droplets to produce much larger droplets. At a point, the droplets are large enough to break free and rise to the surface where they are skimmed or decanted.



Drawing #1



Drawing #2

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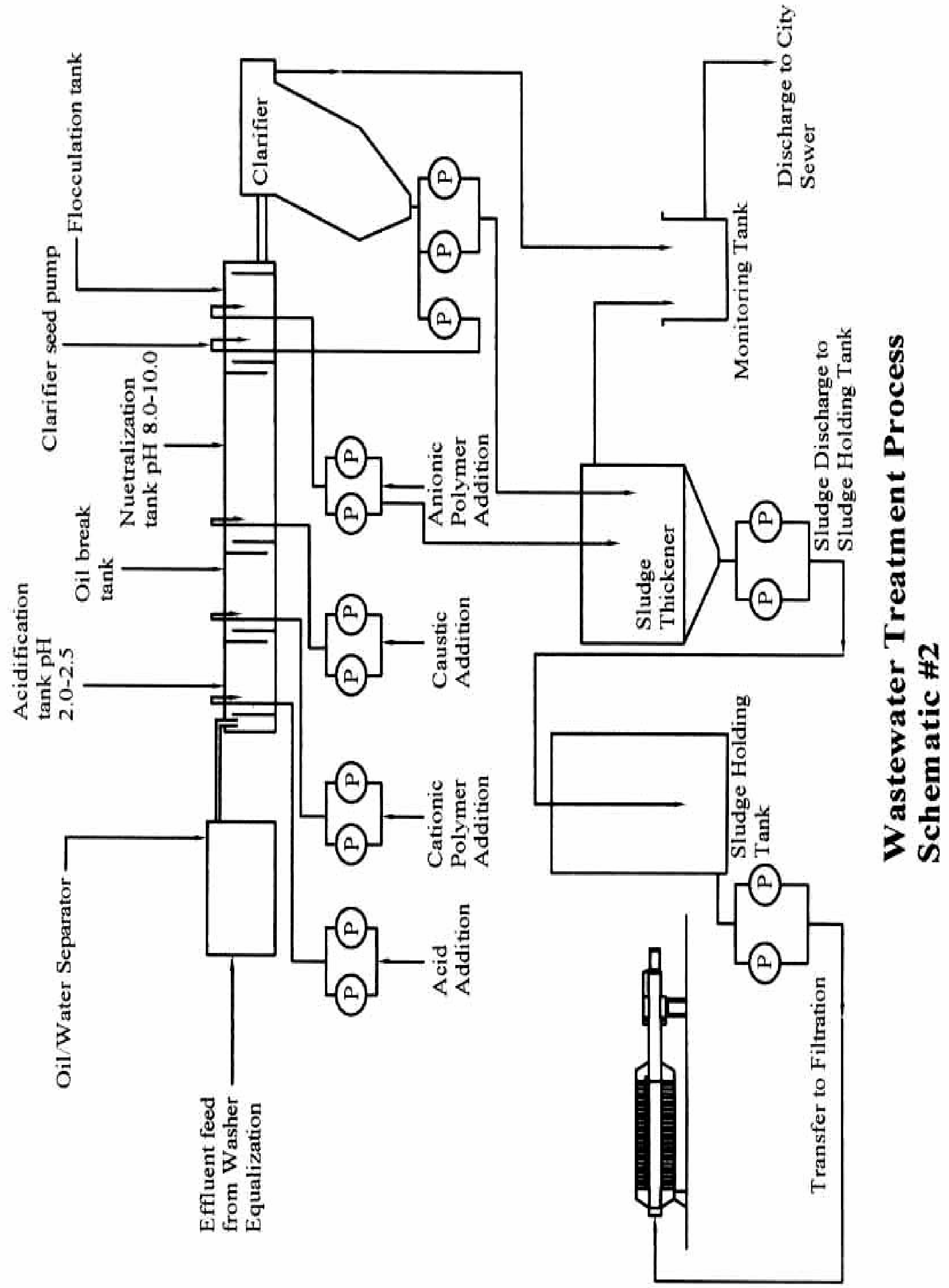

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Acidification

In many cases sulfuric acid needs to be used to adjust the pH of the incoming wastewater to 2.0 - 2.5, to accomplish the first step in emulsion breaking. Acid, in most cases, effectively neutralizes the R-COO (surfactant functional group) to R-COOH, allowing the oil droplets to agglomerate. At this pH most ferric metals will become solubilized, allowing the bond with oil droplets to be broken.

Oil Break

At this stage a chemical coagulant and/or heat is added to start the precipitation of the solids. Many industries generate oily-waste emulsions, i.e., oil dispersed in the water phase; lubricants, coolants, hydraulic oil and gear lubes are rinsed from the can surface during the cleaning operation. Oil droplets in such emulsions are hydrophobic and carry a negative charge, which stabilizes the emulsion. To cause destabilization, a cationic emulsion breaker can be added to neutralize the charge and allow the droplets to coalesce, starting a pin floc.

Neutralization

At this stage either 50% caustic or lime slurry is added (to the low pH wastewater 2.0-2.5) to obtain a pH of 8.0 – 10.0. The acids react with bases to form salts and water; these salts are referred to as precipitate, which can then be removed by the use of a flocculent. This type of reaction is called neutralization. The optimum pH for removal of fluoride and manganese is pH of 9.0, to high or low can result in re-solubilizing of metals. Refer to the Relative Solubility of Metal Hydroxides Vs. pH Chart #1. Another technique for removal of fluoride is the use of calcium chloride $CaCl_2$, which provides calcium ions and pH adjustment in removing fluoride ions from wastewater generated by the aluminum, steel and metal finishing sectors.

Flocculation

The remaining process is flocculation. These polymers are long chain molecules of either charge, which contains many sites along the chain. When this material is mixed into the neutralized and coagulated sample, the accumulated suspended particles are attracted to these sites. This attraction continues until the chain is bound up with suspended solids along its length.

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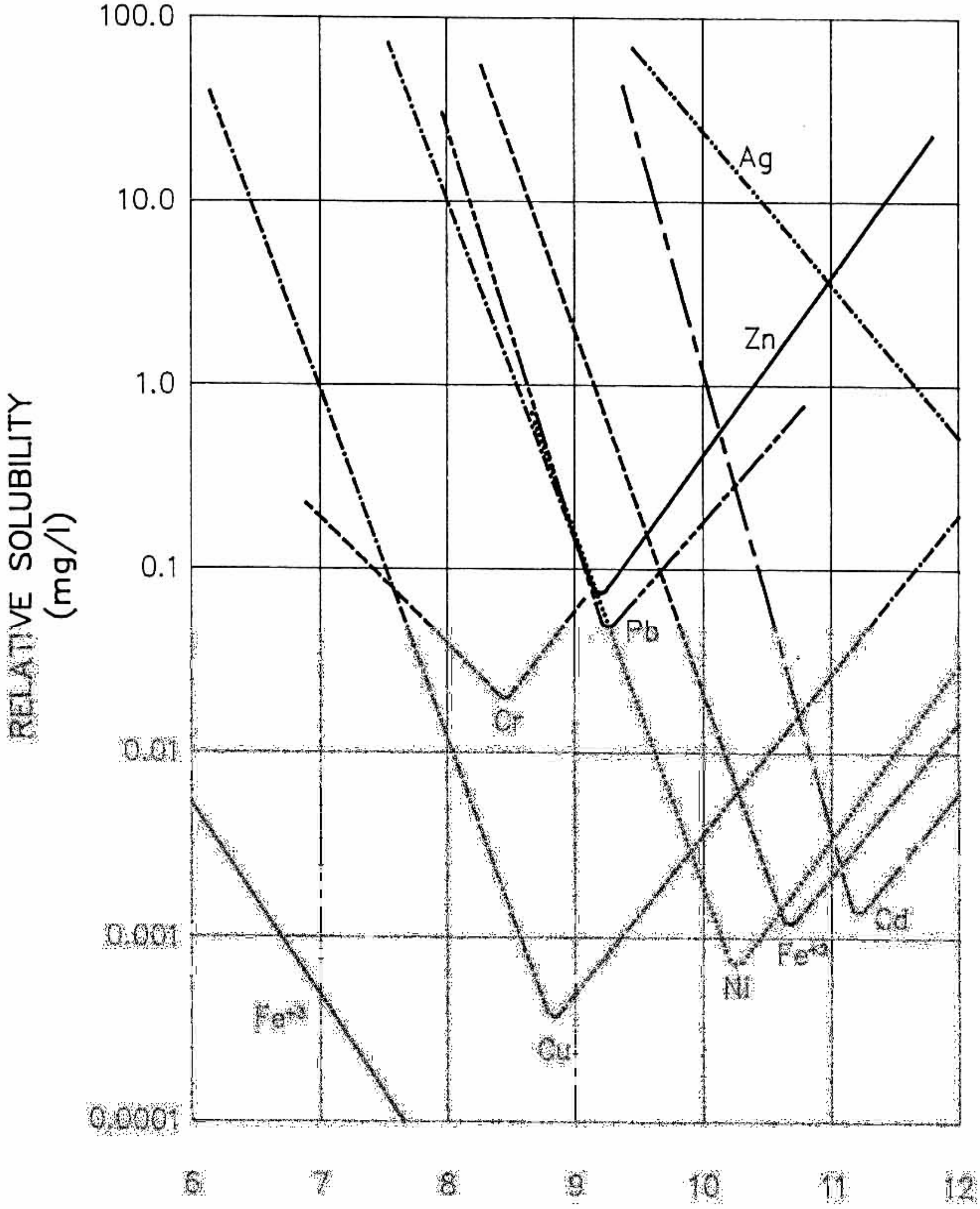
Then the bounded chain drops out and combines with other chains in the form of large flocs. These large floc particles will then be separated from the waste stream.

Schematic #2 shows one sample of how the acidification, oil break, neutralization and flocculation stage's could be arranged.

Solids Separation

Solids separation follows the last stage of treatment (flocculation); the large floc that has been developed in the flocculation stage will be removed. This can be accomplished by a number of means. The two most common ways used in can plants are; Inclined Plate Clarifier or Dissolved Air Flotation (DAF) system.



RELATIVE SOLUBILITIES OF METAL HYDROXIDES VS. pH

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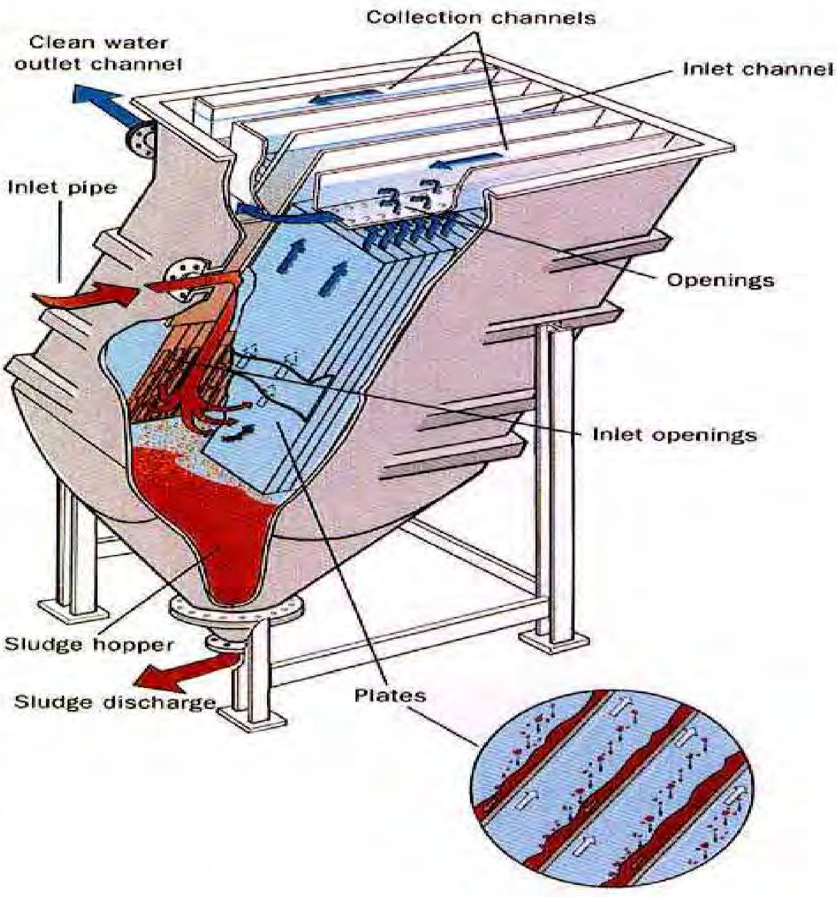
Inclined Plate Clarifier

The wastewater influent containing solids to be separated enters the clarifier through the inlet pipe; flows downward through the inlet chamber in the center of the clarifier and enters the plates through openings on the sides refer to drawing #3. As the liquid flows upward, the solids settle on the inclined, parallel plates and slide into the sludge hopper at the bottom of the unit. In the hopper, the sludge is thickened prior to discharge through the sludge outlet, to a sludge thickener unit or holding tank, for further settling of the sludge.

The clarified liquid leaves the plate assembly through the openings at the top and is distributed into collection channels leading to the clean water outlet. From the clean water outlet the water is gravity feed to the monitoring tank and discharged to the city sewer system.



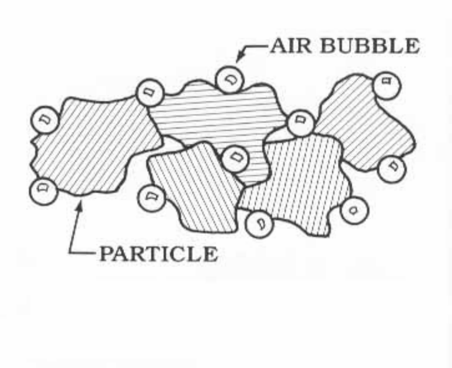
Drawing #3

Dissolved Air Flotation (DAF)

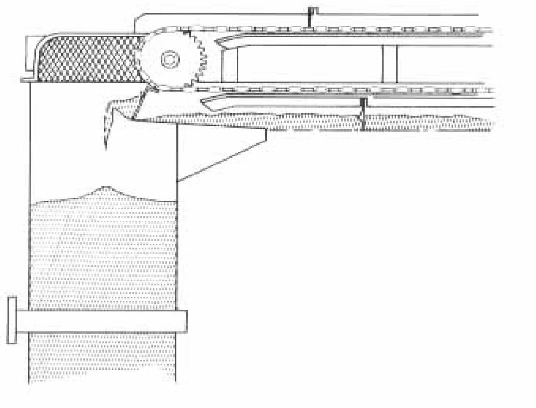
Dissolved Air Flotation (DAF) is an effective way to separate suspended solids and emulsified oils from industrial waste streams. Microscopic air bubbles are produced and mixed with the wastewater influent containing suspended contaminates. The small bubbles attach themselves to the suspended particles, which give them net positive buoyancy, refer to diagram 1-1. These buoyant clusters of particles then float quickly to the surface, creating a floating mass, which is then removed by a skimmer, diagram 1-2.

To produce sufficient air bubbles a portion of the effluent is pressurized (pressure vessel shown to the left of DAF unit in Drawing #4) with an optimum 80 psi air pressure and recycled back into the dirty influent. As the saturated recycle is released into the unit the air comes out of solution creating the microscopic air bubbles, which attach themselves to the floc particles. A schematic drawing of a DAF unit is show in Drawing #4.

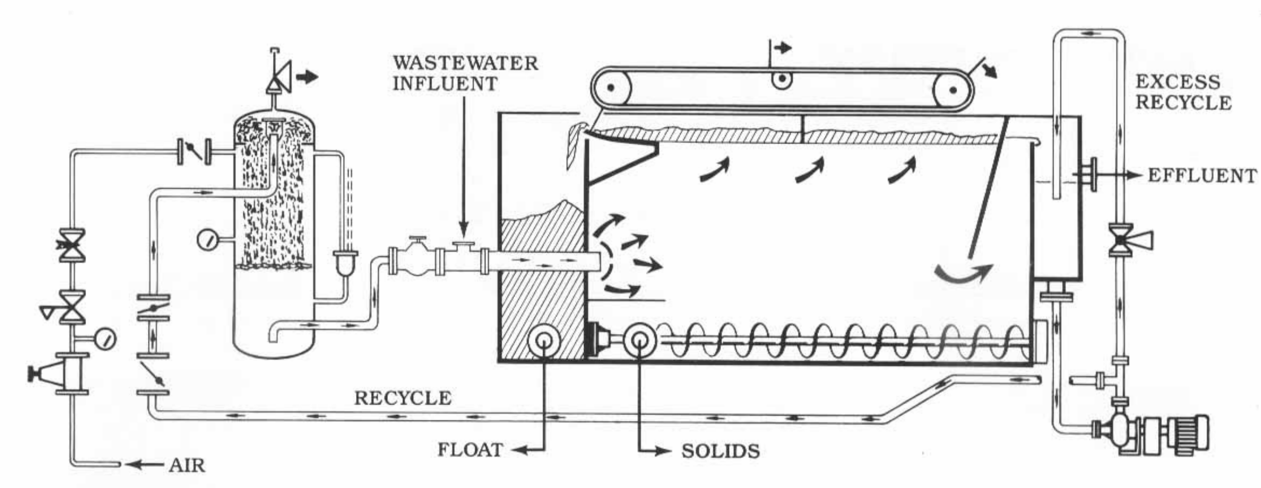
The effluent quality of a DAF is greatly improved with pre-chemical treatment. This is achieved through the treatment steps describe in the earlier discussion of this text.



Air Bubble Attachment
Diagram 1-1



Skimmer
Diagram 1-2



DAF Drawing #4

DAF Bench Test Procedure

Equipment:

1. Five-gallon bucket
2. 4 - 1000 ml beakers (glass)
3. 3 - 3 ml syringe
4. pH meter
5. 50 ml H_2SO_4
6. 50 ml NaOH
7. Stirrer
8. Samples of polymers (cationic and anionic) to be tested

Procedure:

1. Collect 5 gallons of influent just before DAF
2. Using a 1000 ml glass beaker remove 1000 ml of influent from 5 gallon sample
3. Check pH and adjust to approximately 9.0
4. At this point a very small pin-floc should be observed
5. Added polymer (cationic or anionic depending on application) as necessary to precipitate dissolved solids, flocculate suspended solids and produce a suspended floc that is light and fluffy
6. Step 5 may need to be trialed several times to get the correct percentage of polymer needed to obtain the light and fluffy floc
7. If the mixture with flocked particles is light and fluffy and the solids are reasonably stable i.e., floc will reform if agitated, then a DAF will work

- For a rough estimate of flotation, drop an alka-seltzer tablet into the chemically treated beaker. As the tablet dissolves, CO_2 is released and solids should float. Stir the contents very gently while the tablet is dissolving.

1. Final result should be a clear liquid below and a solids layer on the surface of the jar sample.

2. Draw off the clear liquid and analyze to determine if the effluent is acceptable and will meet discharge requirements.

The floating solids and solids that settle to the bottom of the DAF are then transferred to a sludge thickener or holding tank, for further settling of the sludge. The clean effluent is then transferred to the monitoring tank for discharge to the city sewer.

Sludge Thickener

More solids separation occurs after the sludge from either the Clarifier or DAF is transferred to the sludge thickener. The sludge thickener consists of a large tank with a cone shaped bottom with a rake that is located at the bottom of the tank. This rake is slowly rotated to keep the settled sludge moving to the center of the cone. The slow rotation of the rake prevents agitation or breaking of the sludge into smaller floc particles.

As sludge is transferred from the Clarifier or DAF anionic polymer may be added to the sludge thickener, reference to Schematic #2. The addition of the polymer will aid in thickening and settling the sludge to the bottom of the sludge thickener. Similar to the Clarifier, the sludge thickener allows the water free of sludge to overflow a trough, which encircles the inside top of the sludge thickener tank and is drained to the monitoring tank.

Along the side of the cone spouts will be added to check the thickness of the settled sludge. After the sludge has reached a prescribed depth the sludge will be pumped to a sludge holding tank.

Sludge Dewatering

The primary objective of sludge dewatering is to minimize sludge volume for disposal. The sludge collected during the initial consolidation of solids is relatively high in water content. The sludge collected in the sludge holding tank containing high volumes of water is normally dewatered using a Plate and Frame Filter Press or Rotary Vacuum Pre-coat Filter.

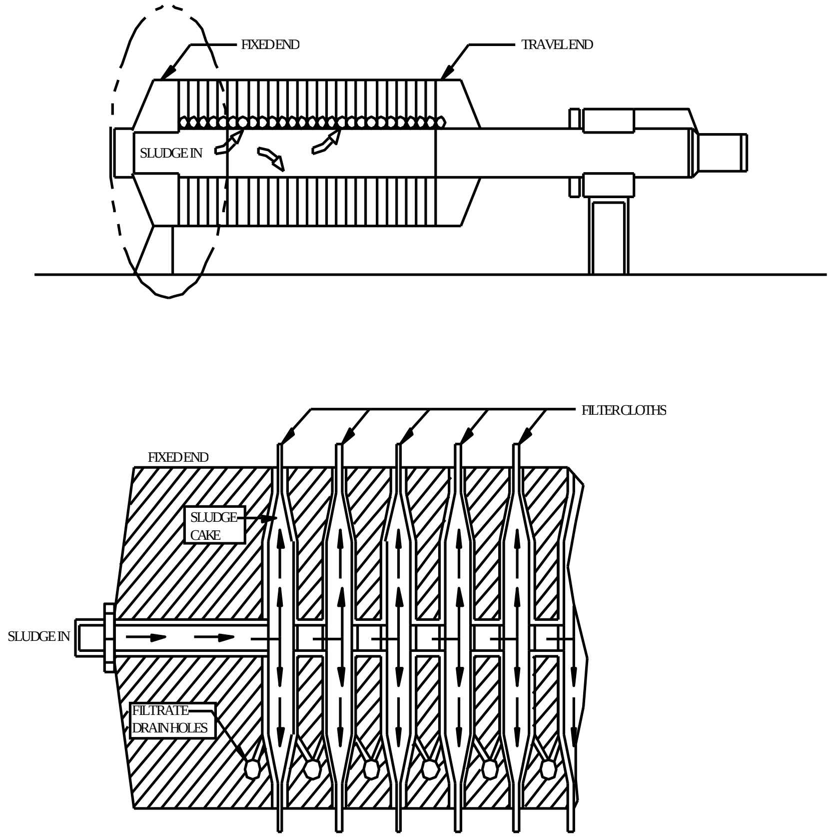
Plate and Frame Filter Press

The liquid sludge containing suspended solids is then pumped into the feed inlet (sludge in) Drawing #6 of the filter press. The sludge is forced into each chamber of the filter press. As the slurry enters each chamber, liquid passes through the filter cloth to channels in filter plate (filtrate drain holes). This liquid then exits through the discharge ports of the filter plate. The sludge filtrate is returned to the process waste prior to the clarifier.

Suspended solids are captured on the surface of the filter cloths. As the solids build, they provide a medium for further filtration. With pressure exerted by the feed pump, solids displace liquid in the chamber. Eventually, a filter cake is formed. To load the filter press the feed pump begins at a low pressure. It is important to slowly increase this pressure until a maximum pressure is reach at which time the pump will automatically stop. If the pump at the beginning of filtration exerts a maximum pressure, solids could be pushed through the filter cloth and could possibly damage the filter cloth, there by reducing the efficiency of the filter press.

When maximum pressure is reached the filter press is vented and the movable head is retracted from the filter plates. The filter plates are then separated to allow formed filter cakes to fall into a disposal container. The dewatered sludge cake that is formed is usually 25 to 50% total solid. Local regulation may require a sludge dryer before disposal check local requirements.

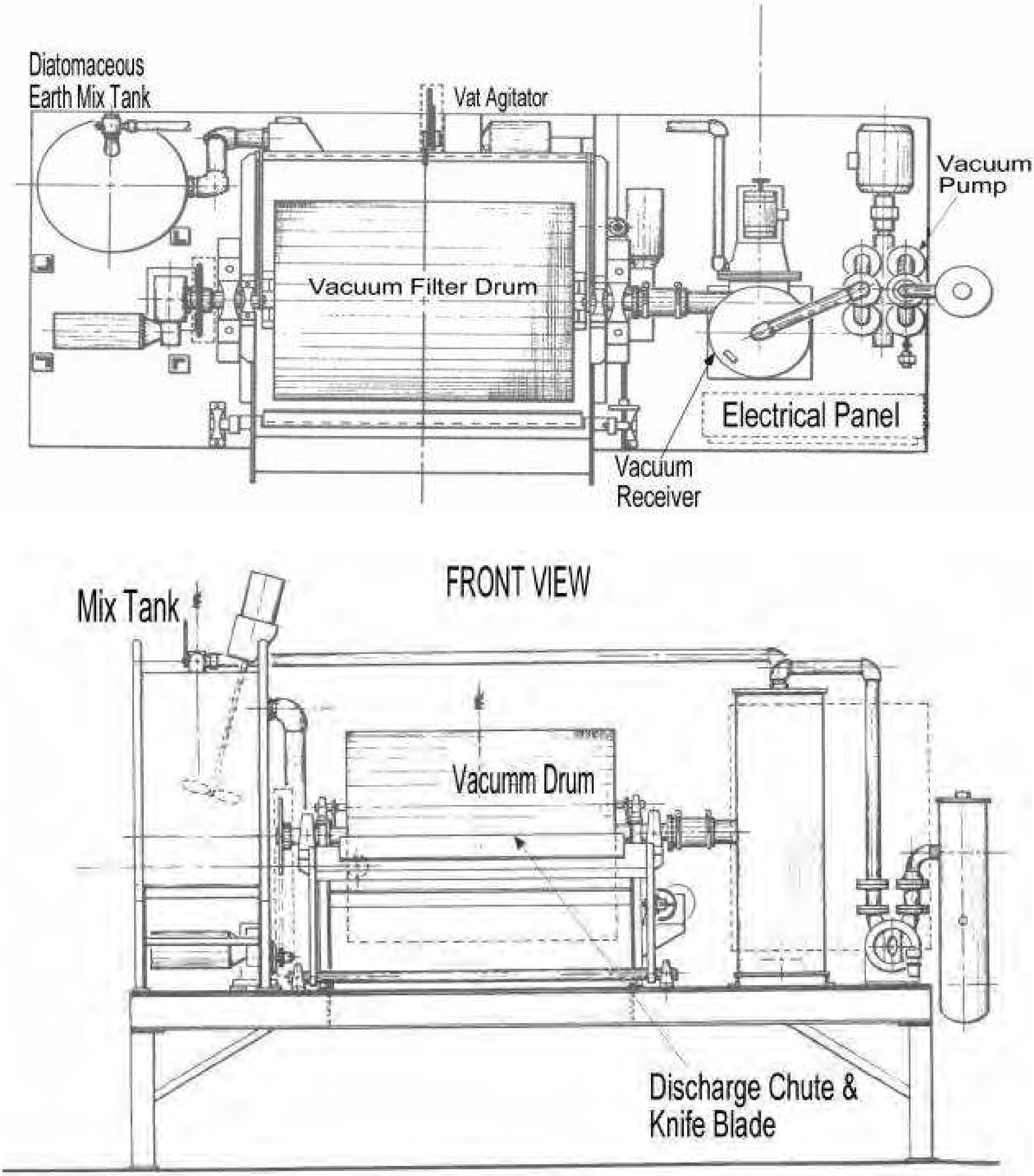
Routine maintenance on media cloth is necessary due to oily films and polymer buildup that occurs through general use. The primary method of cleaning filter media cloth is by power washing.



Drawing #6

Rotary Vacuum Pre-coat Filter

The Rotary Vacuum Pre-coat Filter is uniquely designed to continuously filter wastewater or sludge through a bed of inert silica based filter media called diatomaceous earth. The diatomaceous earth is mixed with water (many times the effluent water from the treatment system is used) to make slurry, which is pumped into the filter basin and vacuumed onto the cloth covered vacuum filter drum. Once a cake of approximately 2” is formed sludge is then pumped into the filter basin, which is then vacuumed through the diatomaceous earth layer. The solids form a layer on the surface of the diatomaceous earth while the clarified water passes through. The solids layer is automatically shaved off the surface of the diatomaceous earth with each revolution of the drum. All of the suspended solids are filtered out of the wastewater. The filter cake solids are dry and able for landfill disposal. Refer to Drawing #7 for top and front schematics of filter.


Diatomaceous
Earth Mix Tank
Vat Agitator
Vacuum
Pump
Vacuum Filter Drum
Electrical Panel
Vacuum
Receiver
FRONT VIEW
Mix Tank
Vacumm Drum
Discharge Chute &
Knife Blade

Drawing #7

Monitoring Tank

The monitoring tank is the final collection point for the treated effluent before it is discharged to the city sewer line. At this collection point a visual check of effluent clarity is possible.

The clarity or some times referred to as “turbidity” consists of suspended material in water, causing a cloudy appearance. The suspended matter may be inorganic or organic.

Another visual check is “color”. Color is contributed primarily by organic material, although some metal ions may also tint water.

Another check although not visual is “odor”; smell is useful because it provides an early indication of contamination, which could reduce the quality of the treated effluent being discharged.

Along with visual checks, volume (gallons per minute) of effluent discharge is monitored here. This volume is calculated using a sensor, normally a sonic sensor, to measure the depth of effluent flowing over a weir. The weir is normally in a “V” shape notch, utilizing either a 45° or 60° angle, knowing this angle and the depth of the tank the sensor can calculate the flow rate. Correct discharge volume is important to calculating ppm or lbs. /1,000,000 cans discharge of pollutants. If the weir, “V” notch, builds up or becomes clogged with sediment the volume (gpm) of effluent discharged will be calculated incorrectly.

A dirty weir or incorrect volume measuring will cause the effluent volume to be over stated, thus lowering the ppm value required to be within local, state and federal discharge guidelines. Maintenance of the monitoring tank becomes very important.

Another important part of the monitoring tank is to check the final pH of the discharge effluent and recorded this pH. Normal pH ranges for the effluent discharge can be 6.5 to 9.0; these numbers will depend on the local and state regulations.

The acidic or basic level of the effluent is measured by pH. The pH is a measure of hydrogen in concentration in water, specifically the negative logarithm (log) of the hydrogen ion concentration.

The measurement of pH lies on a scale of 0 to 14 (Figure #1), with a pH of 7.0 being neutral (i.e., neither acidic nor basic) and bearing equal numbers of hydroxyl (OH^-) and hydrogen (H^+) ions. A pH of less then 7.0 is acidic and great then 7.0 are basic.

							pH							
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
More acidic							neutral						more basic	

Figure #1 – pH value

Since pH is expressed in log form, a pH of 6.0 is 10 times more acidic then a pH of 7.0 and a pH of 5.0 are 100 times more acidic than a pH of 7.0. The pH has an effect on many phases of wastewater treatment such as oil break, neutralization and flocculation.

The pH level can be determined by various means such as color indicators, pH paper or pH meters.

This is also the collection point were a Composite Sampler can be setup to make daily, weekly or monthly collection of effluent depending on city and state regulations. The effluent collected will be sent in for analysis and reports of this analysis are sent into the local authorities and keep on file at the plant for future investigations if needed.

Reference:

1. WaterLink Great Lake Environmental, Industrial wastewater Treatment Equipment and Systems manual 1997, SuperSettlers, Oil Water Separators, Dissolved Air Flotation.
2. General Chemical Industrial Products, Calcium Chloride Industrial uses Chapter 14 – Wastewater and Water Treatment, 2005.
3. Osmonics Pure Water Handbook, 2nd Addition, 1997, 1997 Osmonics Inc.