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wastewater treatment, the clarifier and associated equipment can be sized to handle peak daily flow rather than instantaneous peaks. One advantage of placing equalization after primary clarification is the ability to desaturate the incoming wastewater while hot.

Unlike most wastewater treatment plants, the waste TSS concentrations are near those of clarifier sludge. As a result, primary clarifier underflow to dewatering is a significant portion of the waste flow. Returning the sludge dewatering filtrate to equalization, if located before primary clarification, would require retreating this relatively clean water and increasing the size of the primary clarifiers.

Tertiary treatment is target-pollutant-specific. Metals can be treated through chemical, physical and biological means. Iron co-precipitation removes cationic metals and arsenic and also assists in solids removal through flocculation of negatively charged particles. Adding organosulfide precipitants lowers the levels of cationic metals such as mercury.

Iron, typically from ferric chloride, is added to coagulate suspended solids. Recirculating sludge to this reactor results in improved metals removal and the formation of a denser sludge that improves settling, reduces the need for polymer addition and improves mixed sludge dewaterability. To avoid solids shearing, this and other mix tanks should be designed with large-diameter, variable-speed mixers. Reactor residence time is based on pH control and the mixer should be more like a flocculator than a rapid mixer.

An acid such as hydrochloric acid is added to control pH within the range required for this treatment process. Hydrochloric acid is preferred over sulfuric acid, as the water is near saturation for calcium sulfate. What's more, sulfuric acid can result in calcium sulfate scaling, particularly if filtration is used for polishing.

Enhanced Metal Precipitation

If additional cationic metals removal (particularly mercury) is required beyond what can be done with iron co-precipitation and filtration, organosulfide can be added to enhance these metals' precipitation. Mercury is particularly difficult to remove in FGD wastewater due to the high concentration of chlorides, which can form soluble complexes. To counter the solubility of mercury and other cationic metal chloride complexes, FGD wastewater can be treated with a cationic metal-binding polymer such as an organosulfide.

Polymer is added to aid in removal by subsequent settling. Anionic polymers are typically used, because the previous addition of iron and lime can give the resulting solids a net positive surface charge. It is recommended that polymer be used only if necessary. After sludge recirculation is well established, the use of iron alone should be sufficient to produce a well-settling solid.

Solids that pass through the primary clarifiers and have been generated in the chemical reaction tanks can then be removed by settling in secondary clarifiers. Some of the sludge should be recirculated to the mix tanks to seed a crystalline precipitate to improve settling and dewatering.

Filtration may be required to meet TSS limits and is required to meet parts-per-billion metal limits. Gravity dual-media filters are recommended to follow the secondary clarifiers. The advantage of gravity filters is the lower shear produced by gravity feed. Filter sand is subject to scaling, so if a filter is installed, special care is needed to limit scaling and to monitor and replace media early, rather than after scaling causes filter media cementation.

The solids removed in the treatment processes must be dewatered. If solids are to be landfilled, a regulatory limit of "no free liquid" in the dewatered sludge probably will be imposed. In FGD systems that produce a high solids wastewater, solids dewatering becomes a significant portion of cost and plant size. It is also a critical step and must be designed to leave the over power plant's reliability unaffected.

Residuals management strategies must be considered, given the volume and mass of solids produced. FGD wastewater solids tend to be thixotropic when dewatered to 40 percent to 50 percent solids. In this state, they tend to take the shape of their container and are difficult to remove after transport. Increasing the solids content to 60 percent during dewatering reduces the potential for thixotropy and also reduces the danger of free water forming during transport.

The most common wastewater treatment sludge dewatering technologies are centrifugal dewatering, pressure filtration using belt press and pressure filtration using a plate-and-frame filter press. FGD wastewater fines could also be stabilized for disposal by mixing with a stabilizer such as fly ash. Of the available sludge dewatering technologies, plate-and-frame presses maximize dryness and are the most likely technology to achieve the "no free liquid" requirement. These presses also maximize sludge compaction, reducing the cost of subsequent disposal. The addition of polymer with the other two technologies results in less attractive sludge landfilling characteristics. While belt presses are less expensive to buy and can be fit into a smaller and less expensive building, the additional conditioner costs offset the savings in a few years.

Pumps for Filter Press Operation

Various pumps have been used for filter press operation. It is desirable to rapidly fill the press, then reducing flow as the pressure builds and the water is extracted. Using two variable-speed centrifugal pumps in series provides a cost-effective combination of flow capacity and pressure. The pumps must be programmed to limit flow at low pressure and build speed as the resisting pressure increases. Positive displacement pumps are not economical when combining the need for high flow and high pressure, and require considerable preventive maintenance.

The wastewater's scaling nature and high solids content make sludge piping design critical. Using gravity flow between desaturation and primary clarification results in pipes that are self-draining when the flow is stopped. Piping should be designed for easy cleaning and replacement and should include automated flushing of sludge lines and pumps when turned off.

The rate at which sludge is produced and dewatered varies during the drying cycle. If this is matched by varying the flow of sludge pumps from the clarifiers or if the flow is constant and the pumps are cycled on and off frequently, there will be a tendency for velocity in the sludge lines to be less than needed to keep solids in suspension. By recirculating sludge from the filter press area back to the desaturation tank, the sludge withdrawal from primary clarifiers can be maintained at a constant line-cleaning flow.

Selenium Removal

Modern forced-oxidation FGD system wastewater contains selenium, predominately in the selenate form. While selenite can be somewhat removed by iron co-precipitation, selenate is soluble and is not removed in the treatment processes mentioned earlier. Effective treatment requires reduction to selenite or to elemental selenium.

Treatment of FGD wastewater is complicated by the presence of high concentrations of sulfate, which is very similar to selenate, and nitrates, which compete with the selenate to serve as oxidation sources. In addition, keeping a biological treatment process active is challenged by the variability of the wastewater composition and organic content. Additional work is needed before these treatment processes can be reliably employed.