Retrofitting IFAS Systems In Existing Activated Sludge Plants

by Glenn Thesing

Through retrofitting IFAS systems, communities can upgrade and expand wastewater treatment without the expense and complication of major new construction. For municipalities and regional authorities making critical decisions regarding expansions and treatment upgrades, it’s important to understand the capabilities and limitations of retrofitting IFAS systems, as well as the specialized approach to an IFAS retrofit project.

As many wastewater treatment plants approach their maximum capacities or face stricter effluent limits, communities are weighing different options. Space limitations often constrain the available choices for expansion, and many activated sludge plants are incapable of meeting more stringent effluent requirements with their existing configurations.

Upgrading treatment capabilities and expanding capacities without the expense and complication of demolition and new construction is always desirable wherever possible. Over the past decade, a growing number of communities have found that retrofitting Integrated Fixed Film Activated Sludge (IFAS) technology can be an effective alternative for expanding treatment capacity. For site-constrained facilities or those wanting to reuse existing tanks, retrofitting IFAS technology can represent an especially attractive option.

The IFAS process combines both fixed-film and suspended growth (activated sludge) processes. Combining activated sludge and fixed film media in the same reactor, along with proper aeration, provides control over solids retention time and the ability to manipulate the bacterial environment to facilitate various aspects of wastewater treatment. Since its introduction here from Europe over a decade ago, more than 2-dozen municipal applications of IFAS technologies are in use in the U.S. Also during this timeframe, there have been considerable advances in the areas of design and performance ranges for IFAS systems.

Understanding IFAS Capabilities, Requirements

For municipalities and regional authorities making critical decisions regarding plant expansions and treatment upgrades, it’s important to understand the capabilities and limitations of retrofitting IFAS systems as well as the specialized approach to an IFAS retrofit project.

In the AnoxKaldnes™ Hybrid Biofilm Activated Sludge (HYBAS™) system, an IFAS process from Kruger, mixed liquor suspended solids (MLSS) continue to perform their job in activated sludge tanks, but the process is significantly augmented by the addition of moving plastic carrier elements. Biofilm grows on the media, which is retained in the reactor using media retention screens, and an aeration system provides oxygen to allow the bacteria/biofilm to provide the treatment required.

The free-moving plastic carriers in the tank provide an ideal environment for bacteria growth, with aeration providing the necessary oxygen for microbial growth and sufficient agitation to fully disperse the plastic carriers and wastewater throughout the tank. The agitation also serves to control the biofilm thickness on the plastic media.

Each tank is considered a continuous stirred tank reactor (CSTR), so in order to achieve low outlet concentrations or differentiate between process conditions (BOD, Nitrification, Denitrification); a number of reactors in series are often included in a design. Anaerobic selectors, pre-anoxic mixed liquor zones, and post-anoxic mixed liquor zones can be designed into BNR processes that include an aerated IFAS zone for enhanced nitrification.

By adding the media to a plant’s aeration tanks, capacity is expanded and nitrification is achieved with less tank volume than would be required for a comparable activated sludge nitrification process. The fixed-film media provides substantial surface area for the growth of nitrifying bacteria without bringing about excessive solids loadings in the final clarifiers. In addition, plants retrofitted with this IFAS process can often significantly increase treatment capacity.

Retrofit Considerations

A number of factors must be considered and assessed before a decision is made to retrofit IFAS, including:

- Effluent Requirements
- Existing Tank Volume
- Existing Tank Age & Condition
- Existing Tank Geometry
- Existing Secondary Clarification Capacity/Performance
- Headworks Screening
- Plant Hydraulic profile

Where plants are striving to meet new total nitrogen (TN) removal limits, retrofitting a HYBAS system is highly effective if sufficient existing tank volume is available. Ideally, the process can be implemented in a plant’s existing tanks with no need for additional tankage. In cases where the demand for increased capacity will overtax the system, new tankage may be required, although retrofitting the process minimizes the number and/or size of new tanks that must be installed, reducing capital costs compared to conventional systems and making efficient use of limited space for expansion.

The biofilm carrier elements are made of high-density polyethylene and have a specific gravity of 0.96. The calculation for the amount of media required is based upon the surface area loading rate (SALR) selected and the effective surface area of the media in the basin.

Media of different shapes and sizes provide flexibility to use the most suitable type depending on wastewater characteristics, discharge standards and available volumes. The effective surface area of AnoxKaldnes™ (AK) K5 biomedia for biomass growth, for example, is 800 m^2/m^3 (244 ft2/ft3) and is used in reactors at fill rates of up to 60%, giving a biofilm surface area of approximately 146 ft^2 per ft^3 of tank volume (480 m^2/m^3) of reactor. AK Biofilm Chip™-M Media provides an effective surface area for biomass growth of 366 ft^2/ft^3 in bulk (1,200 m^2/m^3), making it an effective choice for highly constrained retrofit sites.

Tank Age & Geometry

When considering retrofitting an IFAS system, the plant should undergo a mechanical and structural inspection. The age and usage history of the existing tanks must be factored into the IFAS design. It is advisable for plants to consult with a structures or materials group to ensure the integrity of the tanks. The surface of concrete walls should not be rough from exposed aggregate or other sharp, angular protrusions.

The geometry of the plant’s existing tanks also plays a significant role in retrofit design. Square and wide tanks are the simplest to work with; however, long, narrow tanks can be made suitable, given the proper design. Round tanks also require a careful design approach because the IFAS system typically has three to five different zones divided by partition walls.

Achieving this with round tanks is more challenging, but it can be accomplished successfully. Regardless of their geometry, the ideal depths for tanks are between 16 feet and 24 feet, which maximizes oxygen transfer efficiency while making choice of blower simple. Aeration is by a medium bubble system that typically uses 4 mm holes in 1- to 2-inch diameter lateral pipes. These laterals and associated headers are usually fabricated in stainless steel pipe and fixed to the base of the reactors. The aeration system has no parts that need replacement or cleaning and is designed to be maintenance free.

Secondary Clarification Capacity/Performance

Although the fixed-film media provides substantial surface area for the growth of nitrifying bacteria without increasing mixed liquor loadings on the final clarifiers, in some cases there is need for additional clarifier capacity. These include cases where IFAS permits an increase in hydraulic capacity and where a higher mixed liquor concentration is required to achieve stricter treatment goals.

Another critical factor, where new discharge requirements are adding strict total nitrogen limits, is overall clarifier performance. The clarifiers must be able to deliver a very good effluent quality in terms of suspended solids removal because, following the retrofit, these suspended solids will contain nitrogen.

Headworks Screening and Head Loss Considerations

Headworks screening is important in project design. A 3-mm headworks screen is recommended if there are no primary clarifiers upstream of the IFAS zone, and 6-mm is adequate if primary clarification is in place.

Sieves, or media retention screens, in the IFAS zone effluent wall are used to retain the media. Typically these are horizontally mounted wedge wire cylindrical sieves with appropriate wire spacing. In the IFAS application, the movement of the media in the reactor and the agitation by air bubbles from the aeration diffusers keep the sieves from fouling with biological growth or other debris.

Some head loss can be expected with retrofitting a HYBAS system. Typically, plants that are retrofitted have no more than two IFAS zones, and sometimes only one. Each zone adds two to four inches of head loss, so two IFAS zones will contribute an addition four to eight inches of head loss to the overall system. A plant that cannot tolerate much headloss in its existing hydraulic profile may need additional sieves to minimize headloss. Sieves are designed to handle peak instantaneous flows, including recycled activated sludge (RAS) and internal nitrate recycle streams, if present.

Scum & Foam Control

Foam and scum generation is an activated sludge issue, not an IFAS media issue, but in a conventional system there are typically no submerged sieves covering the ports from one tank to another. Most of the flow exits an IFAS tank below the water surface. If the system is prone to produce or accumulate scum or foam, it can float on the surface of the IFAS tank and accumulate. Therefore, IFAS zones are designed with screened ports at the top of the downstream walls, thereby allowing foam to pass from one tank to the other. Spray bars or nozzles can also be installed at those locations to suppress foam and facilitate its migration downstream to the secondary clarifier.

Performance Expectations & Results

An IFAS system could potentially allow for the retrofit of existing basins to achieve nitrification in half the aeration volume otherwise needed for the same level of treatment.

Among the largest plants to undergo the retrofit is the James River Treatment Plant in **Newport News, Virginia**, one of nine major treatment plants operated by the Hampton Roads Sanitation District (HRSD) in southeast Virginia. With the HYBAS process starting in 2011, the plant upgrade will reduce the Total

Nitrogen load discharged into the James River (a major tributary to the lower Chesapeake Bay) while maintaining the existing footprint of the facility and reusing the existing tanks.

The existing treatment processes consisted of 6-mm screens, primary clarifiers, nine plug flow aeration tanks with fine bubble diffusers, and final clarifiers. Wasted biological solids from the final clarifiers are combined with the primary solids and anaerobically digested. The plant is bound by the river to the west, a residential community to the north, a park to the east, and a historical farm to the south. Due to these site constraints, additional aeration tanks and clarifiers would have been difficult and costly to construct.

A major design challenge was to retrofit the existing 200 ft long by 25 ft wide plug flow reactors with pre-anoxic zones for TN removal, an aerobic HYBAS zone for BOD removal and nitrification, and a final swing zone to ensure the 1.0 mg/l of ammonia effluent limit. The plant installed a demonstration train divided into three anoxic zones, one aerobic IFAS zone approximately half of the total tank volume, and one swing zone **(Figure 1)**. Following the two-year demonstration that showed the process could effectively allow the plant to meet its new TN standard of 10 mg/l, the decision was made to proceed with a retrofit for all of the plant’s treatment trains. This option saved significant capital costs and no new construction was required.

At the Dry Creek Wastewater Treatment Plant in **Cheyenne, Wyoming**, a HYBAS system has been retrofitted into a circular basin. The design concept was to incorporate two process trains with an anoxic zone for pre-denitrification followed by two HYBAS aerobic reactors in series. The system was based on data generated from a pilot study conducted on site.

An existing circular basin was converted into two reactors in series and retrofitted with IFAS media. The second train was new construction and uses the two-stage IFAS concept in rectangular basins. Effluent from the reactors is either recycled to the anoxic reactors to allow some pre-denitrification to occur, or flows into the final clarifiers to settle the MLSS **(Figure 2)**. The improvements to the Dry Creek facility have boosted its capacity from 5 MGD/winter and 7 MGD/summer, to 8 and 10.5 MGD, respectively. The fact that the system could be partially implemented using existing tankage was a significant cost-saving factor.

IFAS Retrofit: A Recap

Design and implementation considerations and operational strategies are important to the overall success of IFAS retrofit projects, requiring a comprehensive evaluation of existing facilities, treatment requirements, climate and wastewater temperature, and site constraints. IFAS technology is increasingly being selected over more conventional or small footprint solutions following a careful evaluation phase. IFAS technology provides the advantages of both activated sludge and other biofilm systems without being constrained by their limitations. In addition to often minimizing capital expenditures, advantages include a small footprint, familiarity for operation of activated sludge plants, reliable nitrification in cold temperatures, adaptability to many different tank configurations, and, perhaps most important, the ability to handle significant changes in flow and loading without sacrificing effluent quality.

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