BioMag/CoMag – Frequently Asked Questions

1. General questions about magnetite, the fundamental element used in BioMag and CoMag to increase settling rates and reliability.

Q What is magnetite?

A *Magnetite is fully oxidized iron ore (Fe_3O_4). It is completely inert; it cannot rust; it doesn't degrade with time or usage; it has no effect on chemical or biological floc; and it is not magnetic itself, i.e., it doesn't stick to metal. Recovered magnetite can be reused over and over again without any loss in its effectiveness as a ballast.*

Q Is handling of Magnetite difficult or troublesome as Lime or PAC.

A *Magnetite feed systems are designed with a pneumatic conveyance system, utilizing either a Silo or bulk bag storage mechanism. No direct contact with magnetite is required.*

Q How does magnetite improve the performance of clarifiers and treatment systems?

A *Magnetite is a very dense material with a specific gravity of 5.2. By comparison, the specific gravity of water is 1.0; a chemical hydroxide floc is fractionally over 1.0; and a biological floc is ~1.03. By infusing magnetite into either a chemical or biological floc, the specific gravity is increased by 20 to 50%, thereby significantly increasing the settling rate of the floc and gaining consistent control of the sludge blanket in the clarifier and greater stability for the whole system.*

Q Is magnetite readily available?

A *Yes, magnetite is mined and processed at multiple sites around the world. In the USA, Evoqua has identified multiple vendors that will provide magnetite to our specifications.*

Q What is the cost of magnetite?

A *Magnetite is very inexpensive, ranging from $0.20 USD to $0.50 USD per pound delivered, depending on the location of the distributor and the facility. Moreover, since the recovery rates of magnetite in both the CoMag and BioMag systems are so high, daily consumption is very low. In fact, while evaluating the operating cost of the treatment system, the ongoing cost of magnetite is negligible.*

Q Is the magnetite abrasive? Does magnetite cause excessive wear to pumps?

A Unlike grit or sand, the Evoqua specified magnetite is so fine that it has the consistency of talcum powder; hence, it is not abrasive and doesn't cause abnormal wear and tear on a treatment system pumps, mixers, valves and other components.

Q Does magnetite degrade at high temperatures (or low temperatures) or with changes in pH?

A Magnetite does not undergo any physical or chemical changes at the temperature and pH ranges associated with almost all municipal and industrial water and wastewater treatment.

Q Does magnetite affect pH or the chemical characteristics of the effluent?

A No, magnetite is completely inert. It has no effect on pH or the chemical characteristics of a system's effluent.

Q Does magnetite affect the oxygen content of water?

A As magnetite (Fe_3O_4,) is fully oxidized, it does not consume dissolved oxygen in water being treated.

Q How much magnetite is recovered on the magnetic drum and where does the remainder go?

A *Evoqua has modified the design of conventional magnetic drums to optimize the capture and reuse of magnetite. In BioMag systems, the capture reuse rate is more than 96%, in CoMag systems the recovery is in excess of 99.8%. Any magnetite not captured by the drum is carried away in the sludge where we have found no effect on downstream sludge management systems or processing.*

2. QUESTIONS ABOUT BIOMAG AND THE USE OF MAGNETITE IN BIOLOGICAL PROCESSES.

Q To what types of biological treatment systems can BioMag be applied?

A BioMag is most effective in enhancing the capacity and/or nutrient removal performance of activated sludge systems, including oxidation ditch, conventional air, extended air, HPO, and SBR based systems.

Q Does BioMag work with HPO?

A Yes, Evoqua has successfully tested the ability of BioMag to infuse and recapture magnetite from the relatively small and weak HPO biological floc. Hence, we are confident that magnetite can be effectively used to ballast mixed liquor from HPO facilities.

Q Does the BioMag process effect oxygen transfer efficiency?

A Evoqua has demonstrated that the addition of magnetite does NOT negatively impact oxygen transfer, since it is inert and does not increase the viscosity of the solids.

Q Are there any restrictions on the type of aeration? Surface aerators, diffused air aeration, pure Oxygen injection systems, or mechanical aeration?

A There are no restrictions on the type of aeration device with BioMag. Evoqua has design standards to accommodate various technologies.

Q What is the optimum MLSS concentration for various activated sludge applications: conventional, extended air, SBR, oxidation ditches etc.

A There is no simple answer to this question as the MLSS concentration targets depend on plant objectives for capacity and nutrient removal, the type of activated sludge technology employed, economic practicality and how the above are expected to change over time. With this said, Evoqua has achieved excellent results with MLSS ranging from 5,000 to 12,000 mg/L.

Q What is the optimum ratio of magnetite to MLSS in a BioMag enhanced system?

A We typically design for 1:1 ratio and optimize the system during commissioning to meet a project's specific need. Note that the amount of magnetite in the system can be varied as needed to control the blanket in the secondary clarifier; for example, a ratio of 1.2 magnetite to MLSS would be desirable to manage high wet weather flows passing through the biological treatment system.

Q How much magnetite is maintained in a typical activated sludge system enhanced by BioMag?

A *This depends on the size of the system and the density of the mixed liquor. But consider a 1,000,000 gallon(3.78 ML) bioreactor enhanced with BioMag technology. Assume the system is running 8,000 mg/L MLSS ballasted with 8,000 mg/L of magnetite (a 1:1 ratio). The weight of the water is ~8.34 million pounds (~3,783 metric tonnes); the weight of the MLSS is ~67,000 pounds (30,390 kg) as is the magnetite. Note the magnetite increases the mass of the system by ~ 0.8%. While this is sufficient to manage the settling of the blanket, it is a very small addition to the overall mass of the system.*

Q Keeping an MLSS of 10,000 mg/L that is infused with 10,000 mg/L of magnetite must create challenges in keeping the resulting 20,000 mg/L of solids suspended in the bioreactor. How does Evoqua solve this problem?

A *Much depends on an assessment of the existing or proposed aeration system and the objectives of incorporating BioMag. An increase in MLSS density for the purpose of increasing treatment capacity will necessarily require increased aeration for purposes of oxygen transfer to a larger biomass, a byproduct of which is increased mixing energy. Additional mechanical mixing may also be necessary to maintain full suspension especially if anoxic zones are incorporated. Consideration also has to be given to the type of aeration equipment: course bubble diffusers often provide sufficient mixing energy to keep the magnetite and MLSS in suspension while fine bubble diffusion usually requires additional mechanical mixing.*

Q What types of mixing systems are best suited to achieve the mixing required to impregnate biological floc with magnetite and to keep the floc in suspension?

A *Mixing can be achieved with mechanical mixers, diffused air, jet mixers/aerators, or a combination thereof. Anoxic and anaerobic zones are typically mixed with either submerged or floating mechanical mixers. Aerobic zones are normally mixed with either coarse bubble, jet aeration or a combination of fine bubble and mechanical mixing.*

Q How much mixing energy is required to maintain magnetite infused biological floc in suspension?

A *The mixing equipment for magnetite ballasted systems is designed to ensure suspension of the particles from a cold start which equates to an installed power requirement of approximately 55 BHP per million gallons (11 w/m^3) of tankage.*

Q Does magnetite addition suppress or exacerbate foaming in an activate sludge process?

A *Foaming is a function of the operation of the biological treatment system. The inert characteristics of magnetite neither enhances or diminishes the production of foam.*

Q What effect does magnetite have on the density for the sludge at the bottom of the secondary clarifier?

A Magnetite infused in the biological floc increases the thickening of the sludge blanket to ~ 2% solid.

Q With magnetite increasing the density of the sludge blanket at the bottom of the clarifier, can the RAS flow and the cost of pumping be reduced?

A It depends on the application. If magnetite is added to a system to improve only settling, and average forward flow and MLSS is not increased, there will be an increase in RAS concentration and RAS flow can be decreased accordingly. In typical BioMag applications, however, magnetite is added to enable an increase in MLSS to handle additional flow/loading or increased treatment; these applications will require AN increase in RAS flow commensurate with the increase in flow.

Q What is the effect of the magnetite to the WAS flow?

A. The very same effect as described in the above description of the effect of magnetite on RAS flow.

Q What is defined as well mixed? What mixing tests are performed and how are they measured?

A Well mixed is defined by TSS testing at various depths and locations throughout the bioreactor to maintain MLSS concentrations at ±15%.

Q Can coagulants be added to a BioMag enhanced activated sludge system? Does one type of coagulant work better than others?

A The addition of coagulants to the BioMag system results in precipitation of phosphorus and a higher quality effluent. Extensive testing has been carried out proving that BioMag works equally well with all common coagulants. The selection of coagulant type is typically dependant on client preference.

Q What happens to ortho phosphates?

A Three potential fates: (1) precipitated by coagulant and removed with the sludge; (2) assimilated by the biomass and removed with the sludge; and (3) passed through untreated.

Q When a power outage occurs, what will happen to the biomass ballasted with magnetite? And what happens when the power returns?

A *A full power outage will adversely affect all the systems associated with the activated sludge system, including the plant's aeration system and mechanical mixers. Without any mixing the ballasted biological floc will settle to the floor of the reactors. The same would happen without the enhancement of BioMag. Once the power returns, the ballasted biomass would easily get re-suspended since the biological floc remains approximately 99% water.*

Q How does the cost of operating a BioMag system compare to that of an MBR, IFAS or expanded ASP system.

A *While much depends on the application, the annual operating costs of a BioMag enhanced activated sludge system are about the same as an IFAS, MBBR, or a conventional ASP. Compared to an MBR system, the operating costs are approximately 60% less.*

Q What are the characteristics of the sludge produced from thickener underflow, SG, dry solids concentration and how does the inclusion of magnetite affect the flow?

A *The WAS has very little magnetite after the recovery process. Most of the filamentous bacteria have been broken apart by the shear mill, so the sludge thickens well to the 3-5% solids range. This benefit enables smaller belt press, filter press, centrifuge etc., and therefore, lower Capex and Opex.*

3. QUESTIONS OFTEN ASKED ABOUT THE CoMAG PROCESS AND PERFORMANCE:

Q What is the impact of magnetite on the effluent; TSS, turbidity, etc.

A Less than a half a percent of the magnetite used in CoMag escapes the system; hence, the direct effect on the effluent quality of either system is negligible. It is however, the use of magnetite in Evoqua's CoMag systems that enables both systems to achieve such high levels of contaminant removal. For example, the effluent turbidity from the Concord CoMag system can be easily reduced to levels less than that of bottled drinking water.

Q How does magnetite in the effluent effect the performance of a downstream UV disinfection system?

A Since very little of the magnetite escapes the system, the direct effect is not discernable. In fact, CoMag as a tertiary polishing system is a UV enabler. The fact that CoMag can perform well with alum coagulants and achieve very high levels of transmissivity, makes it possible to employ less UV treatment (and power)to achieve required levels of pathogen removal. The Concord, MA facility uses only 50% of one of its three banks of UV to meet its permit levels.

Q. How does CoMag handle high flows and surges?

A. CoMag uses automated controls to rapidly respond to flow variations. CoMag is also particularly effective in maintaining high removal levels during surges in solids loading. Unlike other ballasted sedimentation systems, the CoMag process recycles a significant fraction of settled solids from its clarifier back to its reaction tanks. The high mass and density of solids in the reaction tanks is many times greater than that of any surge in influent loading. The system is fully capable of managing surges in load with little degradation of performance. The result is superior solids removal, especially compared to those processes that don't incorporate an internal solids recycle.

Q. Can CoMag equipment be serviced over the 20-year design period?

A. All the components of the CoMag process are readily available in the marketplace. The system employs standard pumps, mixers, piping, valves, clarifier systems, and instruments. The magnetic components have been used in the mining industry since the early 1970s. Spare parts are readily available from multiple sources.

Q. What is the cost to install CoMag including the cost of structures, equipment, connecting piping, peripheral support systems, associated power and instrumentation, etc?

A. The installation costs are low for a CoMag system because of its simplicity, small footprint, and readily available parts. In addition and unlike alternative solutions, CoMag

may not need expensive post treatment filters to achieve the required treatment levels of current and expected future permits.

Q. What are the costs of chemicals, additives, power, equipment, and labor associated with the CoMag process.

A. Generally, the operational costs of CoMag are quite low.

Chemical consumption is likely to be less than competitive systems due to the ability of CoMag to achieve required treatment levels with less coagulant and flocculent.

The process provides for a nearly complete recovery and reuse of the magnetic ballast hence the cost is low.

Energy consumption is very low given the gravity flow of the system and the minimum required head. The ballast recovery drum employs permanent magnets and hence consumes no energy other than that required to turn the drum.

The system is fully automated; the need for operator attention is minimal.

The system does not use tube settlers, which require regular cleaning.

Q. Are there major parts that will require replacement?

A. There are no major parts that will require replacement other than the perhaps the pumps and sludge shear mixer, which are expected to have a useful life of 10 years or more. Their replacement is a simple process as they are easily accessible and readily available. None of the parts are hazardous or would require special disposal.

Q. Does CoMag enable the use of alternative chemicals with the same performance?

A. Yes. CoMag will produce nearly the same contaminant removal levels with alum, ferric chloride, or poly-aluminum chloride (PAC), and other conventional coagulants. The size of the CoMag system is the same for any coagulant, unlike other competitive systems. This gives the flexibility to meet limits with a coagulant chemical that best suits it's a plants needs.

Q. Are CoMag and its operation easily understood and operated?

A. Yes, CoMag is very operator friendly. The system readily responds to changing influent flows and loads, easily handling excess solids from the secondary clarifiers. It has few parts needing replacement and no inclined tubes that require regular cleaning to keep them from clogging. CoMag requires no sand filters, which can clog and must be backwashed.

Q. Can the process operate 24 hours with only being manned 8 hours a day?

A. Yes. The CoMag system has fully automated PLC controls.

Q. Are the process and its operation safe for operations and/or maintenance personnel?

A. Yes. CoMag equipment complies with industry standards for safety. It uses chemicals that can be safely handled without additional or specialized training.

Q. Does the process have operational flexibility such as taking some units out of service on a seasonal basis to save on operational costs?

A. Yes. CoMag provides a high level of redundancy and the ability to modify operations to meet effluent requirements

The process design provided by Evoqua is redundant. The design of the CoMag system will hydraulically pass peak flows and meet the treatment requirements.

Inherent in the operation of CoMag is the ability to manage dosage levels to meet effluent contaminant requirements.

Q. Could the process have a negative effect on downstream unit operations, if needed for higher effluent quality in the future?

A. Implementation of CoMag will eliminate the need for downstream filters, thus eliminating the associated capital and O&M costs.

Q. Does the ballast rust or stick to steel pipe?

A. No, the ballast is a type of iron ore that is fully oxidized and does not rust. It is attracted to magnets, but it does not attach itself to steel pipe.