Frequently Asked Questions (FAQ) Regarding Exterran Water Solutions Micro Bubble Flotation (MBF™) Technology

MICRO BUBBLE FLOTATION:

1. What is Micro Bubble Flotation (MBF™)?

MBF™ is a technology of creating micro bubbles of gas to be used in the separation of oil/water/solids by flotation of the oil droplets and solid particles to the surface of a tank or vessel.

2. How is MBF Different from IGF or ISF?

MBF™ utilizes much smaller bubbles of gas for flotation, typically these bubbles are 100 to 1,000 times smaller than those utilized by standard IGF packages. The smaller bubbles allow for a much more efficient separation due to a higher probability of attachment (smaller bubbles = more bubbles), a higher surface area for attachment (smaller bubbles = higher surface area) and a longer time in contact with the droplet (smaller bubbles = slower rise velocity). The net effect is that more oil and solids can be removed even those droplets and particles of a very small size.

The other Unique Feature to MBF™ is that it can be adapted to almost any existing Vessel thereby turning a simple gravity settling tank into a high performance IGF multiphase separator.

3. Where can I Utilize MBF?

Micro Bubble Flotation Packages are available as a pressurized separation Vessel in either a Vertical or Horizontal orientation (depending on Customer needs). These packages marketed under the RevoLift™ tradename are designed to compete with IGF's or ISF's .

Micro-Bubble Flotation Packages are also available for Retro-Fit into an existing IGF , Skim Tank (API 650), Wash Tank or Accumulation Vessel.

Either configuration is an effective addition to a water treatment plant for removal of oil and solids. For new plants this can bring significant capital and operational cost savings. For existing plants this can be an effective way to de-bottleneck while utilizing existing assets and bringing significant cost savings to the facility.

4. What Oil Removal Efficiencies can I Expect From MBF™?

Oil removal efficiencies are always a function of a number of factors including:

- Oil Specific Gravity (API)
- Concentration of Oil in Water
- Emulsification of Oil (droplet size)
- Temperature of Water
- Water Chemistry
- Design of / and Retention Time in Tank or Vessel
- Current Use of Chemicals and Type of Chemicals
- Recirculation rate across the MBF Skid

When properly designed a MBF system can achieve greater than 98% Oil Removal Efficiency.

5. What Solids (TSS) Removal Efficiencies Can I Expect From MBF™?

Solids removal efficiencies are always a function of a number of factors including:

- Specific Gravity of Solids
- Particle Size of Solids
- Concentration of Solids in Water
- Temperature of Water
- Water Chemistry
- Design of / and Retention Time in Tank or Vessel
- Current Use of Chemicals and Type of Chemicals
- Recirculation rate across the MBF Skid

When properly designed a MBF system can achieve greater than 75% TSS Removal Efficiency.

6. What Operational Savings or Increases in Revenue Can be Expected From Implementation of MBF™?

Savings are a function of the type of operation in place, not all facilities utilize the same equipment or face the same operational expenses. The following are examples of significant areas of savings and or revenue generation our clients have realized through implementation of MBF™:

- Recovery of Oil previously lost to disposal of Produced Water
- Reduction in the amount of Chemicals required for Clarification / Flocculation (operating cost savings)
- Capital Cost savings by limiting the amount equipment required at a facility – elimination of the IGF's and reduction in number and size of Tanks
- Reduction in the number of Well Work Overs to maintain disposal well injectivity
- Reduction in manpower required to maintain operation of the water plant due to less equipment and the use of less mechanical equipment

7. How Heavy Can My Oil Be for Effective Removal?

Almost any oil can be effectively removed using MBF™. The heaviest oils successfully tested using MBF™ is of an 8 API. As the oil gets heavier the MBF™ design must compensate by inducing more gas but provided the design has accounted for this almost any oil can be lifted.

8. How Do I Make the Micro Bubbles?

Exterran Water Solutions offers two methods of creating the micro bubbles.

a) A Gas Liquid Reactor – pressure vessel (GLR™) that uses hydraulic flow, shear, impact and pressure to create micro bubbles of gas.
b) An ONYX-MB Pump where the hydraulics within the pump creates the micro bubbles.

9. What Gas is Used for MBF™ and Where does it Come From ?

Almost any gas acceptable to your facilities water chemistry can be used. For economics either produced gas or fuel gas is used. The volume of gas required is quite small and is of little consequence to your operating costs. At temperatures of 60 °C or lower the gas can be induced directly from the headspace of the Tank or Vessel. With higher temperatures a pressurized gas supply to the inlet of the ONYX-MB pump or GLR™ is recommended. An eductor / venturi is required for the GLR™ to self induce gas from a tank headspace while the Onyx pump is capable of self induction .

10. When Do I Choose to Implement the GLR™ vs. the ONYX-MB Pump?

While both the Gas Liquid Reactor and the ONYX-MB Pump have similar abilities to create and entrain micro bubbles into produced water there are a number of considerations that can drive selection of one technology over the other. Some examples include:

Space Available - The ONYX-MB pump has a smaller footprint than the GLR

Water Chemistry / Metallurgy - The GLR vessel can be constructed or coated in any material to meet metallurgy requirements. While the ONYX pump has more limited choices for metals and due to its construction tolerances internal coatings are not an option.

Flow Rates Required - The ONYX-MB pump is available in flow rates up to 600 gpm. Recirculating flow requirements are a function of the total flow of produced water to be treated. For very large projects high recirculating flow can only be met by using banks of multiple ONYX-MB pumps while the GLR is available in much larger sizes still driven by a single pump.

Up-Turn / Down-Turn - The design of the GLR allows for a larger range of flows through a single device

Economics - Due to the design, materials, instrumentation and controls the GLR has a higher capital cost than the ONYX-MB pump. In most cases small to moderate flows are more economical treated with the ONYX-MB pump.

Corporate Philosophy on Pumps - The GLR uses a standard centrifugal ANSI pump while the ONYX-MB pump is of a proprietary multi stage open impeller design where gas is intentionally introduced to the pumps suction.

11. If I Retro-Fit an Existing IGF What Equipment Will be Replaced or Removed?

The equipment to be replaced will be dependent on who the original manufacturer of the IGF was and the design utilized. Typically all mechanical means of inducing gas into the produced water are eliminated along with the motors or pumps driving those processes. Additionally any mechanical means of skimming oil from the waters surface are also replaced. The end result is a streamlined system with no mechanical parts that operates much more efficiently in power consumption and oil / solids removal efficiencies.

12. If I Retro-Fit to an Existing Gravity Separation (Skim) Tank What Work Will be Done Inside the Tank ?

A tank that was initially setup for gravity separation typically has its water inlet heights too low and in a trajectory that is not optimal for MBF™. In addition it is quite common to see outlet piping that draws water straight from a single nozzle. The impact of these two factors is often a short circuit of water from the inlet to the outlet leaving little time for phase separation. The designs that Exterran Water Solutions utilizes for retro-fits are simple flange fitted steel or fiberglass piping to raise the inlet heights internally and allow for effective distribution of water blended with micro bubbles at the appropriate location and velocity. Some designs incorporate an outlet header to create "plug flow" downward in the tank as well. In some cases the optimal design may require more significant internal modifications however wherever possible we avoid recommending designs that require welding inside your tank or vessel.

13. What Factors Increase the Need for Gas for Flotation or Volumes of Water in Recirculation ?

Higher recirculation rates equate to higher entrained gas loads within the system. There are three main factors can increase the demand for a higher gas load:

a) Specific Gravity of the Oil - Heavier oils require more gas to achieve effective and timely separation

b) Temperature of the Water - Bubble rise velocity is impacted by temperature, so as temperatures increases, gas travels to the surface faster, and less gas can be entrained in the volume of water below the surface. The impact is that a larger volume of water must be recirculated to achieve the same gas load as at a lower temperature

c) Retention Time - as retention times get smaller the process must work faster thereby requiring a higher gas load

GAS LIQUID REACTOR (GLR™):

14. What is the GLR™ ?

The GLR™ (Gas Liquid Reactor) is a patented gas/liquid contactor designed to supersaturate liquids with a gas. The GLR™ contains no moving parts, does not require a compressed gas source and is virtually maintenance free. It can be used to dissolve a variety of gases into liquids and in most cases results in a liquid containing the gas at or above the saturation point (supersaturation).

15. How Does the GLR™ Work?

The GLR™ unit uses fluid dynamic processes to exert shear, impaction and pressure upon an entrained gas thereby efficiently creating micro-bubbles. A liquid containing entrained gas is passed through the GLR™ unit, resulting in the production of bubbles with a diameter ranging from 5-50 microns.

16. How is the GLR™ Different From Other Gas Diffusion Devices Available to Me?

Small bubbles are critical to performance. By creating small bubbles, the mass transfer area between gas and liquid phases is maximized. This substantially increases the efficiency of the transfer of the gas to the liquid. There are very few technologies that can create gas bubbles as small as those produced by the GLR™. The GLR™ is fundamentally different because it creates these bubbles without a diffuser head or membrane, which wear or often get plugged with alternative technologies. The GLR™ creates bubbles in an open pipe with nothing to plug or wear. Furthermore a separate compressed gas line is not required if a venturi is utilized.

17. Can I Induce the Gas for Flotation Directly From the Headspace of the Tank or Vessel ?

Gas can only be induced from the tank headspace when the GLR™ is paired with a Venturi / Eductor which utilizes a pressure drop following the pump to create a vacuum to pull headspace gas. In most Oil & Gas installations for practical purposes operators have chosen to directly inject pressurized gas rather than oversize a pump for this pressure drop.

18. What is a Venturi?

A venturi is a tube with a constricted throat that increases velocity and decreases pressure. An opening at the constriction point utilizes the resulting vacuum to entrain gas into the moving liquid. This device can be utilized to replace a gas compressor for any applications of the GLR™.

19. What Maintenance is Required?

There is virtually no maintenance required to keep the GLR™ operating under optimal conditions since the unit has no moving or replacement parts. If the GLR™ purchased operates by manual valve set points (as opposed to automated level controls) it is recommended that water elevations within the unit be inspected periodically (through the site glass) and settings adjusted if necessary. If the site of application experiences freezing conditions and the GLR™ unit will not be operating continuously it is recommended that the unit be winterized by draining the unit of water or alternatively heat tracing of areas that are reservoirs of water.

20. Can I use my Existing Pump With the GLR™?

In some cases an existing pump can be utilized, thereby simplifying installation and reducing capital costs. The existing pump must be capable of producing required liquid flow rates at the required pressure. In most cases the GLR™ requires an inlet pressure of 70 psi which must be provided by the pump. When a venturi is utilized additional pressure is required from the pump to accommodate the pressure drop that occurs across the venturi.

21. Can I Manipulate the Bubble Size Discharging From the GLR™?

Bubble sizes can be customized to almost any diameter desirable through manipulation of the backpressure held at the GLR™ reactor (a single valve adjustment) and/or control of the water level held within the device. This flexibility allows for customization of the flotation process as operating conditions change over time.

ONYX-MB PUMP:

22. What is the ONYX-MB Pump ?

This is a very unique multi-stage pump capable of self inducing up to 20% of its inlet flow as a gas into its casing. While most pumps would not be capable of pumping or at least suffer from severe cavitation with this gas the ONYX-MB pump creates trillions of micro bubbles through shear and pressure with no cavitation. The performance of this pump is primarily due to its proprietary impeller configuration and unique method of moving this multiphase water stream from stage to stage through the pump.

23. How Does this Pump Compare to Other Pumps Capable of Dissolving Gas?

There are very few pumps capable of creating micro bubbles of the size required for MBF™. The ONYX-MB pump is superior to anything on the market due to its higher discharge pressures, higher gas saturation efficiency, multi-stage design, mechanical seal, operational reliability and standard materials of construction. All components other than the impeller are of ANSI specifications which allows for ready access to spare parts and of construction suitable for the harsh operating environments found within the Oil & Gas industry.

24. What is the Commercial Implementation / Operating History of This Pump?

The ONYX-MB pump resulted from the combination of two very proven pump technologies. The hydraulic design was evolved from a DAF pump which has a 23 year long successful history in many industrial & municipal settings outside of the Oil & Gas industry. The mechanical design was directly duplicated from an ANSI (between bearings) pump with a 30 year long successful history - including its shaft, sleeves, seals, lubrication, bearings, etc.

25. Can I Manipulate Bubble Size Discharging From the Pump?

Yes, the bubble size can be modified by adjusting a single valve on the discharge side of the pump. This control ability allows for optimization of bubble size to meet the ever changing flotation requirements of an operating facility.

26. Can I Induce Gas to the Pump Directly from the Tank / Vessel Headspac?

Yes, the ONYX-MB pump is capable of self inducing gas from the headspace of a tank or vessel provided the water temperature is below 60 ºC and the pressure drop across the piping arrangement is not significant. At temperatures above 60 ºC a compressed gas feed is piped directly to the inlet of the pump.

27. What Materials is the Pump Available in?

The pump Casing and wetted parts are available in Ductile Iron, 316 Stainless Steel, Duplex Stainless, Super Duplex Stainless Steel, and Hastelloy C. Our base standard is 316 Stainless Steel with Duplex impellers.