NOTES ON PURE OXYGEN SUPPLEMENTATION.

In intensive fish culture, dissolved oxygen is usually the first limiting factor in determining the carrying capacity of a given water supply. When designing flow-through and recirculating fish rearing facilities, such as hatcheries, water quality criteria are set for dissolved oxygen, ammonia, suspended solids (fecal waste and unused feed) and carbon dioxide. Water flow rates that are required to maintain these criteria are then determined. Usually, the highest flow rate required is that for maintaining the desired dissolved oxygen level.

When water flow rate is fixed and conventional aeration achieves 95 to 100% air saturation, pure oxygen supplementation becomes necessary when uptake of the fish exceeds that available in the incoming water. Back-up oxygen systems may also be necessary for periods of low water flow, power outages or when fish are subject to stress.

Aeration:

Aeration is the introduction of oxygen (and other gasses) into water using air. Since oxygen is only 21% of the air, the dissolved oxygen level achieved through aeration is limited to that which occurs in nature. In designing aquaculture systems, it is normal for the water to be first brought into equilibrium with the air so as to get as much “free” oxygen into the water as possible. Bringing the water into equilibrium with air using an aeration tower or open packed columns is also important for stripping nitrogen and other gasses from the water. Nitrogen super saturation is a common problem when using ground water.

Oxygenation Systems:

Pure oxygen supplementation can significantly increase the production capacity of a rearing facility, or significantly reduce the water flow rate required for a given facility. Pure oxygen systems are basically of two types: low pressure and high pressure. Low-pressure systems are typically low pressured packed columns and diffusers, where pure oxygen is introduced or at near atmospheric pressure. High pressure systems are “down-hole” on U-tube systems, pressurized packed columns are direct sparging into pipelines under pressure usually two or three atmospheres or higher.

A very important, and often limiting factor, with pure oxygen injection is Total Dissolved Gas Pressure (TGP). Criteria set for TGP can limit the amount of pure oxygen that can be injected into the water supply depending on system design and operating pressure. If fish are subjected to TGP’s significantly higher than local barometric pressure, they can be affected by “gas bubble trauma” due to bubble growth in their blood and tissue. Operating pressure of the oxygen injection system will determine the TGP of outgoing water - the higher the operating pressure, the higher the TGP.

It is generally accepted that TGP of fish culture water should be kept below 103% of barometric pressure to avoid fatalities from gas bubble trauma. TGP limitations are usually encountered when the total water supply is injected with pure oxygen in which case low-pressure systems are recommended.

In low pressure systems nitrogen is stripped from the water as oxygen is absorbed. Air saturated water can only absorb more oxygen by displacing nitrogen (stripping). In these systems, dissolved oxygen can be raised to 150% saturation or higher with TGP at 103% or less - depending on system pressure.

In high-pressure systems a lot of oxygen can be absorbed without stripping nitrogen (until the water becomes saturated once again at the elevated pressure), thus leading to very high TGP's. For this reason high pressure systems are not always suitable for treating the total water supply, particularly long raceways where fish at the top end can be subjected to lethal levels of TGP. High pressure systems are best suited for side stream injection, where small quantities of oxygenated water are introduced at intervals into the rearing units to maintain oxygen levels, and hence TGP, at or below saturation levels. As fish consume the oxygen in the water there will be a corresponding reduction in TGP.

The type of rearing unit, mixed flow (circular tanks) or plug flow (raceways) is an important consideration when selecting oxygenation systems. TGP limitations are not so severe with mixed flow units because incoming water is rapidly mixed when entering the tank and TGP's throughout the tank are close to outlet levels. TGP of outgoing water will be lower than incoming water because of oxygen depletion.

Decoupling:
In most oxygenation systems, the incoming water is the carrying medium for supplemental oxygen. If possible, oxygen addition should not be dependent on the water supply, so that it will not break down when water supply falls. Decoupling of the oxygen injection system from the water supply allows it to function as a back-up if it does not depend on water flow for its use. This consideration, together with TGP limitations, is another reason not to inject oxygen into incoming waters, but to inject it directly into rearing units at one or more places. This will keep the water and the oxygen sources distinct and will tend to maximize the benefits of oxygenation while minimizing risks.

Sources Of Pure Oxygen:
The choice of oxygen supplies is an economic decision. The most expensive source of pure oxygen is high-pressure gas cylinders which are really only suitable as a back-up. The next most expensive source is the portable liquid oxygen cylinder, which holds considerably more oxygen because it is stored as a liquid. The next option is bulk storage of liquid oxygen, which requires permanent storage tanks at a facility. Finally, the least expensive source in most cases is on-site oxygen generators.

The choice of an oxygen source is dependent upon the level of isolation of a facility and on the volume required. A remote site that uses a lot of oxygen is probably best off with an oxygen generator. A farm close to a gas supplier using a moderate amount of oxygen is probably best off with portable liquid cylinders or bulk oxygen.

"Pumped Oxygen":
When oxygen is the limiting factor, any water that has to be pumped through a system in excess of that required to flush waste from the system, is being pumped for its oxygen content. The oxygen supplied by pumped water can be termed "pumped oxygen" and there is a cost attached to this pumped oxygen. Many aqua culturists are pumping water for its oxygen content and are not always conscious of the associated cost. It would be wise to compare the cost of "pumped oxygen" with the cost of pure oxygen supplementation with reduced water flow.