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FLOATING LAGOON BAFFLES

Slickbar's Design Philosophy
and
Baffle Terminology

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Slickbar has over twenty five years' experience in supplying floating baffles in municipal and industrial applications. We have manufactured baffles in sizes ranging from less than 100 sq. ft. to over 20,000 sq. ft. To the best of our knowledge none designed in conformance to this philosophy have failed in service, and all have exceeded their life expectancy when properly maintained by their owners.

To achieve this success we have adhered to the following basic engineering principle: we utilize the inherent tensile strength of the fabric membrane from which the baffle is manufactured to resist the tensile forces imposed on the baffle by current flow, wind, and ice.

For our "top-of-the-line" baffles, we use Seaman XR-5 style 6730, 30 oz./sq. yd. black fabric and give our customers a ten-year prorated warranty under most conditions. We recommend this fabric over other coated fabrics because of its higher tensile and tear characteristics. It is designed for "active" fabric structures, such as floating lagoon baffles. For the lower cost and shorter lived baffles, we use a PVC coated 22 oz./sq. yd., high tensile, high tear strength nylon or polyester fabric. Special potable-water-approved PVC and other coated fabrics are available for special circumstances. Please refer to our specifications and drawings for each baffle style.

When the fabric is not of itself strong enough to resist these externally imposed forces, we add one or more top tension members made from a parallel fiber polyester "rope" we call a "synthetic paralay" tension member. It is lightweight and has the same modulus of elasticity as that of the polyester fiber of the baffle's fabric. There is no differential stretching under load such as is caused by chain or steel wire, resulting in chafing, premature fabric wear, and failure.

Under most conditions, baffles fabricated from high strength 30 oz./sq. yd. XR-5 fabric which have an area of less than 800 sq. ft. (i.e., 100 ft. long by 8 ft. deep) or (200 ft. x 4 ft.) do not require a tension member. One tension member is supplied when the baffle's area is between 800 and 2,000 sq. ft. For those baffles with an area in excess of 2,000 sq. ft., we supply two tension members.

Likewise, for baffles using 22 oz./sq. yd. fabric these areas are reduced 40%. Under 500 sq. ft., no tension member; 500 - 1,200 sq. ft., one tension member; over 1,200 sq. ft., two tension members are furnished.

Special designs for in-tank baffles: under-flow/overflow baffles in a series and exceptionally deep baffles may require additional tension members. Please consult the factory in these circumstances.

Slickbar extrudes its own 6 lb./cu. ft. density polyethylene foam which is then molded to densify the skin to produce the Mk 10 and Mk 7 floats which are fastened back-to-back to the top edge of the baffles' fabric membrane. These floats are rugged and very durable, resisting the chafing action of ice and debris very well. Mk 10 floats have a freeboard of about 5-5½ inches--Mk 7 floats about 7½-8 inches, depending upon the depth of the baffle. If a top tension member is present, the freeboard is increased by ½ inch.

For the less expensive Mk E style baffles, we roll our floats into "logs" from polyethylene sheet foam to 6 or 10 inch diameters, depending upon a 5 inch or 8 inch freeboard requirement. We axially restrain the floats within the fabric flotation tube with internal means, thereby better distributing the tensile stresses over the upper 2 to 3 feet of the baffle.

This feature also allows the top tension member to lie in a straight line. Where only one tension member is required, it is placed above the floats allowing the baffle to "hang" naturally from the tension member at the baffle ends. Where the tension member leads up the lagoon's bank, some other designs place the tension member under the float which allows it to flop about in the wind causing wear and tear that leads to fatigue and early failure.

Competitive designs which "pinch" the fabric between floats create problems. The fabric which is "pinched" between floats is longer than the fabric below the floats (the skirt) by approximately .266 x diameter of the float per pinch. If we say we have a "pinch" every 5 ft. and the float is 6" in diameter, then the fabric "pinched" is about 2% short. If larger diameter floats are used, the problem is more serious.

By the same logic and geometry, a top tension member is also approximately 2% "long" when compared to the length of the skirt fabric. Again, larger floats aggravate the problem.

If high tensile forces are placed upon the baffle, they must be resisted by the flotation tube fabric until it stretches the 2 or more percent, and that force also tends to separate or "peel" one side from the other at the "pinch" weld. Since most coated fabrics have a coating adhesion strength of only 10-15 lbs. per inch, it does not take much tension to fail the weld and allow floats to migrate axially within the float tube.

We also internally fold the float tube fabric at the connectors so it is not necessary for the connector to extend above the float (thus minimizing top weight) while not losing the fabric's inherent tensile strength. We also fold the upper 56" to 61" width of fabric at the tapered end to give the baffle double fabric strength at each shoreline end connector.

We use self-riveted lead weights as ballast, usually furnishing 1½ lbs. per foot of baffle. Extra weight can be factory furnished or easily installed in the field if found necessary. Where price is critical, we furnish hot-dip galvanized chain in a sealed fabric pocket at the baffle's lower edge. We do not recommend chain where the baffle might be exposed to relative motion with the lagoon's bottom because the chain may quickly wear through its fabric pocket and become loose from the bottom edge of the baffle. This causes the baffle to "balloon" allowing under-flow, thereby, failing to accomplish its purpose. In lined lagoons the loose chain might damage the lining.

Other manufacturers utilize external concrete weights attached to the bottom edge of the skirt for ballast. We feel their use puts undue local high stress concentration on the fabric's bottom edge. Where bottom anchoring is required we reinforce the attachment point with stainless steel plates to minimise local stresses.

All fabric seaming is accomplished with radio frequency bar sealers, or hot wedge, or hot air welding techniques which guarantee total seam integrity and full tensile strength transfer from one piece of fabric to the next. Sewn seams, on the other hand, will in time fatigue and separate, thereby, causing baffle failure.

Except for possible galvanized steel chain ballast, all connectors and hardware are Types 302 or 304 stainless steel. For special situations, Type 316 stainless steel is available at additional cost.

Shop size and handling capacity dictate that baffle sections be limited to about 1,000 sq. ft. in area. When larger baffles are required, they are made in sections with stainless steel connector plates joining the upper portions of the fabric membranes and tension members. Membranes are joined below the tension members by frequent bolting of grommetted doubled fabric end hems of adjoining sections. If chain is used as a ballast member, the lengths within each section are coupled with "quick links".

When baffles are made in sections, the section length coincides with the recommended spacing of side anchor assemblies. Side anchors consist of tether lines between section connector plates (bridled if two tension members are present) and surface buoys of 1 cu. ft. volume. Shock absorbing nylon anchor lines lead from the surface buoy to concrete anchor blocks (or concrete filled rubber tires if the lagoon is lined). Anchor lines are about 5 times the lagoon's water depth in length and terminate on five feet of galavanized chain to minimise chafing at the anchor block, thus assuring long life.

How long must a baffle be? It must be designed to "fit" the lagoon at the highest expected water level. The most critical dimension to be known, therefore, is the lagoon's waterline length (at high water). Next, the lagoon's design slopes and depth must be known. The entire bottom profile from shore-to-shore must be determined if a baffle is to be installed in an old lagoon which might have been subjected to silting or if dredging is to be accomplished. It is the responsibility of the buyer, contractor and/or engineer to accurately determine this length and profile and give that data to Slickbar.

It is convenient to manufacture the baffle in standard length increments of 5 ft. (for Mk E and Mk 10 styles) and 3'-4" (1 meter) for Mk 7 style baffles. Slickbar end connectors stand slightly offshore, vertical in 6 to 8 inches of water. The gap between the shore and the end connector is sealed with "end flaps" made from the same fabric as the baffle's membrane.

Baffle length, end-connector-to-end-connector, is then the lagoon's waterline length, minus each end slope times the depth of the connector in the water. Let's say the lagoon's waterline length was measured at 180 ft. at highest expected water level. The end connectors were standard 12 inch length and extend 7 inches below the water's surface. One end slope was 3:1 ratio, and the other was 2:1. We must subtract for one end 7" x 3 = 21" and 7" x 2 = 14" for other end; 180' - 21" - 14" = 177' - 1". The baffle should not be drawn absolutely tight and straight, so we add between ½% to 1½% to its length; 180' x ½% = 0.9' (11") to 1½% = 33"--close enough to the 35 inches we had to subtract for connector distance from the shoreline--we will make the baffle 180 ft. long.

Should the baffle in question have been 600 ft. long, we would recommend it to be 600 - 35" + (3'-0" to 8'-0"); or, 605' which is an even 5' increment which fell within the range of 600'- 1" and 609'- 1", giving us a "looseness" of about .85%.

If the first baffle mentioned (180') was 5 ft. overall height and was fabricated from XR-5 fabric (i.e., 720 sq. ft.), it would be made in one piece with no tension member required. If 22 oz./sq. yd. fabric was used, one tension member would be furnished. Two tension members would be required for the second example (600' x 4'). Whichever fabric was chosen, the baffle would be manufactured in three sections--one center section of 205' and end sections of 200' each (with different end tapers). Should the longer baffle have been about 10 ft. overall height (6,000 sq. ft.), we would manufacture it in three sections if 30 oz. XR-5 were used, or four sections if 22 oz./sq. yd. fabric were used. Three pairs of side anchors would be used with 22 oz.. fabric while only two would be required for the stronger fabric.

For baffles deeper than about 12 feet, we recommend section lengths of approximately 100 feet for either fabric. Baffles should not be placed close to aerators as the vibration and movement caused by local turbulance can drastically shorten the life of any baffle. A safe rule of thumb is one foot distance per horsepower. Baffles which must be placed nearer than that rule dictates or those requiring subdivision with "T" connectors may require extra reinforced side and/or end plates for additional anchors. Special anchor point assemblies are available for 90° turns in the baffles.

Attachments for vertical concrete walls or steel tanks, clarifiers, sumps, or treatment basins are available for fixed or variable water levels.

Typical end terminations for each baffle style and model are shown on the drawings following each style's basic specification. Only the local engineer familiar with the soil conditions, the prevalent local wind conditions, and the pressure or absence of currents impinging upon the baffles can estimate the forces on the baffle shore anchor posts.

We give the following formulae to assist in that determination:

D_w = Drag Force due to wind loading

$$= \frac{C_D \rho \omega S(V)^2 L}{4g_c}$$

conservatively = $.0012\, S(V)^2\, L$

where: S = exposed freeboard of baffle in feet

L = distance between supports in feet

V = wind velocity in ft./sec.

1 MPH = 1.47 ft./sec.

T_W = tension in the baffle due to wind = $\dfrac{D_w}{\cos \varnothing}$

Wind velocity at water level is usually about 50% of that taken at the weather bureau's standard anemometer height of 33 feet. If maximum reported local wind (normal to the baffle's alignment) is reported at about 80 miles per hour, then a conservative figure of 40 miles per hour, or 58.7 feet per second should be used when computing shore anchor post and intermediate anchor loads.

Similarly, if any current is impinging upon the baffle the resultant forces must be added to the wind forces.

D_C = drag force due to current loading

approximately = $S(V)^2L$

where: S = water depth in feet

L = distance between supports in feet

V = water velocity in ft/sec.

T_C = tension in baffle due to current = $\frac{Dc}{\cos \varnothing}$

If a baffle is so placed in a lagoon that it must turn the flow 90° we calculate the forces on the local anchors as follows:

Given flow of 12,000,000 gpd

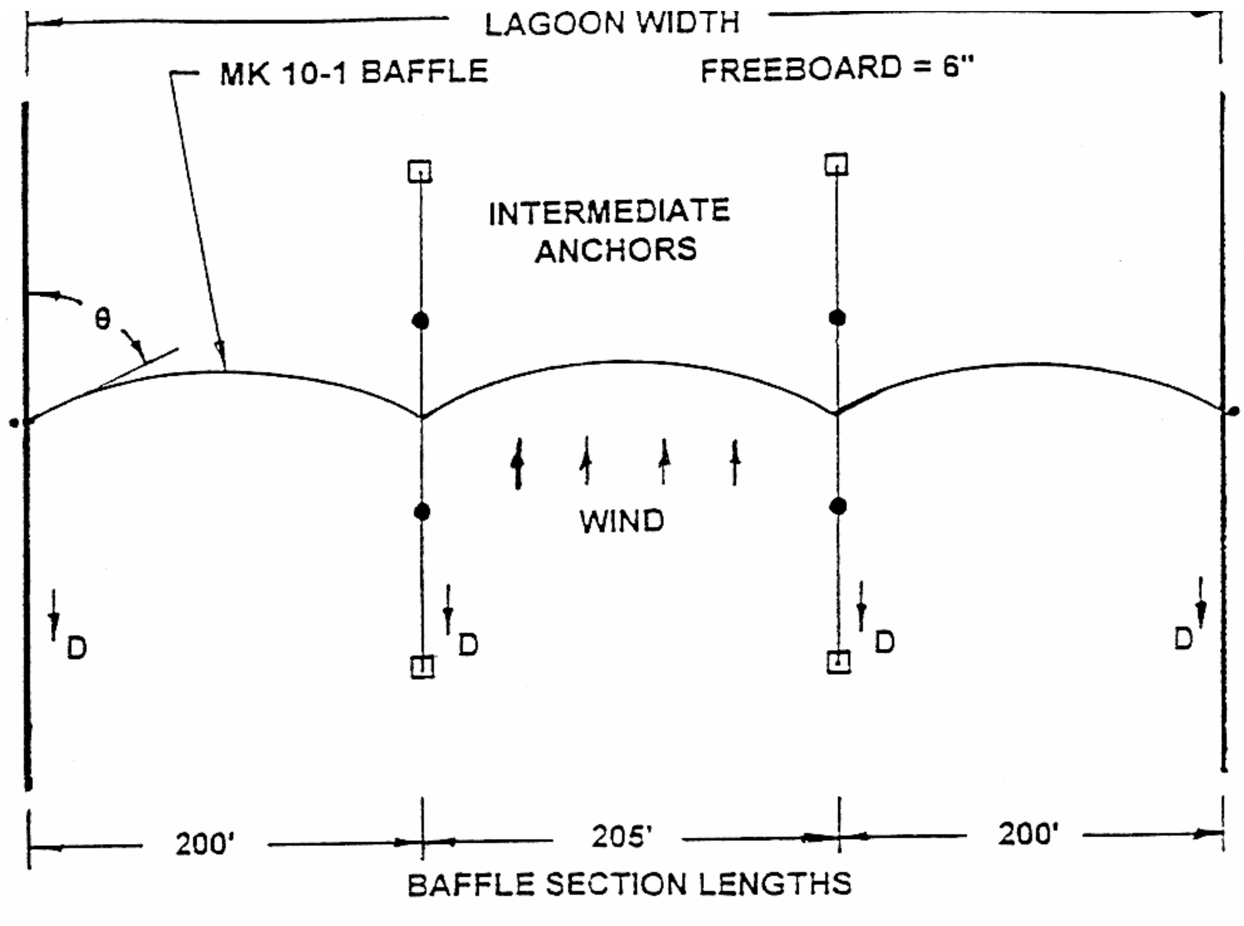
Baffle draft = 8 feet

Width of channeled flow = 100 feet

$$\text{Velocity of water} = \frac{2{,}000{,}000}{24 \times 60 \times 60 \times 7.48 \times 8 \times 100} = .004 \text{ ft./sec.}$$

$Dc = 8\,(.004^2)\,100$

$= .013$ lbs. ---- A Negligible force !



In the previously sited example with the 605 ft. long baffle and 40 mph wind:

D_w at each anchor post = $.0012 \times 0.5 \times (58.7)^2 \times 200$

= 415 lbs.

D_w at each intermediate anchor = $.0012 \times 0.5(58.7)^2 \times (200 + 205)$ = 840 lbs.

(not a very high number, but if the lagoon is lined, rubber tire anchors may slide and anchor lines terminating on shore anchor posts located at the ends of the lagoon should be considered). Angle ∅ equals approximately 75° in our example.

$$T_w \approx \frac{840}{\cos 75^\circ} = \frac{840}{.26} = 3{,}200 \text{ lbs.}$$

Note that if no intermediate anchors were used, the tension in the baffle at the shore anchors would be:

$$T_w \approx \frac{.0012 \times 0.5 \times (58.7)^2 \times 605}{.26} = 4{,}800 \text{ lbs.}$$

If no top tension members were furnished and the fabric is single thickness at a 12" end connector, the stress on that fabric would be 400 lbs./inch!

One particularly dangerous situation can occur if shore anchor posts are located higher up the bank than the baffle's end and the lagoon water level can drop more than a foot from the highest expected (design) level. The baffle ends would be exposed to the wind, and if wind velocity exceeds about 30 mph they can lift, exposing more area, more force, lifting more baffle, etc. We have experience with 200 feet (of a total length of 600 feet) of a 23 foot deep baffle flying 35 feet in the air like a giant ship's sail...until the end wire failed at the anchor post. Therefore, we **<u>highly</u>** recommend that the end wires pass through screw anchor eyes (or equivalent) located within 6 inches in elevation of the waterline.

If the water level fluctuates and might drop more than a foot or so below the design water level and high winds might occur (as in local thunderstorms), end lace lines may be required. To prevent wind forces from lifting the baffle's exposed ends and causing the baffle to "fly" in the air, the lace line is tightened at low water level. Several pairs of screw or buried plate anchor eyes are located at 40" to 60" intervals along the baffle ends which would be lying on the shore at low water (corresponding to one line per float). The lace line is attached to the eye farthest from the shore anchor post, passed over the baffle, through the other eye of the pair, through the eye of the next pair toward shore (on same side of the baffle); thence, over the baffle, to the next pair of eyes, etc., until it is made fast to the anchor post. As the water level recedes from normal elevation, the lace line is tightened to prevent the exposed baffle on the shore from being lifted by the wind. As the water returns to normal level, the line is loosened to allow the baffle to float normally. Refer to Drawing #20B3749.

Slickbar also takes a conservative design approach to "flow-thru" windows or "flow-around" baffles. Where practical, we limit the liquid velocity passing through a window to 3 ft./min. Although with special reinforcements and extra tension members below a row of windows, flow velocities of 30 feet per minute have been accommodated.

Total window area or flow around-the-end area is calculated as follows:

$$A\ (\text{sq. ft}) = \frac{\text{lagoon throughput (gallons/day)}}{24(\text{hr/day}) \times 60(\text{min./hr}) \times 7.48(\text{gal/cu. ft.}) \times 3(\text{ft./min.})}$$

Window height should be limited to approximately ¼ total height of the baffle. Long, narrow horizontal windows are preferable to vertical windows to minimize tensile stresses on the remaining membrane. The corners of the windows are reinforced to minimize tearing stresses.

If baffles are used to channel flow up and down a lagoon and the water velocity is essentially the same on both sides of any given baffle, then current forces are in balance. We only take current forces into consideration under the following conditions: when the current impinges upon a baffle section which must force the current to change direction; or, when the channel on one side is smaller than that on the other side and their velocities, therefore, are different.

These extra forces tend to make the baffle "fly" under water. That is, the membrane lifts off the bottom to allow passage of water, thus relieving the force. More weights can be added to minimize the lift of the bottom edge or a bottom tension member and intermediate lines to existing or supplementary anchors can be added. If the external forces require extra ballast or anchoring, a vertical cross-section of the baffle should be analyzed to determine if more buoyancy is required.

Slickbar baffles are furnished with stainless steel wire extensions of tension members and ballast chains (where used) and wires attached to the baffle end connectors. When baffles are installed, nominal tension is placed on tension members. Baffle end connectors are positioned just offshore, as indicated on the drawings (distance dependent upon slope). No tension is placed upon chain ballast (just slack removed) as this tension would only tend to lift the baffle off the bottom.

Silt can build up on one side of a baffle, trapping the bottom of the membrane against the bottom and pulling the floats under water. When you see the freeboard dimension decreasing, lift the floats up to dislodge the silt.

All baffles should be inspected every six months for loose hardware, frayed end wires, corrosion, tears, worn spots on the membrane, and general alignment and appearance. If anchors have shifted, they should be returned to proper location so as to equalize slack between the baffles' anchors. (If possible, check wind from both directions normal to the centerline of the baffle.)

The following baffle terminology definitions are provided so as to standardize vocabulary for this industry:

Ballast: Weight applied to the skirt to improve boom performance

Bridle: A device attached to a baffle to distribute the load exerted by anchoring the baffle

Bulkhead Riser: A small wheeled "car" attached to an End Connector that rolls vertically on a Bulkhead Riser Track to allow a baffle to adjust to changing water levels

Bulkhead Riser Track: A vertical track sealed to the shore of a lagoon or edge of a tank upon which a Bulkhead Riser rolls - The Bulkhead Riser Track extends from below lowest expected water level to above highest expected water level.

Drag Force: The load imposed on a baffle installed in a lagoon resulting from current and/or wind forces

End Connector: A device permanently attached to the baffle used to transfer the Tension Force to the End Wires or Shore Anchor Post

End Wire: Stainless steel (or other material) wire rope used to transfer Tension Forces from Tension Members or End Connectors to Shore Anchor Posts

Float: That separable component of a baffle that provides buoyancy

Flotation: That portion of a baffle which provides buoyancy

Flotation Tube: That fabric tube which contains the Flotation elements

Intermediate Connector: A device permanently attached to the baffle used to transfer Tension Forces from one baffle section to the next

Lace Line: A line led from a screw anchor over the baffle through succeeding screw anchors to prevent the wind from flying the ends of the baffle

Membrane: The continuous portion of a baffle which serves as a barrier to the movement of a substance

Shore Anchor Post: An anchor "post" installed on the shore of the lagoon designed to withstand the total Tension Force imposed by the baffle End Wires

Side Anchor: An anchor located on the bottom or shore of the lagoon to accept Drag Forces imposed upon a baffle through anchor lines run essentially 90° to the direction of the imposed force.

Skirt: That continuous portion of the baffle below the floats (or flotation tube)

Tension Force: The numerical value of the tension loads imposed upon the baffle by current and/or wind Drag Forces

Tension Member: Any component which carries horizontal (axial) tension loads imposed upon the baffle