TANK BAFFLES

The proper design of tank baffles is important in obtaining good mixing results. The following write-up will cover these topics:

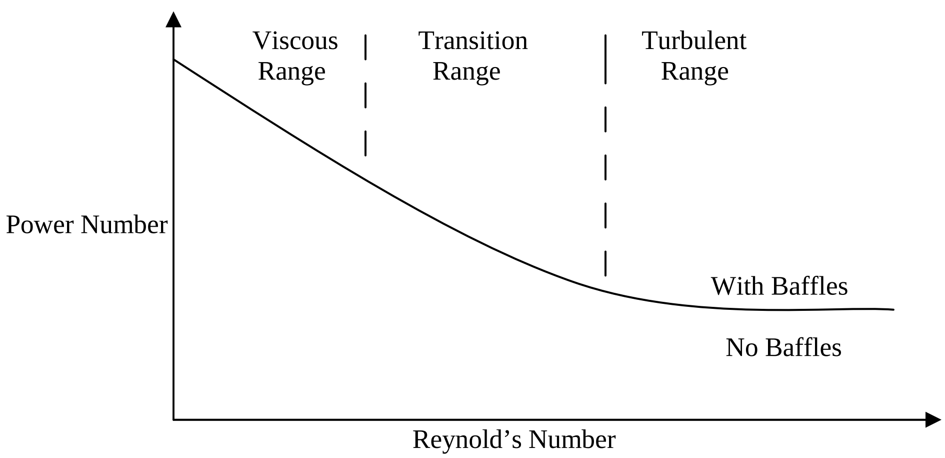
A – General
B – Power response in low viscosity liquids
C – Viscosity effect- Newtonian liquids
D – Viscosity effect- non-Newtonian liquids
E – Power level effect
F – Offset and length
G – Square and rectangular tanks
H – Horizontal cylindrical tanks
I – Thickness and supports
J – Special Designs- Cruciform baffles
- Angle Baffles
- Adjustable baffles

A- General:

There are three primary reasons why we use baffles. They are;

1. Power response
2. Flow pattern
3. Mechanical design loads

1. In the Power Number versus Reynolds's Number plot for a typical impeller, the solid line is the curve for "baffled" conditions, and the dashed line for "un-baffled" conditions.



When we operate at low viscosity (high Reynold's Number) without baffles, we find that we produce mainly rotary motion and a deep vortex. We are limited in how much power we can transmit to the fluid because of the decreasing Power Number and the tendency for the system to become unstable, with collapsing and reforming vortexes.

2. Both axial flow and radial flow impellers, operating in un-baffled tanks at low viscosity, will produce identical flow patterns characterized by

- A rotary or swirling motion
- A deep vortex,
- A lack of top to bottom motion

In effect, these installations become low-grade centrifuges, designed to separate things, not mix them.

The addition of baffles allows each type of impeller to develop its characteristic flow pattern with

- An essentially flat surface,
- Little swirling motion,
- Strong top to bottom turnover,
- Good mixing.
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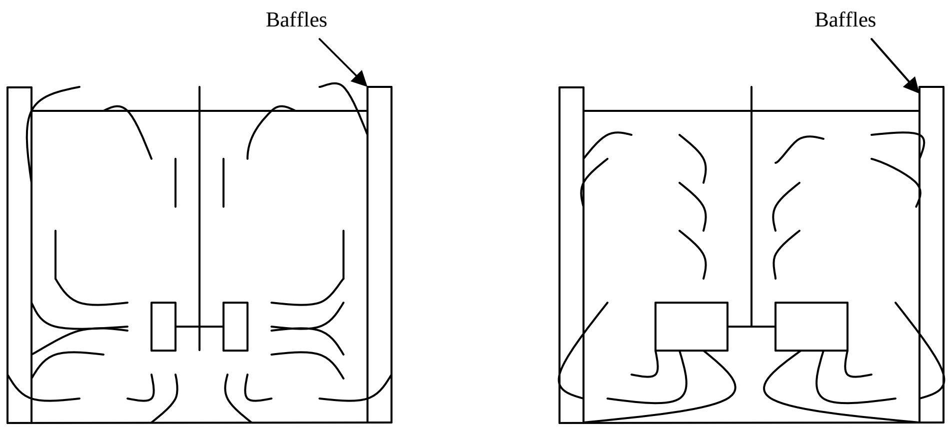


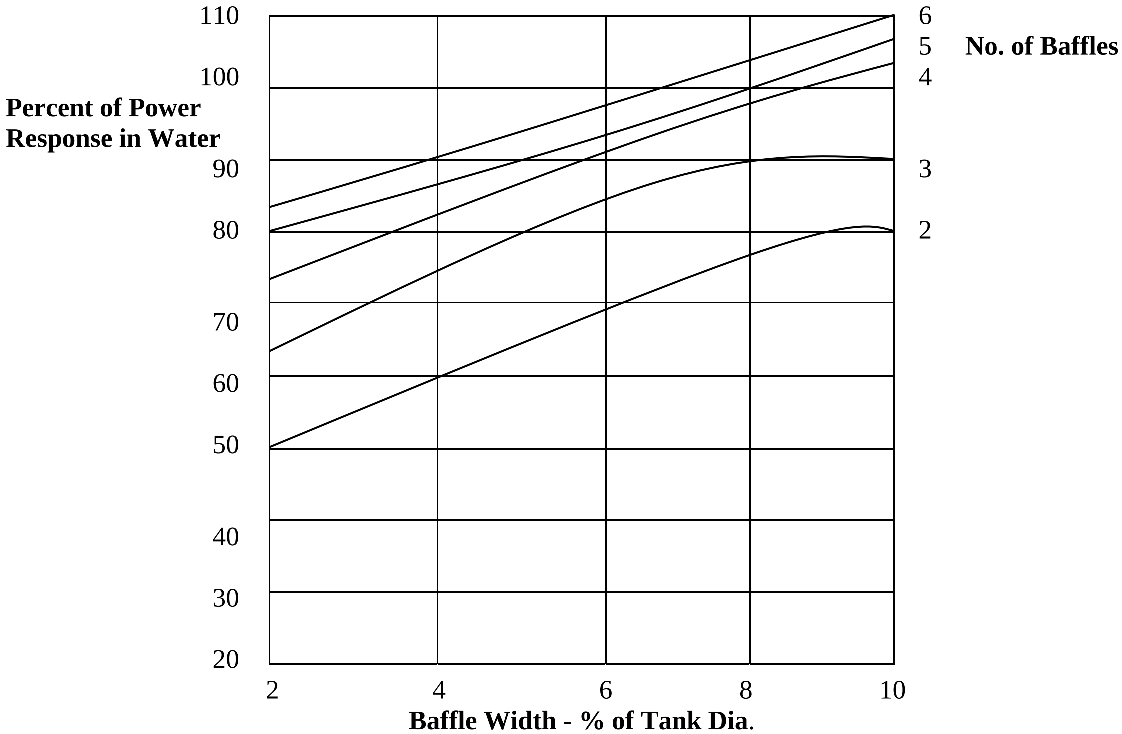
Radial   Axial

3. Baffles result in a more stable fluid regime with less shaft buffeting. The benefit is a decrease in the side force, bending moment stress, and shaft run out.

Since a large number of mixer selections are controlled by shaft design criteria, rather than by process requirements, this can be important to the customer both in terms of first cost and maintenance costs.

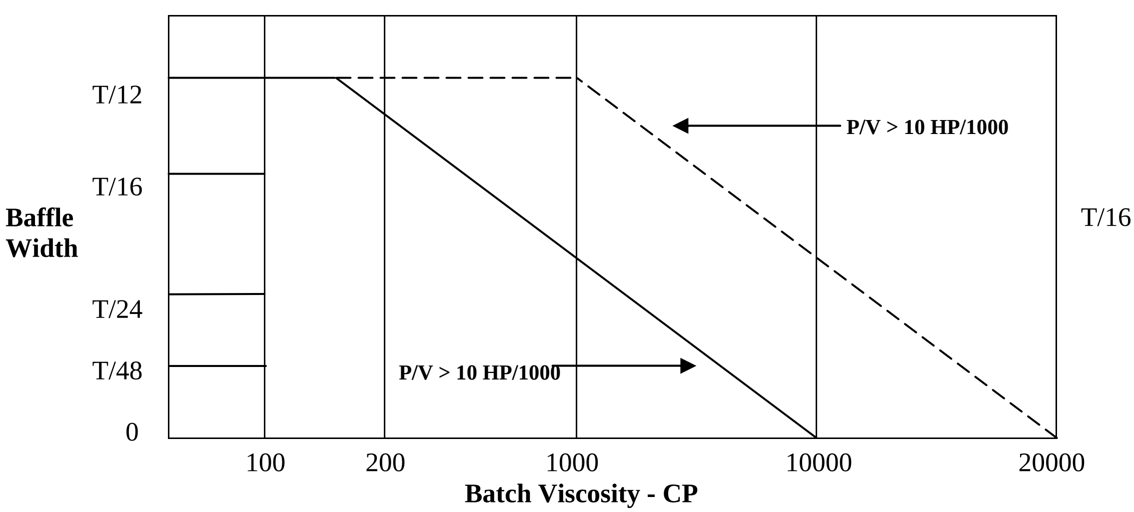
B- Power Response in Low Viscosity Liquids:

“Standard” baffles have been defined as 4 baffles, each 1/12 of the tank diameter in width. These will result in normal, or 100%, power response in water. The effects of varying the quantity and/or width can be seen in the following plot.



C- Viscosity Effect – Newtonian Liquids:

As batch viscosity increases, viscous dray on the tank walls and other internals will also increase. This reduces swirl and the need for tank baffles from a power draw standpoint.



D – Viscosity Effect – non-Newtonian Liquids:

Non-Newtonian liquids in mixing applications usually appear to be pseudopastic (apparent viscosity decreases with increasing shear rate). Since the highest shear rates are near the impeller(s), these materials will often be "fluidized" in the impeller zone, but relatively "stagnant" at the tank wall and the liquid surface.

Tank baffles will increase the tendency for stagnation, so they must be reduced in width and offset from the tank wall, approximately ½ their width.

Determine the apparent viscosity at 0.23 reciprocal seconds with a Brookfield RVF Viscometer at 2 rpm, and use that viscosity value with the curve above.

On borderline cases, have the customer install baffle clips in the tank and help him/her decide what baffles, if any, are needed after start-up.

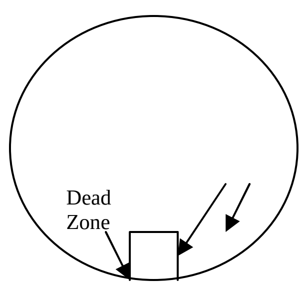
E- Power Level Effect:

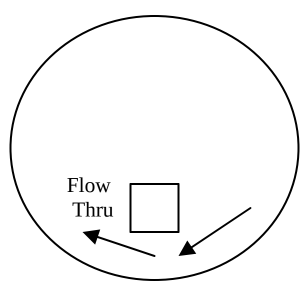
As the applied power per unit volume decreases, the tendency for excessive swirling of the batch diminishes. This is especially true with hydrofoil impellers. It is not possible to put hard number on this effect. With hydrofoils, you might get by without baffles P/V less than 0.2 hp/1000 gallons.

F – Offset and Length:

Baffles mounted flush with the tank wall have a "quiet zone" on the downstream side. This can be minimized by mounting the baffles with a wall offset of 1/3 the baffle width.

For viscous materials, especially non-Newtonian, increase the offset as noted in section "D".

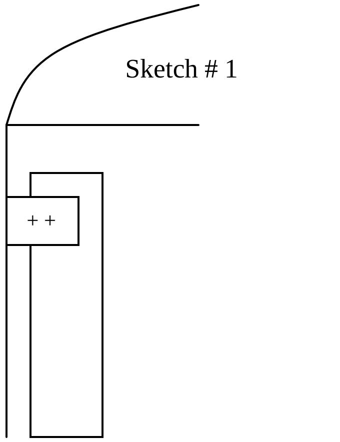




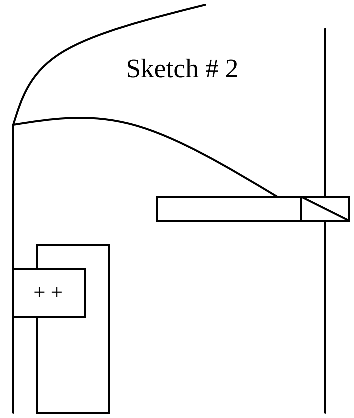
Baffles are normally designed to extend the full straight shell height of the tank. There are, however, many situations where the top or bottom ends should be modified.

The top of the baffles can be cut off below the liquid surface;

- for cleanliness if there is a tendency for material to build up at the air-liquid interface (see sketch #1, next page)
- in order to intentionally vortex an upper impeller when trying to wet out light solids or reincorporate gas from the vapor space (see sketch #2, next page).

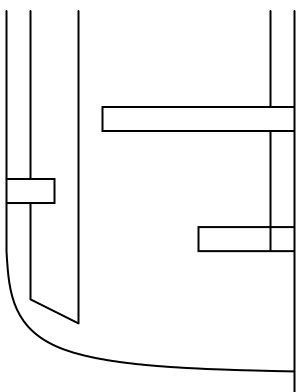


Sketch # 1

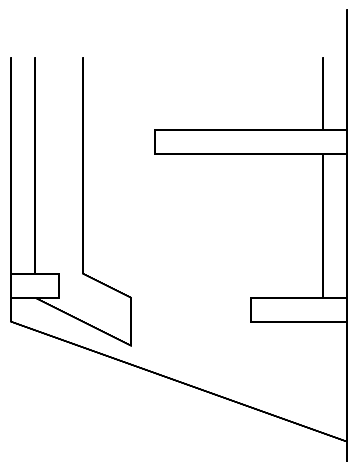


Sketch # 2

The Bottom of the baffles should be extended to the tank bottom when good mixing is required at low levels, as in draw down of solids suspensions. The following sketches illustrate the principle.



Dish Bottom

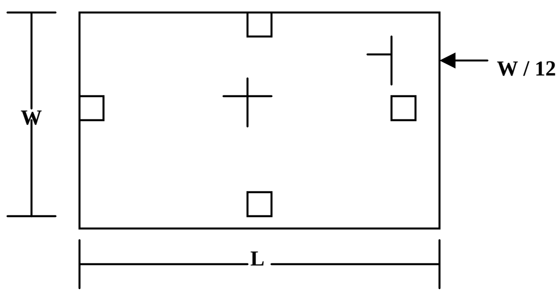


Cone Bottom

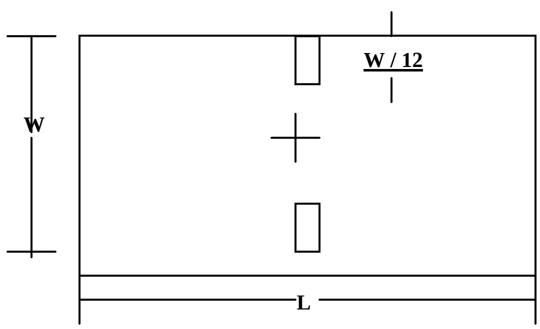
G – Square and Rectangular Tanks:

These tanks are asymmetrical with respect to the mixer shaft. The sharp corners and end shapes help to reduce the swirling tendency.

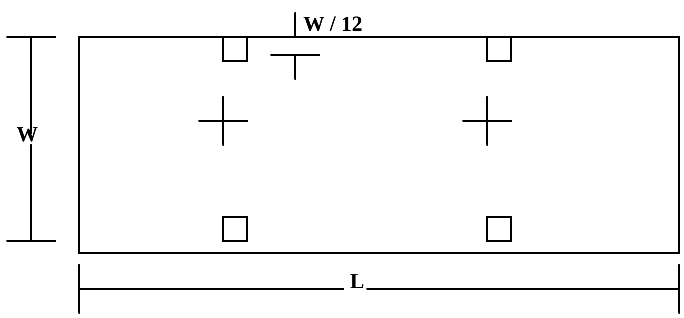
These tanks will generally not require baffles at applied power levels below 1 hp/1000 gallons. At higher power levels, install baffles as shown below.



For L = W (square)
Up to
L = 1.5 x W



For L = 1.5 x W
Up to
L – 2.0 x W

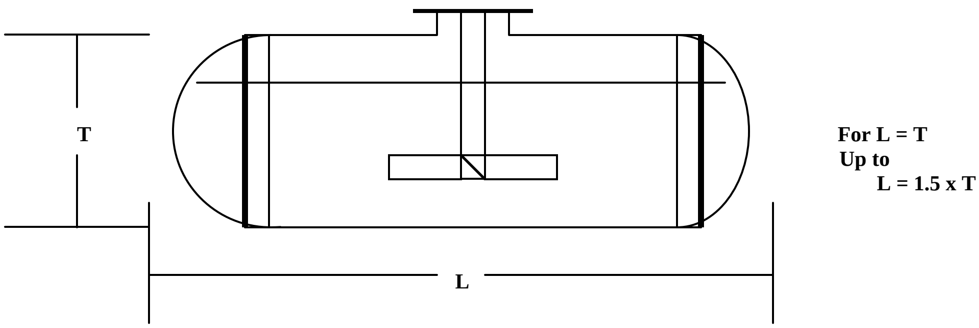


For L > 2 x W

H – Horizontal Cylindrical Tanks:

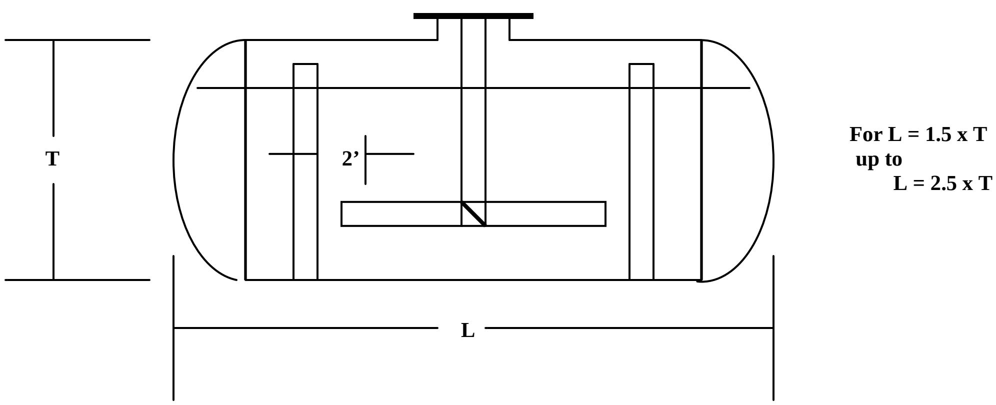
These tanks are also asymmetrical with respect to the mixer shaft, and are self-baffling at power levels up to 1 hp/1000 gallons.

For lengths, including the heads, up to 1.5 times the tank diameter, use 2 baffles, each T/8 in width, on the long centerline of the tank at the ends of the straight side.



For lengths up to 2.5 times the tank diameter, use 2 baffles, each T/8 in width, on the long centerline of the tank with a 2 foot running clearance.

For even longer tanks, requiring more than one mixer, use 2 baffles per mixer, as above.



I – Thickness and Supports:

The maximum hydraulic force, in pounds, acting on each baffle can be calculated from the transmitted torque, divided by one half the distance between the baffle edges and by the number of baffles.

$$\text{Force, lbs} = \frac{(63000)\,(Hp)\,(DF)}{(B)\,(T/2)\,(N)}$$

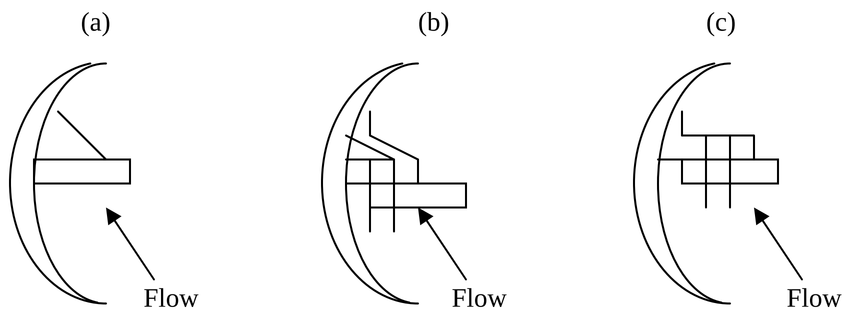
where Hp = Motor horsepower
DF = Dynamic Factor (=2)
B = Number of Baffles
T = Distance between outer edges, in.
N = Impeller speed, rpm.

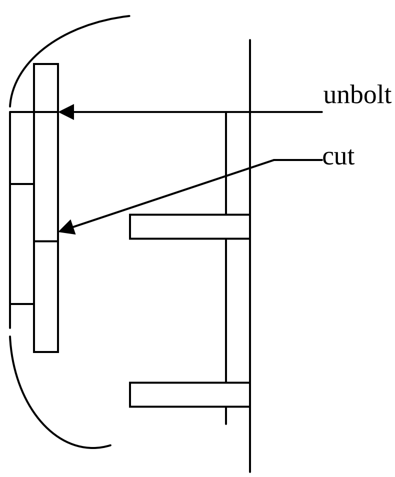
We leave the responsibility for determining baffle thickness and the location of baffle supports to the customer and/ or the tank fabricator.

As a rule of thumb, for open tanks, baffles should be of the same thickness as the tank shell, but not less than 1/8" on 1000 gallon and smaller, or ¼" on larger sizes.

Baffle support methods include:

(a) Baffle skip welded to tank wall with guests welded behind it.
(b) Strip hangers welded to tank wall with baffle bolted to hangers, with offset.
(c) Angles welded to tank wall with baffle bolted to angles, with offset.

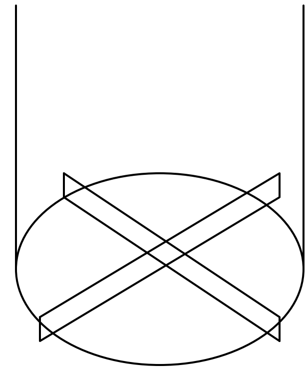




Vertical spacing of gussets or supports is up to the Fabricator. A minimum of three supports work well If the baffles ever have to be shortened (see Sec. F)

J – Special Design:

- Cruciform Baffles - These baffles consist of two strips, each 1/12 the tank diameter in width, in the form of a cross on the tank bottom. They are quite effective with single axial flow impellers located near the bottom (O.B.<1.0 D), and at low power levels (<1 hp/1000 gal).

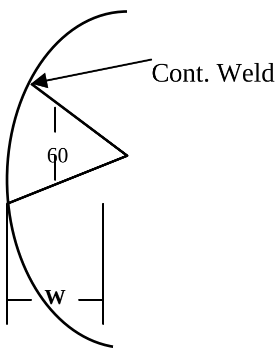


Many processes have wide variations in viscosity, such that baffles are helpful (or necessary) during part of the process, but are detriment during the rest of the process.

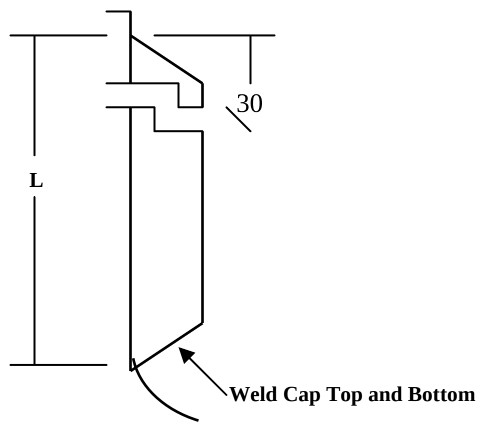
The following two baffle designs have been used for these processes.

-Angel Baffles - In the adhesive industry, a "rubber Dissolver" is a tank used to dissolve chunks of rubber (polymer) in a solvent. The viscosity will be water like at the beginning and 20,000 cps to 60,000 cps at the end. The pieces of rubber got tacky and have a tendency to hang up on normal plate baffles.

Angle baffles are used to give sufficient baffling for effective mixing at the low viscosity, and to produce minimum dead-zone and build-up problems later in the process.



PLAN



ELEV.

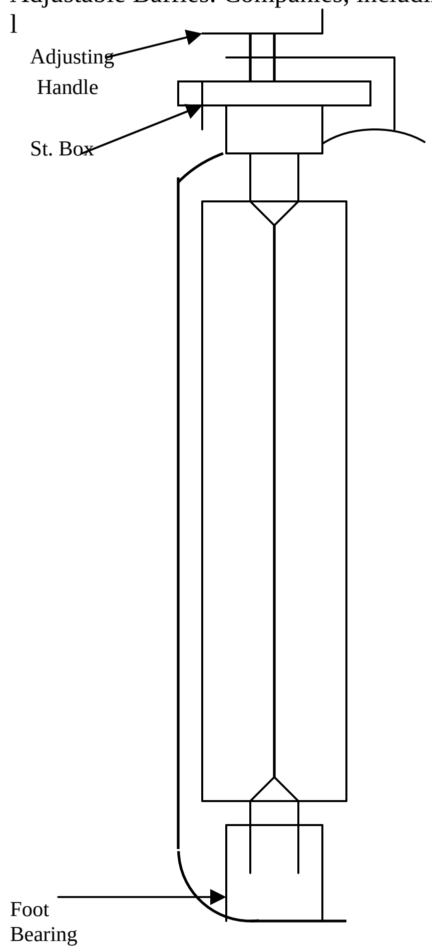
Angle baffles, as shown, can be made with a 60 degree, or 90 degree, included angle. The projected width is selected from Section C. For rubber dissolvers, use a viscosity of 1,000 to 2,000 cps.

These baffles can also be used very effectively in C.I.P situations, where a spray head must be able to contact all surfaces, and the tank internals are welded and polished. Examples might be Photo Emulsion Prep Tanks, and many food applications.

The Drawbacks Are:

- The relatively high installation cost,
- The loss of heat transfer surface when they are installed in jacketed tanks.

Adjustable Baffles. Companies, including custom formulators, that make large variety of products in a l limited number of mix tanks, will sometimes have their tanks Built with shaft-mounted baffles. The shaft seats in a foot bearing at the bottom and passes through a stuffing box (or bushing) at the top. The shaft will have an indexing plate and locking mechanism so the baffle angle (and projected width) can be varied to suit the process viscosity.



Note: also see following write up on heat transfer coils, vertical tubes, and plates. They will have an effect on baffle selection.