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fps vs GPM - 101

Some "notes" from Wade Arens at AquaStar Pool Products Inc...
Let's first understand the differences between fps (feet per second) and GPM (gallons per minute).
fps (velocity) has to do with how FAST (in feet, yards, miles, etc) the water is moving through a particular AREA (square inches of pipe, drain cover openings, etc.) GPM deals with the VOLUME (gallons, cubic feet, etc.) of water. Volume is 3-dimensional, Area is 2-dimensional.
When you water your lawn the pressurized water is traveling thru the 1.0" diameter hose at let's say 20 gallons/min. When you put your hand in front of that water stream, your hand barely moves. Now, if you narrow that 1.0" hose opening down with a nozzle or your finger tip, what happens to the water stream? It moves a lot FASTER (velocity, fps) and farther because it's still moving at the constant 20 GPM but through a smaller opening (down from 1.0" diameter to let's say 0.5").

EXAMPLE: Radius = 1/2 x Diameter
Area (of a circle) = π (pi) x (Radius squared)
A (of 1.0" hose) = $3.14 \times r^2$
A = 3.14 x (.5 x .5)
A = 3.14 x .25
Area (of 1.0" hose) = .79 sq. in. opening

EX: (cont'd)
A (of restricted 0.5" hose) = 3.14 x (.25 x .25)
A = 3.14 x .0625
Area (of restricted 0.5" hose) = .20 sq. in. opening

Note: You will never have to calc the sq. in. on our suction outlet covers. These will always be done by us on the computer and will be included in all literature, catalogs, spec sheets from now on. The above is just a representation to assist with our example.

Now let's compare the different velocities (fps) the water is going through the different size hose openings at the constant 20 GPM. (Remember this equation)

$$\text{fps (ft/sec)} = \frac{.3208 \times \text{GPM}}{\text{sq. in. opening}}$$

$$\text{fps} = \frac{.3208 \times 20 \text{ GPM}}{.79 \text{ sq. in. (1.0" hose opening)}}$$

1.0" hose = 8.1 fps @ 20 GPM

$$\text{fps} = \frac{.3208 \times 20 \text{ GPM}}{.20 \text{ sq. in. (1.0" hose restricted to 0.5" opening)}}$$

0.5" hose = 32.1 fps @ 20 GPM

Notice how FAST the water velocity increases? If you don't want the fps to increase with the smaller opening you'd have to slow down the GPM.
Using the previous formulas: $\text{fps} = \frac{.3208 \times \text{GPM}}{\text{sq. in. opening}}$

EX: (8.1 was the fps for the 1.0" hose @ 20 GPM AND we want it to remain the same with the 0.5" hose... now calculating for the new, lower ? GPM)
8.1 fps = $\frac{.3208 \times \underline{?}\ \text{GPM}}{.20 \text{ sq. in. (of 0.5" hose)}} = 1.6 \times \underline{?}$ GPM; So, GPM = $\frac{8.1}{1.6}$ = 5.1 GPM
Notice how we had to lower the GPMs from 20 to 5 in order to keep the fps (8.1) for both hose openings? We would do this by turning the valve down at the hose bib. The same applies to our drain covers, plumbing and pumps. When you analyze the attached chart you'll notice how the GPMs drop from the anti-entrapment tested flow rates to the 1.5 fps that Florida and other states are requiring.
EX: 10" AV – IAPMO certified "2007" flow rate (for floor) is 206 GPM at 5.8 fps BUT drops to 52 GPM at 1.5 fps.

So if you're at one of the health departments in CA they would want to see the calcs for AquaStar's 10" AV to not exceed 6.0 fps (regardless of IAPMO's 206 GPM rating for anti-entrapment).
EX: 6 fps = $\frac{.3208 \times ?\text{GPM}}{11.2 \text{ sq. in.}}$ = 210 GPM
Since our rating with IAPMO is lower (206 GPM), CA would base everything on the lower rating. CA's standards, by the way, are 6 fps for ANTI-VORTEX covers and 2 fps for FLAT grates.

When you're in FL, NY, NJ, CT, etc, re public and semi-public pools, they want to see 1.5 fps. As I pointed out before, even though a suction outlet cover has been tested and certified to a certain flow rate at 5.8 fps without hair or body entrapment, many states insist today on the 1.5 fps standard. Remember: the SLOWER the water moves through an opening, the less turbulence, etc will occur at that point (and in theory, the less chance for hair entrapment). This is especially important with gravity drain systems...but we won't get into that here. Noteworthy is the fact that we (all manufacturers) can bypass the HAIR entrapment tests if we just assume the lower flow rates. (less than 60 GPM for our 10" AV) But the BODY entrapment test must still be done. Almost all "flat grates" fail even at low flows of 60 GPM @ 0.34 fps!! Residential standards usually only go by the tested GPM ratings.

Keep the following formula in your memory bank also: When wanting to "quick-calc" for 1.5 fps, multiply 4.675 by the sq. in. of opening to get the GPMs.

EX: AquaStar's existing 12x12 grate (the 12101-08, not the RFS) has 89.8 sq. in. of opening. Florida wants 1.5 fps so simply figure: 4.675 x 89.8 = 419 GPM
Our "ponytail" test at IAPMO maxed out at 470 GPM, but IAPMO subtracts a safety factor of 25% from all tests, so we were listed at 376 GPM back in 11/07 before the "2007" standard was adopted (ponytail plus full head of hair and body entrapment tests, etc ...)
In May we took our original 12x12 and 9x9 square grates back to IAPMO for additional testing to determine the GPM that we need to lower to in order to pass the body entrapment and full head of hair tests. (the "ponytail" test is usually the most forgiving) This way AquaStar will be able to provide a suction outlet cover that will comply with BOTH the new "2007" AND Florida's standard! And that's just the beginning. We have "new stuff" in the pipeline that will blow your little minds.
Again, keep the following formulas in mind:

$$\text{fps} = \frac{.3208 \times \text{GPM}}{\text{sq. in. opening}}$$

GPM @ 1.5 fps = 4.675 x sq. in. opening