THE GAMGRAM

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ANATOMY OF A JET FUEL PIPE

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Do you know what "half fast" engineering is? In handling jet fuel, this kind of engineering takes form when someone begins to think it is just like any other fuel -- heavier than gasoline, lighter than fuel oil. He whips out a few calculations, looks at some pressure drop data in Cameron's Hydraulic Data book, selects a pump that barely "squeaks" by and then compensates by going up 2 pipe sizes to make sure the pump will work. He justifies the larger pipe "for future plant expansion". Oh Wow! What an engineer he is!

Here is a real-life story. An oil company terminal supplies fuel to a major airport using transport trailers. The loading rack at the terminal can handle 2 transports at a time, one loading arm on each side of an island. A 1200 gpm filter separator is located 100 ft. from the rack. About 70 ft. of the pipe is 8" and is underground -- the last 30 ft. length is 12" and is aboveground, running the length of the rack island. The fuel is received into the terminal storage tanks from a common-carrier pipeline and is then prefiltered through clay before it enters a receiving filter separator. Over a period of time, the filter membranes were B 2 (by ASTM Test Method D-2276) out of the filter separator near the loading rack.

The customer at the airport receives the fuel through a filter separator. The "white bucket" test is performed on every trailer load before it is off-loaded.

Recently, the number of particles in the bucket increased to such an extent that the customer began refusing loads of fuel. The membrane tests remained entirely acceptable from a color standpoint. In checking back through the system, the particles were found to exist at the loading rack but not at the discharge end of the filter separator. The particles were mostly iron oxide -- the size of coffee grounds.

The 12" pipe was opened under the rack. The upper 3/4 of the pipe surface was covered with rust particles, coffee ground size. The bottom 1/3 of the pipe was deep in wet slime, rust and dirt. We used shovels to dig it out!

Calculations show that the velocity in the 12" pipe at the 1200 gpm rated flow was only 3.4 feet per second. However, investigation revealed that the technical department had ordered a reduction of maximum flow rate to 550 gpm to insure adequate static charge relaxation time. This incredibly low flow resulted in a velocity of a "trickling" 1.6 feet per second. This was the cause of the dirt -- a flow rate so low that the pipe was not being swept clean. Water condensed out of the fuel in the underground portion whenever the tank temperature was greater than ground temperature. It condensed out of the above-ground section every night that the temperature dropped. The water could not get out of the pipe. It couldn't be drained out -- it simply collected and caused rust and slime growth.

A prime lesson to be learned by this experience is that you should make fuel do its own housekeeping. Design and maintain flow velocities that will keep pipes swept clean and dry. We recommend at least 6 feet per second.

A good "rule of thumb" to remember is that jet fuel holds about as many parts per million of water as the temperature in degrees Fahrenheit. In other words, at 80° F there can be about 80 ppm of water dissolved in the fuel. If the temperature drops to 60° F in an underground pipe, there can be 20 ppm of free water to deal with.

We all know that water collects in tanks because of "condensation"-- water dropping out of solution. Why is it that so many of us seem to forget that the same thing happens in piping? Only more so! The temperature of fuel in pipes changes more (and far more rapidly) than in tanks because of low mass and large exposed surface area.

In a recently finished airport fuel system, we just learned that a mile long, underground 24 inch pipe will handle a maximum flow rate of 2400 gpm during the next 3 years until a hydrant system is built. That means a velocity of 1.7 feet per second! It is not a pipe – it is a mile long condenser! And there are no water draw-off sumps. This is the type of design that keeps the filter separator manufacturers in business. This one is going to be a "king sized engineered problem".

QUICK CALCULATIONS

You can appear to be a mathematical whiz by calculating approximate pipe velocities in about 20 seconds. Here is the trick:

Step 1. Multiply the pipe size by itself
Step 2. Then divide that number into gallons per minute
Step 3. Then multiply by 0.4

Example: Pipe size is 6 inches
Flow rate is 360 gpm

Step 1. 6 times 6 equals 36
Step 2. 360 divided by 36 is 10
Step 3. 10 X 0.4 equals 4 feet per second

NOTE: If your mind works in barrels per hour (bbl/hr), instead of gpm, use bbl/hr in Step 2 and multiply by 0.3 in Step 3.

For anyone who wants the whole formula, use the pipe's actual inside diameter in this equation:

$$V= 0.4085 \text{ X GPM}/d^{2} \text{ or } 0.286 \text{ X bbl/hr}/d^{2}$$