(((ECHOMETER)))

Q & A Ask Echometer Session 6 – June 24 2020

How Much Liquid Does My Sucker Rod Pump Actually Pump?

Does the plunger length effect the slippage?

Question addressed at time: 58:20 during the session.

Yes. Every foot increase in the pump plunger length, L, reduces the slippage approximately 5%. For example, if the plunger length is 4ft, you would then multiply the slippage by 1/4. If you had a 5ft plunger ratio would be 1/5. So the impact of the plunger length would change from 25% constant at 4ft to 20% at 5ft. The slippage is reduced by 1 over the length of the plunger. (1/plunger length). Units of plunger length should be input as inches.

$$453\cdot\left[\left(0.14\cdot SPM\right)+1\right]\frac{DPC^{1.52}}{L\mu}$$

Why is it that on different wells with the same effective plunger travel and 60% fillage, the blue line is closer in one well and farther in other wells effective plunger line?

Question addressed at time: 59:20 during the session.

It's really critical to have the valve open/close points selected correctly at the corners of the pump card. Often if you're using the TAM software, you haven't clicked the Annotation button and turned on the Valve Open/Close points, and noticed if the software is picking those open/close points correctly. So the first thing you need to make sure is that you select the valve open and close points and then look at the calculated pump discharge pressure and the calculated pump intake pressure based on the height of the pump card. Those are fairly important in this adjusted pump displacement calculation.

How to determine tubing gradient more accurately when gas is presence when not knowing how much gas entering the pump?

Question addressed at time: 1:00:23 during the session.

I thought when we did this that we would put the multi-phase flow method in the software and use the gas up the tubing to calculate the gradient based on multi-phase flow and it would be accurate. We still have some work on that but it works really well on high oil cut wells now and we have a lot of good matches on tubing fluid gradient on high oil cut wells and there may be a bug we need to look at when the water cut is high. Tubing fluid calculation currently is not accurate for high water cuts. The multi-phase flow method in TAM does a good job calculating the gradient if it's high percent oil, but it does a poor job if it's high percent water cut. There is probably some kind of breakdown but we will need to figure it out in the software calculations. But we use the multi-phase flow program and the flow between the rods bodies and the tubing along with a friction factor for flow, along with the viscosity, and it looks like right now we've got some kind of small issue we need to address. But we use the gas from the pump discharged up the tubing so we know how much free gas is discharged up the tubing.

Some dyno cards in heavy oil field are wavy on the upstroke and downstroke? Is it downhole friction or measurement error?

Question addressed at time: 1:01:50 during the session.

That's a good question. When you have a wavy pump card, on the upstroke and downstroke, in viscous crude normally it's due to several things. If you have a really big plunger and it's a shallow well, and the big plunger causes the discharge pressure above the plunger to increase during the upstroke because the restrictive flow out of the pump into the tubing, that could cause the bottled up pump to increase in load and then the peak load will echo up and down the tubing and create a wavy pump card. So that peak load is impacted by bottled up pumps and shallow wells and you'll see a wavy line. And that's a pressure force caused by a large diameter pump and a shallow well. Most of the wells that we see in this area aren't typically that shallow. They're deeper than 3000ft and we usually don't see the wavy characteristic on our pump cards in this area. The other thing that can cause it to be wavy is if you had your rod string entered upside down or incorrectly into the TAM software. The wave equation models the behavior of the rod strong. So if the rod string that is models is not what's in the well, then the resulting pump card will be wavy. So the first thing to do is check that the rod string is entered correctly. It could be wavy if the fluids are surging away from the pump which is unlikely. Most cases, the discharge pressure and intake pressure are constant. So the idea of a flat line on the upstroke and downstroke of the pump card means there's no change in load acting across the plunger. And possibly a few wells in the world the pressure across the pump may not be constant during the upstroke or during the downstroke and that could cause a changing load. Like the bottled up pump, the pressure goes way up, and then it appears to drop off after the flow begins.

The viscous fluid causes more dampening on the rods. If the pump card is concave outward like a bowl, you can increase your damping factor and flatten the pump card out. That's fluid friction. Fluid friction in the wells in Venezuela is 5 or 10 times what we would normally see in the U.S.

The presence of viscous crude means you need to have a higher damping factor.

Is pump clearance a clearance of one side, for example, heavy oil in Kuwait use 10/1000", so clearance in equation is 0.01, right?

Question addressed at time: 1:06:41 during the session.

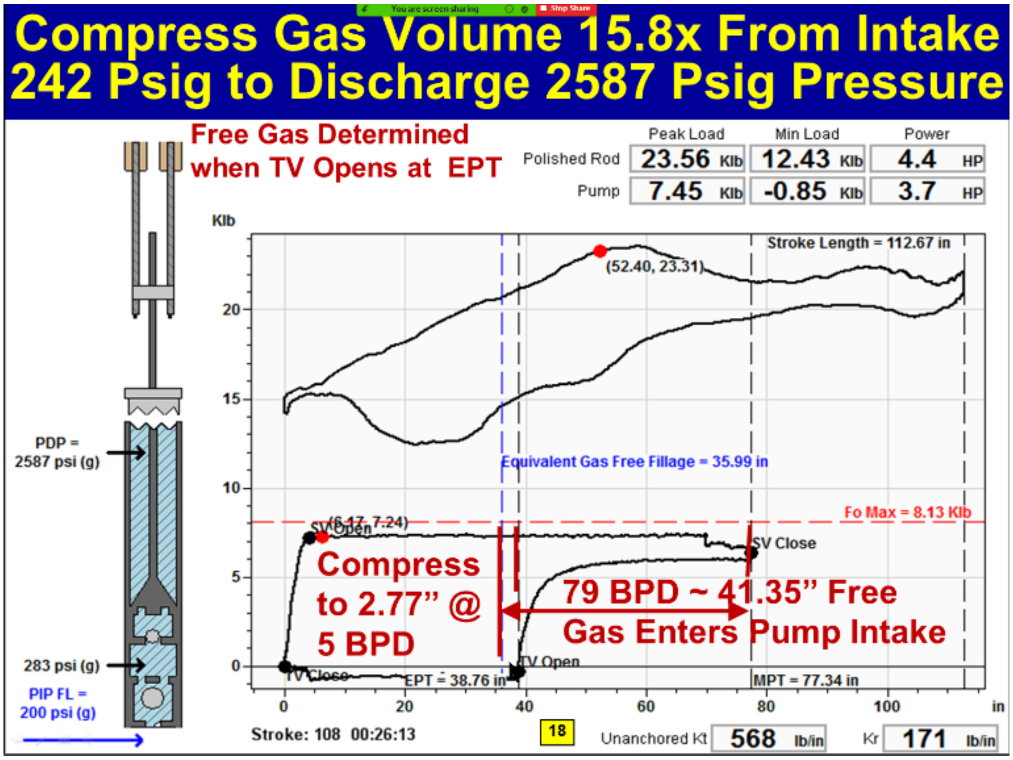
Correct. If it was centered, it would be half of that, but we don't calculate it that way.

The pump clearance is the OD of the plunger subtracted from the ID of the barrel. So, for Kuwait, their wells are very shallow, and they have very viscous 10API gravity crude, and in a lot of cases, their temperature is changing because they're trying do to a thermal flood – they're trying to heat the oil up and that drops the viscosity. But if they don't maintain the heat, then the temperature of the earth cools oil back to normal temperature of the earth and the oil becomes much more viscous. It's an issue of not just the gravity of the crude, but it's also an issue about the temperature; hot temperatures reduce viscosity and cool temperatures increase viscosity.

What drives the position of the the gas free fillage point relative to the TV open point? (i.e why is there a gap between the blue and black dotted lines on slides 15-17)

Question addressed at time: 1:08:35 during the session.

When you start at the intake pressure, and the pump fills up with liquid and gas, it fills up with the amount of liquid represented on the pump card from the TV close point to the Equivalent Gas Free Fillage line and gas represented on the pump card from the Equivalent Gas Free Fillage line to the SV close point. If you could separate the free gas all to the top of the barrel, on this example there would be 41 inches of liquid and then at the very top of the stroke when the slippages occur the rest of the pump would be filled with gas. When the plunger moves down, the pressure increases as the load on the rods is decreasing and the pump load acting on the bottom of the rods is decreasing and at the TV open point, the pressure inside the pump chamber has increased to the discharge pressure. The volume of free gas inside the pump equals 2.77" when the TV opens. The volume of free gas inside the pump equals 41.35" when the SV ball goes on seat at the top of the stroke at the intake pressure. The distance between the equivalent gas free pump fillage line to the TV open line represents the inches of free gas inside the pump when the TV opens.



<u>What considerations, if any, should one make if there is a measure of sand being produced in the well?</u>

Question addressed at time: 1:11:20 during the session.

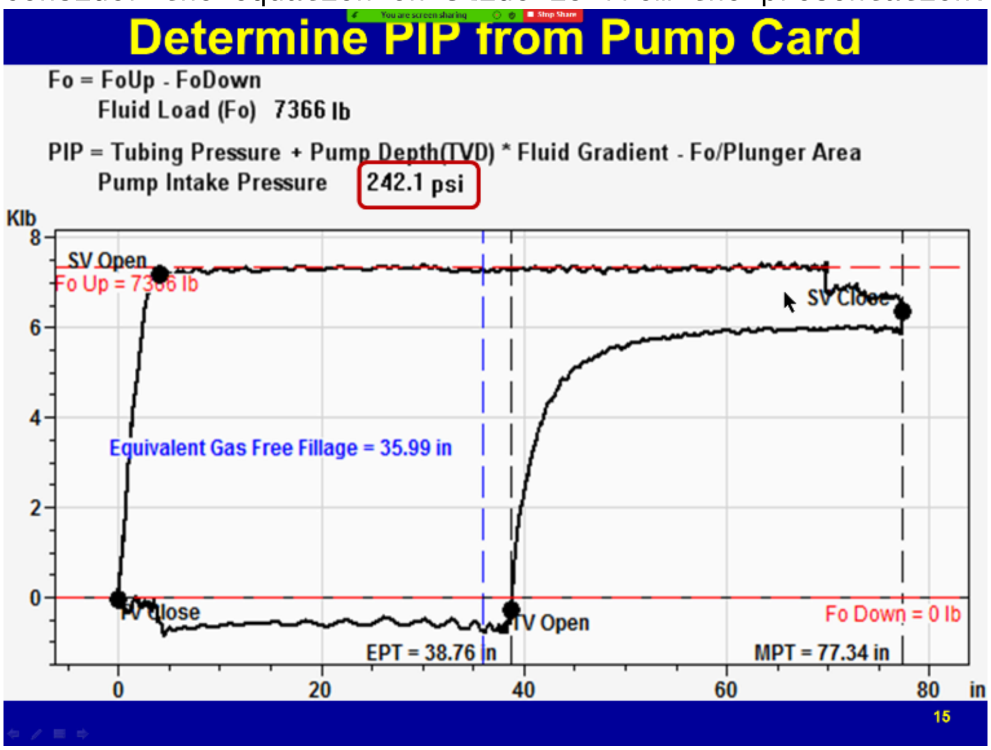
Sand is just solids that take up space like oil. And usually the sand is carried by the oil and maybe by the water. But if you take in a large amount of sand, there are two problems: One problem is the sand causes pump sticking and that may be why you need to open your pump clearances up to prevent scoring of the barrel. But the other is that if you produce 5% sand, then that means your liquid volume is actually 5% larger and the sand is taking up some of that space. So you should consider the sand volume as part of the liquid volume. It doesn't effect your calculations; you're just going to have sand as part of the calculation of the total liquid volume inside the pump.

For example. If you make 5% sand, then the liquid volume calculated at the pump adjusted for stock tank conditions should still be 5% too high because there still should be some sand volume that was inside the pump and it was assumed to be liquid. So it really won't make much difference other than we're going to calculate too large a liquid volume.

What is the precision of calculating the PIP with the dynamometer? What are the most important variables to consider?

Question addressed at time: 1:13:00 during the session.

Consider the equation on Slide 15 from the presentation:



Any of these parameters could be wrong which will affect the accuracy of the calculated PIP. You can look at the top of the pump card, and if it matches fairly close with the Fo From Fluid Level line and is flat, that would indicate most of the parameters used in the PIP from the dynamometer card are correct or are close and the precision is good. The plunger area is the most critical variable to consider.

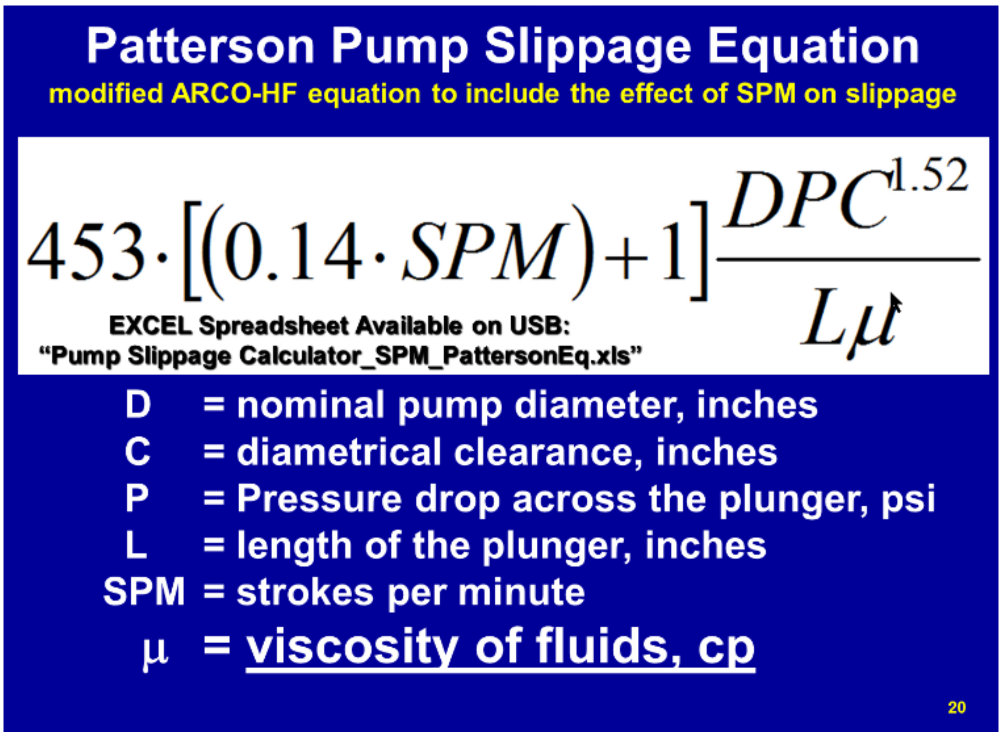
Fluid viscosity is o.76 Cp by default but although I type a low API gravity (11.5) in fluid properties the software omits this condition. should the software show an alert, in this case, telling me I must change the fluid viscosity?

Question addressed at time: 1:18:01 during the session.

For right now, Echometer provides a spreadsheet that you can use to type in a different viscosity in the TAM software that will provide a better match for your well conditions. If you find something different that what is in the spreadsheet, please let us know and send us data and we will try to make those adjustments to the program.

<u>What is the maximum viscosity where this calculation can still be applicable?</u>

Question addressed at time: 1:20:07 during the session.



There may be some limitations, but they are not known at this time.

<u>What else would you look at if you were happy with estimates of slippage and gas losses but you still had some unexplained differences between expected and actual production?</u>

Question addressed at time: 1:22:25

Possibly pump wear. If you think the calculations have been matching well and you start to see things changing, then you might start to expect a pump wear problem. The calculations are based on a new pump. As an example, in a field in Wyoming, the operator would use the slippage equation because they had a certain rate of wear due to the sand they produced. And they knew that as they produced a well, over time they would get more slippage because they sand would start to wear on the pump and then they would increase the speed. So probably the number one thing we don't know about is the pump wear.

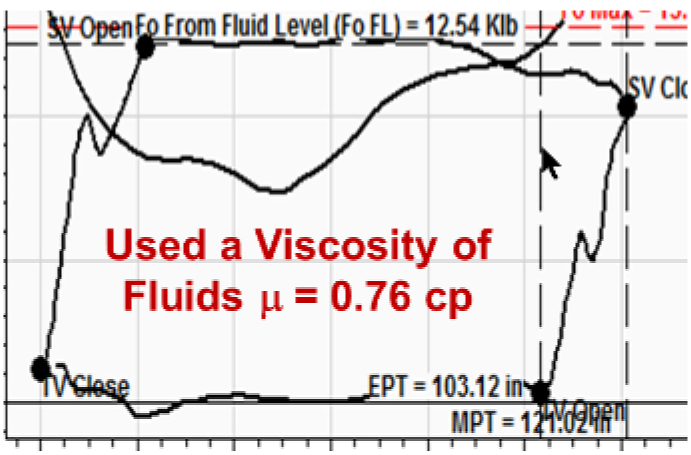
In the edit window entry for fluid viscosity, should the temperature entered be surface or downhole?

Question addressed at time: 1:23:43

The temperature entered is the formation temperature at the pump. Use the PIP for the bubble point pressure to determine gas in solution.

What could explain the oscillation in force on the sides of the pump card (in slide 50)?

Question addressed at time: 1:26:55



When there's quite a bit of clearance, the plunger moves and then due to the harmonics of the rod string it pauses. So the bounce on the upstroke is due to the harmonics of the rod string. Meaning, it takes a certain amount of time to travel through the rod string once the rods start to pick up the pump load. So this is a typical shape on the left and right side of the pump card when slippage is present and the tubing is anchored.

When you have heavy oil, we frequently have an unaccounted friction that makes the downhole card look taller than it really is. Will this affect the gas free line calculation?

Question addressed at time: 1:29:44

You’re essentially asking “What’s the fluid load?” When the Red line Fo Up doesn’t match the pump card, this indicates a review of the pump card analysis is needed and possible adjusting of the damping factor to account for friction. Increasing the damping factor will correct for the viscous friction. But increasing the damping factor will NOT correct for mechanical friction due to mechanical contact.

I got a perfect textbook pump card unanchored tubing fluid level @2800 pump at 3200' sn at 4000' but no fluid coming out of bleed valve to take build up is there a possibility of a tubing leak or something else?

Question addressed at time: 1:32:10

Most likely yes it’s either the casing check valve or a tubing leak. You should isolate the casing and see if your pump will pressure up the tubing. A quick check is to close off the valves at the surface and don’t take too many strokes because if it’s a leaky check at the surface it’s going to let fluid leak back down the casing and if you close that off the pressure is going to increase quickly and you’ll have identified whether you have a bad check or the check could be installed backwards.

There is a paper on troubleshooting rod pump wells by shooting down the tubing that can be downloaded from our website. You can shoot down the tubing and see if you have liquid coming out of a hole.

The time for the gas to go into solution, should that be the time for one stroke or about 8 seconds?

Question addressed at time: 1:34:42 using a TAM Example.