ADJUSTABLE VALVE ROD GUIDE AND PULL TUBE GUIDE TO HELP MAXIMIZE THE COMPRESSION RATIO IN DOWNHOLE SUCKER ROD PUMPS

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ABSTRACT AND SCOPE

The Adjustable Valve Rod and Pull Tube Guide are designed to allow for precise spacing in a down-hole sucker rod pump. In historical installations the spacing is based on the valve rod or pull tube length. This length is usually in one-inch increments from the factory, or the rod or tube is field cut and threaded to maximize the pump compression ratio. This patented guide allows the spacing to be adjusted with greater precision and will compensate for manufacturing tolerances and reduce field cutting and threading of pull rods and pull tubes. Proper spacing can improve compression ratios essential in pumping gassy wells.

This paper will describe how the guide is designed, its specific applications and its advantages over conventional sucker rod and pull tube guides.

INTRODUCTION AND BACKGROUND

The beginning and ending volume during the down stroke of the pump determine the compression ratio in a sucker rod pump. Sucker rod pumps require a minimum of two valves, a standing valve and a traveling valve. These valves open by pressure differential and close by fluid flow with a little help from gravity in vertical wells and strictly by flow if the pump is in a horizontal position. These valve assemblies always have a certain amount of un-swept volume that affect the final ratio. On the down-stroke the standing valve will close due to fluid flow and the traveling valve will open when the pump chamber pressure is greater than the hydrostatic pressure holding the ball closed. Fig. 1 shows the compression formula along with an example of a down stroke compression calculation.

The un-compression ratio on the upstroke faces a similar problem but the forces are now acting on the standing valve. On the upstroke the traveling valve closes due to flow and the standing valve will now open when the pump intake pressure is greater than the pump chamber pressure. Any gas that is trapped with the fluid in the un-swept area of the pump chamber at the bottom of the down stroke will be at the hydrostatic (tubing) pressure and will expand as the pressure in the pump chamber drops on the upstroke. If we leave temperature out of the equation and consider that this trapped gas has a fixed mass it will act according to Boyle’s law. This means that the pressure in the pump chamber will be inversely proportional to the volume of the pump chamber. On the upstroke the volume of the pump chamber increases as the plunger moves upward and the gas pressure decreases.

In Fig. 2 I have used Bole’s law to demonstrate how gas trapped in the pump chamber must expand to lower the pump chamber pressure to below the pump intake pressure to allow the standing valve to open.

PUMP CONSTRUCTION AND TOLERANCES

During the assembly process of a sucker rod pumps great care can be taken to space the plunger as close to bottom as possible and many shops have carefully worked out valve rod lengths to achieve this goal, however there are several factors that make it almost impossible to consistently do so with great accuracy.

One of the reasons is the tolerance that has to be allowed on dimensions during manufacture. A typical pump may have 15-21 parts and each one will have tolerances from a few thousands of an inch to a quarter of an inch and these tolerances can change the lengths of the plunger assembly, barrel assembly, and valve rod length. API Specification 11AX specifies these tolerances and some manufactures use tighter tolerances than specified but if you followed API specifications the barrel can have a tolerance of +/-.250”, the plunger can have +/-.250, the valve rod is allowed +/- .125 so if just these 3 parts happen to stack out in one direction you could have 5/8ths inch of variance from pump to pump. If you add in the other parts and the variance that can occur in tightening the tapered thread of the valve rod, the allowance will be close to one inch and this is what is typically built into API valve rod length tables.

With the adjustable guide it is possible to fine-tune each and every pump to the closest possible spacing.
The adjustable guides are designed with 1-1/2” of adjustment. With a 1-1/4” bore pump being able to lower the plunger by 1” will reduce the volume by 1.22 cubic inches. If we subtract this from our original 9.5 cubic inches of uncompressible space, we now only have 8.28 cubic inches. If we use this figure in the compression ratio example in fig. 1, we would end up with a compression ratio of 20.85 to 1 instead of 18.3 to 1. If we multiply our 400 psi pump intake pressure by 20.85 we arrive at 8,340 psi instead of 7,320 psi achieved at the 18.3 ratio or a difference of over 1,000 psi.

Fig.3 Typical Adjustable Valve rod/Pull tube Guide assembled and in parts.

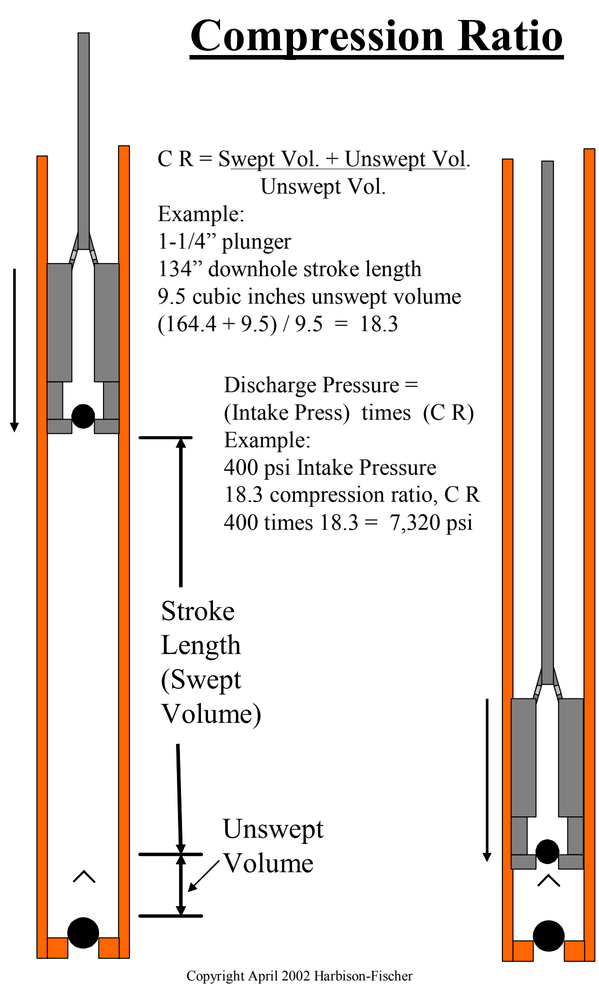

Figure 1

BOYLE'S LAW

THE PRESSURE OF A FIXED MASS OF GAS AT CONSTANT TEMPERATURE IS INVERSELY PROPORTIONAL TO THE VOLUME

$$p_1 V_1 = p_2 V_2$$

PUMP VOLUME CUBIC INCH	HYDROSTATIC PRESSURE PSI
173.9	15.62
152	31.25
76	62.5
38	125
19	250
9.5	500

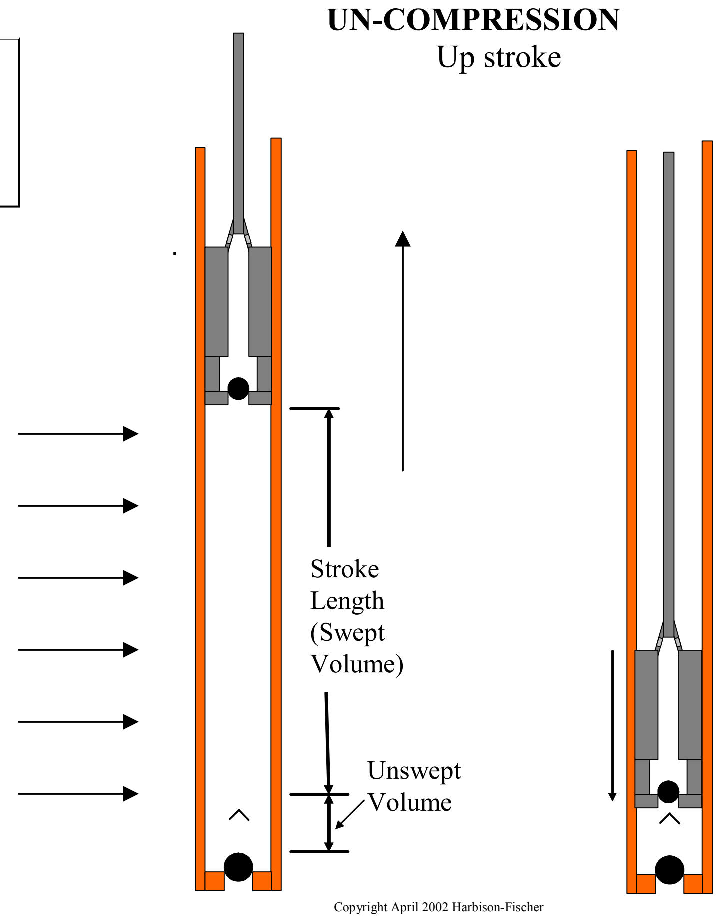

Figure 2

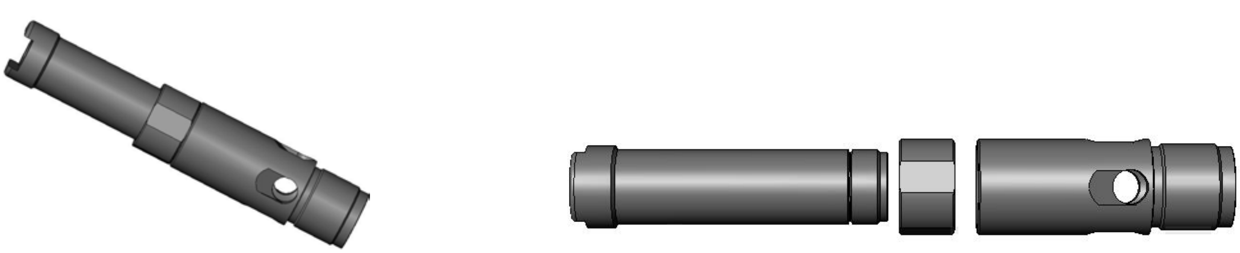

Figure 3