ACOUSTICAL WELL SOUNDING

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ABSTRACT

Electronic equipment is available to determine the fluid depth in oil wells quickly and accurately. The fluid depth is determined by producing a sound wave at the surface and recording the reflections on a strip chart. Therefore, the instrument is called an acoustical well sounder (AWS).

The most common means of producing the sound waves is by firing a black powder blank into the annulus. Recent innovations of gas guns have improved the safety and performance, and decreased the cost of using as AWS.

The acoustical well sounder is primarily used to determine producing fluid levels, shut-in levels, and fluid build-up curves of an oil well.

INTRODUCTION

The fluid level of an oil well is defined as the distance from the surface to the well fluid in the casing-tubing annulus. Knowing the fluid level is essential in sizing and analyzing production equipment. Sequential fluid levels can be used to formulate draw-down and build-up curves as shown in Figure 1. These curves are used to analyze the reservoir performance.

An acoustical fluid level is obtained by producing a sound wave at the annulus inlet valve and recording the reflections on a strip chart. The sound waves are created by firing a black powder blank (.45 and 10 gauge are the most commonly used) or a blast of carbon dioxide (CO_2) or nitrogen gas (N_2) into the annulus. The sound waves are reflected when a change in annulus area occurs. Normally, the reflections are due to a decrease in area. A decrease in area could be caused by tubing collars, anchors, casing liners, well fluid, or any other obstruction. Sound waves are also reflected by an increase in area which could be due to a casing hole.

COMPONENTS OF AN AWS

The acoustical well sounder consists of three main components: the well head assembly, the electrical cable, and the recording instrument.

A well head assembly consists of a microphone, bleeder valve, firing mechanism, and a two inch threaded nipple. The well head assembly should be pressure tested to 6000 PSI with a working pressure of 2000 PSI. Black powder blank well head assemblies can be purchased with either manual or electrical firing mechanism. The electrical firing mechanism allows the operator to fire the shot remotely, adding to the safety. At this time, all gas guns are fired manually.

The cable is used to electrically connect the microphone and firing mechanism to the recorder. The cable should be shielded to reduce outside interference.

The recording unit consists of electronic circuity to accept, filter, and amplify the signal from the microphone and a mechanical chart recorder to record the reflections. The recorder has two filtering channels, a high frequency (18.5 CPS) for the collar reflections and low frequency (2.5 CPS) for the fluid reflection. The fluid reflection can be recorded in either the high or low frequency mode. The tubing reflection can only be recorded in the high frequency mode. The amplification of the reflections can be varied by potentiometers called Sensitivity Controls. The recording units are powered by rechargeable batteries.

CHART INTERPRETATION

The difficulty of chart interpretation will vary depending on well conditions; casing pressures, casing-tubing annulus area, and well noise can distort the reflection and reduce the number of tubing reflections.

Figure 2 is an example of the fluid level charts. Chart A shows tubing collars being recorded until the reduction in amplitude makes them uninterpretable. The frequency is then switched to the low frequency so that only the fluid reflection will be recorded. On some recording units, switching frequencies can be done manually or automatically. Chart B shows the tubing collars and fluid recorded in the high frequency mode.

Normally, the fluid level is determined by counting the number of tubing collar reflections to the fluid reflection. This is accomplished by first marking the shot point on the chart. A recording unit with a suppression circuit makes this easier. Next, the fluid level and any anchors or liners should be identified. Beginning at the shot point count the number of tubing reflections to the fluid reflection. Where tubing collars are uninterpretable, a set of 11 point dividers can be used to determine tubing collar spacing.

If no interpretable tubing collars are recorded, the fluid level can be determined from knowing the chart speed and calculating the acoustic velocity of the sound wave in the annulus.

RECENT INNOVATIONS OF GAS GUNS

In 1981, two AWS manufacturers introduced compact, versatile gas guns to the oil field. Using a blast of gas pressure to produce the sound wave is not a new idea. CO_2 and N_2 have been used successfully for many years. The gas guns previously used were bulky assortments of valves and pipe. The new gas guns are 2.5 inch square to 12 inch long, weighing 6 or 15 pounds depending on the manufacturer.

The gas gun consists of a gas chamber, pressure gauge, inlet fitting (used to input gas or bleed the gas chamber), microphone, firing valve, and a two inch pipe connection. The sound wave is generated by exploding gas from the gas chamber to the well annulus or by imploding the well gas into the gas chamber.

When the explosion method is used, the gas chamber is pressured above the annulus pressure from an external gas bottle. The amount of pressure required to produce distinguishable reflections will vary depending on well noise, depth, temperature, and annulus area. Normally, 200 PSI above annulus pressure gives good results.

The implosion method can be used when the casing pressure is 50 PSI or more. Pressure requirements for satisfactory results depends on the same variable as the explosion method.

CO_2 is the preferable gas to use with gas guns. CO_2 is readily available in various quantities, normally from 9 ounce to 50 pound bottles. Also, CO_2 is safer to use than N_2. Under normal operating temperature, the maximum pressure attainable from CO_2 will not exceed the operating pressure of the gas gun.

Nitrogen is used when sufficient pressure cannot be obtained with CO_2. As shown in Figure 3, the maximum pressure obtainable from CO_2 will vary from approximately 1033 PSI at 85 F to approximately 228 PSI at $-20^{o}F$. The critical temperature of N_2 is $-321^{o}F$. Above $-321^{o}F$, more than sufficient pressure can be obtained from N_2.

In most cases, the gas gun is perferable to the blank gun. The possibility of creating a fire with a gas gun is nonexistant. The gas gun is less expensive to operate. Using the explosion mode, the cost of firing a blast of gas pressure is about 1/70th the cost of firing a 10 gauge blank. The ability to vary the amount of pressure used to create the sound wave to match the well requirement improves performance. The force of the pressure pulse from a gas gun at maximum pressure is much greater than the force created by firing a 10 gauge blank. In deep, low pressure wells, this extra power may be necessary to obtain good results.

CONCLUSION

The acoustical well sounder is an electronic instrument used to determine fluid levels accurately and quickly. The fluid level data is essential to design and analyze production equipment and to study the reservoir performance.

Although black powder blanks are still an effective method to generate the sound waves, recent innovation in gas guns has improved the safety, performance, and has decreased the cost of acoustical well sounding.

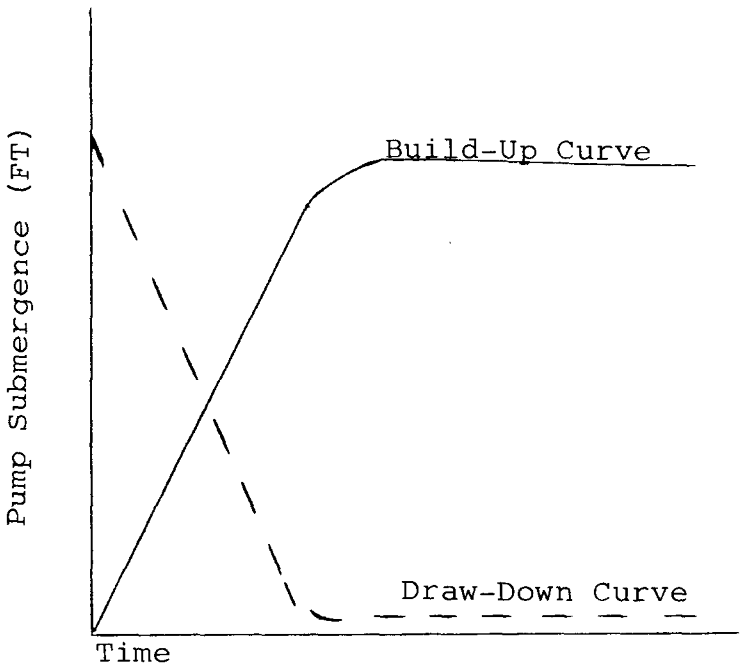

Figure 1 Reservoir Performance Curves

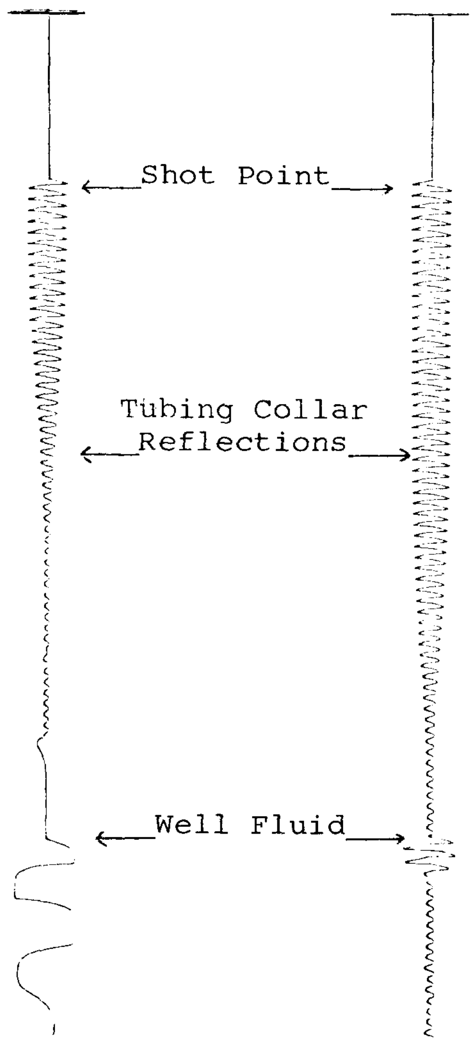

Figure 2 Acoustical Fluid Level Charts

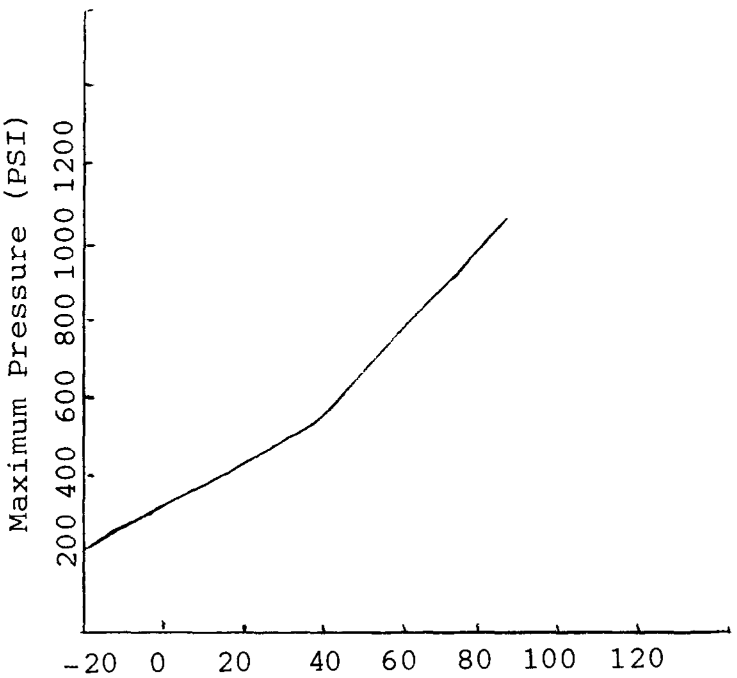

Figure 3 Pressure vs. Temperature for CO_2