Preparing Wells for Inspection by Downhole Camera

Introduction

Successful camera surveys always begin with proper planning and consideration of potential sources of dirty, opaque fluids, and the associated execution of well preparation/clean up methods. Sources of dirty wellbore fluids are identified and techniques for controlling each source are offered. Recognition of dirty fluid sources and initiating tactical procedures that work to counteract their effects will ensure the highest probabilities that down hole cameras get the desired results with the least investment of time and resources.

A prerequisite for successful downhole camera usage is a transparent medium to see through, usually clear water, dry gas, or air. In the presence of unfavorable well conditions such as dirty, contaminated, or opaque well fluids, the result is often poor images taken downhole via the deployed camera system. Understanding all the methods/techniques available which can deal with these various situations can significantly increase the likelihood of a successful camera deployment.

The provision of optimum viewing conditions within the wellbore for camera surveys is a critical factor and should not be overlooked, as this would often result in poor images being gained.

- Dry gas or using a camera within air are commonly the most effective viewing mediums.
- When working in a fluid, a clean, transparent fluid is a necessity.
- When the well fluid is to be displaced, the ideal displacement fluid should be filtered to 5 micron, although less filtering is often acceptable.

In the event that the well in which the camera survey is to be carried out does not fall within the criteria described above, then corrective action needs to be carefully considered. A sample of the well fluid or of the fluid that will be pumped into the wellbore to provide a clean viewing medium should be provided so a simple test can be performed. This test involves using a container which can contain a minimum of 6” of well media (such as a bucket) and a coin. If the coin cannot be viewed clearly when resting at bottom of the vessel, then it is unlikely that the well fluid is clean enough for camera operations to commence.

General Rules for Different Well Types

- **Dry gas wells:** Minimal preparation required
- **“Wet” gas wells:** Capability to inject small amounts of clean water should be planned for
- **Oil producing:** At least 24 hours preparation prior to run
- **Geologic core holes, Air:** No treatment; **Water:** Allow to stand for at least 24 hours
- **During well construction activities:** Mud must be displaced with a clear fluid
- **Injection wells, water:** Inject clear fluid at time of survey

Wells which can be circulated clean, or where dirty/contaminated, well fluids should be displaced into the formation using cement pumping units. (Assure that the tanks have been properly cleaned and flushed a number of times.)

If there is any doubt with regard to the integrity or actual drift of the tubing (especially if opaque fluids are expected in the tubing to an extent that viewing will be diminished, or when using a memory camera), it is advisable to perform a drift run prior to the camera survey. This should be carried out two to three days prior to the planned survey, as the drift run is likely to scrape scale, etc. off the tubing walls, creating debris that may become suspended in the well fluid. This debris will tend to settle out after a couple of days.

It is generally recommended to leave the well undisturbed for a minimum of 24 hours prior to the survey run (unless injecting clear filtered fluid at the time of the survey). This rule also applies for the period between any wireline runs and the camera survey run.

Recommended fluids for wellbore displacement:

- Filtered fresh water
- Filtered sea water
- Filtered brine
- Grade I diesel

Note: Lower grade diesel is only recommended where the camera can get very close to the object to be viewed, i.e. less than 4” (100mm).

Injection wells

When injecting into the formation, the filtered fluid is pumped down while the camera is lowered into the well. Where the addition of fluids into the formation is to be minimized, running through tubing or drill pipe and circulating the fluid back to surface is an option.

Note: The condition of the string is crucial. Scale, mud, cement, acid, etc. in the string will have the effect of causing even pristine clear water to become unusably opaque.

(In one case where clear water was being injected through a Kelly hose, even after pumping 200bbls, the fluid was opaque. On eliminating the Kelly hose, the fluid started to clear immediately.) As the fluid is circulated it should be pumped through a 5 micron filter. The filter cartridges should be changed during the run, as necessary, to maintain fluid clarity.

Typical displacement pumping rates vary from about 1~5 barrels/min, depending on bore size.
When planning for a fluid circulation survey, the rates should also be tailored to avoid fluid turbidity.

Producing wells

Wells with a water cut of 80% or higher may simply be shut in prior to rigging up the camera. The static fluid column will be primarily water with an oil cap on the top. Wells with a lower water cut may require different procedures depending on the viewing requirements/depth. If casing/tubing inspection is required in the area containing the oil cap, it this will have to be displaced by filtered fluid or gas. A minimum of two full tubing volumes should be pumped downhole to ensure good visibility. This can normally be achieved at around 4~6barrls/min. A 5 micron filter is recommended for good visibility, and should be used when injecting or pumping is being carried out whenever possible. Once two tubing volumes have been pumped, maintaining the pump at a minimal level will help contain the dirty fluids/oil in the reservoir so that the camera survey can take place. The use of a 5 micron filter during injection of clean fluids for displacement purposes is the best tool in gaining the correct environment for a camera to see downhole. Non-filtered brine (10# brine or KCl water) causes milky properties. Clay-Fix 2 is a recommended solution to this problem of clouding. Synthetic KCl should not be used. Sea water or filtered KCl can be used to remedy problems with polymer fluids.

Experience has shown that in wells with even only a 7% water cut, shutting the well in 12 hours prior to the survey will likely result in a standing column of water throughout the perforated interval, providing an excellent viewing medium through that region.

When the camera has been lowered to the area to be surveyed, the well can be brought on to flow slowly. Several passes are made over a few hours. This allows production to stabilize. Production regimes will often change during the first 3~4 hours.

Fluid Turbidity

The most widely used measurement unit for turbidity is the FTU (Formazin Turbidity Unit). ISO standards refer to its units as FNU (Formazin Nephelometric Units).

There are several practical ways of checking water quality, the most direct being some measure of attenuation (that is, reduction in strength) of light as it passes through a sample column of water. The alternatively used Jackson Candle method (having units of Jackson Turbidity Unit or JTU) is essentially the inverse measure of the length of a column of water needed to completely obscure a candle flame viewed through it. The more water needed (the longer the water column), the clearer the water. Of course water, alone, produces some attenuation, and any substances dissolved in the water can attenuate some wavelengths more than others. Modern instruments do not use candles, but this approach of attenuation of a light beam through a column of water should be calibrated and reported in JTUs.

The tendency of particles to scatter a light beam focused on them is considered a more meaningful measure of turbidity in water. Turbidity measured in this way uses an instrument called a nephelometer, with the detector set up to the side of the light beam. More light reaches the detector when there are many small particles scattering the source beam than when there are few. The units of turbidity from a calibrated nephelometer are called Nephelometric Turbidity Units (NTU). To some extent, how much light reflects for a given amount of particulates is dependent upon properties of the particles such as their shape, color, and reflectivity. For this reason (and the reason that heavier particles settle quickly and do not contribute to a turbidity reading), a correlation between turbidity and total suspended solids (TSS) is somewhat unique for each location or situation.

Turbidity in lakes, reservoirs, channels, and the ocean can be measured using a Secchi disk. This black and white disk is lowered into the water until it can no longer be seen; the depth (Secchi depth) is then recorded as a measure of the transparency of the water (inversely related to turbidity). The Secchi disk has the advantages of integrating turbidity over depth (where variable turbidity layers are present), being quick and easy to use, and being inexpensive. It can provide a rough indication of the depth of the euphotic zone with a 3-fold division of the Secchi depth, however this cannot be used in shallow waters where the disk can still be seen on the bottom.

Fluid Information

- Additives and inhibitors tend to emulsify fluids and require displacement.
- When using brine, the brine mix needs to be pre-mixed and placed in a holding tank on location for at least one day prior to use. This allows the brine mixture to dissolve and the particles to settle to the bottom of the tank.
- Tests have shown that 12% or 74# KCl solution is the heaviest or highest concentration able to be used and made optically clear by running through 5 micron filters. During these tests, it was found critical that the mixture was **allowed to settle overnight**, prior to filtering and pumping.
- An optically clear gel has also been used as a viewing medium for short sections. It can be provided in a very heavy mixture which keeps back formation and pressure as well as displacing mud or even oil based mud.

Well Entry

- When installing the camera in the pressure control equipment, it is essential that the internals of these components are also clean, as it is likely that any accumulation of debris in the system could be transferred to the camera lens during subsequent operations.
- Prior to opening up the wellbore, it is recommended to have a small pressure differential in favor of the pressure control equipment to the wellbore, so that when the isolation valve is opened, no debris can be blown on to the lens from the well/Christmas tree/etc. Keeping the camera as high in the pressure control equipment as possible when opening the isolation valve also minimizes the amount of debris that reaches the lens.
- Often, a camera lens can be contaminated when passing through from air (or gas) to a fluid, commonly known in the oil industry as the fluid level. A dirty skim can often be present there which, when in contact with the camera lens, may result in the failure to gain good images further down in the wellbore. Use of a surfactant on the camera's windows will greatly diminish adhesion of this skim. “Splashing through” the fluid/air interface again can also displace stuck debris.

Additional Sources of Information

- SPE-35680-MS: Well Preparation - Essentials to Successful Video Logging
- SPE-54105-MS: Development of a Portable Downhole Camera System for Mechanical Inspection of Wellbores
- SPE-62522-MS: Downhole Video: A Cost/Benefit Analysis
- SPE-30134-MS: Downhole Video Services Enhance Conformance Technology
- SPE-39539-MS: Perforation-Specific Inflow Fluid Characterization With Downhole Video
- SPE-38295-MS: Diagnosing Horizontal Well Production in the Belridge Field with Downhole Video and Production Logs
- SPE-26043-PA: Diagnosing Production Problems With Downhole Video Surveying At Prudhoe Bay
- SPE-108084-MS: Production and Video Logging In Horizontal Low Permeability Gas Wells
- SPWLA1996-EEE: Visualizing Production in Flowing Oil Wells