REGAINING CIRCULATION AND FREEING STUCK PIPE WITH NITROGEN

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Introduction

On many occasions, lost circulation is associated with stuck pipe and once circulation is regained the pipe may become free. With a good mud system sometimes it is not advisable to contaminate the mud with other fluids; however, with Nitrogen the mud may be circulated through a degasser or across the shale shaker to break the gas out leaving uncontaminated mud.

Nitrogen technical manuals will show pressure gradients of commingled nitrogen and liquid densities up to 11 lbs/gal. All gas laws are incorporated into their design. At low concentration of nitrogen and high pressure the charts show near linear conditions. An equation for field use by engineers will show the pressure gradient and amount of nitrogen required to lower the hydrostatic pressure of any weight fluid.

Example:

Drilling	18000 ft
Mud	17 lb/gal
Capacity	675 BBLS

Choke on flow line - 500 PSI Back Pressure
Cut Mud Weight by approximately 20 Per Cent with Nitrogen

Temp. Avg.	200°F
Pump Rate	6 BPM

$$Pgn = PPG\ (1-Pc) + \frac{(.34355)(Pc)(Pa)}{(Ta)\quad(Z)}$$

$$= 17\ (1-.20) + \frac{(.34355)(.20)(8206)}{(660)\quad 1.39}$$

$$Pgn = 14.2$$

$$(14.2)(.052)(18000) = 13291\ \text{PSI @ 18000 Ft.}$$

Using average pressure and temperature the volume factor of nitrogen is 1775 SCF per barrel of space. (1)

$$Qn2 = (PC)(QT) = (.20)\ (6) = 1.2\ \text{BPM}$$
$$qn2 = (Qn2)(Bn2) = (1.2)(1775) = 2130\ \text{SCF/MIN.}$$
$$Qm = QT - Qn2 = 6 - 1.2 = 4.8\ \text{BPM}$$
$$SCF/BBL = qn2/Qm = 2130/4.8 = 444\ \text{SCF/BBL}$$

Nomenclature

Pgn - Pound per Gallon Fluid and Nitrogen
PPG - Pounds per Gallon Fluid
Bn2 - Nitrogen Volume Factor
BPM - Barrel per Minute
Pa - Pressure Average
Pc - Percent Mud Weight Cut
QT - Total Rate
Qn2 - Rate of Nitrogen
Qm - Rate of Mud

qn2 - Nitrogen Rate (SCF/MIN)
Ta - Temperature Average (^{O}R)
Z - Nitrogen Compressibility Factor at Pa and Ta

Another consideration is that Nitrogen must occupy space and will expand the mud; therefore, it was determined that the expansion factor is 1.249. 675 barrels divided by 1.249indicates that after pumping 540 barrels of mud and Nitrogen, complete returns of mud and Nitrogen would be attained. Caution should be exercised if a high pressure kick can be anticipated.

At low pressure and medium depths another set of gas laws would be required as the expansion factors get as high as 20:1 and nitrogen weight in neglible.

Partial Displacement of Annulus or Pipe

The first attempt to free stuck drill pipe was a joint experimental venture with a major oil company in Gary County, Oklahoma. The procedure utilized was a partial displacement of the annulus between the intermediate string and the drill pipe. After displacing to a predetermined depth a strain was taken on the drill pipe and the annulus side was opened to atmosphere causing a sudden pressure drop on the annulus side and the drill pipe was freed.

The same procedure is still in use today as exemplified by a recent job. While drilling at 16,000 feet with 16.2 PPG mud, the drill pipe became stuck. Pipe design was surface pipe 5,000 feet, intermediate string of 7 5/8 set at 10,500 feet. It was decided to displace the mud in the annulus to 4,500 feet if reverse circulation could be maintained. A well head pressure of 3,290 PSI of Nitrogen was determined and to be accurate, the returns were measured to assure accuracy.

A total of 187,365 SCF was required. After clearing the rig floor of unnecessary personnel, the driller pulled on the pipe while the crew released the Nitrogen. The pipe was free and after pulling up the hole and circulating, the mud was reconditioned.

Pumping a Nitrogen Bubble Down Drill Pipe Followed by Nitrified Mud

On shallow to medium depth wells (4-7,000 feet) it has been determined through field experience the best procedure is to pump a bubble of Nitrogen down the stuck string followed by an nitrified column. By observing pressure recorders and monitoring pump rates it is easy to determine the depth of the lost circulation zone. After pumping the bubble; commence nitrifying at about 300 SCF/BBL. The surface pressure will increase as the hydrostatic pressure decreases with the addition of Nitrogen.

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The surface pressure will increase as the hydrostatic pressure decreases with the addition of Nitrogen. By observing the recorder it will be noted that the pressure will suddenly flatten out. This is a normal reaction as when the bubble of Nitrogen reaches a low pressure zone it will bleed back into the formation. What Nitrogen is not lost to the formation will be absorbed by the mud system. Ordinarily a bubble of 5,000 SCF per 1,000 feet of depth is pumped prior to nitrifying the remainder of the mud system. On a 6,000 foot well with 10.7 mud, the space occupied on bottom at temperature and pressure is about 28 barrels. The calculation of Nitrogen per barrel and expansion factor is the same as in nitrifying the complete system. By keeping a constant pull on the drill pipe it will usually become free before the nitrified mud reaches the surface.

For shallow to medium depth wells the bubble confirguation appears to be the best procedure as indicated by the below table:

COUNTY	DEPTH	NITROGEN	TIME ON LOCATION (hours)	COST
WARD	5,000	115,000	3	1.910.
TOM GREEN	5,300	50,000	3.5	1.271.
GARZA	3.940	68,000	2.5	1.590.
TERRY	6,750	70,000	3	1,550.
HOWARD	5,000	40,000	2.5	1,101.
CROSBY	4,030	111,000	7	2,451.
DAWSON	6,700	60,000	3	1,376.
UPTON	4.280	58,000	4	1,360.

Conclusion

Before attempting any job whether it be a workover, stuck on bottom, or a drilling project it is of utmost importance that the service technician and the company or drilling rig superintendent confer. Some points should be stressed: what is the best procedure for the conditions, is the rig crew trained to handle a a gas kick and what safety precautions are necessary?

Spotting of oil or specially formulated fluids have their place in many situations and should not be discarded. These fluids can be expensive considering hauling cost, storage, rig time, and possibly contaminating a mud system. So all procedures should be considered on the basis of efficiency and overall cost.

References:

1. NOWSCO Technical Manual 1980

2. Mobil Oil Company