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Stuck Pipe Engineering Manual

PENTAFLOW

PIPE RELEASE AGENT FOR LOW TO MEDIUM DENSITY WATER BASED & OIL BASED DRILLING FLUIDS

SD27X (HDC Mk II)

PIPE RELEASE AGENT FOR MEDIUM TO ULTRA HIGH DENSITY WATER & OIL BASED DRILLING FLUIDS

SECONDARY APPLICATIONS:

PentaFlow – **BIT & BHA De-Balling, OBM removal from casing, $CaCO_3$ scale dissolving**

SD27X (HDC Mk II) – **Stimulation and settled Barite removal**

Introduction

PentaFlow was developed and field tested in 1992 as an alternative to oil and lubricant based pipe release agents, which were becoming (and now are) unacceptable risk to the environment. Since that time it has been used in hundreds of stuck pipe applications round the world with a 65% success rate when applied within 24 hours of the sticking incident.

During this period, contractors and Operators have defined a number of applications for ***PentaFlow***, such as bit and BHA de-balling in highly inhibited water based mud's, cased hole scouring for cement, carbonate and rust removal, as well as a formation friendly product for the removal of carbonate and polymers prior to open hole completion operations. With this background in successful product development, ***PentaFlow*** was seen to also have the ability to remove oil films, making it particularly effective in oil based pipe release. ***PentaFlow*** is now commonly used in cased hole well bore cleanup between oil based mud and water based mud displacements, as well as pipe release in highly inhibited water based drilling fluids.

Drilling Contractor's Statistics prove that chemical solutions to formation related stuck pipe are effective in over 60% of instances world wide – if applied within 24 hours of the sticking incident. Afterwards, the recovery of the BHA and the associated "jewellery" is less than 10%. This is a simple way of saying – "If a good chemical contingency is on board, you have a chance. If you don't …there's no chance at all……."

This manual is intended to be a guideline for field users and planning staff alike. It is also guide for use during well budgeting. Risk assessment and hazard mitigation are all part of the oil well drilling planning process; particularly reduction of loss potential. Sidetracking, target acquisition loss, the implications of operational day rate cost for every down time incident all have impact on the AFE of a well. Blowing off the string and "cutting your losses" are an option when nothing on board is available to free a stuck string. However – ***if it was your money that was at risk*** – with the implications of a lost slot on a platform, three to seven days more rig cost on a programme, lost in hole cost to the tool contractor- would you prefer a 1 in 6 chance in your favour of avoiding those losses for a cost of .009% of the well cost ($30,000) of a $3,000,000/30 day well, or a $450,000 side track bill? If the risk includes loss of target, poor kick off cement in unconsolidated clays, weather implications, or loss of production zone acquisition – the equation becomes untenable.

Contents

PentaFlow

Low to Medium Density Water Based and Oil Based Mud Stuck Pipe Release Agents

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PentaFlow – Product Description

Product	**:**	**PentaFlow**
Appearance	**:**	**Clear to pale blue liquid**
Specific Gravity	**:**	**1.128**
pH	**:**	**1.0 - 2.0 (aqueous phase)**
Supply	**:**	**Supplied in 200 litre drums**
Use	**:**	**For use in stuck pipe applications in *water based* and oil based drilling fluid systems**

1.0 The *PentaFlow* Chemistry

PentaFlow is an extremely effective pipe release agent for drilling fluid applications. Used neat, it dissolves polymers, additive carbonates, and drilled carbonates whilst creating a turbulent reaction across the filtercake or well bore face.

The extremely active (and aggressive) ionic environment, causes rapid separation of clay particles, drying and subsequent Embrittlement. This process allows the transmission of the drill string jarring and pulling action to be transmitted directly to firm, fractured and weakened clay formations, as opposed to soft, plastic and energy absorbing shale.

2.0 The Base Reaction Mechanisms

2.1 Acid decomposition of carbonates & polymers

PentaFlow's acid base will destroy most drilling fluid polymers in minutes. The same acid base violently reacts with most drilled carbonates, as well as added carbonates and carbonates formed during the drilling process. The dissolution of the polymer base of the drilling fluid filter cake destroys the base integrity of the cake whilst the carbon dioxide release from the carbonate reaction causes violent near surface turbulence to aid in cake removal.

2.2 Electrolytic Decomposition and Embrittlement of Clays

PentaFlow's powerful electrolytic base causes massive base ion exchange within the molecular structure of clays causing rapid dewatering and platelet collapse, then total shrinkage causes collapse of the filter cake integrity. The drier and shrunken clays transmit the hydraulic power of jarring and pulling much more effectively than the plastic sticky clays nominally causing the stuck situation. In addition to the filter cake effect, cuttings (clay based or carbonate based) are degraded giving the Operator a far greater chance of releasing the pipe. This dehydration and Embrittlement of clay structures in conjunction with the polymer and carbonate removal effectively destroys water base filter cakes allowing total fluid and pressure communication between the pipe and the formation – all of which maximise the chance of string recovery.

3.0 Which Fluids To Use It In

PentaFlow can be used in any water based drilling fluid. ***PentaFlow*** is particularly effective in polymer, salt polymer, polymer glycerol and poly-glycerol mud systems. **PentaFlow** is also effective in oil based systems.

4.0 Which Formations is PentaFlow Effective In

- **Tertiary Clay Formations**

In tertiary formations, even in salt inhibited polymer muds, the total reaction time for cake removal is approximately 60 minutes. In dispersed bentonite systems in the same formation reaction time will double to 120 to 140 minutes to total cake dissolution.

- **Jurassic Clay Formations**

Reaction time in these formations is halved (30 minutes to 45 minutes) for all water based mud types.

- **Carboniferous Formations**

Extremely fast reaction times are seen in these formations. The reaction times vary from a few (10 to 15) minutes to 35 minutes depending on mud type.

Note**

In all lab simulated verifications, enough fluid (PentaFlow) must be exposed to the cake in order to calculate approximate reaction times. For bench testing purposes, a typical API filter cake of 2/32nd of an inch can be degraded 45 to 65% in a petri dish volume of PentaFlow.

5.0 Product Usage

- **Stuck Pipe**

PentaFlow is used neat in pipe release applications. As the product cannot be weighted up due to the foaming tendencies with barite (foaming is due to impurities in commercial barites), it is normal to pump a weighted pill ahead of the **PentaFlow** if the stuck pipe requires a weight greater than 1.2 SG. The table below gives relative weight requirements for increasing the weight of the mud ahead of the **PentaFlow** spotting fluid in mud weights in excess of 1.20 SG.

Table 1: Weight Balance

Initial Mud Weight In PPG	Vol. PentaFlow In Barrels	Volume Mud (ahead) in Barrels	Barite Required In Tonnes
11.0	10	9.66	0.22
12.0	10	9.29	0.49
13.0	10	8.89	0.76
14.0	10	8.49	1.03
15.0	10	8.09	1.30
16.0	10	7.69	1.71
17.0	10	7.29	1.84

- **Spotting Volumes**

PentaFlow should be used in adequate quantities to ensure dissolution of the filter cake or formation causing the problem. Volume is very dependent on hole size and the length of BHA to be covered. To cover nominally 400' of BHA (annular volume) for a sixty minute exposure, with fluid movements every ten to fifteen minutes, the following volumes are recommended.

Table 2: Spotting Fluid Volumes

Hole Size	Spotting Time (Minutes)	BBLS PentaFlow
12 ¼"	**60 to 180**	**60**
8 ½"	**60 to 180**	**30**
6"	**60 to 180**	**16**

The volumes above reflect the need to move fluid (pump past ± 1 to 2 bbls) at regular intervals to ensure new, unspent fluid is available for reaction.

6.0 Effect On Drilling Fluid

A spacer is not required with **PentaFlow** between the mud system and the pill. The pH of the mud will drop sharply at the interface of the fluids, with carbon dioxide gas generated during the spotting period. Fluid loss in the immediate volumes (1 to 2 barrels) either side of the pill will be elevated. These effects and by-products will be strung out and diluted back in the drilling fluid when normal circulation commences to some extent. If desirable, fluid on either side of the spotting pill can be dumped, or additions of Caustic Soda and or Lime can be made to restore pH values and fluid parameters. It should be kept in mind, that incorporation of a 50 bbl pill of **PentaFlow** in a normal drilling fluid system, equates to less than 1.5% by volume or a .25 cc fluid loss increase in a 10 cc API system, and a 1 unit pH drop in a 10 pH system of 1500 bbls +.

For **PentaFlow** used in oil based applications, the fluid effect is similar to that of any aqueous intrusion into an OBM. The mud system should be pre-treated with light water wetting agents in case the **PentaFlow** is incorporated into the drilling fluid, with the alkalinity adjusted accordingly.

7.0 Stuck Pipe Removal Agent Formulation

PentaFlow should be used neat in all applications, nominally behind a weighted spacer to adjust the hydrostatic column to balance if weights required are above 11.2 ppg. When spotted, the nominal volume is 4 times the annular volume to be covered, with the PentaFlow pill moved every fifteen to thirty minutes to move the fluid and carry away spent product as well as cake and formation particles.

8.0 Differentially Stuck Pipe

PentaFlow, when applied, will rapidly solubilise the filter cake around the drill string in water-based environments, permitting pressure transmission, both from the formation and from the surface, to be effectively translated to the steel held in place.

Used in conjunction with a “U” tube approach, with the **PentaFlow** formulation calculated to be placed across the face of the target zone at maximum weight reduction, will ensure the greatest chance of success.

9.0 Tight Hole or Sticking Due To Cuttings Bed Build Up

Cuttings beds aggravated by high density barite solids build up during the drilling of high angle wells is a frequent causative agent of stuck pipe.

PentaFlow can be used to remove cuttings due to its ability to specifically dissolve polymers and carbonates which add to the compaction and “smoothing” of the cuttings bed.

Barite sagging during static well bore conditions creates an ideal situation for the cementation of fine to coarse drill solids by ultra-fine reground barite particles. As

the solids settle, they become compacted much in the same manner as filtercake depositions, with the resulting hardness and smooth surface which, if thick enough, constricts the hole, making wiping difficult with the resulting drag and torque on the drill string. **PentaFlow** reacts through the build up of barite, removing the cementation effects of formulated drilling fluid additives such as polymers and bridging agents. Once these solids are solubilised, the cementation effect is essentially lessened, loosening the solids and releasing them for removal through normal circulating procedures.

PentaFlow should not be used for this application in stable shale formations as the product will destabilise the area immediately around the spot zone. This procedure should only be used in carbonate and sand stone reservoirs.

For these applications, **PentaFlow** can be temporarily viscosified utilising 2 to 3 ppb of high quality polymers. A pill of viscosified **PentaFlow** will remain in a high rheological state for approximately 2 hours before decomposing due to temperature, pH, and the activity of the **PentaFlow** itself.

10.0 Sticking Due To De-stabilised Clay Formations and/or Collapsed Clay Formations

PentaFlow is an active and quite aggressive shale de-stabilising product which utilises excess free potassium ions to force movement of water to and from the formation which has collapsed, and more so, through the larger surface area exposed by the collapsed sections of the cuttings causing the stuck situation. This movement through already destabilised shale further weakens the shale, causing Embrittlement, which can be used to the advantage of the drill string during jarring operations.

PentaFlow whilst removing the cementation effect of the polymers settlement throughout the pack off area of the stuck pipe, is effectively exposing the surface area of the shale as it penetrates the shale platelets causing drying out and Embrittlement.

** It should be noted at this point, that in these situations, the fluid used to drill the hole has not performed its function in stabilising the formation, whether the collapse is due to chemical or mechanical reasons. By adding a destabilising agent to the fluid, one is targeting the collapsed formation around the drill string, which is already inherently unstable, in an attempt to recover the BHA and lose as little of the original hole as possible. The resulting size or stability of the hole after the string is recovered is likely to be of little significance in a spotting situation, as
whatever caused it to collapse in the first place will have to be rectified prior to reaming out the original hole or side tracking a new one.

This mechanism of “destructive” chemistry has been successfully utilised in these stuck pipe applications with great success, in low to medium weight environments.

11.0 On Board Cuttings Bed, Bit & BHA Balling Removal

In addition to being used as a stuck pipe additive, **PentaFlow** is applicable for scouring and removal of composites of cuttings beds and barite. It is quite effective (particularly in glycol inhibited fluids) for breaking and drying out bit and BHA balling.

12.0 Open Hole Pre-Completion Clean Up

PentaFlow can be used to remove filtercake components in sandstone and carbonate reservoirs prior to running screens and gravel packs due to its aggressive filtercake removal qualities.

PentaFlow is used to scour casing prior to completion operations to remove ingrained carbonate, rust and cement films.

13.0 Supply

PentaFlow is supplied in 200 litre drums, or customized on request.

SD27X (HDC Mk II)

OBM/WBM Stuck Pipe Release Agent

SD27X– Product Description

Product	**:**	**SD27X (HDC Mk II)**
Appearance	**:**	**Clear to pale yellow liquid**
Specific Gravity	**:**	**1.31**
pH	**:**	**12+**
Supply	**:**	**Supplied in 200 litre drums**
Use	**:**	**For use in stuck pipe applications in both WBM and OBM/SBM**

SD27X is a single phase solution, solids free, and non-damaging.

14.0 Formulations & Reaction Mechanisms

- **Stuck Pipe Removal Agent Formulation**

SD27X is supplied at an effective density of 1.31 SG. On request, a higher density fluid can be supplied, but that is with Cesium Formate thus significantly affecting the cost.

The **SD27X**, and any weight variants thereof, are all designed to be used neat.

15.0 The Active Mechanism

SD27X is an ultra advanced descaling, solvent concentrate which works by dissolving barite solids, carbonates and sulphates which are introduced to a well bore through drilling fluid additives, or form as a result of adverse chemical reactions during drilling operations. **SD27X** penetrates oil films and or encapsulating materials carried in the drilling fluid.

SD27X will dissolve most if not all drilling fluid components, in under two hours under standard pressures and temperatures above 175°F. Reaction times on formations vary, but can be accurately tested in the laboratory if samples are available. At low temperature reactions are slowest. The same density fluid components, at temperatures above 100 degrees Celsius, would be removed in approximately 70 minutes.

SD27X applications for stuck pipe situations can be analysed on several different levels. The most effective application is in differentially pipe sticking situations, where differential pressure and poor filtercake composition can be the main causative factors in the stuck phenomenon.

16.0 Differentially Stuck Pipe

SD27X will rapidly solubilise the filter cake around the drill string in water or oil environments, permitting pressure transmission, both from the formation and from the surface, to be effectively translated to the steel held in place. Used in conjunction with a “U” tube approach, with the pipe release formulation calculated to be placed across the face of the target zone at maximum weight reduction, will ensure the greatest chance of success.

17.0 Tight Hole or Sticking Due To Cuttings Bed Build Up

Cuttings beds aggravated by high density barite solids build up during the drilling of high angle wells is a frequent causative agent of stuck pipe. **SD27X** can be used to remove cuttings due to it’s ability to specifically dissolve barite, carbonates and drilling fluids additives without destabilising the well bore itself.

Barite sagging during static well bore conditions creates an ideal situation for the cementation of fine to coarse drill solids by ultra-fine reground barite particles. As the solids settle, they become compacted much in the same manner as filtercake depositions, with the resulting hardness and smooth surface which, if thick enough, constricts the hole making wiping difficult with the resulting drag and torque on the drill string. **SD27X** reacts through the build-up of solids, removing the cementation effects of barite and formulated drilling fluid additives such as polymers and emulsifiers. Once these solids are solubilised, the cementation effect is essentially removed, loosening the solids and releasing them for removal through normal circulating procedures.

For these applications, **SD27X** can be temporarily viscosified utilising 2 to 3 ppb of a specially tailored high quality polymers, whereby the pill itself can be caught at surface if desired. A pill of viscosified **SD27X** will remain in a high rheological state for up to 12 hours before decomposing due to temperature, pH, and the activity of the **SD27X** itself.

Note** **SD27X** is non-reactive with clay and shale molecules. Exposure of water sensitive clays and shale to **SD27X** will not affect these formations as the K+HDC is formulated in an extremely stable state to prevent mobilisation of these particles and formations.

18.0 Sticking Due To De-stabilised Clay Formations and/or Collapsed Clay Formations

SD27X can be converted to a shale de-stabilising state by the addition of dry potassium chloride on the rig site. **SD27X** is manufactured with a minimal amount of free potassium, which was calculated to stabilise sensitive formations which are water sensitive. However, if potassium chloride is added in to the weight formulation in an **SD27X** spotting fluid, excess free potassium forces movement of water to and from the formation which has collapsed, and more so, through the larger surface area exposed by the collapsed sections of the cuttings causing the stuck situation . This movement through an already destabilised shale, further weakens the shale, causing Embrittlement, which can be used to the advantage of the drill string during jarring operations.

SD27X whilst removing the cementation effect of the barite settlement throughout the pack off area of the stuck pipe, is effectively exposing the surface area of the shale as it penetrates the oil based emulsion or water based fluid coat “protecting” them.

It should be noted at this point, that in these situations, the fluid used to drill the hole has not performed its function in stabilising the formation, whether the collapse is due to chemical or mechanical reasons. By adding a destabilising agent to the fluid, one is targeting the collapsed formation around the drill string, which is already inherently unstable, in an attempt to recover the BHA and lose as little of the original hole as possible. The resulting size or stability of the hole after the string is recovered is likely to be of little significance in a spotting situation, as whatever caused it to collapse in the first place will have to be rectified prior to reaming out the original hole or side tracking a new one.

This mechanism of “destructive” chemistry has been successfully utilised in other stuck pipe applications with great success, in low weight environments.

Note** Solubility of potassium chloride in various weight **SD27X** solutions changes with available free water at surface. If the bottom hole temperature is taken into account, solid potassium chloride can be carried into the spotting fluid,

which will solubilise down hole if calculated correctly. As a rule of thumb, an effective destabilising weight of potassium Chloride in an **SD27X** solution would be in excess of 148/gl (50ppb) at the actual BHT.

19.0 SD27X – Drilling Fluid Impact

SD27X, or any dilution there of, can be incorporated into the drilling fluid without loss of density or substantial quality loss. The spotting fluid, composed of ionic brines, emulsifies quite easily when strung out through the system, and exhibits no risk to human health or marine life. Fluid loss control and electrical stability will have to be restored at the interface of the pill volumes where synthetic or oil based fluids are used, as with the case of any water intrusion into an OBM system.

In water based muds, the pH of the spotting fluid would have the biggest impact, but this is easily treated using citric acid or allowed to deplete back to system pH as it blends in the drilling fluid. Fluid loss and viscosity will have to be remedially treated to restore over all properties, with the weight however, unaffected.

If used as directed, **SD27X** will in effect, become spent during the spotting period, and have no effect outside the critical zone.

Note** In seawater based fluids, the solubilised barium in the fluid will revert to barium sulphate due to the sulphate ions present in seawater.

20.0 Issues

- **Laboratory Projection**

SD27X reactions can be laboratory verified to remove filtercake components, and cause the decomposition of formation components, at fixed rates under set conditions of temperature and pressure. This means that valuable rig time can be saved by knowing in advance that the pill pumped will react in a finite time frame, and that time frame is fast.

- **Well Control**

Use of these products require no solids additions to adjust weight, no phase separation in oil based environments, and are thermally stable to > 400° F. Well control will not be an issue if used as directed.

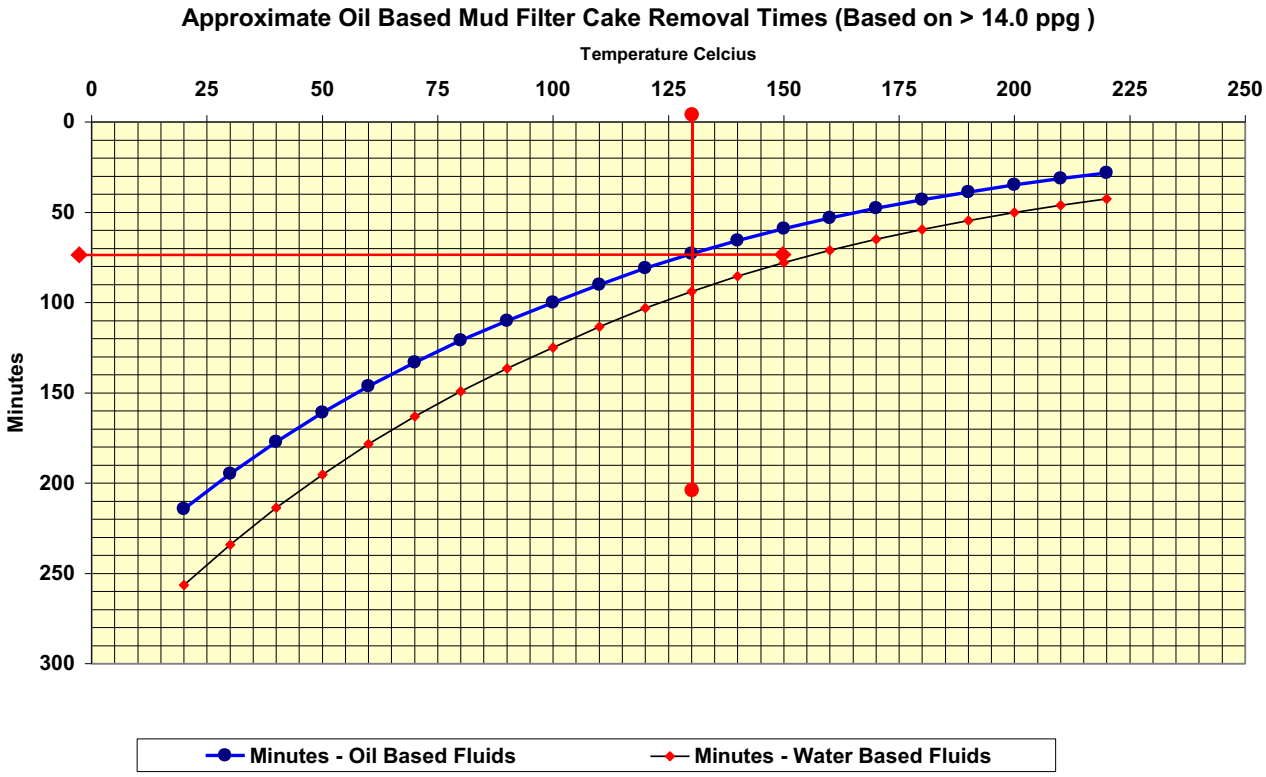
- **Can Be Used In Oil Based, Synthetic Base & Water Based Environments**

Under most conditions, the effectiveness of **SD27X** is unaffected by the previous fluid environment, and as such, works in oil environments, albeit very marginally slower than in water based environments. At elevated temperatures however, the delay in reaction time becomes much less pronounced, and it is measured in minutes.

- **On Board Cuttings Bed and Barite Removal**

In addition to being used as a stuck pipe additive, **SD27X** viscosifies easily, and is ideal for scouring and removal of composites of cuttings beds and barite .

In well testing applications, neat **SD27X** will dissolve large volumes of barite from tools, valves and perforations in under two hours, in any fluid environment.



General Engineering Data

1.0 Mud Pump Tables

Displacement Of Duplex Mud Pumps In bbl/Stroke @ 100% Efficiency						
Liner Sizes (Inches)	Stroke Distance In Inches					
	12	14	15	16	18	20
	Rod Diameter In Inches					
	2.00	2.00	2.25	2.25	2.50	2.50
4.00	0.0550	0.0640	-	-	-	-
4.25	0.0620	0.0730	-	-	-	-
4.50	0.0710	0.0830	0.0860	0.0960	0.0990	0.1110
4.75	0.0800	0.0930	0.0970	0.1040	0.1130	0.1260
5.00	0.0890	0.1040	0.1090	0.1160	0.1270	0.1420
5.25	0.0990	0.1160	0.1210	0.1290	0.1420	0.1580
5.50	0.1100	0.1280	0.1350	0.1440	0.1580	0.1760
5.75	0.1210	0.1410	0.1490	0.1580	0.1740	0.1940
6.00	0.1320	0.1540	0.1620	0.1730	0.1920	0.2130
6.25	0.1440	0.1680	0.1780	0.1890	0.2090	0.2330
6.50	0.1560	0.1820	0.1930	0.2060	0.2280	0.2530
6.75	0.1690	0.1970	0.2090	0.2230	0.2470	0.2750
7.00	0.1830	0.2130	0.2260	0.2410	0.2670	0.2970
7.25	0.1960	0.2290	0.2430	0.2590	0.2880	0.3200
7.50	-	-	0.2610	0.2780	0.3100	0.3440
7.75	-	-	0.2790	0.2980	0.3320	0.3690

Displacement Of Triplex Mud Pumps In bbl/Stroke @ 100% Efficiency									
Liner Size In Inches	Stroke Length In Inches								
	7.00	7.50	8.00	8.50	9.00	9.25	10.00	11.00	12.00
3.00	0.0153	0.0164	0.0175	0.0186	0.0197	0.0202	0.0219	0.0240	0.0262
3.25	0.0180	0.0192	0.0205	0.0218	0.0231	0.0237	0.0257	0.0283	0.0307
3.50	0.0208	0.0223	0.0238	0.0252	0.0267	0.0276	0.0298	0.0326	0.0357
3.75	0.0238	0.0257	0.0273	0.0290	0.0307	0.0317	0.0340	0.0376	0.0408
4.00	0.0271	0.0290	0.0311	0.0330	0.0350	0.0360	0.0388	0.0429	0.0467
4.25	0.0307	0.0328	0.0350	0.0374	0.0395	0.0404	0.0438	0.0483	0.0526
4.50	0.0345	0.0369	0.0392	0.0419	0.0443	0.0455	0.0493	0.0540	0.0590
4.75	0.0383	0.0411	0.0438	0.0466	0.0493	0.0507	0.0547	0.0602	0.0657
5.00	0.0426	0.0455	0.0486	0.0517	0.0548	0.0562	0.0607	0.0669	0.0729
5.25	0.0469	0.0502	0.0535	0.0569	0.0602	0.0620	0.0669	0.0736	0.0802
5.50	0.0514	0.0550	0.0588	0.0624	0.0661	0.0678	0.0736	0.0807	0.0880
5.75	0.0562	0.0602	0.0643	0.0683	0.0721	0.0743	0.0802	0.0883	0.0964
6.00	0.0611	0.0655	0.0700	0.0743	0.0786	0.0809	0.0874	0.0961	0.1050
6.25	0.0664	0.0712	0.0759	0.0807	0.0855	0.0878	0.0948	0.1043	0.1138
6.50	0.0719	0.0719	0.0821	0.0871	0.0924	0.0949	0.1026	0.1129	0.1230
6.75	0.0774	0.0830	0.0886	0.0940	0.0995	0.1023	0.1107	0.1217	0.1328
7.00	0.0833	0.0893	0.0952	0.1010	0.1071	0.1100	0.1190	0.1310	0.1430

2.0 Drill Collar Data – Weight, Capacity & Displacement

Drill Collar Size In Inches	Drill Collar Weight lb/ft	Capacity In bbl/ft	Displacement In bbl/ft
3.125	22.00	0.00151	0.00796
3.500	26.70	0.00218	0.00971
3.750	31.60	0.00218	0.01147
4.000	32.00	0.00390	0.01160
4.250	37.50	0.00390	0.01360
4.500	40.60	0.00490	0.01480
4.750	46.80	0.00490	0.01700
5.000	53.30	0.00490	0.01940
5.250	60.10	0.00490	0.02190
5.500	67.30	0.00490	0.02450
5.750	74.80	0.00490	0.02720
6.000	82.60	0.00490	0.03010
6.250	90.50	0.00490	0.03290
6.250	83.80	0.00770	0.03030
6.500	99.50	0.00490	0.03620
6.500	92.80	0.00770	0.03340
6.750	102.00	0.00770	0.03660
7.000	111.00	0.00770	0.03990
7.250	120.00	0.00770	0.04340
7.500	130.00	0.00770	0.04690
7.750	140.00	0.00770	0.05070
8.000	157.50	0.00490	0.05730
8.000	147.00	0.00870	0.05350
8.000	151.00	0.00770	0.05450
8.250	158.00	0.00870	0.05750
8.500	169.00	0.00870	0.06150
8.750	181.00	0.00870	0.06580
9.000	192.00	0.00874	0.06994
9.250	205.00	0.00874	0.07437
9.500	217.00	0.00874	0.07892
9.750	230.00	0.00874	0.08360
10.000	243.00	0.00874	0.08839
11.000	299.00	0.00874	0.10880
11.250	314.00	0.00874	0.11420

3.0 Drill Pipe Data – Weight, Capacity & Displacement

Drill Pipe Size In Inches	Notes	Drill Pipe Weight lb/ft	Capacity In bbl/ft	Displacement In bbl/ft
2.375	IF	6.65	0.003200	0.002419
2.875	IF	10.40	0.004495	0.003784
3.500	IF	13.30	0.007421	0.004839
3.500	IF	15.50	0.006576	0.005639
4.000	IF	14.00	0.010836	0.005093
4.500	IF	16.60	0.014219	0.006390
5.000	X Hole	19.50	0.018876	0.005457
5.000	X Hole	25.60	0.017760	0.007090
5.500	IF	21.90	0.022000	0.008037
6.625	IF	25.20	0.034500	0.008070
HW Drill Pipe Size In Inches	**Notes**	**HW Drill Pipe Weight lb/ft**	**Capacity In bbl/ft**	**Displacement In bbl/ft**
3.500		26.00	0.004200	**
4.000		28.00	0.006470	**
4.500		42.00	0.007450	**
5.000		50.00	0.008860	**
Tubing Size In Inches	**Notes**	**Tubing Weight lb/ft**	**Capacity In bbl/ft**	**Displacement In bbl/ft**
2.375		4.60	0.003870	0.001670
2.875		6.40	0.005790	0.002330
3.500		10.20	0.008290	0.003700
4.000		11.00	0.011740	0.004000
4.500		12.60	0.015220	0.004580

4.0 Casing Data – Weight, Capacity & Displacement

Casing Size In Inches	Casing Weight Lb/ft With Couplings	Gross Volume - Barrels Per Foot
4.500	9.50	0.0163
4.500	10.50	0.0160
4.500	11.60	0.0155
4.500	13.50	0.0149
5.000	15.00	0.0189
5.000	18.00	0.0178
5.000	20.30	0.0170
5.000	23.20	0.0159
5.500	14.00	0.0244
5.500	15.00	0.0240
5.500	15.50	0.0238
5.500	17.00	0.0232
5.500	20.00	0.0222
5.500	23.00	0.0212
6.625	17.00	0.0365
6.625	20.00	0.0355
6.625	24.00	0.0341
6.625	28.00	0.0326
6.625	32.00	0.0312
7.000	20.00	0.0405
7.000	23.00	0.0393
7.000	26.00	0.0383
7.000	29.00	0.0371
7.000	32.00	0.0360
7.000	35.00	0.0350
7.625	26.40	0.0472
7.625	29.70	0.0459
7.625	33.70	0.0445
7.625	39.00	0.0426
8.625	24.00	0.0637
8.625	28.00	0.0624
8.625	32.00	0.0610
9.625	32.30	0.0787
9.625	36.00	0.0773
9.625	40.00	0.0758
9.625	43.50	0.0745
9.625	47.00	0.0732
9.625	53.50	0.0708
10.750	32.75	0.1009
10.750	40.50	0.0981
10.750	45.50	0.0962
10.750	51.00	0.0943
11.750	38.00	0.1207
11.750	42.00	0.1193
11.750	47.00	0.1175
11.750	54.00	0.1150
11.750	60.00	0.1127
13.375	54.50	0.1546
13.375	61.00	0.1522
13.375	68.00	0.1497
13.375	72.00	0.1481
16.000	65.00	0.2259
16.000	75.00	0.2222
16.000	84.00	0.2189
20.000	94.00	0.3553
20.000	106.50	0.3507
20.000	133.00	0.3408

5.0 Riser Capacities

Riser I.D.	Wt./Ft.	Capacity/bbl/100'
18.73	NA	34.07
19	NA	35.06
19.12	NA	35.52
20.5	NA	40.86
20.7	NA	41.66

6.0 Useful Oil Field Conversion Tables

Multiply	By	To Obtain
Atmospheres	14.70	Pounds Per Square Inch
Barrels	5.6146	Cubic Feet
Barrels	0.1590	Cubic Meters
Barrels	42	Gallons
Barrels	158.90	Liters
Barrels per hour	0.70	Gallons per Minutes
B.T.U.'s per minute	0.0236	Horsepower
Centimeters	0.0328	Feet
Centimeters	0.3937	Inches
Cubic Centimeters	0.061	Cubic inches
Cubic Feet	0.1781	Barrels
Cubic Feet	7.4805	U.S. Gallons
Cubic Feet	28.32	Liters
Cubic Feet of steel	489.60	Pounds of steel
Cubic Feet	1728	Cubic inches
Cubic Inches	16.387	Cubic Centimeters
Cubic Inches	0.0043	Gallons
Cubic Inches	0.0164	Liters
Cubic Inches	0.0006	Cubic Feet
Cubic Meters	6.2897	Barrels
Cubic Meters	35.314	Cubic Feet
Cubic Meters	1.308	Cubic Yards
Feet	30.48	Centimeters
Feet	0.3048	Meters
Feet of Water	0.4331	Pounds per Square Inch
Gallons - U.S.	0.0238	Barrels
Gallons - U.S.	3785	Cubic Centimeters
Gallons - U.S.	3.7850	Liters
Grams	15.432	Grains
Grams	0.001	Kilograms
Grams	1000	Milligrams
Grams	0.0353	Ounces
Grams	0.0022	Pounds
Inches	2.54	Centimeters
Inches	0.0833	Feet
Kilograms	1000	Grams
Kilograms	2.2046	Pounds
Kilometers	3281	Feet
Kilometers	0.6214	Miles
Liters	1000	Cubic Centimeters
Liters	61.02	Cubic Inches
Liters	0.2642	Gallons
Liters	1.0567	Quarts
Meters	100	Centimeters
Meters	3.281	Feet
Meters	39.37	Inches
Meters	1.094	Yards
Miles	5280	Feet
Miles	1.609	Kilometers

Useful Oil Field Conversion Tables

Multiply	By	To Obtain
Ounces	437.50	Grains
Ounces	28.349	Grams
PPM	0.0584	Grains per Gallon
PPM	8.340	Pounds per Million Gallons
Pounds	453.60	Grams
Pounds	7000	Grains
Pounds Per Gallon	0.1198	Grams per cubic Centimeter
Pounds Per Gallon	0.0520	Pounds/square inch per foot of depth
Pounds per Million Gallons	0.1198	PPM
Quarts	0.9460	Liters
Quarts	946.36	Milliliters
Square Centimeters	0.1550	Square Inches
Square Feet	929	Square Centimeters
Square Feet	0.0929	Square Meters
Square Inches	6.452	Square Centimeters
Square Kilometer	0.3861	Square Miles
Square Meters	10.76	Square Feet
Square Meters	1.196	Square yards
Tons - Long	2240	Pounds
Tons - Metric	2205	Pounds
Tons - Short	2000	Pounds
Tons - Metric	1000	Kilograms
Tons - Metric	6.297	Barrels of Water
Tons - Short	907.20	Kilograms

Temperature Conversions

To convert Fahrenheit temperature to Centigrade:

$$\text{Temp. } ^\circ C = .5555(\text{Temp. } ^\circ F - 32)$$

To convert Centigrade temperature to Fahrenheit:

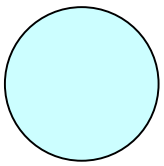
$$\text{Temp. } ^\circ F = 1.8(\text{Temp. } ^\circ C) + 32$$

Geometric Figures

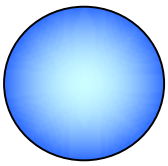
Where:

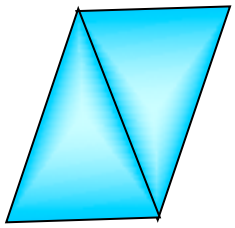
A = area
a = altitude
r = radius
D = Diameter
V = Volume
b = Length of base or side

Area of a Circle = πr^2



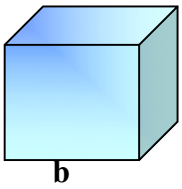
Volume of Sphere = 1.333 πr^3



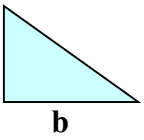


Volume of a Cone or Pyramid = 1/3**a** (area **A** of base)

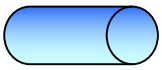
Volume of a Cube = b^3



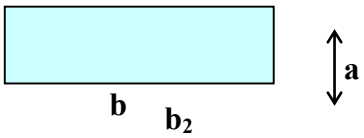
Area of a Triangle = ½ **ab**



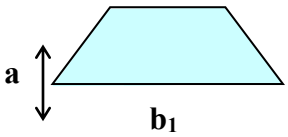
Volume of Prism or Cylinder = **a** (area **A** of base)



Area of Rectangle or Parallelogram = **ab**



Area of a Trapezoid = ½ **a** (b_1 + b_2)



Note Pad:

	Metric	Imperial
Well Depth		
Hole Diameter		
BHA Length		
BHA - Capacity		
BHA - Displacement		
Capacity + Displacement BHA		
Hole Capacity		
Annular Volume – Hole/BHA		
Pill Volume Required		
Pump Output bbl/stk		
Pump Output SPM		
Capacity Drill Pipe		
Total String Capacity		
Pump Strokes/Surface To Bit		
Pump Strokes Bit To Top BHA		
Strokes To Move 1 bbl/pill		

Calculations & Notes:

Start Time: Pill In Place Around BHA:
Time of Pill Movement One:
Time of Pill Movement Two:
Time of Pill Movement Three: