



AADE-05-NTCE-45

OPERATIONAL GUIDELINES USING POINT-THE-BIT TECHNOLOGY WITH BICENTER BITS

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This paper was prepared for presentation at the AADE 2005 National Technical Conference and Exhibition, held at the Wyndam Greenspoint in Houston, Texas, April 5-7, 2005. This conference was sponsored by the Houston Chapter of the American Association of Drilling Engineers. The information presented in this paper does not reflect any position, claim or endorsement made or implied by the American Association of Drilling Engineers, their officers or members. Questions concerning the content of this paper should be directed to the individuals listed as author/s of this work.

ABSTRACT

Point-the-bit rotary steerable technology is now being used in the Gulf of Mexico to complement the use of bicenter bits. The use of hole-opening devices is prevalent in the Gulf primarily because of aggressive pore and fracture profiles in the deepwater arena. In the deep Shelf arena, operators use these devices to provide contingency options at deeper depths. Push-the-bit rotary steerable systems (RSSs) and reamers provide excellent solutions where rathole (the portion of open hole underneath the reamer that has not been enlarged) length is not a concern. If rathole length is a concern, it is possible to enlarge the rathole at the expense of a reaming run. Point-the-bit RSS and bicenter bit combinations enable gauge hole enlargement in one run while retaining RSS characteristics such as increased rate of penetration (ROP), superior hole cleaning, and steerability. Reservoir engineers and geologists also benefit when using azimuthally sensitive formation evaluation measurements with this bit and driver combination. Continuous rotation and a gauge hole provide a phenomenal environment for full borehole formation evaluation coverage.

INTRODUCTION

When bicenter bit technology first emerged approximately 10 years ago, it was used in conjunction with a mud motor for the driver. Concerns with gauge hole and steerability quickly developed. It soon became apparent that several operational issues must be resolved to achieve required steering ability and to ensure a gauge hole. For example, the motor bend setting needed to be 1.5° or higher with bicenter bits to achieve comparable doglegs using conventional polycrystalline diamond compact or rock bits at

lower motor bend settings. It was also determined that the pilot portion of the bicenter bit needed to be firmly anchored so that the bicenter wing could sweep around, resulting in a gauge hole that was larger than the previous casing string. With advent of point-the-bit technology using bicenter bits, the same concerns have resurfaced. This paper presents operational guidelines that maximize steerability while producing a gauge hole when using this technology combination. The operational guidelines were developed using a dataset from ChevronTexaco.

CASE STUDY

The project well is located in the South Timbalier field, Block 189, offshore the Gulf of Mexico (GOM) Shelf. The well was drilled using a jack-up rig with a rated water depth and drilling depth of 250 and 25,000 ft, respectively.

The run under consideration was designed to exit the 9 5/8-in. casing shoe, continue the in-progress curve, and drill to total depth (TD) at 15,400 ft true vertical depth (TVD) holding the inclination and azimuth after completing the curve.

The curve was designed for an RSS point-the-bit system in combination with a bicenter bit. The standard triple-combo logging-while-drilling (LWD) tools were used during the run. Gamma ray, resistivity, direction and inclination measurements, while-drilling annular pressure,

drilling vibrations, density, and neutron porosity were the main real-time data transmissions.

The bicenter bit had a drill diameter of 9 7/8 in. and was engineered for hole-opening applications that involve steering. The pass-through diameter was 8½ in., which made this bit suitable for most offshore GOM applications.

It was jetted with 5 x 14mm nozzles and 3 x 12mm carbide port fixed jets with a resultant total flow area of 1.083 in². Refer to Fig. 1.

The mud used was synthetic oil-base and the properties are displayed in Table 1.

The bottomhole assembly (BHA) comprised a bicenter bit, point-the-bit system, LWD tool, 8 3/8-in. stabilizer, survey tool, formation evaluation tool with 8¼-in. stabilizer, nonmagnetic collar, heavy-weight drillpipe, jar, and heavy-weight and standard drillpipe to surface. There was a ported float in the RSS tool. A schematic diagram of the BHA is shown in Fig. 2.

The BHA had only two stabilization points, one between the gamma ray-resistivity tool and the survey tool, the other on the formation evaluation tool. The stabilizer spacing was approximately 50 ft and the standard 5-in. 19.5-lbm/ft S-135 NC50 drillpipe was used to surface.

The 9 5/8-in. casing shoe was set at XX622 ft MD. Prior to starting the bicenter run, the float equipment, shoe, and 10 ft of new formation was drilled out with an 8½-in. rock bit. At this point the bicenter point-the-bit system was run in the hole, completed the curve, and drilled to TD of XX762 ft MD in one run. A plan view of the drilled section is displayed in Fig. 3.

The blue line in Fig. 3 represents the planned trajectory and the red is the actual well path. Four of the well's five drill targets were penetrated during this point-the-bit bicenter run.

ANALYSIS

To determine steerability all surface and downhole drilling mechanics parameters were analyzed in conjunction with continuous direction

and inclination data. To determine hole quality, density caliper measurements from the LWD tool were analyzed. Unconfined compressive strength (UCS) of the formation was also calculated and analyzed with the parameters previously mentioned. Several interesting trends began to develop.

Figures 4 and 5 analyze UCS, dogleg severity (DLS), and caliper versus depth. In both figures the weight on bit (WOB) is 10,000 lbm and the RSS set on 30%. This setting on a point-the-bit RSS tool indicates the intensity of effort required to steer the tool in a certain direction and inclination. The bicenter bit should be drilling at least a 9.875-in hole.

The formation in Fig. 4 has a relatively low UCS strength. DLS through this section seems to be low. The caliper indicates areas where the hole is slightly undergauge.

In Fig. 5, the UCS is relatively high and the DLS is also high. The caliper indicates the hole is very close to gauge.

The analysis of these two graphs suggests that high formation strength helps to achieve high DLS for a given setting. It also suggests that high formation strengths help produce a gauge hole.

Figures 6 and 7 analyze collar revolutions per minute (rpm) from the measurement-while-drilling tool, DLS, and caliper versus depth.

In Fig. 6, the collar rpm is steady at 120. At this rotation speed the DLS is averaging 1.5°. The caliper indicates some hole rugosity at XX551 ft MD.

In Fig. 7, the collar rotation is decreasing from 100 to approximately 50 rpm; however, DLS is increasing from 0.5° to 3.2°.

The analysis suggests that collar revolutions and DLS are inversely proportional

OPERATIONAL GUIDELINES

Based upon the analysis above, the following guidelines can be developed to achieve higher DLS and produce a gauge hole:

1. During the planning phase, determine UCS strengths through offset data. If UCS strengths cannot be calculated, use offset ROPs to qualitatively identify if formations are hard or soft.
2. Design a well trajectory that will accommodate expected DLS with respect to UCS strengths.
 - a. The higher the UCS strengths, the higher the DLS. The converse of this statement is also valid.
3. Actively monitor continuous inclination and azimuth from the point-the-bit tool while drilling to develop trends.
4. While drilling through formations with low UCS strength (200 to 1500 psi), increase steering setting and increase WOB to produce a gauge hole and increased DLS.
5. Decrease RPM if DLS is not being achieved at this point.
6. Determine hole quality through real-time calipers. In the planning phase, consider a wiper trip as a contingency if the real-time caliper indicates undergauge hole.
7. Develop and populate a database. Use the database to predict DLS while achieving a gauge hole.

CONCLUSIONS

The operational guidelines developed herein have been validated through field experience and extensive analysis. However, it is recognized that the datasets for bicenter bits and point-the-bit technology are limited. It is also recognized that other parameters such as flow rate have a strong effect on hole gauge and DLS. Flow rate was not taken into account in this analysis.

Overall, point-the-bit RSSs used with bicenter bits provide a reliable solution for hole enlargement. The most essential key to ensure high DLS and gauge hole is diligence while planning the well. Assiduousness is required while determining surface and subsurface characteristics and relationships. Development of in-depth contingency plans is also essential to reduce the risks.

ABOUT THE AUTHORS

Roi Lam works in house for Energy Partners Limited in New Orleans, Louisiana. He began his career in well services in 1996 providing cementing and drilling fluid services. He cross-trained in drilling and measurements and now provides managerial support for the Schlumberger Drilling Engineering Center in the Gulf of Mexico, which provides drilling engineering and risk-management services.

Niall Casimire works in house for ChevronTexaco in New Orleans. He started his career in mud logging in 1993, providing wellsite geological sample analysis, hydrocarbon show analysis, and pore pressure evaluation. He then moved to LWD in 1997, where he served as nuclear cell manager. He is associated with the Drilling Engineering Center in the Gulf of Mexico.

Dave Renshaw is a drilling engineer with ChevronTexaco in New Orleans and was responsible for planning the well studied in this paper. His prior assignments included work in Bakersfield, Midland, and Maracaibo. Although it was his first experience with RSSs, he planned the well with panache and excellence.



Figure 1 – Bicenter bit used in conjunction with point-the-bit technology

MUD		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Depth	Ft	XX672	XX339	XX184	XX105	XX943	XX459	XX762
MW	lbm/gal	14.1	14.4	14.3	14.3	14.3	14.5	14.5+
VIS	S	86	80	96	94	94	106	122
Temp	°F	116	124	126	126	128	136	120
PV	CP	44	52	51	54	58	58	59
YP	Lbf/100ft ²	10	11	9	12	11	13	14
10s Gel	Lbf/100ft ²	5	3	4	3	4	5	3
10m Gel	Lbf/100ft ²	12	6	9	9	14	9	9
30m Gel	Lbf/100ft ²	20	14	15	15	21	16	15
Filtrate	Cm ³	2.8	2.4	2.8	2	2	2	2
Cake	in/32	3	3	3	3	3	3	3
Retort Sol	%	28	28	30	29	31	31	30
OWR		81/19	82/18	81/19	84/16	81/19	83/17	80/20
CI	ppm	48000	40000	40000	40000	40000	40000	40000
Sand	%	0.1	0.1	0.1	0.1	0.25	0.1	0.1

Table 1 – Mud properties



	Cum. Len. (ft)
5" 13.50 DPS, Premium	1061.07
5" HwDP (8 joints)	1030.07
Hydraulic Jar	790.19
5" HwDP (20 joints)	757.80
6 3/4" Non-Mag Collar	126.56
Form. Eval. w/ 8 1/4" SZR	95.83
Survey Tool	78.42
8 3/8" Stabilizer	50.61
Gamma Ray / Resistivity	46.29
Point the Bit Tool	26.17
8 1/2" x 9 7/8" BiCenter Bit	1.04

Figure 2 - BHA configuration

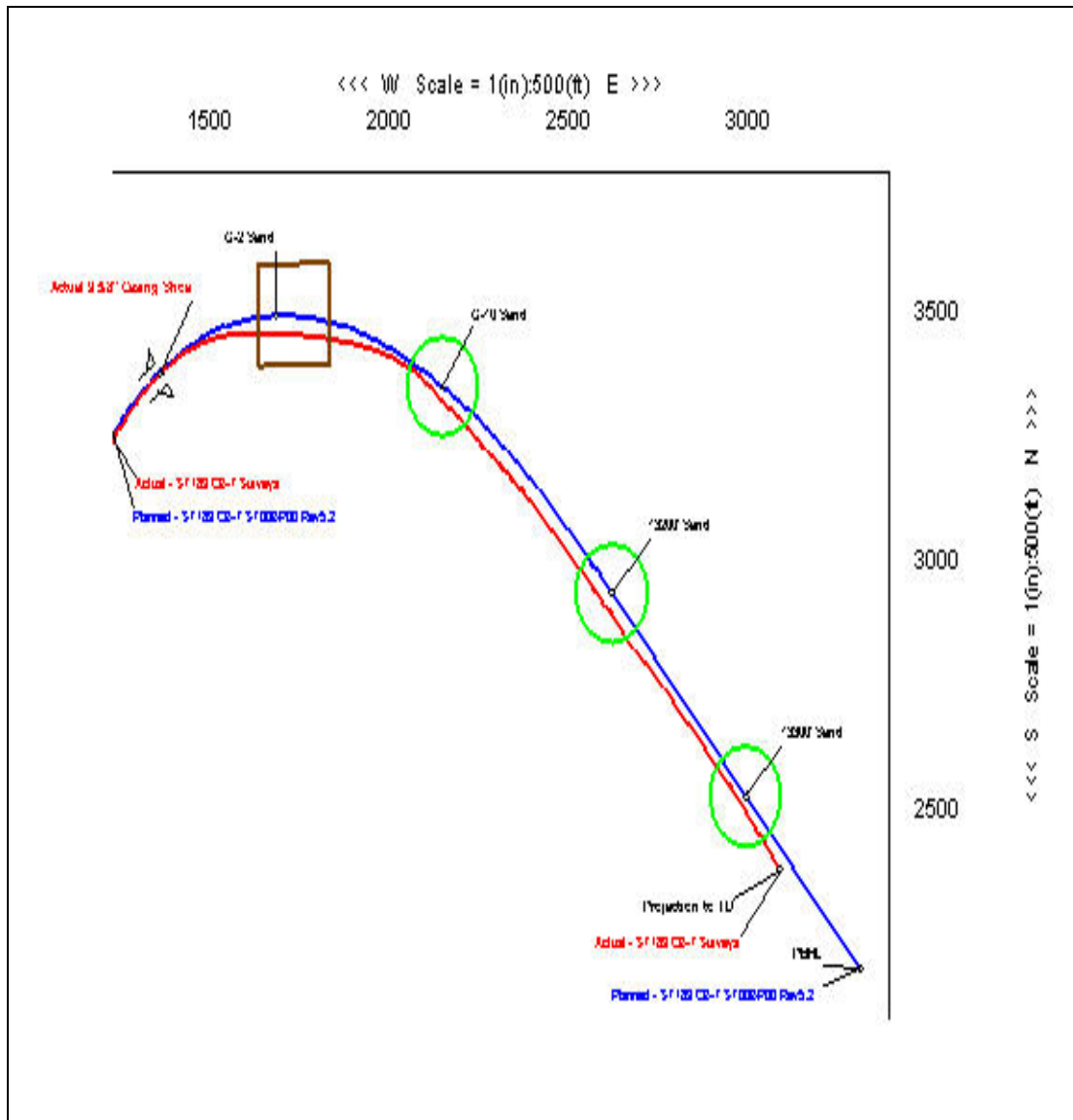


Figure 3 – Plan (blue line) versus actual (red line) well path

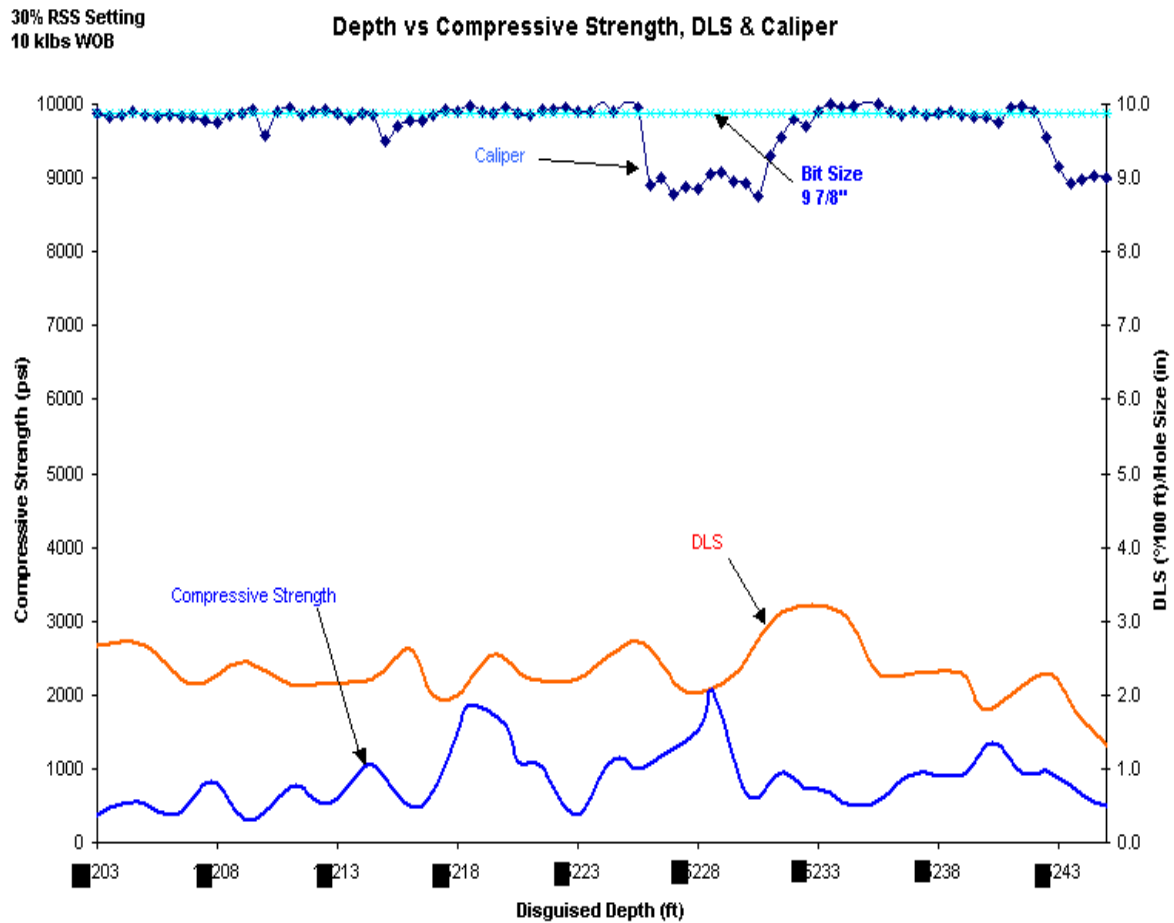


Figure 4 – Compressive strength, DLS, and caliper versus depth. Note the low compressive strength and the corresponding low DLS. The hole is slightly undergauge at XX228 ft.

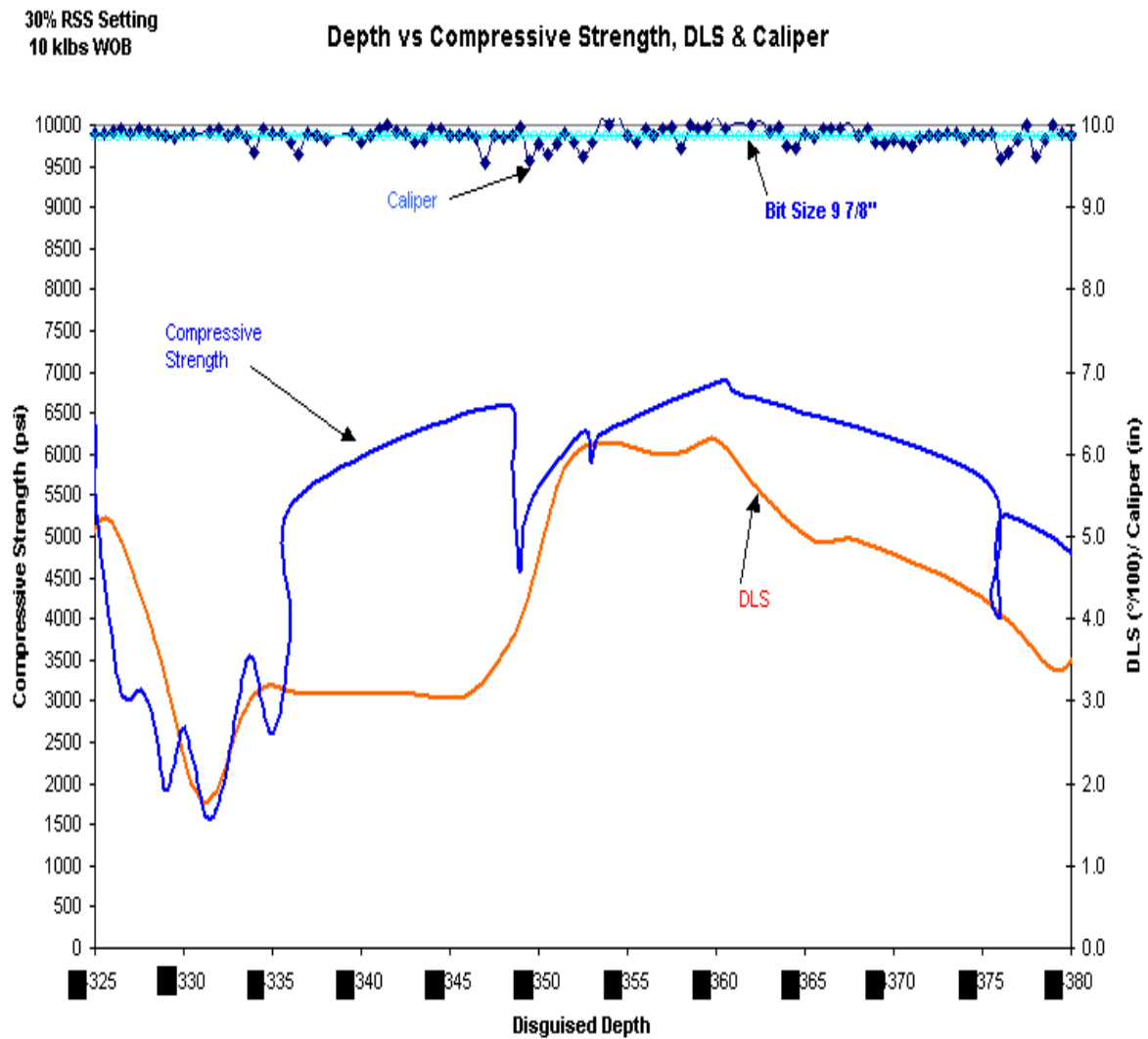


Figure 5 - Compressive strength, DLS, and caliper versus depth. Note the higher compressive strength and the corresponding higher DLS. The hole is in gauge.

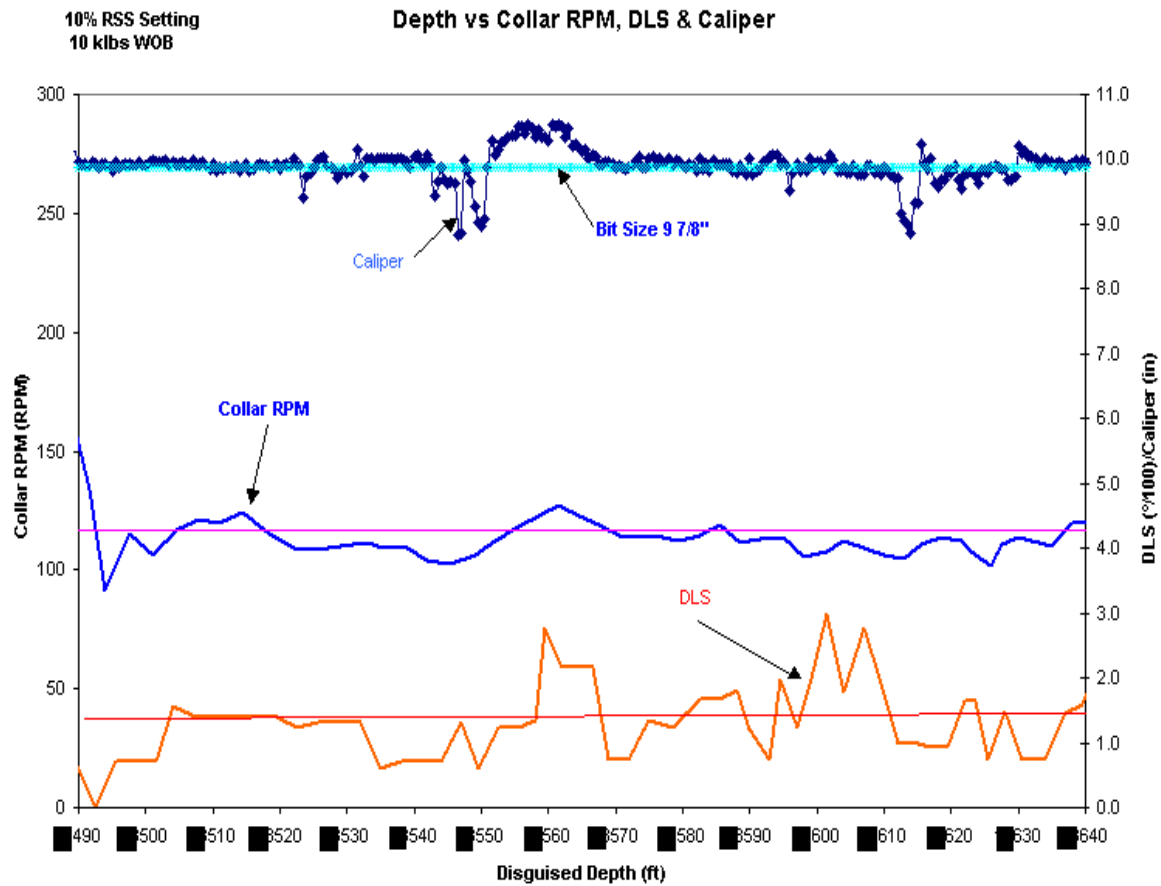


Figure 6 – Collar rpm, DLS, caliper versus depth. Note the fairly constant 120 rpm, represented by pink line. The resulting DLS is averaging 1.5°/100 ft, represented by the red line.

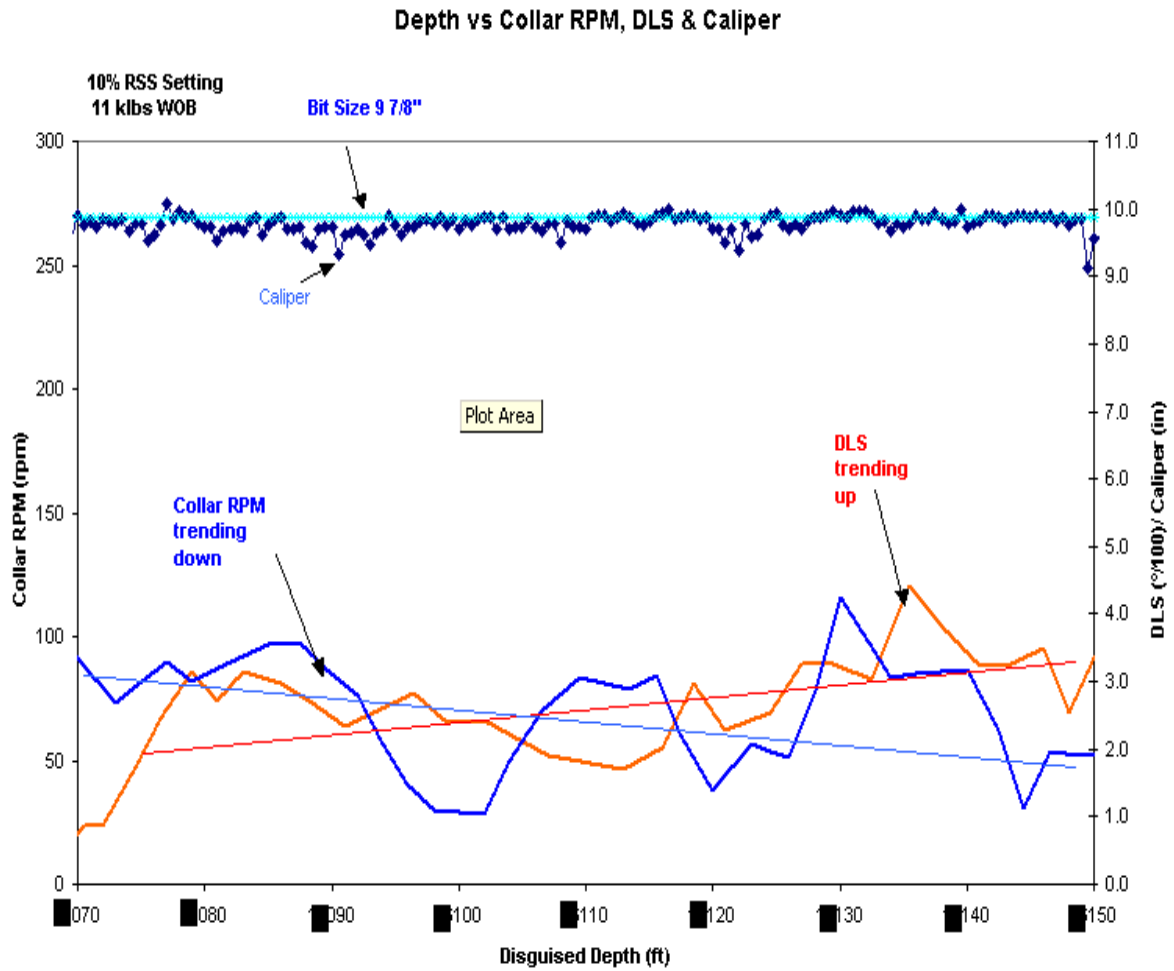


Figure 7 - Collar rpm, DLS, caliper versus depth. Note the downward rpm trend, represented by light blue line. The resulting DLS trends upward, represented by the red thin line.