

DOWNHOLE VIBRATION MONITORING & CONTROL SYSTEM QUARTERLY PROGRESS REPORT #13

Starting date: October 1, 2005

Ending Date: December 31, 2005

Principal Author: Martin E. Cobern

Date Issued: January 17, 2006

DOE Award Number: DE-FC26-02NT41664

Submitting Organization APS Technology, Inc.
800 Corporate Row
Cromwell, CT 06416

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ABSTRACT

The objective of this program is to develop a system to both monitor the vibration of a bottomhole assembly, and to adjust the properties of an active damper in response to these measured vibrations. Phase I of this program, which entailed modeling and design of the necessary subsystems and design, manufacture and test of a full laboratory prototype, was completed on May 31, 2004.

The principal objectives of Phase II are: more extensive laboratory testing, including the evaluation of different feedback algorithms for control of the damper; design and manufacture of a field prototype system; and, testing of the field prototype in drilling laboratories and test wells.

Work during this quarter centered on the testing of the rebuilt laboratory prototype and its conversion into a version that will be operable in the drilling tests at TerraTek Laboratories. In addition, formations for use in these tests were designed and constructed, and a test protocol was developed.

The change in scope and no-cost extension of Phase II to January, 2006, described in our last report¹, were approved. The tests are scheduled to be run during the week of January 23, and should be completed before the end of the month.

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Executive Summary

The objective of this program is to develop a system to both monitor the vibration of a bottomhole assembly, and to adjust the properties of an active damper in response to these measured vibrations. Phase I of this program, which entailed modeling and design of the necessary subsystems and design, manufacture and test of a full laboratory prototype, was completed on May 31, 2004.

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Design

Redesign of laboratory prototype

Complete. The redesign valve now has the coils located in the non-reciprocating portion of the tool. This lends itself to a more reliable electrical connection and better protection of the coils from the abrasive MR fluid.

Design of feedback system

COMPLETE.

Intermediate prototype design

According to the revised Statement of Work, the laboratory prototype design was revised to allow the prototype to be run in the drilling laboratory at TerraTek. Among the changes were:

- Replace the instrumented “bit” element with the appropriate bit box.
- Install the battery-operated vibration monitoring sub
- Install the internal motion controller input.
- Manufacture new upper sub to interface with the TerraTek commutator.

All of these items are complete.

Experimental

Retesting of DVMCS prototype

The reworked prototype, with external coils, was tested during this period. The results are given in Appendix A.

Preparations for Testing at TerraTek

The new and revised components of the prototype were manufactured and were being assembled at the end of the period. The test procedure and matrix were developed, and are given in **Appendix B**. [Note that the plan has been updated after the end of the period to reflect the latest information.]

In addition, four test formations were designed and built. These each consist of a slab of hard granite mounted at an angle of 10° within a larger hard concrete block. (See **Figure 1- Figure 5**.) The contrast in hardness at the inclined interfaces should induce significant vibration in the drilling, which will serve as a test of the efficiency of the damper and its feedback algorithms. [Note that the holes shown in **Figure 1** are schematic only, and do not represent the planned drilling pattern.]

The test are scheduled to run from January 23-27, 2006.

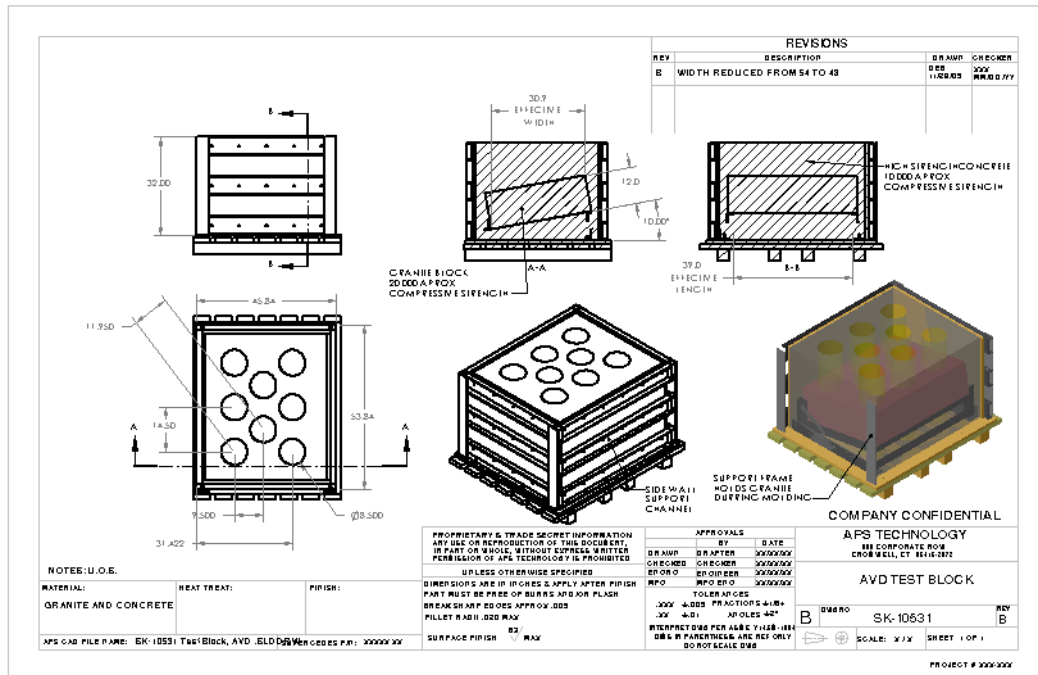


Figure 1: Drawing of test blocks for drilling lab testing



Figure 2: Granite blocks and concrete molds ready for assembly



Figure 3: Positioning granite block at 10° angle before concrete pour



Figure 4: Pouring concrete for first block



Figure 5: Finished blocks begin setting process

Analysis

The test described above were analyzed by Mark Wassell, and his conclusions are included in Appendix A. The dynamic range of the revised damper circuit was less than that of the original. This was attributed to two factors:

- The reworked mandrel was slightly smaller than the original, which resulted in a larger gap. This, in turn, reduced the 'power off' damping coefficient and also reduced the applied field for a given current.
- The reworked mandrel still had some of the internal structure of the original coil winding slots. While these were filled in, the interfaces would interfere with the magnetic flux lines, decreasing the efficiency of the magnetic circuit.

Despite these results, it was decided to go ahead with the testing using the current design. Since the 'power off' coefficient was quite low, we have reduced the gap. This should increase the dynamic range. While there was no time or funds to manufacture a new mandrel, some effort was made in smoothing the internal structure. These two changes should result in a more satisfactory performance in our tests at the drilling laboratory.

Units

To be consistent with standard oilfield practice, English units have been used in this report. The conversion factors into SI units are given below.

1 ft.	=	0.30480 m
1 g	=	9.82 m/s
1 in.	=	0.02540 m
1 klb.	=	4448.2 N
1 lb.	=	4.4482 N
1 rpm	=	0.01667 Hz
1 psi	=	6984.76 Pa

References

¹ APS Technology, Inc., "Downhole Vibration Monitoring & Control System Quarterly Progress Report #12," DE-FC26-02NT41664, 31 October, 2005.

Appendix A: AVD Outer Coil Tests

M Wassell
Nov 16, 2005

Scope

For manufacturing and assembly considerations the MR damper coils have been moved to the outer sleeve. The coil grooves on the inner shaft were filled with a material similar to the shaft, allowing for a continuous magnetic field path. The load range was also increased so that tests could be conducted up to 15,000 lbs WOB. The original tests could only be performed at lower WOB (5,000 lb WOB). Higher loads exceeded the capabilities of the motor and test frame.

Conclusions

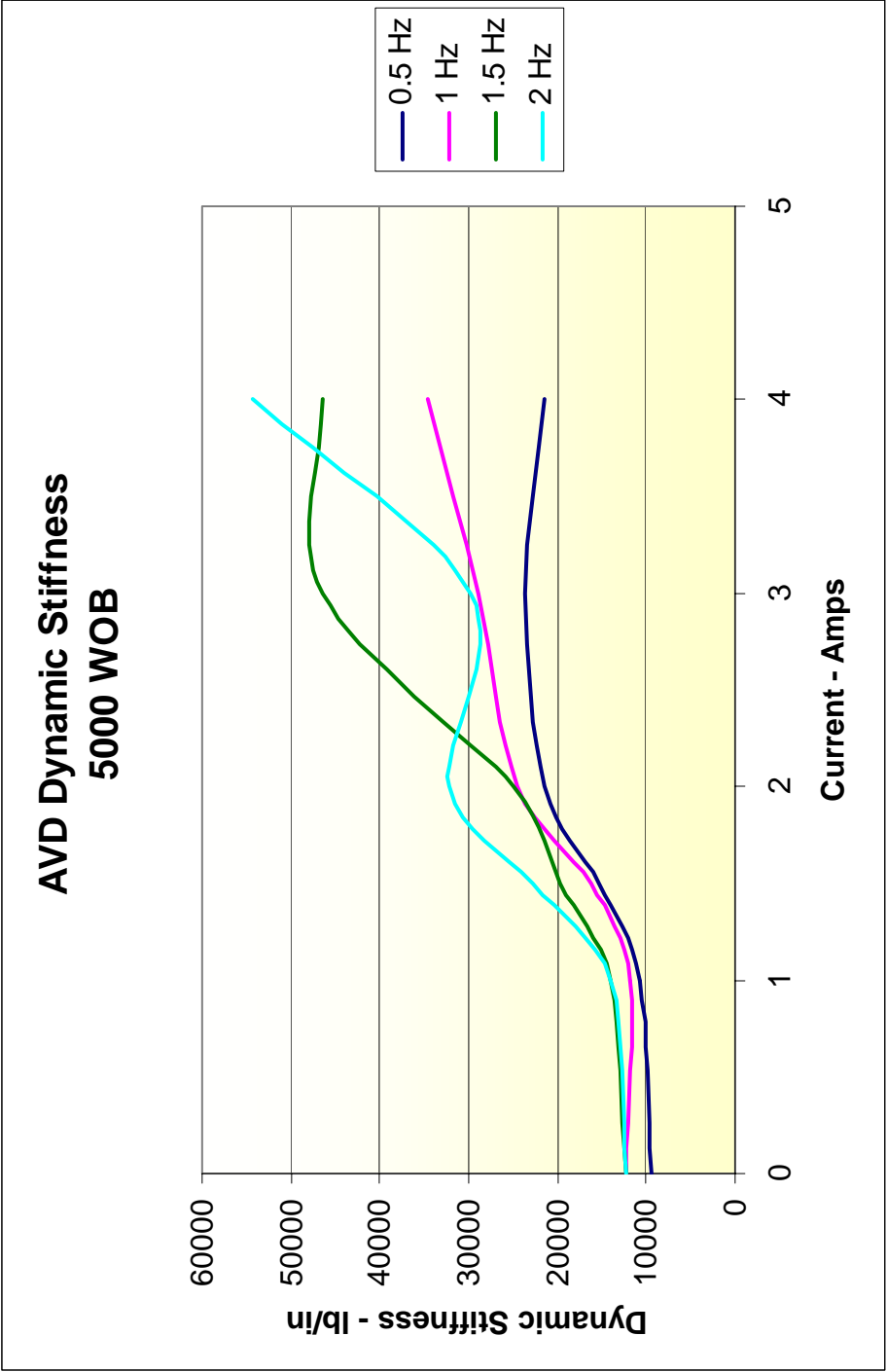
1. The results from this test are not as good as for the previous test with the coils mounted on the inner shaft. With the coils mounted on the outer sleeve, the maximum dynamic stiffness is 54,000 lbs / in. The previous tests, with the coils mounted on the inner shaft produced a dynamic stiffness of 120,000 lb/in
2. The dynamic stiffness of the outer coil in the off state is less than the off state for the inner coil.
3. The ratio of stiffness ranges from 2.5 to 4.6 for the new design. The inner coil design ratio is 7 to 10.
4. The dynamic stiffness decreases with the increase in WOB. At 5,000 lbs WOB the dynamic stiffness is 54,000 lbs/in, at 10,000 lbs it drops to 40,000 lbs WOB and at 15,000 lbs WOB it is 26,000 lbs /in.
5. Based on items 1 – 4 above, the gap should be reduced.
6. The dynamic stiffness reduction could be attributed to:
 - Damper gap – The reduced off state dynamic stiffness suggests that the gap could be reduced. This would significantly increase the on state damping, hopefully giving a higher damping ratio.
 - Losses due to filling in the old coil grooves
 - Fixture damping problems with the test fixture. – Each time we set up tests the pneumatic and hydraulic actuators operate differently. The wobble in the graphs could also be attributed to the pneumatic and hydraulic dampers.

Discussion

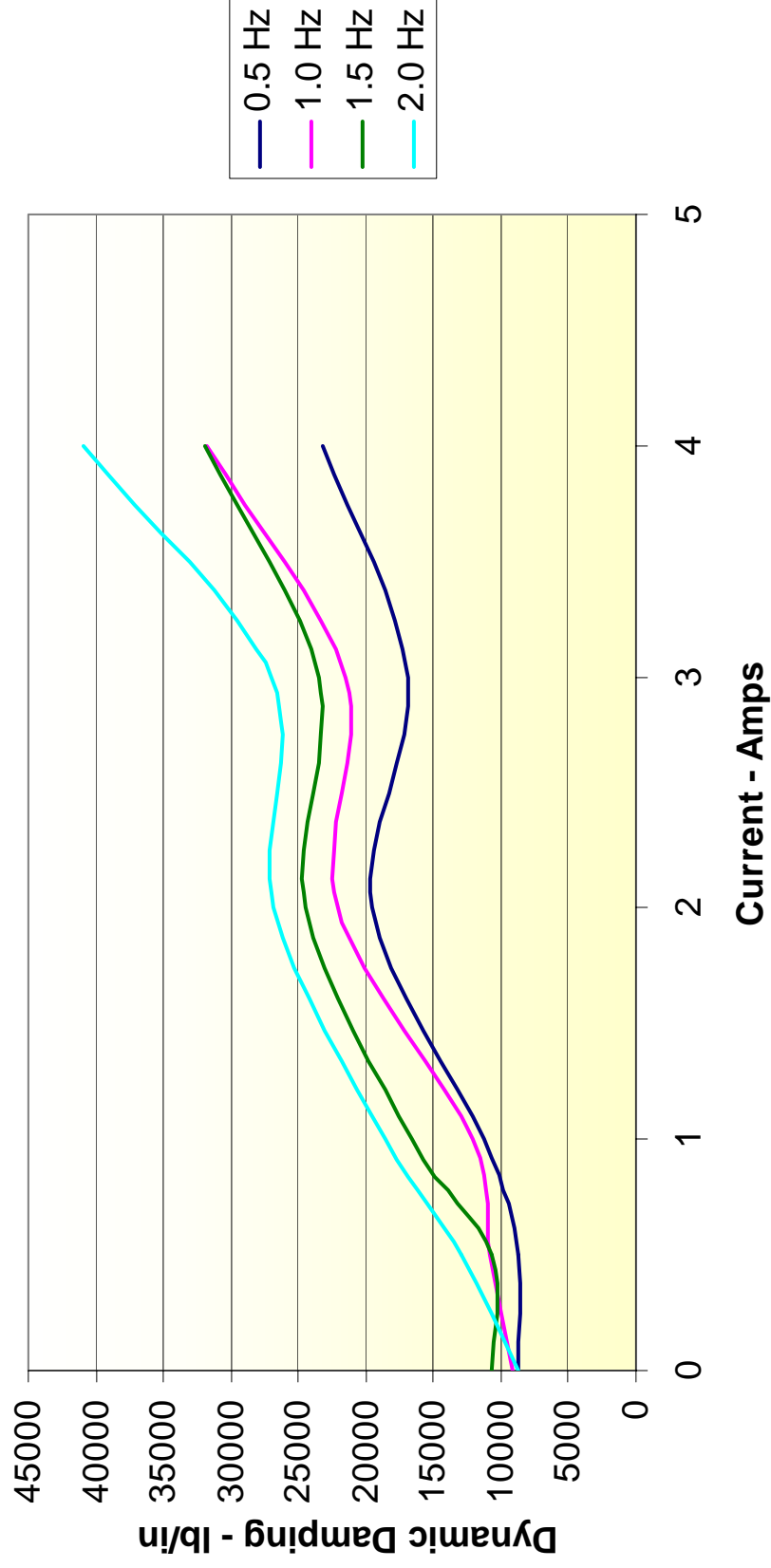
Test Parameters

- MR Fluid – 6:1 mixture
- Gap – 0.031”
- Valve materials – 410SS
- Cam displacement – 0.708”

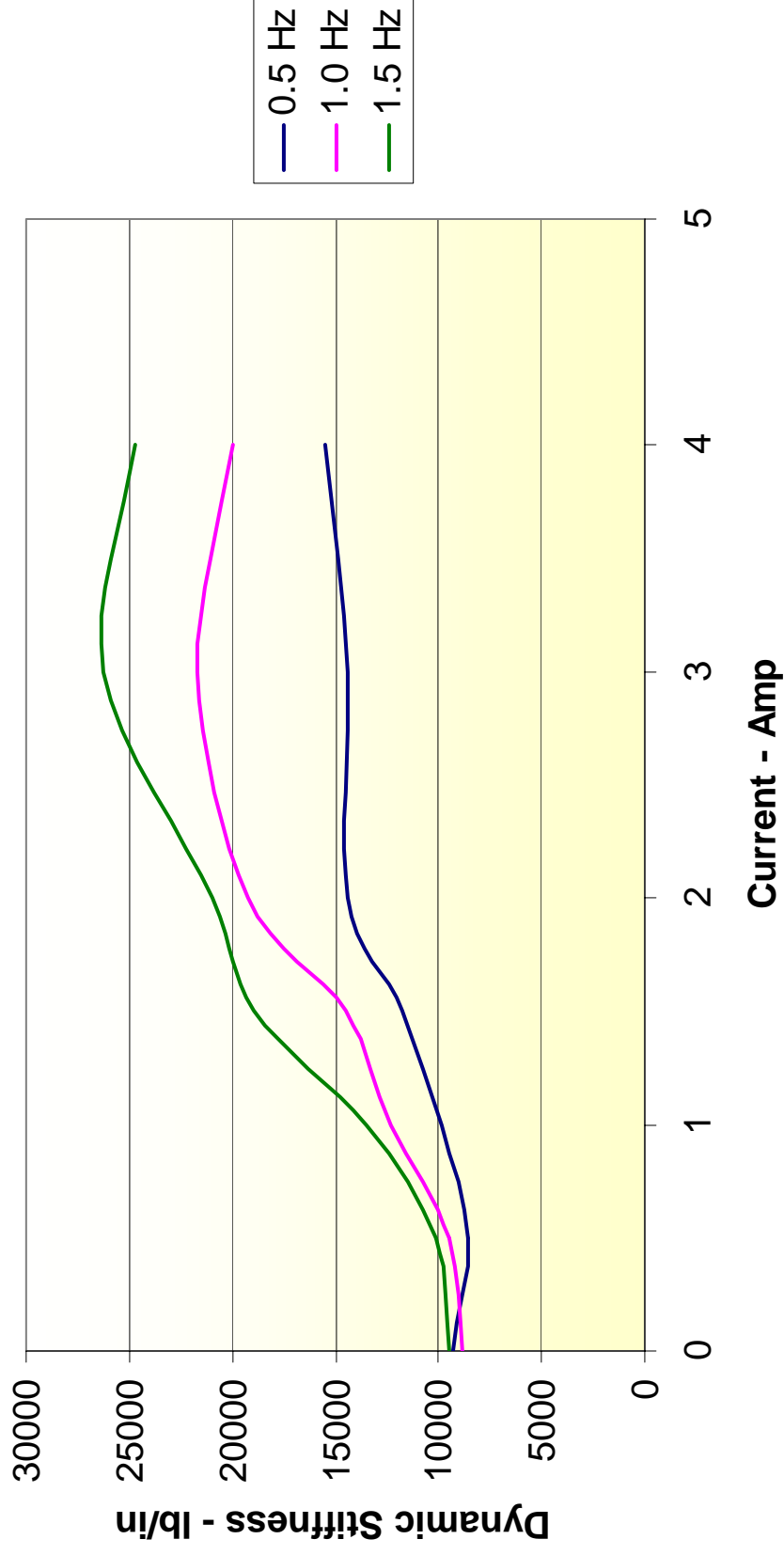
Outer Coil Results

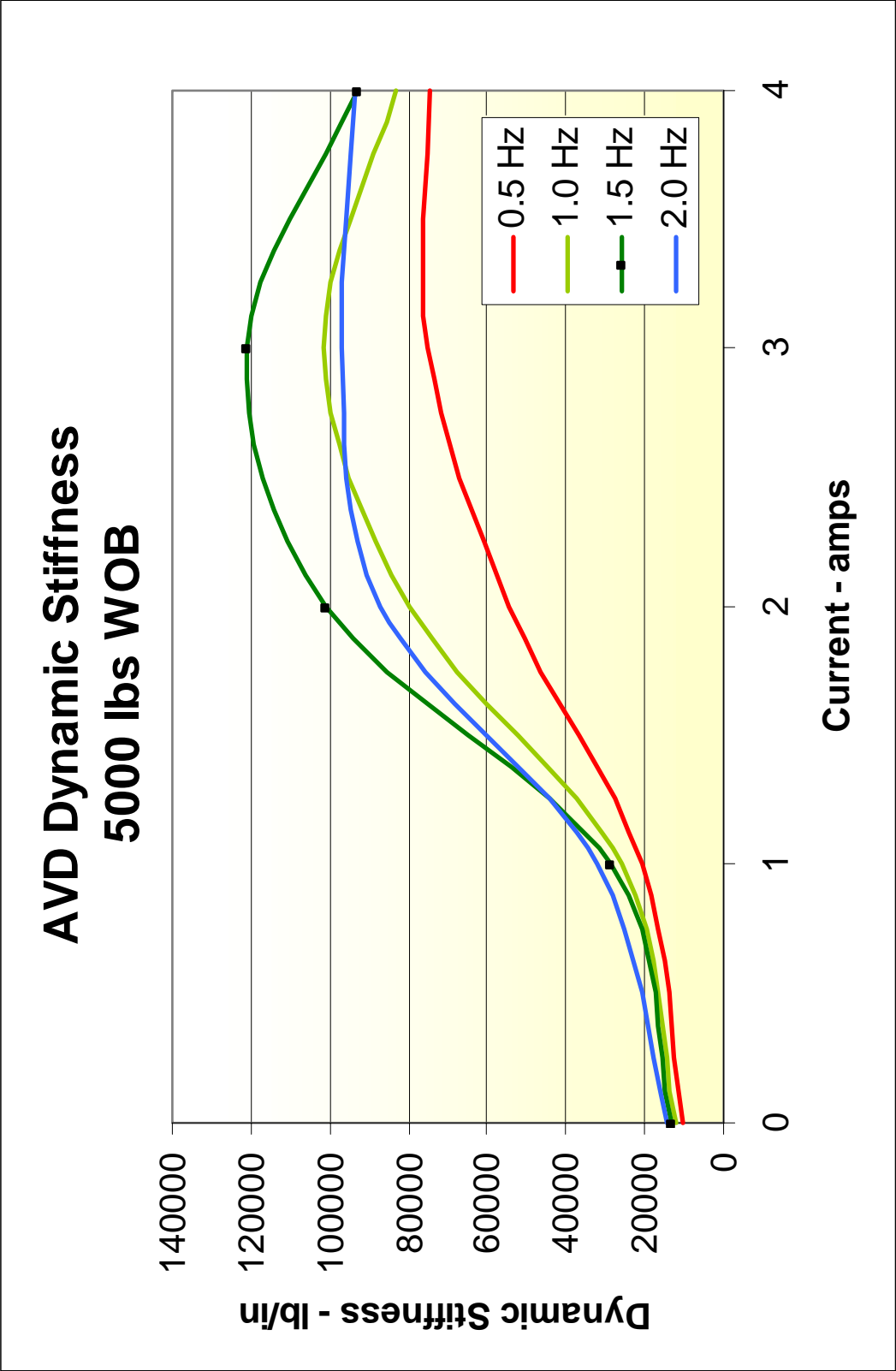


AVD Dynamic Stiffness 10,000 WOB



AVD Dynamic Stiffness 15000 WOB





Appendix B: AVD / TerraTek Test Plan

(1-17-06)

With four composite concrete/granite/concrete blocks, we will have the ability to drill (36) 8-1/2" holes.

Equipment

APS AVD Tool P/N T-10967

SK-10531 AVD Concrete/Granite Test Formation Block

Labview DAQ

Assembly Configuration #1

TerraTek Drive

6" DRILL COLLAR

SLIP RING

4-1/2" PIN-PIN CROSS-OVER SUB

6-3/4" DRILL COLLAR

8-1/2" TRI CONE BIT

Assembly Configuration # 2

TerraTek Drive

6" DRILL COLLAR

SLIP RING

6-3/4" AVD Tool

8-1/2 TRI CONE BIT

Testing

TEST #	Config.	WOB (lb)	RPM	AVD Power
1	1	5,000	0-240 sweep	N/A
2	1	5,000	120	N/A
3	1	5,000	180	N/A
4	1	10,000	120	N/A
5	1	10,000	180	N/A
6	1	15,000	120	N/A
7	1	15,000	180	N/A

Notice any test conditions that appear to be problematic, with excessive bit bounce, rig and string vibration. Record these operating parameters and run the AVD tool in similar conditions prior to running the scheduled tests that follow.

TEST #	Config.	WOB (lb)	RPM	AVD Power
6	2	5,000	120	0-3/3 SWEEP
7	2	5,000	180	0-3/3 SWEEP
8	2	10,000	120	0-3/3 SWEEP
9	2	10,000	180	0-3/3 SWEEP
10	2	15,000	120	0-3/3 SWEEP
11	2	15,000	180	0-3/3 SWEEP
12	2	15,000	120	1/3
13	2	15,000	120	2/3
14	2	15,000	120	3/3
15	2	15,000	120	Program
16	2	15,000	180	1/3
17	2	15,000	180	2/3
18	2	15,000	180	3/3
19	2	5,000	120	1/3

TEST #	Config.	WOB (lb)	RPM	AVD Power
20	2	5,000	120	2/3
21	2	5,000	120	3/3
22	2	5,000	180	Program
23	2	5,000	180	1/3
24	2	5,000	180	2/3
25	2	5,000	180	3/3
26	2	5,000	180	Program

Monitor: ROP

WOB

RPM

Torque

Accelerations at top of AVD, accelerometer mounted on slip ring, with signal commutating thru same

Accelerations at the bit, accelerometer in bit box, stored in memory.