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1	/	Cog.Eng. R. J. Blanchard	[signature]		S7-12						
1	/	Cog. Mgr. D. W. Hamilton	[signature]		S7-12						
1	/	QA M. L. McElroy	[signature]		S7-07						
1	/	Safety J. A. Harvey	[signature]	1/3/96	S7-07						
1	/	K. S. Witwer	[signature]		L6-13						
1	/	M. L. Schliebe	[signature]	1/3/96	L6-13						

18. R. J. Blanchard [signature] 1/3/96 Signature of EDT Originator / Date	19. N/A Authorized Representative for Receiving Organization / Date	20. D. W. Hamilton [signature] 1/3/96 Cognizant Manager / Date	21. DOE APPROVAL (if required) Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

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Test Plan for Core Drilling Ignitability Testing

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Abstract: The objective of this testing is to determine if ignition occurs while core drilling in a flammable gas environment. Drilling parameters are chosen so as to provide bounding conditions for the core sampling environment. If ignition does not occur under the conditions set forth in this test, then a satisfactory level of confidence will be obtained which would allow field operations under the normal drilling conditions.

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TEST PLAN

FOR

CORE DRILLING IGNITABILITY TESTING

WHC-SD-WM-TP-411
REV. 0

January 30, 1996

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CORE DRILLING IGNITABILITY TESTING

1.0 INTRODUCTION

1.1 BACKGROUND

Recent analyses[1] of some Hanford nuclear waste tanks have shown flammable gas mixtures present which are suspected to have a greater potential for ignition than previously sampled gas mixtures. Earlier ignitability testing[2] carried out by the Westinghouse Hanford Company (WHC) Engineering Testing Laboratory (ETL) and the United States Bureau of Mines (USBM) demonstrated that normal rotary mode sampling operations would not pose a safety hazard when drilling into a flammable gas environment. This flammable gas mixture, however, was based on an analysis from tank 241-SY-101 (a flammable gas watch list tank). More current analyses of tanks have revealed gas mixtures which have a potential to be ignited at a lower spark energy than mixtures previously evaluated.

The increased possibility for ignition of these new gas mixtures has prompted the need for additional ignitability testing. The purpose of this document is to outline the scope and process of this additional testing.

An ignition source while drilling could be the result of frictional heating between the bit and saltcake or heating/sparking between the bit and an immovable hard object. The hard object during actual field sampling could be the waste tank liner, a tank riser, a discarded piece of equipment or a rock that is present in the waste. Administrative controls currently in place prevent drilling without an inert purge gas present. This effectively eliminates the concern of high temperature autoignition. Spark ignition issues, however, remain unresolved; the following plan describes tests designed to resolve this concern.

1.2 PROPOSED TESTING

Of the flammable gas constituents found in the waste tanks, Hydrogen (when combined with an oxidant) has been shown to be bounding, in terms of ignition hazard. Studies by the United States Bureau of Mines[3] have shown that hydrogen when mixed with oxygen or air has the lowest minimum spark energy required for ignition of any of the flammable gas combinations found in the waste tanks. This testing will involve drilling into a test chamber filled with a stoichiometric mixture of hydrogen and oxygen or hydrogen and air at an elevated temperature of approximately 100°C. If an ignition of either of these gas mixtures occurs, then either a reduction in downward force, and/or a reduction in drill speed, and/or the addition of nitrogen purge gas will be implemented in subsequent tests to prevent an ignition.

Past field sampling has been limited to the following operating envelope constraints:

1) 1170 lbs maximum downward force
2) 55 RPM maximum drill speed
3) 30 SCFM minimum purge gas flow

Initial testing will exceed this downward force and drill speed by approximately 15% and the purge gas (which has a cooling and diluting effect) will initially not be used to add an additional level of conservatism. Testing described herein will involve drilling into high carbon steel and rock. A 1040 grade steel will be drilled into since it bounds most metals in terms of relative incendivity (ability to generate a spark)[4]. The rocks used will be indigenous to the Hanford site - specifically those found in the Waste Tank Farms area.

The drilling parameters used for testing will initially be set at:

1) 1350 lbs downward force
2) 65 RPM drill speed
3) 30 SCFM Nitrogen Purge (when used)

2.0 OBJECTIVE

The objective of this testing is to determine if ignition occurs while core drilling in a flammable gas environment. Drilling parameters are chosen so as to provide bounding conditions for the core sampling environment. If ignition does not occur under the conditions set forth in this test, then a satisfactory level of confidence will be obtained which would allow field operations under similar drilling conditions.

As outlined in the test description below, test conditions will begin with a "worst case" environment. Should ignition occur, test conditions will be modified until a non-igniting environment is identified.

3.0 SCOPE

This testing is directed by the Westinghouse Characterization Equipment Engineering Group and will be performed by ETL and USBM personnel at the Pittsburgh Research Center in Pennsylvania. USBM will provide consultation, design input, test support, and some test results of the core drilling. ETL will provide the results from this testing in a supporting document to the Characterization Equipment Group and LANL for use in the safety documentation for the Rotary Mode Core Sampling System. Ongoing consultation between WHC, USBM, and Los Alamos National Laboratories (LANL) personnel will occur throughout the testing. This consultation will occur, as a minimum, after any significant event during testing (such as an ignition during drilling).

4.0 DESCRIPTION OF TEST

4.1. TEST ITEM

Testing will proceed under the logic of the decision tree shown below. As can be seen, a flammable gas mixture of a stoichiometric hydrogen and oxygen gas will be used first. The trend of this testing is to start with the worst case, "most likely to ignite" condition initially and successively move to "less likely to ignite" conditions as necessary (ie., if an ignition occurs). This initial gas mixture will be used for all materials drilled into unless an ignition occurs. If an ignition occurs, a less flammable, stoichiometric hydrogen and air mix will be used. Using air would actually simulate the realistic case of a field drilling operation where air might be introduced into the drill string before drilling begins. Pure oxygen should never be freely available in the waste tanks; however, it is initially used in this testing because it is easier to ignite with hydrogen than air, and is therefore a more conservative boundary.

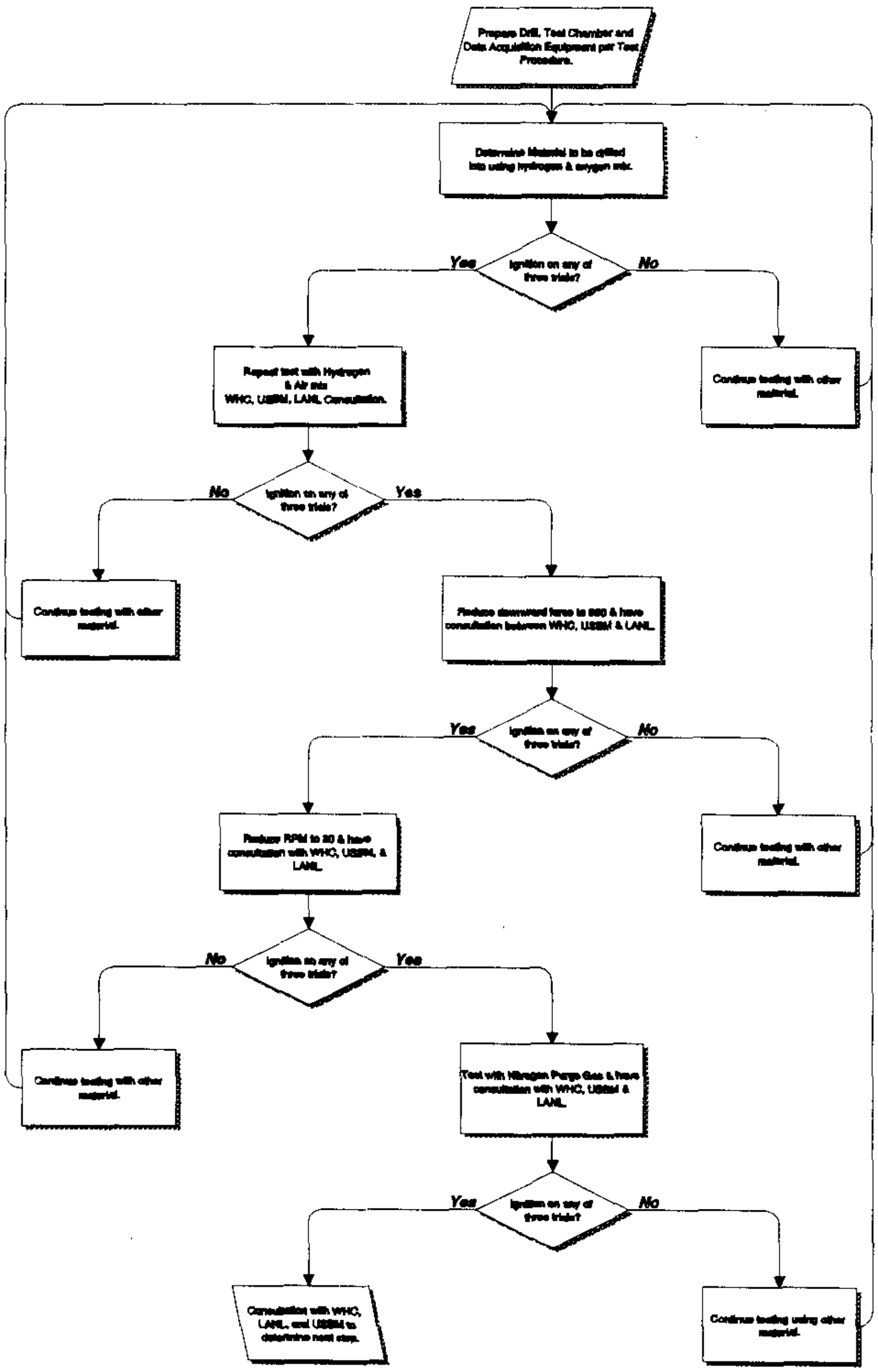

Figure 1 - Decision Tree for Ignition Testing

If ignition occurs using the hydrogen & air mix, then the downward force will be reduced to 860 lbs (115% of recent envelope testing limits). If ignition occurs here, the rotational speed will be reduced to 30 RPM. Finally, if an ignition occurs under this last condition, then nitrogen purge gas will be introduced at stepwise increasing flow rates until an ignition does not occur.

4.1.1 Test Scenario 1 - Contact between drill bit and hard object

The purpose of this test is to simulate the action of a drill bit striking a hard object laying inside a waste tank, such as a piece of structural steel or a rock, and determine what, if any, core drilling conditions exist which will ignite the flammable gas mixtures.

The test arrangement will involve mounting a piece of carbon steel or rock in the test chamber such that an edge is exposed for the bit to strike against while descending and rotating. This will be used initially regardless of the gas mixture used. The test will run for at least three minutes and if a passing "no ignition" condition occurs while drilling with this arrangement, a different piece of material will be placed into the test chamber to be drilled against. This test will be repeated using the following materials:

1) Carbon Steel Angle (1040 steel or equiv.) or other structural shape
2) Assorted rocks found in the area of the Hanford Tank Farms

The test materials will be mounted in the chamber such that they are securely held in place by a bracket secured to the internal surface of the test chamber. Each test will be carried out with two different rotary mode drill bits. The two drill bits are described in section 4.3 below.

4.1.2 Test Scenario 2 - Contact between drill string and tank riser material

This test effectively simulates the action of a drill string section rubbing against a tank riser during a drilling operation. It will initially involve using the stoichiometric hydrogen/oxygen mix as was initially used in test scenario 1. Should an ignition occur, then the same procedure of using air instead of oxygen and then reducing drill speed and then addition of nitrogen purge gas will be followed. Each material will be tested using the hydrogen/oxygen mix first.

A core drill pipe will rotate within the test chamber while having a side load pressed against it. This side load will act against the drill string itself and not the drill bit. The following materials will be used for the drill string.

1) A standard uncoated steel drill string rubbing against 1040 (rusted) steel
2) A standard steel drill string with pipe joint compound on it rubbing against 1040 steel
3) A nickel plated and fluted drill string rubbing against 1040 steel
4) A fluted drill string with the nickel coating ground off rubbing against 1040 steel

Each passing (no ignition) test in scenarios 1 and 2 will be carried out a minimum of three times for repeatability.

4.2 TEST ENVIRONMENT

Testing will be conducted at the Pittsburgh Research Center in Pittsburgh, PA . The USBM Fires, Explosives and Explosions Group will be responsible for the actual testing site and necessary support equipment. The Pittsburgh facility is ideally suited for these tests since it is designed to handle the potential explosion hazard that exists. Core drilling will be done in an area that is physically separated, by a safety barrier, from test personnel. Operation of the core drilling machine will be done behind these barriers using remote controls to insure operator safety. USBM standard operating procedures and safety oversight will be in effect for these tests.

4.3 FACILITIES AND EQUIPMENT

The core sample drill bits to be used for testing are Longyear[1] Part Nos. 100IVD/5 (currently used style) and 9505-15B (new prototype bit) as shown in figures 2 and 3 below. A standard 2.5" diameter smooth surfaced core barrel as well as a nickel plated fluted core barrel will be used. Other materials may be used if ongoing consultation with WHC, LANL and USBM demonstrates a need for additional testing.

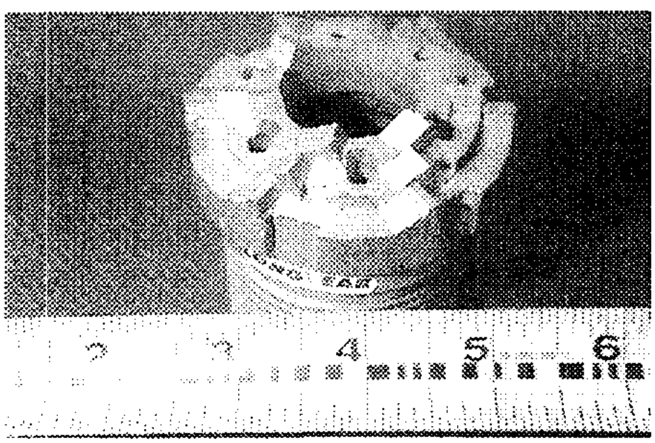

Figure 2 - Standard Rotary Mode Sampling Bit

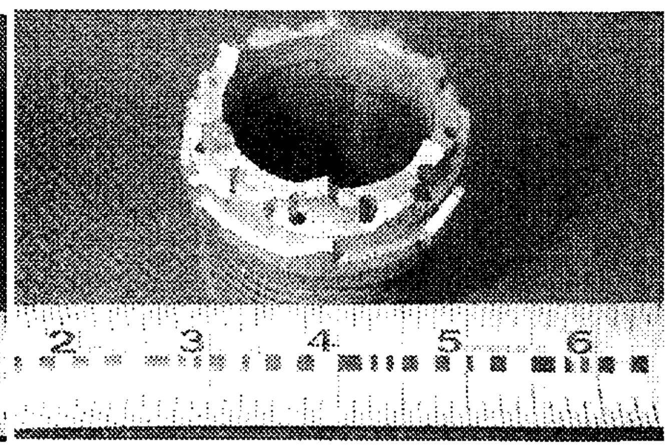

Figure 3 - Prototype TSAP Sampling Bit

4.3.1 CORE DRILLING MACHINE

The drilling machine to be used is a Longyear Model 34. This testing drill is essentially the same type of drill as is installed on the core sample trucks for field sampling operations. A drawing of the drill is shown in figure 4 below. During testing, the drill will be mounted on concrete blocks to provide stability and necessary height for drilling.

1. Longyear is a trademark of Longyear Incorporated

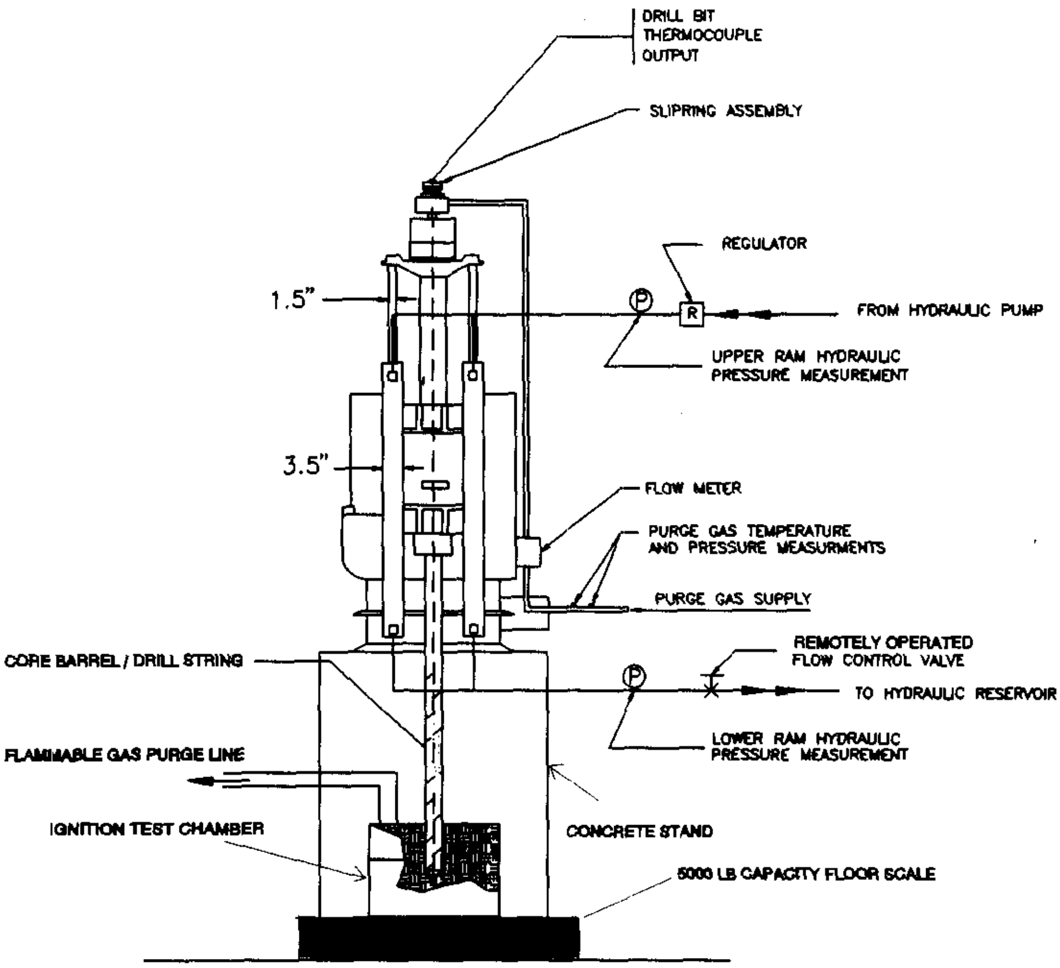

Figure 4: Drilling Machine Test Setup

4.3.2 IGNITION TEST CHAMBER

As seen in Figure 5 below, a small test chamber will be used to contain the flammable gas and objects to be drilled against. This chamber will be sealed so that the flammable environment can be closely controlled. It is designed such that were an ignition of the flammable gas to occur, thin diaphragms located on the walls of the chamber would rupture, allowing the sudden pressure to vent, thereby protecting the test chamber and any surrounding test equipment.

A separate pressurized mixing chamber is used to provide the flammable gas to the test chamber. It supplies gas for both the initial purging of the test chamber and a continuous .1 ft^3/min gas flow to maintain a slight positive pressure in the chamber during testing.

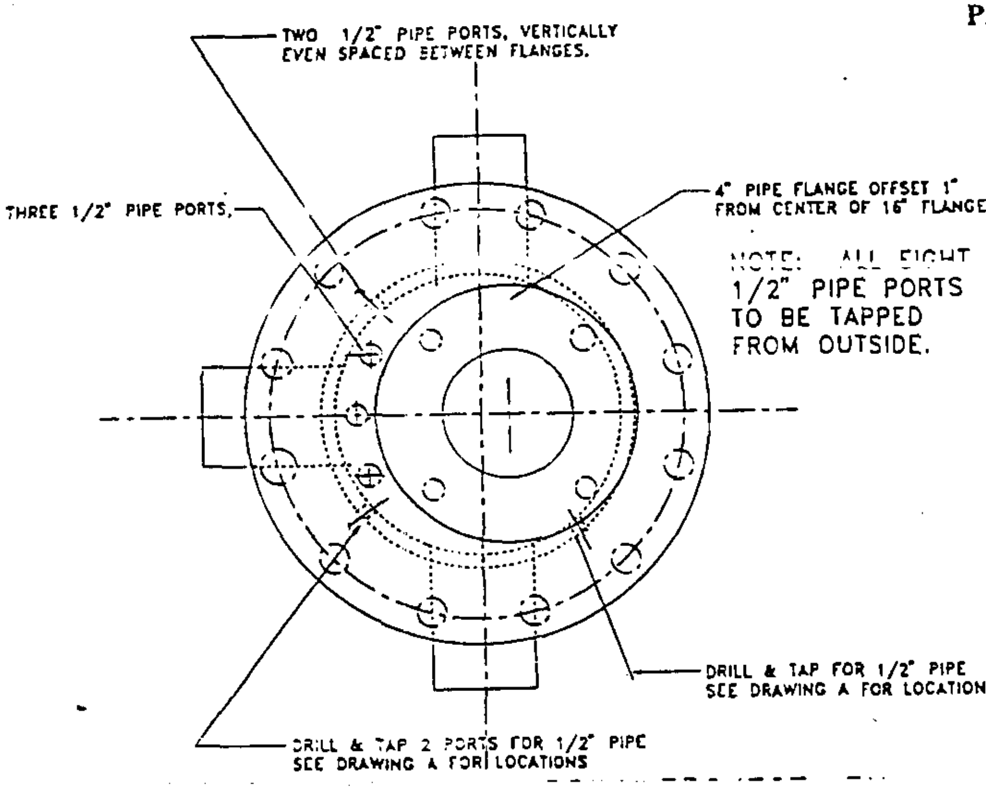

Figure 5 - Ignition Test Chamber -Plan View

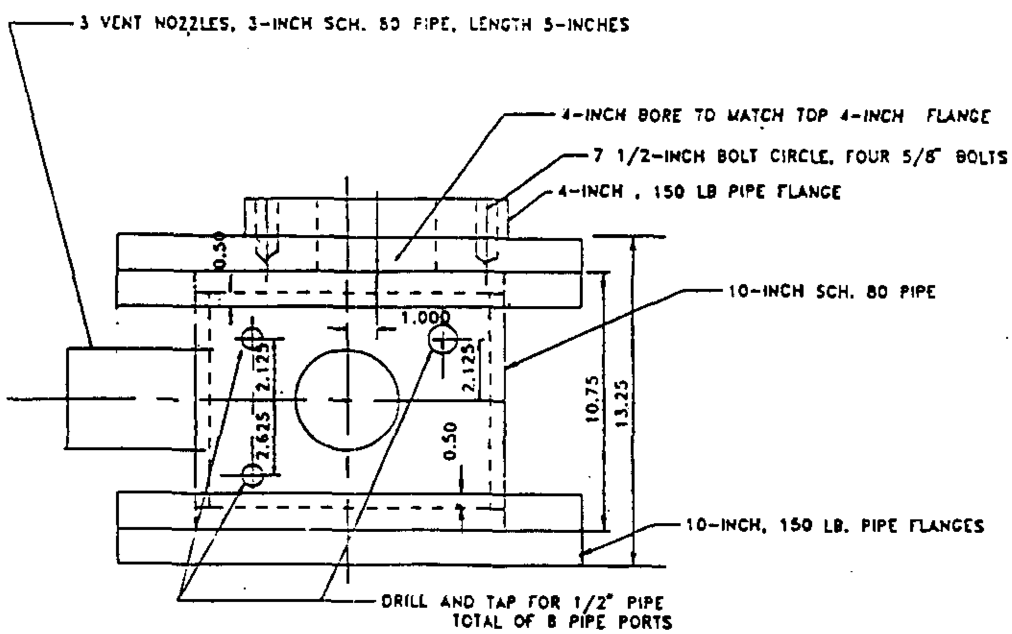

Figure 5 - Igntion Test Chamber Side View

4.3.3 INSTRUMENTATION

A micro computer with a Validyne[2] data acquisition system will be used to gather and record various sensor inputs from the drilling rig (ie., drill bit depth, bit rotational speed, downward force and purge gas inputs [flowrate, temperature and pressure]).

The USBM also has data acquisition equipment used for measuring the test chamber pressure, flow rate of flammable gas and gas mixture percentages. A high speed camara will be utilized to record the ignition also.

4.3.4 MAJOR COMPONENTS

The following table lists the major components needed for testing and the responsible agency for providing the component. See Appendix A for any specific information (serial no.'s, calibration, etc.).

Table 1: Equipment Responsibilities

ITEM	RESPONSIBLE PARTY
DRILL-LONGYEAR MODEL 34 DRILLING MACHINE AND ASSOCIATED FITTINGS	WHC
DRILL BITS AND DRILL CORE-BARRELS	WHC
INSTRUMENTATION AND DATA ACQUISITION SYSTEM FOR MONITORING DRILLING	WHC
TESTING FACILITY	USBM
SUPPORT MATERIALS FOR DRILL (GAS, OIL, ETC.)	USBM
GAS MIXTURE, PRESSURE CHAMBER AND GAS DISTRIBUTION HARDWARE	USBM

4.4 DATA

Data will be collected both electronically using a PC, and by hand in a laboratory log book[5]. All data will be presented in the final supporting document to be released at the completion of the testing. Recorded data from the USBM's equipment and logs will also be used in the preparation of the final report.

Validyne is a Trade Name of Validyne Engineering Corporation

5.0 EXPECTED RESULTS

Results will demonstrate whether an ignition can occur under these specified conditions. These results will then be used in the safety documentation for the Rotary Mode Core Sampling System. Although an ignition is not expected to occur during testing, the flammable gas will be deliberately ignited at the end of each test run using an electric match to provide verification that an explosive atmosphere had been present during testing.

6.0 TEST PROCEDURE

Below is a step by step procedure that will be used for conducting the tests.

1) Place material to be tested into the preheated test chamber and secure firmly. Locate it such that either the drill bit (scenario #1) or the drill string (scenario #2) makes proper contact during testing.

2) Place rubber drill string pipe wiper and steel flange over drill pipe. Apply sufficient lubricant to the pipe wiper to minimize frictional heating.

3) Lower drill ram until the drill bit or drill string is at initial drilling point. Set data acquisition system to read this point as 0 inches depth.

4) Raise drill string about 1" and secure pipe wiper and flange onto test chamber.

5) Start drill machine, set downward force to 1350 lbs and rotation to 65 RPM. Close hydraulic ram flow valve (remotely located in safe room), and engage rams for downward motion.

6) Insure that the test chamber is at approximately 100°C and begin filling with the flammable gas mixture. Continue filling until any atmospheric gasses that were present have been purged. Set flow rate of flammable gas mixture into test chamber at .1 ft^3/min for duration of test.

7) Insure that personnel are safely located away from drilling location, begin recording with data acquisition system and open the remotely positioned flow control for downward ram travel.

8) If this is a test using a drill bit, leave flow control valve open until the material has been drilled into for 3 minutes. If, however, downward motion is seen to move rapidly past the predetermined point of contact with the material, immediately close the flow control valve before the bit reaches the bottom of the test chamber. If this is a test of the drill string, allow flow control valve to stay opened only until a predetermined depth is reached. At this point, close the control valve and allow rotation to continue for at least three minutes.

9) At conclusion of three minutes (or other unusual condition described in step 8 above, shut off flammable gas supply, and remotely set off electric match located inside the test chamber to insure flammability of mixture. Discontinue recording of drilling parameters at this time

10) Close hydraulic flow control valve for drill rams (if not already closed) and purge the test chamber with nitrogen until all traces of flammable gasses are removed.

11) Loosen flange bolts, raise drill string and prepare test chamber for next test as directed in the logic flow tree (Figure 1).

7.0 SAFETY

An explosion hazard exists. USBM has facilities, personnel, and safety procedures prepared to accommodate an explosion. Personal protective equipment and personal and area monitoring as prescribed in the WHC Hygiene Manual[6] and the WHC Safety Manual[7] will be referenced if necessary.

8.0 QUALITY ASSURANCE

The pertinent measuring devices will be calibrated or characterized before shipment to Pittsburgh by the WHC Standards Laboratory. Upon arrival in Pittsburgh, sensors will be checked for damage and verified that they are operating properly. If damage is discovered, repair will be completed at an NIST traceable calibration facility either in Pittsburgh or elsewhere. Appendix B shows equipment identification numbers as well as their calibration information.

9.0 RESPONSIBILITIES

Engineering Testing Laboratory - WHC

Responsible for test direction and for provision and transportation of major components needed for testing (see Table 1) to USBM Pittsburgh Research Center and back to Hanford at conclusion of testing. Also responsible for setup, operation and tear down of core drilling equipment as well as final test report generation and release. WHC Cognizant Engineer is Keith Witwer. Other WHC points of contact are Greg Ralston, Roy Blanchard, and Dennis Hamilton.

Quality Assurance - WHC/USBM

The instrumentation for recording the drilling parameters will be calibrated by the Westinghouse Standards Laboratory prior to conducting testing. Additional instrumentation supplied by the USBM will be checked against generally accepted standards prior to use in Pittsburgh.

Pittsburgh Research Center, USBM-Pittsburgh

Responsible for providing the testing facility, setup of testing, various flammable gas hardware and instrumentation, support personnel, and assistance in preparing final test report. This testing falls under a Memorandum of Agreement[8] between WHC and USBM. USBM point of contact with is Kenneth L. Cashdollar of the Fires, Explosives and Explosions Group, Pittsburgh Research Center.

Los Alamos National Laboratory - New Mexico

Los Alamos National Laboratory will provide ongoing consultation with the test personnel via telephone, or in person if necessary. Their points of contact are Jack Edwards and Cetin Unal.

10.0 SCHEDULE

WHC personnel will travel to Pittsburgh approximately one week after shipment of drilling rig and other equipment. Setup of the drill rig will commence as soon as it arrives and actual testing will begin as soon as possible thereafter. Testing is estimated to take between one to two weeks, depending on the outcome of initial test and is expected to start the third week in January, 1996.

11.0 REPORTING

A Supporting Document Test Report will be generated and delivered to Characterization Equipment Engineering within three weeks after completion of testing.

12.0 REFERENCES

1. A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101, LA-UR-92-3196, April, 1995.

2. WHC-SD-WM-TRP-224 Rev. 0, Ignitability Testing for the Core Drilling System, K. Cashdollar, K. Witwer, 6/95.

3. USBM Bulletin 680 - Investigation of Fire and Explosion Accidents in the Chemical, Mining, and Fuel-Related Industries - A Manual, J.M. Kuchta, 1985

4. R. Blickensderfer, et al., Testing of Coal Cutter Materials for Incendivity and Radiance of Sparks, BUMINES-RI-7713 (November, 1972)

5. Laboratory Logbook WHC-N-984-1, K. Witwer custodian

6. Hygiene Manual, WHC-CM-1-11

7. Safety Manual, WHC-CM-1-10

8. MOA between WHC and USBM, #14-09-005-3666

13.0 APPENDIX A - PERTINENT EQUIPMENT AND IDENTIFYING NUMBERS

ITEM	PN/SN
Longyear Model 34 Drill	HO 225272 / IDW00782
Instrument Control Panel	Shop Built
Micro Computer System	WC32764
Validyne PC Acquisition Board	UPC608

14.0 APPENDIX B - TRANSDUCER CALIBRATION DATA

ITEM	STANDARDS LAB #	RANGE/ ACCURACY	EXPIRATION DATE
HEDLAND 647060 GAS FLOWMETER	999-28-03-036	10 TO 60 CFM APPROX. 5% ERROR AT 30 SCFM	09/26/96
TOLEDO 8140 FLOOR SCALE 0-5000 LB CAPACITY	750-66-01-004	0 TO 2000 LB CAL. +/- 2 LB ACCURACY	12/21/96
OMEGA TYPE K PURGE GAS THERMOCOUPLE	750-78-02-007	0 TO 300°C RANGE +/- 2.2°C ACCURACY	08/10/96
0 TO 100 PSI MARSH BOURDON TUBE TYPE PRESSURE GAUGE	750-31-04-015	0 TO 100 PSI RANGE +/- 2% OF FULL RANGE ACCURACY	09/08/96

A Celesco Model PT101-40A Position transducer and a built in tachometer (Longyear, Inc) will be verified as operating correctly upon setup of equipment in Pittsburgh. These need to be checked in situ and will be verified as such in the official testing log book.

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	Characterization Equipment Design	Date 01/31/96
Project Title/Work Order		EDT No. 613810
Test Plan for Core Drilling Ignitability Testing		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
G. L. Ralston	H5-68	X			
K. S. Witwer	L6-13	X			
G. N. Boechler	H5-09	X			
R. Y. Seda	H5-09	X			
C. E. Hanson	H5-09	X			
R. J. Blanchard	S7-12	X			
D. W. Hamilton	S7-12	X			
A. P. Mousel	S7-12	X			
R. E. Raymond	S7-12	X			
G. P. Janicek	S7-12	X			
G. J. Bogen	S7-03	X			
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T. J. Rainey	S7-12	X			
J. S. Schofield	S7-12	X			
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