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FLAMMABLE GAS INTERLOCK SPOOLPIECE FLOW RESPONSE TEST PLAN AND PROCEDURE

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Abstract: The purpose of this test plan and procedure is to test the Whittaker electrochemical cell and the Sierra Monitor Corp. flammable gas monitors in a simulated field flow configuration. The sensors are used on the Rotary Mode Core Sampling (RMCS) Flammable Gas Interlock (FGI), to detect flammable gases, including hydrogen and teminate the core sampling activity at a predetermined concentration level.

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FLAMMABLE GAS INTERLOCK SPOOLPIECE FLOW RESPONSE

TEST PLAN AND PROCEDURE

REV. 0

APPROVAL DESIGNATOR SQ

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Characterization Equipment Engineering Projects
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February, 1997

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FLAMMABLE GAS INTERLOCK SPOOLPIECE FLOW RESPONSE TEST PLAN AND PROCEDURE

1.0 INTRODUCTION

The Flammable Gas Interlock system (FGI) is required to support Rotary Mode Core Sampling (RMCS) of single shell flammable gas watch list tanks. The FGI spoolpiece is installed in the portable exhauster ventilation ducting to monitor for hydrogen and other flammable gases in the exhaust stream and automatically terminate the core sampling activities upon detection of a preset flammable gas concentration or rate of change. The system uses two diverse detection sensors, an electrochemical cell and a catalytic bead combustable gas cell. The system has been designed and built utilizing the sensor vendor guidance for duct mounting of the sensors. The duct application is somewhat unique for the sensor systems and due to the critical application it is necessary to perform a functional test to validate the spoolpiece operation.

The purpose of this test plan and procedure is to define the methodology used to test the performance of the FGI spoolpiece and sensors using simulated field hydrogen gas concentrations. This test will be performed using the guidelines as defined in WHC-CM-6-1, *Standard Engineering Practices*, EP-4.2, Section 2.2.1, "Development Testing". The main purpose of the test is to resolve the engineering issues regarding the performance of the sensors at duct flows that will be experienced during Hanford Site tank farm deployment. The parameters for the test will be provided by the core sampling team (CST) and by the gas characterization team (GCT) from experience gained while developing the Standard Hydrogen Monitoring Systems (SHMS). The test configuration, inlet pressure, and flow rates will be similar to the actual FGI system.

2.0 DESCRIPTION

The test will be conducted in the 305 Engineering Test Laboratory (ETL), in the 300 area of the Hanford Site, Richland, Washington. It will use grounded metal ventilation ducting or conductive flexible ducting where potentially flammable gas concentrations exist. The ducting between the gas injection point and the flammable gas sensors will be of adequate length to establish a fully mixed gas concentration. The test setup will include a FGI spoolpiece, installed with the two gas sensors and built to field specifications, a blower to provide the same flow rates expected in the field installation, a precision total flow meter, a precision injection gas flow meter, and support process temperature and pressure instrumentation including a target flow switch and solenoid valve to terminate hydrogen injection gas upon loss of duct flow. Additionally a gas chromatograph (GC) will be used to validate the duct gas concentrations. Compressed gases will also be employed for the sample injection gas, sensor and GC calibration gas and GC carrier gas. The blower will be initially installed upstream of the gas injection port, which alleviates the need to use a blower qualified for use with a classified flammable gas and will only pressurize the ducting by approximately 0.5 "H_2O at the operating flows. An alternate configuration will place a qualified blower downstream of the spoolpiece to more closely simulate the field conditions. The test gases will be contained in the duct system and will be exhausted outside the building. The fully mixed gas concentrations will be administratively controlled to remain below 25% of the lower flammability level for hydrogen in air. Refer to FIGURE 1 for a simple piping and instrumentation diagram (P&ID) of the test equipment arrangement and Appendix A for the definition of the main equipment shown in FIGURE 1 and discussed in this section.

The main duct flow will be established at nominally 200 standard cubic feet per minute (SCFM) using the blower (P1) and a throttle valve (FCV-1). The main flow value will be determined using a precision laminar flow element (FE-1), differential pressure transmitter (FT-1) and absolute pressure transmitter (PT-1). The duct gas temperature will be monitored for reference by a type K 1/16" stainless steel jacketed thermocouple (TE-1). The hydrogen injection gas flow, in the range of 0.4 to 1.5 SCFM, will be established using a precision laminar flow element (FE-2), differential pressure transmitter (FT-2) and absolute pressure transmitter (PT-2). The injection gas temperature will be measured by a type K 1/16" stainless steel jacketed thermocouple (TE-2). The injection gas line will be purged following each test with nitrogen gas supplied via the purge gas bottle pressure regulator (PCV-7) and isolation valve (MV-7). The duct gas concentration is determined by the ratio of the mixed gas streams. The actual duct hydrogen gas concentration will be measured just upstream of the spoolpiece using a gas chromatograph (GC-1) calibrated with standard gases.

The sensors tested will be calibrated using the procedures identified in Appendix F. The output of the Sierra Monitor Corporation (SMC) transmitter (NE-2) will be measured and logged on the HP data logger (DL) channel A6. The Whittaker electro-chemical cell (WEC) hydrogen sensor (NE-1) output will be connected in the field configuration using a intrinsically safe barrier (EB-1), and measured by a Newport voltmeter/transmitter (NIT-1) and logged on the HP data logger channel A4. The data logger will also measure the raw WEC signal on channel A11 for comparison to the previous testing performed by *Test Procedure for Measurement of Performance vs Temperature of Whittaker Electrochemical Cell*, HNF-SD-WM-TC-072. The process instruments including the WEC chamber temperature thermocouple (TE-3) and ambient temperature thermocouple (TE-4) will be measured and logged on the HP data logger channels A10 and A7 respectively. The logged data files will be used to develop instrument response graphs as well as steady state readings. The gas chromatograph data will be compiled using vendor supplied software and the concentration values will be stored in a data file and provided as a portion of Appendix C to this procedure.

The GC duct monitoring system includes a dual column GC (GC-1) with thermal conductivity detectors, flow indication and control, a metal bellows sample pump qualified to transport flammable gases, sample bypass and calibration gas isolation valves and a pressure equalizing three-way solenoid valve. The sample pump (P-2) draws a sample from the duct just upstream of the spoolpiece and returns it to the duct downstream of the spoolpiece. Under normal sampling operation, the sample pump (P-2) draws a sample through GC-1, which is monitored by a rotameter (FI-4) and controlled by a flow control valve (FCV-4), and through the bypass line. The bypass line includes an isolation valve (MV-4), flow indicator (FI-3) and an integral flow control valve (FCV-3), which provides 5-10 times the GC flow to constantly provide the sample point with fresh duct gas. During the sample injection, the pressure equalizing solenoid valve (EV-2) is operated momentarily under the GC control. During the calibration operation, the sample isolation valve (MV-4) is closed and the calibration gas isolation valve (MV-5) is opened. The calibration gas line includes an isolation valve (MV-5), flow indicator (FI-5) and an integral flow control valve (FCV-5) which provides the same 5-10 times the GC flow to the sample point to assure that the GC is measuring calibration gas that has not been diluted by the duct air. The nitrogen carrier gas is supplied to the GC, via the bottle pressure regulator PCV-2 and isolation valve MV-2, at 80 psig to provide all pneumatic control requirements.

A minimum of two test sequences will be performed. The initial testing will involve low concentration gas provided by an injection source of 3 to 5% hydrogen in balance nitrogen which is a non flammable mixture. This testing will be used to validate the development of the mixed gases prior to the spoolpiece inlet by measuring the flow stream gases with a gas chromatograph (GC). If the measured GC concentration is consistent with the calculated and anticipated value, it can be concluded that the gas stream is mixed. The second test sequence will involve the use of pure hydrogen and will provide adequately high concentrations to assess the sensor response times and output linearity.

Since the measured gas is injected upstream of the sensors, the gas transport time will be calculated and subtracted from the overall response times to obtain an actual system response time. The system response time is the change in output signal with a near instantaneous input of gas. The response time data will be affected by the sample rate of the data logger, and will be considered in the test report. This testing in conjunction with the *Test Procedure for Measurement of Performance vs Temperature of Whittaker Electrochemical Cell*, HNF-SD-WM-TC-072, will provide a good understanding of the Whittaker cell response characteristics.

The hazards associated with the performance of this test are primarily due to the use of high concentrations of hydrogen gas. There have been precautions taken to avoid any ignition sources in the flow system. The test employs administrative controls to preclude a hydrogen ignition during the test. The test procedure limits the measured duct hydrogen gas concentration to 25% of the LFL. The following are the engineered precautions:

* All the instruments that come in contact with the duct gas downstream of the injection point are qualified to handle flammable gases or have mechanical or electrical engineered barriers to preclude ignition sources.

* The unqualified main duct blower is located upstream of the injection gas port. In the event that the configuration changes to draw flow through the duct, a blower qualified for use with a classified flammable gas will be employed.

* The ducting downstream of the injection point is grounded metal or conductive flexible duct for a distance of at least 60 feet.

* The hydrogen gas injection line is provided a fail closed solenoid valve (EV-1) that is energized to provide injection gas. The solenoid is powered from the blower motor power through a manual switch (HS-1) and a target flow actuated switch (FS-1). Therefore, the injection gas solenoid valve will automatically close upon loss of the duct blower power or duct flow and manually close by the actuation of the ON/OFF switch HS-1.

* A nitrogen purge system is used to purge the hydrogen injection gas lines.

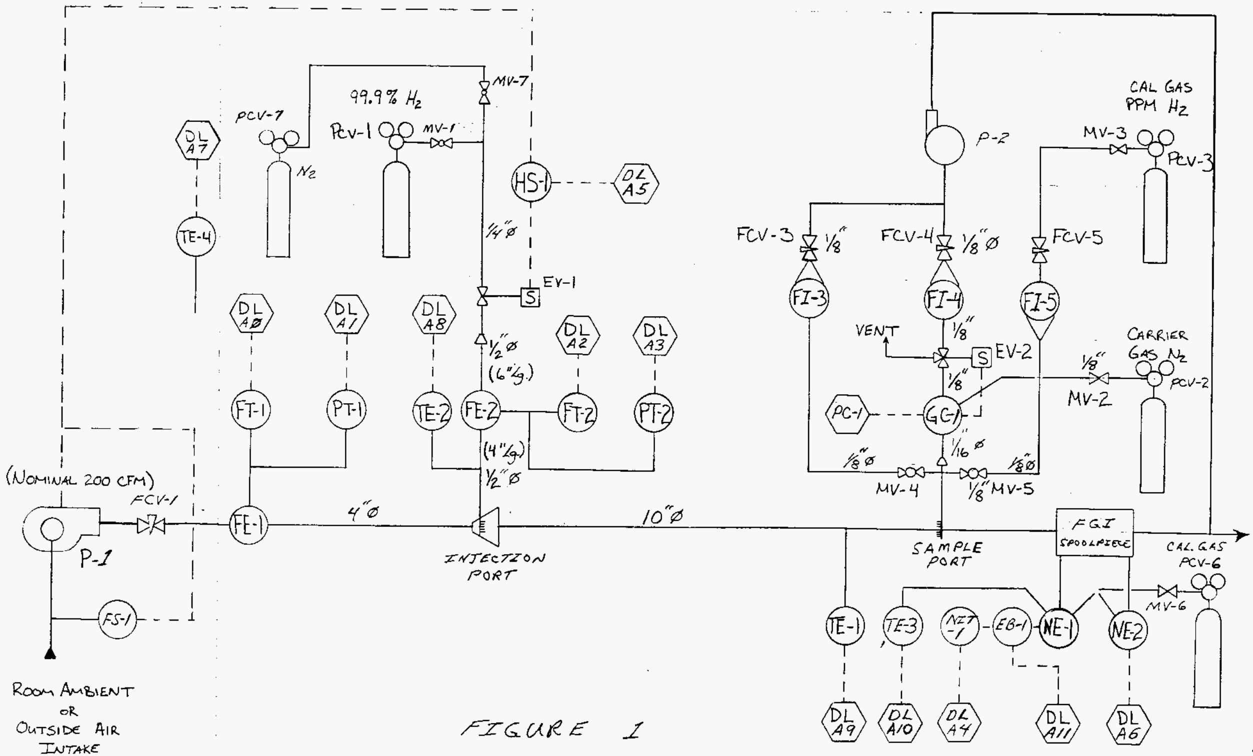
ROOM AMBIENT OR OUTSIDE AIR INTAKE
(NOMINAL 200 CFM)
P-1
FCV-1
FS-1
FE-1
FT-1
PT-1
TE-2
FE-2
FT-2
PT-2
TE-4
DL A7
DL AØ
DL A1
DL A8
DL A2
DL A3
DL A5
HS-1
EV-1
MV-7
MV-1
PCV-7
PCV-1
N_2
99.9% H_2
4"Ø
10"Ø
1/4"Ø
1/2"Ø
(6"Lg.)
(4"Lg.)
INJECTION PORT
SAMPLE PORT
FGI SPOOLPIECE
CAL. GAS
PCV-6
MV-6
TE-1
TE-3
NZT-1
EB-1
NE-1
NE-2
DL A9
DL A10
DL A4
DL A11
DL A6
P-2
CAL GAS PPM H_2
MV-3
PCV-3
FCV-3
FCV-4
FCV-5
1/8"
1/8"Ø
FI-3
FI-4
FI-5
VENT
EV-2
CARRIER GAS N_2
PCV-2
MV-2
PC-1
GC-1
1/16"Ø
MV-4
MV-5

FIGURE 1

3.0 REQUIREMENTS

3.1 General Requirements

3.1.1 Test Controls

This test shall be conducted under the guidelines set forth in this document. This is a limited use procedure not written in a step by step format and therefore requires that the test performers are intimately knowledgeable of the test hazards and operation of all the test equipment. Refer to section 4.2 for the listing of responsible persons. The Test Procedure section shall define the test sequence. The test sequence may be changed by the test director with concurrence of the cognizant RMCS exhauster engineer and the facility manager, as long as the change does not affect equipment, facility or personnel safety. **Procedural controls will limit the concentration of the duct gas to below 10,000 ppm which is 25% of the lower flammability level of hydrogen in air.**

3.1.2 Retest Requirements

Any portion of the test may be re-run or re-started. However, no previously recorded data shall be destroyed and all data shall be included in the test report. All deviations from the test procedure will be noted in the Test Log and/or on a Test Exception if appropriate. Additionally, it shall be the goal of this test plan to proceed sequentially through the test procedure. All activities for retest shall be at the approval of the test director.

3.1.3 Deviations from the Test Plan/Procedure

Deviations are allowed to the test plan if they are approved by the test director, cognizant RMCS exhauster engineer, and the 305 ETL manager, or his designee. The cognizant RMCS exhauster engineer's approval may be acquired by telephone. This approval shall be documented by initialing of the test procedure, by the test director and cognizant engineer, at the appropriate place in the procedure. Deviations from the test plan must be documented in the test log and by the preparation of a Test Exception. The deviations will be discussed in the test report.

3.1.4 Measurement and Test Equipment

All measurement and test equipment shall have a valid calibration sticker traceable to the National Institute for Standards and Testing (NIST) and shall bear the date calibration expires as well as an authenticating signature, stamp or initial.

There are two general exceptions to the measurement and test equipment (M&TE) calibrations. The first exception will be the laminar flow elements, which have vendor certificates of calibration, and the SMC and Whittaker sensor systems, which are calibrated using standard gases and special calibration procedures included in this procedure.

The second exception will be three rotameters used to monitor relative flows for the following:

* The GC calibration gas flow minimum requirements must indicate a flow larger that the GC sample flow. This assures that the GC will measure all calibration gas and not a dilute sample.

* The GC sample flow minimum requirements must indicate that the GC is drawing a sample within a wide range of permissible flows.

* The GC sample bypass flow minimum requirements must indicate that the sample is being provided to the GC inlet sample port at a rate which exceeds the GC sample flow.

The rotameters will be functionally verified using either a calibrated rotameter of the same range for the higher range flowmeters or a bubble flow meter for the low range flow meter. The results of the validation will be recorded in the test log. Each instrument and sensor used in this test shall be recorded in Appendix A of this test procedure.

3.1.5 Standard Gas Bottle Record

The record of all gas bottles used in this test shall be documented in Appendix B of this test procedure. This shall include the supplier, controlled bottle number, type of gas, and concentration. As part of the supporting documentation a copy of the manufacturers' specification tag/sheet, for any bottle used, shall be included in the test report.

3.1.6 Training

Adequate training shall be provided to the testing personnel to allow safe and successful operation of the test equipment, including the M&TE. This training shall be provided by the 305 ETL cognizant engineer or his representative. A record of the personnel qualified to operate the test equipment shall be maintained, on file, by the 305 ETL cognizant engineer. No other training is required.

3.1.7 Facility Identification

The testing facility shall be the 305 ETL, 300 Area, Hanford site, Richland, Washington. The simulated portable exhauster and FGI spoolpiece system are located in this facility.

3.1.8 Safety Requirements

The 305 ETL cognizant engineer shall instruct the testing personnel pertaining to safety, within the 305 ETL as well as safety practices pertaining to operation of the test system, including precautions about compressed gases and flammable gases. Training sessions will be noted in the test log. All personnel, present during testing in the 305 ETL, shall abide by these requirements. These include:

* wearing of OSHA approved eye protection at all times
* wearing of OSHA approved hardhat protection when crane operations are overhead (There is to be no flow testing during overhead crane operations.)
* utilizing the "buddy system" when performing work in the facility.
* post a copy of the approved Job Hazard Analysis (JHA) at the job site

3.1.9 Personnel Identification

The key personnel identified for the performance of this task are as follows:

- Test responsible engineering manager: C. E. Hanson
- 305 ETL responsible manager: M. J. Schliebe
- Cognizant RMCS exhauster engineer: E. J. Waldo/J. D. Robinson
- Cognizant 305 ETL engineer: K. S. Witwer
- Test Director: T. C. Schneider

Other support personnel shall be supplied, as necessary, from 305 ETL or Remote Sensing and Sampling Equipment Engineering (RSSEE).

3.1.10 Approval Designators

As a minimum, this test plan shall be approved by Lockheed Martin Hanford Company Design Authority, Characterization Project Safety Quality and Health, Numatec Hanford 305 ETL engineer, and technical peer review. The personnel assigned for the peer review shall be as designated by the cognizant RMCS exhauster engineer. They include the Numatec Hanford Corporation (NHC) Cognizant Engineer and Cognizant Manager. These approvals and reviews shall be authenticated by signature on the engineering data transmittal (EDT) for this plan/procedure.

3.1.11 Test Procedures/Revisions

This document defines the test sequence and test order. It is the intent that the test procedure be followed to complete the test under the test criteria defined in Section 5. However, if the test intent is not compromised, the test setup, sequence, or test order may be changed with the approval of the cognizant RMCS exhauster engineer, the test director, and the 305 ETL manager, or his designee. See Section 3.1.3.

4.0 ORGANIZATIONAL RESPONSIBILITIES

4.1 Customer

The customer for this test is the Lockheed Martin Hanford Characterization Project Operations (CPO). The responsible engineering organization, for the RMCS, is Numatec Hanford Company. The exhauster, and supporting flammable gas interlock, supports RMCS.

Characterization Project Cognizant Manager: M. A. Payne
Program Manager (NHC): R. E. Raymond

4.2 Remote Sensing and Sampling Equipment Engineering

The RSSEE organization will be responsible for the test. This includes the generation of the test plan/procedure, test report, execution of the test in the 305 ETL, and interface with the 305 ETL engineering and management personnel.

Manager: C. E. Hanson
Test Director: T. C. Schneider *
Cognizant RMCS exhauster engineer(alternate): J. D. Robinson
Supporting Personnel: As Required
* Matrixed to RSSEE from NHC Equipment Engineering for this testing

4.2.1 Test Director

The test director will be responsible for all interface to perform the test. This includes the generation of the test plan/procedure, test report, minutes of the pre-test meeting in the 305 ETL, expediter for all document signature reviews/approvals, execution and direction of the test, and all signature and log entries to the procedure.

4.2.2 Numatec Hanford Company (NHC) Equipment Engineering

NHC will be responsible to assist RSSEE in the preparation of the test plan/procedure, and the test setup. NHC will be available as Test Director for this test plan/procedure, as well as consultants in the matters of gas characterization and analysis.

Manager: W. C. Miller
Supporting Engineer: T. C. Schneider

4.2.3 Numatec Hanford Company (NHC) 305 ETL

NHC provides the engineering and technical support for the 305 ETL. They will be responsible to assist RSSEE in the preparation of the test plan, test procedures, assist the test director in the execution of the test, overall responsibility for the safe operation of the test, which includes 305 ETL building safety training and orientation, technician support, and the test setup. This will include supplying of some test instrumentation including the data logging system.

Manager:	M. J. Schliebe
Facility Cognizant Engineer:	K. S. Witwer

4.2.4 Numatec Hanford Company (NHC) Field Engineering

NHC field engineering will be responsible for use of the FGI in the field. The cognizant RMCS exhauster engineer will be from this organization, and involved in the preparation of the test plan and conduct of the test procedure.

Manager:	J. S. Schofield
Cognizant RMCS Exhauster Engineer:	E. J. Waldo

4.2.5 Cognizant RMCS Exhauster Engineer

The cognizant RMCS exhauster engineer will have the overall responsibility of the test. For this testing he will have signature approval of all test documentation and test changes or deviations, designator authority for peer reviewers, and the final authority on any aspects of the test.

An alternate cognizant RMCS exhauster may be used. This engineer will be supplied from RSSEE.

5.0 CRITERIA

The equipment under test is intended to detect hydrogen and other flammable gases being exhausted from a Single Shell Hazardous Waste Tank vapor space during Rotary Mode Core Sampling activities. For the purpose of this test, hydrogen has been selected as the flammable gas to be measured, since it is the only gas that both sensors will detect. *Test Procedure for Measurement of Performance vs Temperature of Whittaker Electrochemical Cell*, HNF-SD-WM-TC-072, has been prepared to measure temperature affects on the Whittaker sensor signal offset, span and response time to hydrogen gas. This document will augment that procedure by testing both the SMC flammable gas sensor and the Whittaker hydrogen electrochemical sensor for signal response in a simulated duct flow field environment.

5.1 <u>Test Conditions and Criteria</u>

5.1.1 The FGI spoolpiece shall be provided flow in the range of 180 to 220 SCFM for the test. This is the expected flow rate during field operation of the FGI.

5.1.2 The FGI spoolpiece flammable gas sensors shall be provided concentrations of hydrogen gas in the range of 200 to 7500 ppm. The initial test will provide nominally 200 ppm gas to validate the duct gas mixing with the GC and observe any spoolpiece sensor output. The second test set will provide a minimum of three concentrations of nominally 2,000, 4,000 and 6,000 ppm which will be introduced into the spoolpiece with the output of the sensors monitored and logged for response time and output signal linearity. The actual gas concentrations will be validated using a gas chromatograph functionally calibrated using standard gases.

5.1.3 The hydrogen gas concentrations will be injected into the flowing gas stream for a minimum of 15 minutes to assure the sensors have had adequate time to reach their final output value. The sensors must reach 90% of the full scale output value in less than 2 minutes. The sensor output will be measured and recorded every 5 seconds. The sensor outputs at 14 minutes and 30 seconds shall be 99.5% of the outputs at 15 minutes.

5.1.4 The sensors under test will be calibrated using the guidance provided in Appendix F, and the transmitter output conditioned to provide signal to the data logger for display and record.

5.1.5 The FGI spoolpiece instrumentation will be operated in the 305 ETL with a nominal ambient temperature between 65 and 75 °F.

5.2 Acceptance Criteria

5.2.1 The sensors under test, when subjected to an instantaneous, mixed gas concentration, shall have a response time requirement of reaching 90% of the full scale output voltage in less than two (2) minutes for all concentrations. Reference WHC-SD-WM-SAD-035, Section U.3.1 second bullet and Section U.3.2 second bullet.

5.2.2 The sensors under test, when subjected to validated mixed gas concentrations, shall provide output relative to their calibrated values. (There is currently no stated accuracy requirements in WHC-SD-WM-SAD-035 for the sensors. The test concentration data taken from the WEC and the SMC sensors will be compared to the GC measured concentrations and evaluated to determine the sensor's ability to accurately represent the duct gas concentrations.)

6.0 DOCUMENTATION

This section will describe the supporting documentation as well as the actual test documentation required.

6.1 References

* WHC-CM-6-1, *Standard Engineering Practices*, EP-4.2, Testing Requirements, Westinghouse Hanford Company, Richland Washington, July 31, 1996.

* WHC-CM-1-10, *Safety Manual*

* WHC-CM-1-11, *Industrial Hygiene Manual*

* WHC-CM-4-40, *Industrial Hygiene Manual*

* WHC-SD-WM-SAD-035, *A Safety Assessment of Rotary Mode Core Sampling in Flammable Gas Single Shell Tanks*, Rev. 0A, Los Alamos National Laboratory, Los Alamos New Mexico, August 1996.

* HNF-SD-WM-TC-072, *Test Procedure for Measurement of Performance vs Temperature of Whittaker Electrochemical Cell*, Rev. 0, SGN Eurisys Services Corporation, Richland Washington, Jan. 17, 1997

* WHC-WM-SD-OMM-015 Rev. 0, *Standard Hydrogen Monitoring System-B Operation and Maintenance Manual*

* 6-TF-408, Rev. 1-B, *Whittaker Model 114D038-10 Hydrogen Cell with Newport Infinity Electronics, Calibration*

6.2 Test Documentation

The test documentation will include the following:

6.2.1 This test plan/procedure will provide the test direction and will include the following Appendices:

* Appendix A: Measurement and Test Equipment Data Sheet
* Appendix B: Gas Bottle Record
* Appendix C: Data Records
* Appendix D: Test Exception Record
* Appendix E: Test Log Record
* Appendix F: Special Calibration and Operating Procedures

6.2.2 Instrument calibration reports are provided to assure the M&TE used have been calibrated using traceable standards. Special instrument calibration procedures and the test log entries associated with the performance of those procedures will assure that those related instruments are correctly set up for testing.

6.2.3 The test procedure will contain a test log (Appendix E) that will log the test events. The test log will be kept in the controlled log book HNF-N-3 1 and the entry pages copied and included in Appendix E.

6.2.4 Test data sheets will be compiled for each test required by Table 1. The data sheet form is included in Appendix C. The data sheet will be copied and annotated with the appropriate test identification to support each required test. The completed data sheets will be included in Appendix C, Data Records.

6.2.5 The test report, HNF-SD-WM-TRP-275, *Flammable Gas Interlock Safety Shutdown Spoolpiece Test Report*, will compile the data obtained and provide a summary of the findings, discussion of any test exceptions, recommendations and conclusions.

TABLE 1
FGI FLOW TEST MATRIX

Test ID. No.	Main Duct Flow	Duct H_2 ppm Concentration	Injection H_2 Gas Standard
1-1	200 SCFM	200-300 ppm	3.0% H_2 Bal. Air or N_2
1-2	200 SCFM	200-300 ppm	3.0% H_2 Bal. Air or N_2
1-3	200 SCFM	200-300 ppm	3.0% H_2 Bal. Air or N_2
2-1	200 SCFM	2,000-3,000 ppm	99.9% H_2
2-2	200 SCFM	2,000-3,000 ppm	99.9% H_2
2-3	200 SCFM	2,000-3,000 ppm	99.9% H_2
2-4	200 SCFM	4,000-5,000 ppm	99.9% H_2
2-5	200 SCFM	4,000-5,000 ppm	99.9% H_2
2-6	200 SCFM	4,000-5,000 ppm	99.9% H_2
2-7	200 SCFM	6,000-7,000 ppm	99.9% H_2
2-8	200 SCFM	6,000-7,000 ppm	99.9% H_2
2-9	200 SCFM	6,000-7,000 ppm	99.9% H_2

7.0 SCHEDULE

In order to support the earliest deployment of the RMCS Truck 4, the assembly of the test equipment will begin during the preparation of this test plan/procedure. The testing will begin as soon as the plan/procedure is approved and any modifications to the test assembly arrangement has been made. The test report will be prepared and released as soon as the test data has been compiled and evaluated.

8.0 QUALITY ASSURANCE

Quality Assurance will review the documentation associated with this testing as part of the review process. There are no QC hold points or verifications required for this testing.

9.0 SAFETY

Safety will review the test plan and procedure as part of the review process. A Job Hazards Analysis will be prepared as a part of this testing program and will be included in the test report. All work will be performed under the guidelines of WHC-CM-1-10, Safety Manual, WHC-CM-1-11 and WHC-CM-4-40, Industrial Hygiene Manuals.

10.0 TEST PROCEDURE

10.1 Test Prerequisites

Prior to the initiation of testing the following conditions shall be verified:

10.1.1 The job hazards analysis (JHA), for the performance of this testing in 305 ETL has been prepared and approved.

Verified ______________________________
Test Director Date

10.1.2 The information for all instruments and test equipment has been recorded in Appendix A.

Verified ______________________________
Test Director Date

10.1.3 All bottled gases initially required for the testing have been staged. The information for all gas bottles has been recorded in Appendix B.

Verified ______________________________
Test Director Date

10.1.4 The test apparatus has been assembled, configured, connected and initially verified operational, according to FIGURE 1 and Appendix A. Verify that the exhaust ducting has been routed outside of the building.

Verified ______________________________
Test Director Date

10.1.5 The hydrogen injection piping has been pressure tested, to 20 psig, for leaks using a soap bubble solution (Snoop) and documented in the test log.

Verified ______________________________
Test Director Date

10.1.6 A pretest safety briefing has been held with the testing personnel and recorded in the test log. The briefing will be conducted by the 305 ETL cognizant engineer.

Verified ______________________________
Test Director Date

10.2 Test Procedure

If any steps in this section cannot be performed as required or results in an abnormal condition, then prepare a sequentially numbered Test Exception Record in Appendix D and a log entry identifying the problem. The resolution of the Exception will determine what testing, if any will need to be repeated.

The testing may be suspended at any time at the request of the 305 ETL facility manager, cognizant engineer or test director when an unsafe condition exists that could harm the facility, equipment or personnel.

10.2.1 Test Equipment Calibration

Calibrate the test equipment in preparation for testing.

10.2.1.1 Verify that the Whittaker hydrogen monitoring system is calibrated per the directions in Appendix F-2.

10.2.1.2 Verify that the SMC combustible gas monitor is calibrated per the directions in Appendix F-1.

10.2.1.3 Verify that the GC system is calibrated per the directions in Appendix F-3.

10.2.2 Low Hydrogen Concentration Testing

The low hydrogen concentration testing will use hydrogen injection standard gas that is below the lower flammability limit of hydrogen. This testing is to determine if the sensors will detect a low concentration of hydrogen present in the flow duct.

10.2.2.1 Provide power to all the instruments and verify that, with no duct flow, the instruments indicate nominal background values:

Temperatures indicate ambient, differential pressures are near 0 "H_2O, absolute pressures are near 14.5 psia and the hydrogen monitoring sensors indicate near 0 ppm.

10.2.2.2 Verify that the main duct flow is established per Appendix F-4.

10.2.2.3 Verify that the injection flow parameters are established, per Appendix F-5, to provide the nominal main duct concentration requested on the test matrix Table 1. Verify that the injection gas isolation valve MV-1 is closed.

10.2.2.4 Allow the system to purge until the hydrogen monitoring sensors and GC are reading a near background value determined by testing. The background value shall be less than 5% of the final value anticipated. The Whittaker cell may be purged with air through the calibration port to expedite the purging process.

10.2.2.5 Perform the sensor response test per the guidance of Appendix F-6.

10.2.2.6 Repeat steps 10.2.2.2 through 10.2.2.5 as required to complete all the required low concentration tests as defined by Table 1 then proceed.

10.2.2.7 Close the hydrogen injection gas bottle isolation valve and adjust the pressure regulator PCV-1 to minimum fully CCW.

10.2.2.8 Verify that the main duct flow is still adjusted to 200 SCFM.

10.2.2.9 Open the injection gas valve MV-1 and slowly increase the pressure regulator PCV-1 to allow the bottle pressure to vent into the duct.

10.2.2.10 Open the nitrogen purge isolation valve MV-7 and purge the hydrogen injection gas line for 1 minute.

10.2.2.11 Close the injection gas isolation valve MV-1 and the nitrogen purge isolation valve MV-7.

10.2.2.12 Secure the all the test instrumentation and gas bottles per the test director in preparation for the next series of testing.

10.2.3 High Hydrogen Concentration Testing

The high hydrogen concentration testing will use 99.9% hydrogen injection standard gas. This testing is to determine the response time for the hydrogen sensors under test as well as the entire mechanical system. A simple gas transport time calculation will be prepared, by Appendix F-4, to determine the time required for the mixed gas to travel between the injection port and the FGI spoolpiece hydrogen sensors.

10.2.3.1 Provide power to all the instruments and verify that, with no duct flow, the instruments indicate nominal background values:

Temperatures indicate ambient, differential pressures are near 0 "H_2O, absolute pressures are near 14.5 psia and the hydrogen monitoring sensors indicate near 0 ppm.

10.2.3.2 Verify that the main duct flow is established per Appendix F-4.

10.2.3.3 Verify that the injection flow parameters are established, per Appendix F-5, to provide the nominal main duct concentration requested on the test matrix Table 1. Verify that the injection gas isolation valve MV-1 is closed.

10.2.3.4 Allow the system to purge until the hydrogen monitoring sensors and GC are reading a near background value determined by testing. The background value shall be less than 5% of the final value anticipated. The Whittaker cell may be purged with air through the calibration port to expedite the purging process.

10.2.3.5 Perform the sensor response test per the guidance of Appendix F-6.

10.2.3.6 Repeat steps 10.2.3.2 through 10.2.3.5 as required to complete all the required tests as defined by Table 1, then proceed.

10.2.3.7 Close the hydrogen injection gas bottle isolation valve and adjust the pressure regulator PCV-1 to minimum fully CCW.

10.2.3.8 Verify that the main duct flow is still adjusted to 200 SCFM.

10.2.3.9 Open the injection gas valve MV-1 and slowly increase the pressure regulator PCV-1 to allow the bottle pressure to vent into the duct.

10.2.3.10 Open the nitrogen purge isolation valve MV-7 and purge the hydrogen injection gas line for 1 minute.

10.2.3.11 Secure all the instrumentation and gas bottles as directed by the test director.

APPENDIX A
MEASUREMENT AND EQUIPMENT DATA SHEET

FE-1	Main Duct Flow Element	Laminar Flow Element, Meriam Inst. Model 50MC2-4, Serial No. 757200-K1 Range: 0-424.6 SCFM air at std. temp./press. Accuracy: 1.0% of reading Cal. Std.: Vendor Cal. Record Curve
FT-1	Main Duct Flow Xmitter	Diff. Press., Rosemount, Model 3051CD, Serial No.32686 Range: 0-25"H_2O Accuracy: 0.1% FS Cal. Std.: Std. Lab. No. 750-80-02-026 Cal. Due Date: 2-3-98
PT-1	Main Duct Press Xmitter	Abs. Press., Rosemount, Model 3051CD, Serial No. 65843 Range: 0-30 psia Accuracy: 0.1% FS Cal. Std.: Std. Lab. No. 750-80-02-023 Cal. Due Date: 2-3-98
FE-2	Injection Flow Element	Laminar Flow Element, Meriam Inst. Model 50MJ10-10, Serial No. 753510-J3 Range: 0-1.6087 SCFM air at std. temp./press. Accuracy: 1.0% of reading Cal. Std.: Vendor Cal. Record Curve
FT-2	Injection Flow Xmitter	Diff. Press., Rosemount, Model 3051CD, Serial No. 33807 Range: 0-25"H_2O Accuracy: 0.1% FS Cal. Std.: Std. Lab. No. 750-80-02-025 Cal. Due Date: 2-3-98
PT-2	Injection Press Xmitter	Abs. Press., Rosemount, Model 3051CD, Serial No. 0266492 Range: 0-30 psia Accuracy: 0.1% FS Cal. Std.: Std. Lab. No. 355-80-02-055 Cal. Due Date: 5-6-97
FI/FCV-3	GC Bypass Flow	Rotameter with outlet control valve, Wallace & Tiernan, Model 32E083S1XX3 Range: 0-2.5 CFH air Accuracy: 10% FS Cal.: Test Log Comparison (Indication Only)
FI-4	GC Sample Flow	Rotameter, Matheson, Model FM-1050 E1-4Y101-E910 Range: 0-100 ccm air Accuracy: 5% FS Cal.: Test Log Comparison (Indication Only)

FI/FCV-5 GC Cal. Flow	Rotameter with inlet control valve, Wallace & Tiernan, Model 32E083S1XX2 Range: 0-2.5 CFH air Accuracy: 10% FS Cal.: Test Log Comparison (Indication Only)
TE-1	Type K stainless steel jacketed thermocouple Cal.: Std. Lab. No. 750-78-02-013 S/N 002 Cal. Due Date: 2-5-98
TE-2	Type K stainless steel jacketed thermocouple Cal.: Std. Lab. No. 750-78-02-013 S/N 236 Cal. Due Date: 2-5-98
TE-3	Type K stainless steel jacketed thermocouple Cal.: Std. Lab. No. 750-78-02-013 S/N 001 Cal. Due Date: 2-5-98
TE-4	Type K stainless steel jacketed thermocouple Cal.: Std. Lab. No. 750-78-02-013 S/N 400 Cal. Due Date: 2-5-98
GC-1 H_2 Concentration Std.	Dual Column GC, Micro-sensor Tech. Inc., Model M200D, Serial No. 150313 Range: 100-30,000 ppm Accuracy: 10% Reading Cal.: Standard Gas per Appendix F-3
PC-1 GC Control Computer	Lap Top PC, Toshiba Satellite Pro Model 405CS, Serial No. 02628992-1 Range: N/A Accuracy: N/A
DL-1 System Data Logger	H-P Data Logger, Model 3497A, Serial No. 2222A09660 Range and Accuracy: 0-0.1 Vdc (±18uVdc), 0-100 Vdc (±0.3mVdc), T/C (±1°C) Cal.: Std. Lab. No. 752-67-11-002 Cal. Due Date: 2-5-98
NE-1 Whittaker Sensor	Electro-Chemical Cell, Whittaker, Model 109D020-2, Serial No. HS-1226 Range: 0-10% H_2 by Volume Accuracy: 0.2% Absolute Cal.: Standard Gas per Appendix F-2
NE-2 SMC Sensor	Combustible Gas Module, Sierra Monitor Corp., Model 4101-02, Serial No. 96-B-4455 Range: 0-100% LFL H_2 Accuracy: 3% FS Cal.: Standard Gas per Appendix F-1
Handheld Digital Multimeter	Fluke Model 702, Serial No. 6240608 Cal.: Std. Lab. No. 750-13-71-001 Cal. Due Date: 12-06-97

APPENDIX B
GAS BOTTLE RECORD

APPENDIX C
DATA RECORDS

FGI FLOW TEST DATA SHEET

TEST ID. No. ________ DATA FILE No. GC ________ DL ________

SMC ID. No. ________ WHITTAKER ID No. ________

MAIN DUCT FLOW PARAMETERS:

REQUIRED FLOW ______CFM CALCULATED FLOW ______CFM

DIFF. PRESS. ______"H_2O ABS. PRESS. ______PSIA TEMP. ______°F

DUCT LENGTH ______FT. FLOW VELOCITY ______FT/SEC

TRANSPORT TIME ______SEC.

INJECTION FLOW PARAMETERS:

DESIRED H_2 CONCENTRATION ______ppm MEASURED H_2 CONCENTRATION ______ppm

DIFF. PRESS. ______"H_2O ABS. PRESS. ______PSIA TEMP. ______°F

SENSOR CONCENTRATION OUTPUT:

2 MINUTE CONCENTRATION VALUES:

SMC ______ppm WHITTAKER ______ppm

14 MINUTE 30 SECOND CONCENTRATION VALUES:

SMC ______ppm WHITTAKER ______ppm

15 MINUTE CONCENTRATION VALUES:

SMC ______ppm WHITTAKER ______ppm

TEST PERFORMER ____________________/________
Date

TEST DIRECTOR ____________________/________
Date

APPENDIX D
EXCEPTION RECORDS

TEST EXCEPTION SHEET

			Title of Test: HNF-SD-WM-TC- RMCS FGI FLOW RESPONSE TEST		
EXCEPTIONS			CORRECTION APPROVAL		
Procedure Step Number	Date	Description	Initials/Date		
			Test Engineer	Test Director	Witnesses

TEST APPROVED WITH EXCEPTIONS

______________________/__________
Test Director / Date

______________________/__________
Quality Assurance / Date

EXCEPTION RESOLVED

______________________/__________
FGI Cognizant Engineer / Date

______________________/__________
Quality Assurance / Date

APPENDIX E
TEST LOG RECORDS

APPENDIX F-1

This appendix provides guidance for the calibration of the Sierra Monitor Corporation (SMC) Combustible Gas Module (CGM) model 4101-02 under test. The data obtained during this calibration will be recorded in the test log for reference. This calibration does not need to be performed before each test, but should be performed daily if the testing continues for multiple days.

Equipment Required:

1. A calibrated digital multimeter

2. A span gas hydrogen standard between 6,000 and 9,000 ppm in balance air is available for calibration. (Include the calibration gas certification data from the calibration gas data sheet in Appendix B and record the value in the test log.)

3. A zero gas standard of bottled laboratory or breathing air is available for calibration. (Include the available gas certification data on the calibration gas data sheet in Appendix E and record the value in the test log.)

Prerequisites:

1. The SMC has been installed in the test duct assembly, wired to a 24Vdc power supply and the data logger.

2. The SMC sensor has been powered for a minimum of 10 minutes prior to beginning calibration.

Calibration Steps:

1. Establish the FGI spoolpiece duct test flow conditions. The flow will be set to nominally 200 SCFM.

2. Determine the sensor gas flow rate at the test duct flow rate, by reading and recording, in the test log, the value indicated on the sensor assembly rotameter.

3. Turn OFF the duct flow blower.

4. Place the system three way flow selector valve in the position to provide the cell with calibration gas.

5. Connect the air standard zero gas to the assembly calibration port and adjust calibration gas flow for the flow measured with the system flow at nominally 200 SCFM. Use the guidance provided in the SMC Model 4101-02 Instruction Manual to establish a zero gas output signal from the SMC at the developed flow.

6. Connect the span calibration gas to the assembly calibration port and adjust calibration gas flow for the flow measured with the system flow at nominally 200 SCFM. Use the guidance provided in the SMC Model 4101-02 Instruction Manual to establish a span gas output signal from the SMC at the developed flow, except that the SMC span output (20 mA) shall occur at an equivalent 10,000 ppm H_2 concentration of calibration gas. (Example: With a span calibration gas of 8,000 ppm H_2 the SMC output span adjust should be set to deliver 16.8 mA or 4.2 Vdc across the 250 ohm load resistor.)

7. Repeat the zero and span gas adjustments as required.

8. Remove the calibration gases and place the three way flow selector valve in the position to provide duct sample gas to the sensor.

APPENDIX F-2

This appendix provides guidance for the calibration of the Whittaker electrochemical cell hydrogen monitoring system under test. The data obtained during this calibration will be recorded in the test log for reference. This calibration procedure should not be performed for each test, but should be performed weekly if the testing continues for an extended period of time.

Equipment Required:

1. A span gas hydrogen standard between 7,000 and 30,000 ppm in balance air or nitrogen is available for calibration. (Include the calibration gas certification data on the calibration gas data sheet in Appendix B and record the value in the test log. The selected calibration gas should be close to the expected full scale measurements to provide a more accurate calibration.)

2. A zero gas standard of bottled air or pure nitrogen is available for calibration. (Log the available gas certification data on the calibration gas data sheet in Appendix B and record the value in the test log.)

Prerequisites:

1. The Whittaker cell has been installed in the test duct assembly, wired through the intrinsic barrier module to the Newport programmable voltmeter, and the output of the voltmeter wired to the data logger.

2. The Newport voltmeter has been initially programmed per the guidance given in WHC-WM-SD-OMM-015 Rev. 0, *Standard Hydrogen Monitoring System-B Operation and Maintenance Manual*.

Calibration Steps:

The calibration of the Whittaker system will use the guidance of the approved maintenance calibration procedure, 6-TF-408 Rev. 1-B, *Whittaker Model 114D038-10 Hydrogen Cell with Newport Infinity Electronics, Calibration*, for the calibration of WEC in SHMS cabinets. However, since the component numbers in a SHMS do not relate to the components in the test assembly, the intent of the calibration procedure will be followed to control calibration gas flows and times and obtain cell output voltages. The system programming steps, identified in the procedure, will perform the actual calibration and test log entries will be made to document the calibration.

The following steps will provide general guidance.

1. Connect the zero calibration gas, air or pure nitrogen, to the WEC chamber calibration port.

2. Establish the FGI spoolpiece duct test flow conditions. The flow will be set to nominally 200 SCFM.

3. Establish a cal. gas flow of 2 CFH through the calibration port and exiting the cell. Maintain the 2 CFH flow for 15 minutes. Read and record the cell/barrier zero output voltage as displayed on the Whittaker display meter.

4. Remove the zero cal. gas from the calibration port and connect the span gas of nominally 3% hydrogen in balance air or nitrogen.

5. Establish a cal. gas flow of 2 CFH through the calibration port and exiting the cell. Maintain the 2 CFH flow for 15 minutes. Read and record the cell/barrier span output voltage as displayed on the Whittaker display meter.

6. Remove the span gas from the calibration port and purge the cell with air or nitrogen for at least 10 minutes to re-establish a baseline signal.

7. Program the Newport meter per procedure 6-TF-408 guidance based upon the zero and span gas data gathered.

APPENDIX F-3

This appendix provides guidance for the calibration of the Microsensor Technology Incorporated (MTI) model M200D gas chromatograph used to validate the gas stream hydrogen concentration. The MTI GC utilizes a personal computer and commercial software for control and data analysis. The data obtained during this calibration will be recorded in the test log for reference and maintained in a permanent data file to be provided as part of Appendix C. Since this is concentration measurement standard, the calibration should be performed daily to assure that the GC is reading the correct value.

Equipment Required:

1. A span gas hydrogen standard of nominally 1,000 ppm in balance air or nitrogen is available for calibration. (Verify that the calibration gas certification data has been included in the calibration gas data sheet in Appendix B and recorded in the test log.)

Prerequisites:

1. The GC, its associated lap top personal computer (PC) and gas sample pump have been installed per the test configuration.

2. Calibration and carrier gases have been installed per the test configuration.

Calibration Steps:

1. Verify that the nitrogen carrier gas regulator (PCV-2) has been set to 80 psig and the bottle isolation valve (MV-2) is OPEN.

2. Energize the GC and PC and establish a sampling routine per the test director.

3. CLOSE the sample bypass isolation valve (MV-4) and OPEN the calibration gas isolation valve (MV-5).

4. Adjust the cal. gas flow control valve (FCV-5) to provide a cal. gas flow between 2 and 2.5 CFH as indicated by the cal. gas rotameter (FI-5).

5. Adjust the GC sample flow control valve (FCV-4) to provide a sample flow between 15 and 30% as indicated on the GC sample gas rotameter (FI-4). Record that flow value in the test log for reference during subsequent testing.

6. Continue to analyze the calibration gas until the variations between three samples is less than 10 ppm. Perform a calibration per the system software and record the next three analyzed values in the log as indication of calibration. The calibration file shall be named with the date and identified as a calibration and saved for inclusion in the test report Appendix C.

Example: 02077cal (Feb. 07,1997 calibration)

7. Restore the configuration to allow duct gas sampling.

APPENDIX F-4

This appendix provides guidance on establishing the main duct test flows and should be performed whenever the required duct flow is changed. The flow meter used to measure the main duct flow is a Meriam laminar flow element Model 50MC2-4 S/N 757200-K1. The flow element provides a linear differential pressure output of 8.0 "H_2O at a flow rate of 424.6 CFM at standard pressure (14.695 psia) and temperature (70°F).

Assumptions:

The flow element calibration curve renders a calibration factor of 3.72"H_2O at 200 CFM with a slope of 0.0188"H_2O per CFM calculated between 180 CFM and 220 CFM.

Background:

The actual differential pressure output of the laminar flow element is affected by system pressure as well as gas temperature and viscosity. The output will reflect an equivalent flow value (SCFM*) that is related to the equation:

SCFM* = SCFM X (14.695 psia / Pg) X (Tg / 530°R) X (ug / 181.87 micropoise)

Pg = System pressure in absolute psia
Tg = System temperature in degrees Rankin (°R = 460 + temp. in °F)
ug = System viscosity in micropoises

For this test the main duct flow will be air, which will take the system viscosity factor to 1. Temperature and pressure will be considered in the actual calculation but for all practical purposes, those factors should also be 1.

Flow Adjustment and Calculation:

1. Verify all the instrumentation systems are energized and select the data logger channel A7 to monitor the main duct flow T/C.

2. Energize the system blower motor and adjust the throttle valve for the desired differential pressure across the flow element. The initial differential pressure as read on FT-1 should be 3.72 "H_2O for 200 SCFM.

3. Once the flow pressure value is obtained, read and record the flow element absolute system pressure indicated on PT-1.

4. Read and record the duct air temperature in °F.

5. Calculate the equivalent SCFM* flow in the duct using the equation given above.

6. If the calculated flow is not within 5 SCFM of the desired flow, make a slight flow adjustment and recalculate the equivalent flow.

7. Record the measured temperature, differential pressure, absolute pressure and calculated flow on the appropriate test data sheet.

8. Measure the 10 inch diameter duct length between the hydrogen gas injection port and the center of the sensors in the FGI spoolpiece and record that value on the data sheet. Calculate and record the results, on the appropriate data sheet for the duct flow velocity and transport time. Use the simple formulas below.

A = Duct Area (Sq. Ft.)
V = Flow Velocity (Ft./Sec.)
F = Flow Rate (SCFS)
L = Duct Length (Ft.)
T = Transport Time (Sec.)

$A = \pi R^2$

$V = F \div A$

$T = V \div L$

APPENDIX F-5

This appendix provides guidance on establishing the hydrogen injection flows and should be performed for each new concentration value or whenever the main flow has changed. The flow meter used to measure the main duct flow is a Meriam laminar flow element Model 50MJ10-10. The flow element provides a linear differential pressure output of 8.0 "H_2O at a flow rate of 1.6087 CFM at standard pressure (14.695 psia) and temperature (70°F).

Assumptions:

Since the injection flows will vary over a wide range of the flow element, the average flow calibration value will be used for the testing. The flow element calibration factor is listed above as providing a differential pressure of 8.0 "H_2O for a flow rate of 1.6087 CFM at standard pressures and temperatures and viscosity of air.

Background:

The actual differential pressure output of the laminar flow element is affected by system pressure as well as gas temperature and viscosity. The output will reflect an equivalent flow value (SCFM*) that is related to the equation:

SCFM* = SCFM X (14.695 psia / Pg) X (Tg / 530°R) X (ug / 181.87 micropoise)

Pg = System pressure in absolute psi
Tg = System temperature in degrees Rankin (°R = 460 + temp. in °F)
ug = System viscosity in micropoises
(ug for hydrogen at 70 °F is 87.6 with a slope of 0.11/ °F)

For this test the injection flow viscosity will change significantly between the 3-5% hydrogen and the 99.9% hydrogen injection gas. Viscosity, temperature and pressure shall be considered in the actual calculation.

Flow Adjustment and Calculation:

1. Verify all the instrumentation systems are energized and select the data logger channel A8 to monitor the injection flow T/C.

2. Energize the system blower motor and adjust the throttle valve, as necessary, for the required test flow (listed in TABLE 1) per Appendix F-4.

3. Calculate the nominal pressure expected across the flow element for the desired injection gas concentration using the above equation.

4. Verify that the GC is sampling the gas stream.

5. Open the injection gas (3-5% or 100% H_2) bottle regulator isolation valve and energize the isolation solenoid valve. Open the injection line isolation valve MV-1 and adjust the regulator pressure to provide the desired differential pressure.

6. **Verify that the GC is indicating the nominal mixed gas concentration and that it has not exceeded 10,000 ppm (25% LFL) of hydrogen.**

7. Measure and record in the log, the following injection port parameters:

* Injection gas regulator delivery pressure
* Flowmeter differential pressure in "H_2O
* Flowmeter inlet pressure in psia
* Injection gas temperature in $^{\circ}F$

8. Using the parameters measured, recalculate the equivalent *SCFM and the anticipated mixed gas concentration.

9. Verify that the GC is indicating the nominal mixed gas concentration.

10. Iterate on the flow adjustments as necessary to obtain the desired mixed gas concentration. **ASSURE THAT THE GC MEASURED CONCENTRATION REMAINS BELOW 10,000 ppm OR 25% OF THE LOWER FLAMMABILITY LIMIT FOR HYDROGEN.**

11. Record the final GC measured and calculated concentration values and measured temperature, differential pressure, absolute pressure and calculated flow on the appropriate test data sheet and in the log.

12. Close the injection gas isolation valve MV-1 to isolate the injection flow. **DO NOT CHANGE THE REGULATOR SETTING**

13. Open the nitrogen purge bottle isolation valve and adjust the nitrogen purge gas regulator (PCV-7) to 10 psig and open the purge isolation valve MV-7 to purge the hydrogen injection line for 1 minute.

14. Close the nitrogen bottle isolation valve and the injection line purge isolation valve MV-7.

15. Allow the main flow to sweep out the hydrogen and allow the instruments to return to a low baseline value prior to performing the response time test. The baseline value shall be less than 5% of the final anticipated value. The Whittaker cell may be purged with air through the calibration port to expedite the purging process.

APPENDIX F-6

This appendix provides guidance on the performance of the FGI hydrogen sensor response testing. This appendix will be repeated for each set of test parameters identified by TABLE 1. The Initial Conditions are preparation for each test segment and should therefore be verified as a checklist prior to performing the following procedural steps.

Initial Conditions:

* All of the hydrogen monitoring instruments have been calibrated and are ready for testing.

* The main duct flow has been adjusted and is flowing at the flow required by TABLE 1.

* The injection flow pressure regulator has been adjusted and duct gas concentrations verified per Appendix F-5.

* The data logger system is prepared to log data.

* Verify the test valve lineup as follows:

MV-1 CLOSED MV-2 OPEN MV-3 CLOSED
MV-4 OPEN MV-5 CLOSED MV-6 CLOSED
MV-7 CLOSED (USED ONLY FOR INJECTION GAS LINE PURGE)
EV-1 ON (OPEN) EV-2 ON (OPERATED BY THE GC)

* Verify the PCV settings as follows:

PCV-1	ADJUSTED FOR TESTING PER APPENDIX F-4
PCV-2	ADJUSTED TO 80 PSIG
PCV-3	MINIMUM (NOT USED)
PCV-6	MINIMUM (NOT USED)
PCV-7	10 PSIG (USED FOR INJECTION GAS LINE PURGE)

* Verify the following flows and adjust their associated FCV as required.

FI-3 2 CFH
FI-4 15-30% (SAME AS FLOW DURING GC CALIBRATION)
FI-5 MINIMUM (NOT USED)

Procedure:

1. START the GC sampling duct gas with a unique file name to store the concentration values. The file names shall be identified as to date and test number. Example: 020771-1 (Feb. 7, 1997 test 1-1)

2. Simultaneously START the data logger recording at a 5 second sample rate and OPEN the injection gas regulator isolation valve MV-1.

3. **VERIFY THAT THE DUCT GAS CONCENTRATION AS READ ON CG-1 IS LESS THAN 10,000 ppm (25% LFL OF HYDROGEN IN AIR).**

4. RECORD the process variables for 15 minutes to assure the final concentration value is obtained. Record the measured concentration values for the SMC and Whittaker at 2 min., 14 min. 30 sec. and 15 min.

5. CLOSE the injection gas regulator isolation valve MV-1 and OPEN the injection gas line purge valve MV-7 to purge the injection gas line. Purge for 1 minute.

6. CLOSE the purge gas isolation valve MV-1.

7. Allow the system main duct flow to continue until the hydrogen measuring instruments indicate background values. The background values are defined as less than 5% of the final value measured. The Whittaker cell may be purged with air through the calibration port to expedite the purging process.

DISTRIBUTION SHEET

To	From	Page 1 of 1
DISTRIBUTION	Characterization Projects	Date Feb. 10, 1997
Project Title/Work Order		EDT No. 619506
Rotary Mode Core Sampling / N4H2B		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
CB Bryan	S7-01	X			
CE Hanson	S7-12	X			
JA Ranchau	S7-07	X			
GP Janicek	S7-12	X			
TD Jarecki	S7-03	X			
ML McElroy	S7-07	X			
RE Raymond	S7-12	X			
MJ Schliebe	L6-13	X			
TC Schneider	L6-37	X			
JS Schofield	S7-12	X			
DD Tate	L6-37	X			
GF Vargo Jr.	H5-09	X			
EJ Waldo	S7-12	X			
KS Witwer	L6-13	X			
Central Files	A3-88	X			