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Interim Report on

# DETERMINATION OF THE MINIMUM ELECTROMAGNETIC FIELD INTENSITY REQUIRED TO IGNITE A HYDROGEN-AIR GASEOUS MIXTURE

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# SECTION I
# INTRODUCTION

## A. PURPOSE

The primary purpose of this investigation is to determine the minimum electromagnetic field intensity required to produce sufficient energy to ignite a hydrogen-air gaseous mixture encompassing two receiving antenna elements. Arcing was caused by manual separation of the antenna elements when positioned in an electromagnetic field.

## B. SCOPE

The information presented in this report provides a narrative, graphic and analytical description of test data obtained while illuminating two elements of a dipole receiving antenna with RF energy at 260 MHz. The two one-quarter wavelength elements forming the dipole were connected and separated in a hydrogen-air atmospheric chamber.

## C. TEST EQUIPMENT

A drawing of the hydrogen chamber used in this test is illustrated in figure 1. The enclosed volume of the chamber with the antenna elements inserted is 22 cubic centimeters (cc). The dipole antenna elements were steel rods designed to be resonant at 260 MHz. A standard medical 5-cc Stylex syringe was used to inject a specific volume of hydrogen. Additional equipment used in this test is listed in table I.

TABLE I. TEST EQUIPMENT LIST

| Item | Manufacturer | Model | Serial No. |
|---|---|---|---|
| Meter, Field Intensity | Fairchild | EMC-25 | 250158-R |
| RF Signal Generator | Philco | 470-A-500 | 208 |
| Antenna, Illuminating | Stoddart | 91870-2 | |
| Antenna, Tripod | Stoddart | 91933-2 | |
| Antenna, Field Intensity | Stoddart | DM-105-T3 | 72 |
| Hydrogen Supply | General Monitors | | |

## SECTION II
## DESCRIPTION

### A. GENERAL

The primary objective of this report is to demonstrate the possibility of igniting a hydrogen-air gaseous mixture from a spark produced by making and breaking contact between the elements of an energized RF receiving antenna.

This effort is a continuation of a study initiated by NASA under Contract NAS10-5173 to investigate RF phenomena associated with Saturn launch site environment[3]. The results of this previous study indicated that if sufficient RF energy was available at the Saturn V launch site the hydrogen-air gaseous mixture might ignite, assuming the metal structures in the area act as RF receiving antennas. The first part of this report contains the results of experiments attempting to ignite a hydrogen mixture with RF energy radiated at 260 MHz. The final part of this report indicates the direction for future studies in this area.

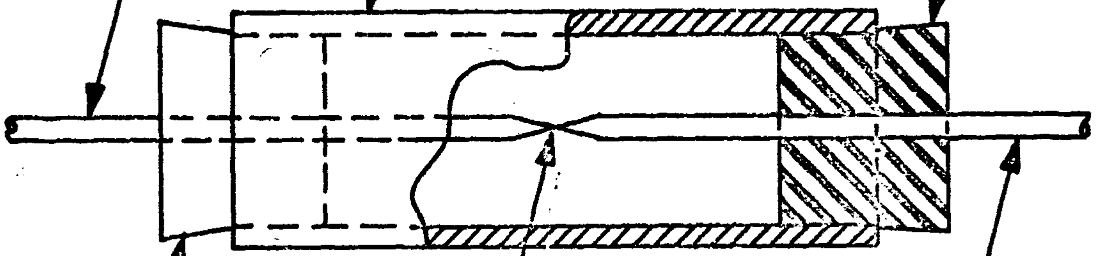
### B. TEST PROCEDURE

The hydrogen-air environment encompassing the two elements forming the RF receiving dipole antenna was contained in a sealed tygon chamber as shown in figure 1.

The two antenna elements penetrating the rubber plugs of the chamber were machined to a point forming the electrodes. The hydrogen was injected between the plug and tygon wall with a 5-cc Stylex syringe. Seven cubic centimeters of hydrogen were injected, and the syringe needle left in place momentarily to allow the chamber pressure to return to atmospheric pressure. Since the chamber volume was 22 cc with the antenna elements in position (electrodes touching), the 7 cc of hydrogen injected produced approximately a 30 percent hydrogen-air gaseous mixture which requires the minimum ignition energy at one atmosphere (see figure 2).

The RF energy source used in this experiment was a Philco 80-watt RF signal generator coupled to a Stoddart dipole antenna which was tuned to be resonant at 260 MHz. The hydrogen chamber antenna (HCA) apparatus formed by the two one-quarter wavelength elements as shown in figure 3 was measured and fabricated to be resonant at 260 MHz. The initial testing to determine the

[3]Morissett (see Appendix)




CHAMBER DATA

Gas ..........30% Hydrogen, 70% Air
Temperature ..75°F
Pressure .....1.0 Atmosphere
Volume ......22.0 cc

Figure 1. Hydrogen Chamber Antenna Apparatus

feasibility of electrode sparking caused by RF energy was performed in the RF Shielded Room at the CIF Building with an antenna spacing of 1.15 meters. The signal generator was tuned to 260 MHz and was operated with an output of 80 watts.

An insulated handle was attached to one end of a receiving one-quarter wavelength element so that it could be used in manually opening the gap between the elements, thereby disrupting the electrical continuity of the antenna inside the hydrogen chamber. Sparks were observed when the elements of the energized antenna were separated in a dark room. There was no hydrogen in the chamber at this stage of the experiment.

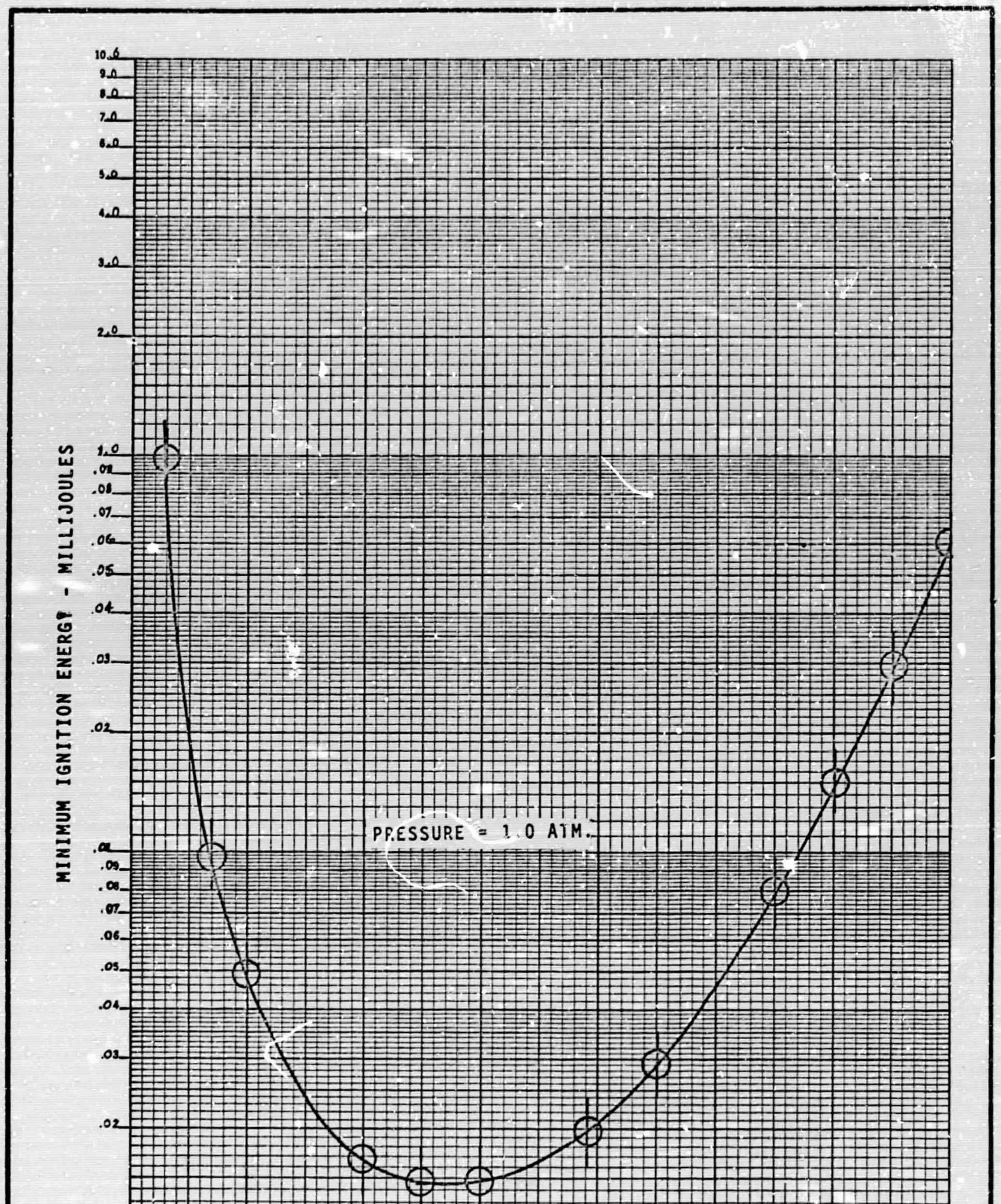



Figure 2. Minimum Ignition Energy Versus Percent of Hydrogen in Air

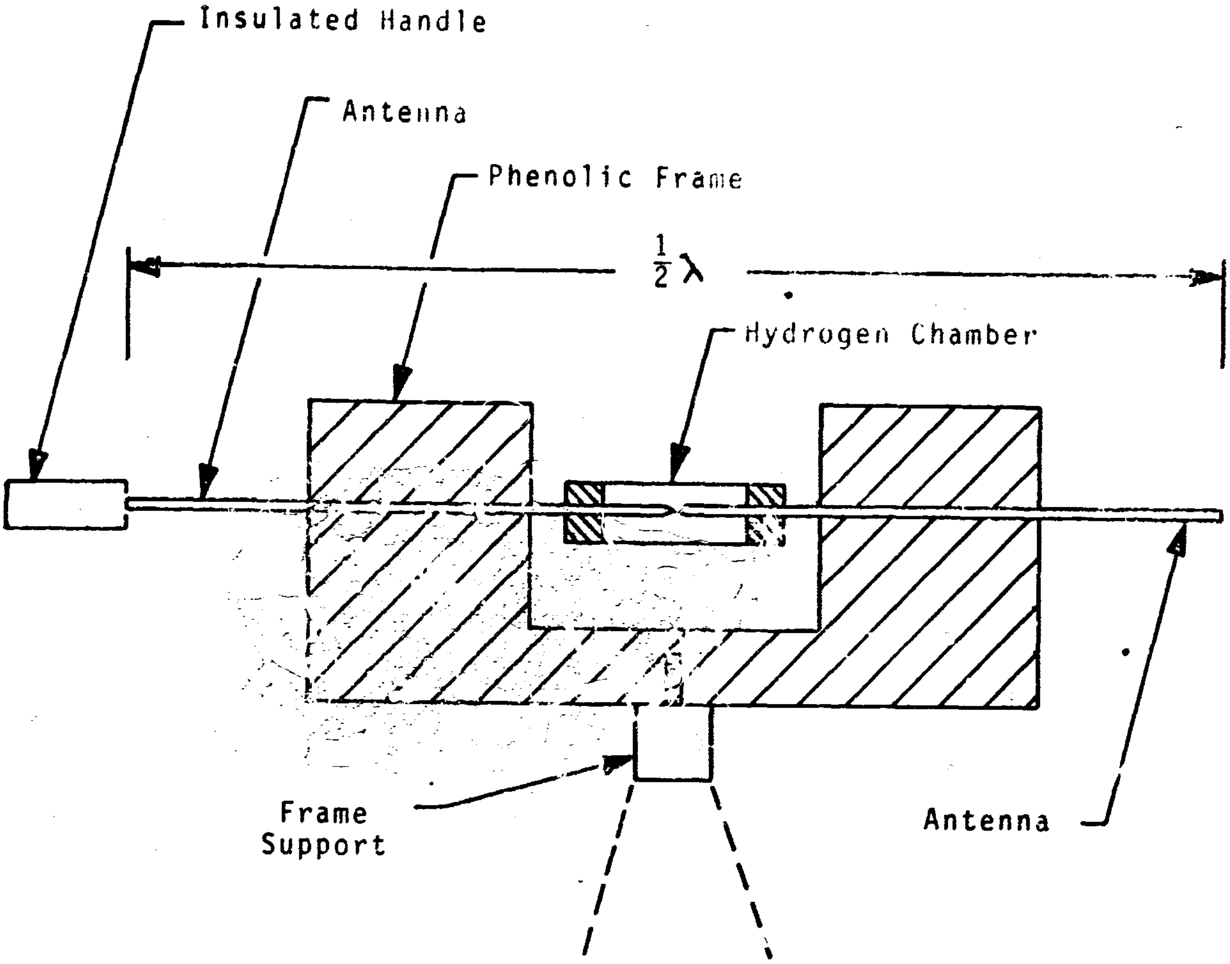



Figure 3. Hydrogen Chamber Antenna Apparatus Mounted

The HCA radiating equipment and measuring instruments listed in table I were arranged on the roof of the CIF Building as shown in figure 4. The roof was selected since power was available there, and being open, eliminated the possibility of hazardous concentrations of hydrogen gas. After radio frequency clearance was obtained, the signal generator was set at 260 MHz and operated at 80 watts. A 7-cc volume of hydrogen was injected into the hydrogen chamber, producing a 30 percent hydrogen-air gaseous mixture. The hydrogen chamber antenna apparatus was positioned at a distance of five wavelengths from the transmitting antenna and moved progressively closer to the signal source. Test data is presented in table II.

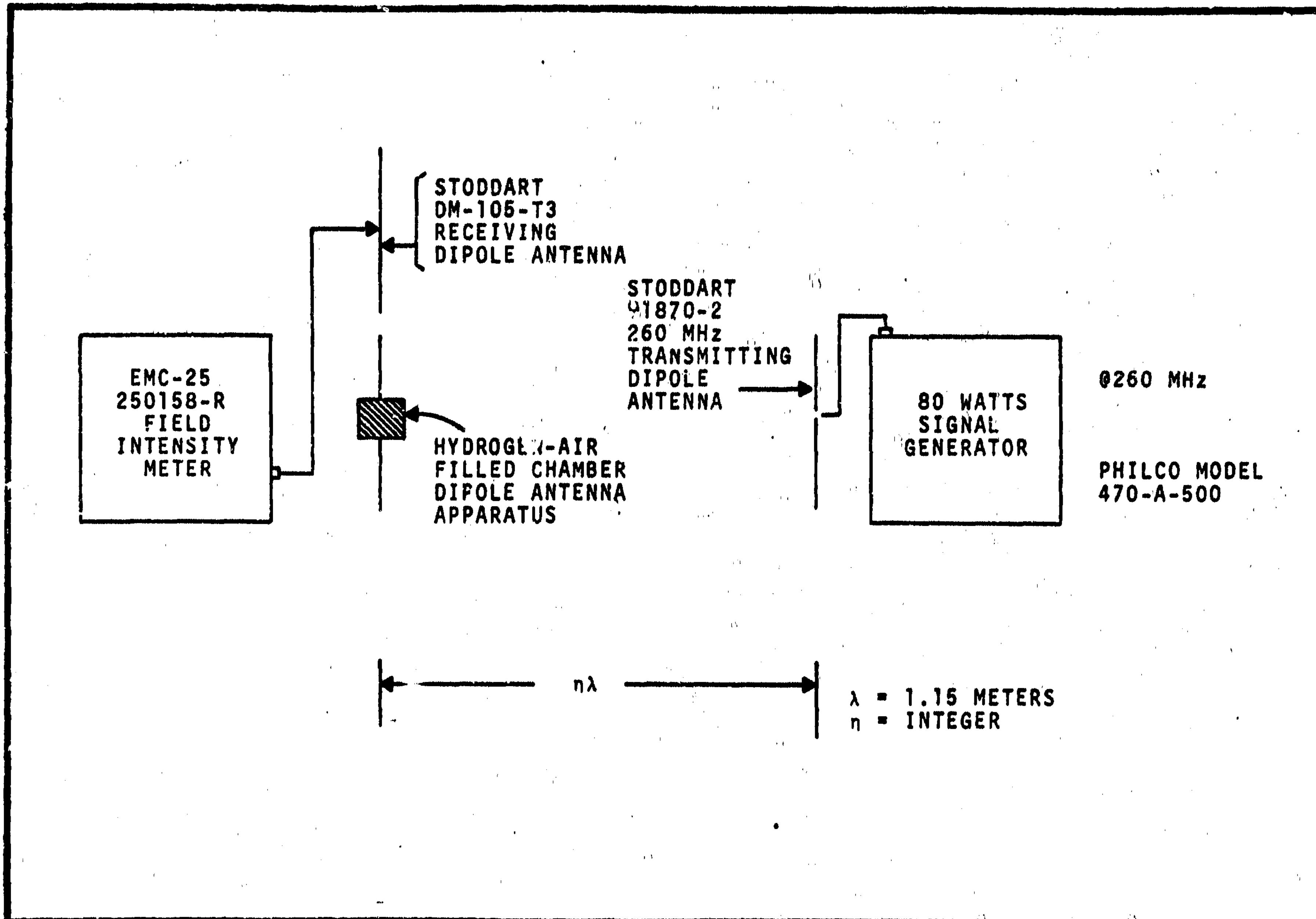



Figure 4. Hydrogen-Air Gas Antenna Spark Ignition Experiment Equipment Schematic.

TABLE II. TEST DATA

| Distance From Source (Wavelength) | Radiating Power (Watts) | Chemical Reaction |
|---|---|---|
| 5 | 80 | None |
| 4 | 80 | None |
| 3 | 80 | None |
| 2 | 80 | None |
| ½ | 80 | None |

## C. TEST RESULTS

From the data of table II, it appears that regardless of the distance between the radiation and receiving antennas, ignition of the gaseous mixture could not be detected. It was concluded that either (1) hydrogen ignition could not be detected, or (2) there was insufficient energy for ignition.

Since sparking could not be observed due to the daylight the equipment was transferred to the RF Shield Room and set up under the same conditions, using a 30 percent hydrogen atmosphere. With the Shielded Room darkened, sparking was observed between the receiving element electrodes when radiating with RF energy. Again, the Hydrogen-Air Gaseous mixture failed to ignite. To verify that ignition of the gaseous hydrogen mixture could be detected, a 10Vdc power supply was connected to the HCA device and was adjusted to produce a current flow of 100 milliamps. Separation of the antenna elements resulted in ignition of the Hydrogen-Air mixture which was clearly evident. The resulting rapid chemical reaction forced the one-quarter wavelength element support plug out of the chamber and caused a sharp report.

The antenna hydrogen chamber apparatus was removed and replaced by a Stoddart, Model DM-105-T3 dipole antenna positioned at a distance of 1.15 meters from the 80-watt signal source.

An EMC-25 field intensity meter was connected to the DM-105-T3 dipole antenna for a field strength measurement. The EMC-25 indicated a field strength of 118 dB above a microvolt per meter at 260 MHz, which produces a power density level of 12.6 milliwatts per square meter. This field strength level will produce an induced voltage in the one-half wavelength dipole antenna of approximately 0.5 volt.

## SECTION III
## CONCLUSION AND RECOMMENDATION

### A. CONCLUSION

It must be concluded from previous work[3] that an illuminated antenna sparking or arcing in a flammable gaseous environment is a potential problem. The test results compiled in this report indicate that sparking between antenna elements does not necessarily indicate sufficient energy to ignite the hydrogen-air mixture. A frequency of 260 MHz was selected since it is common to the launch site RF environment.

However it appears that much larger antennas and lower radiating frequencies will be required to provide sufficient energy in a receiving antenna to ignite a hydrogen-air gaseous mixture.

### B. RECOMMENDATION

Future efforts should be directed at determining specific antenna parameters such as length and inductance sufficient for RF energy to induce electrical current capable of igniting hydrogen-air gaseous mixtures.

[3]Morissett (see Appendix)

## APPENDIX
## REFERENCES


1) Loeb, L.B., Basic Processes of Gaseous Electronics, Academic Press, 1961.

2) Brown, S.C., Introduction to Electrical Discharges in Gases, J. Wiley & Sons, Inc. 1966.

3) Morissett, S., Study of RF Phenomena Associated with Saturn Launch Site Environment. IITRL, No. E6019

## APPROVAL

**DETERMINATION OF THE MINIMUM ELECTROMAGNETIC FIELD INTENSITY REQUIRED TO IGNITE A HYDROGEN-AIR GASEOUS MIXTURE**

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