HAZARD STUDIES WITH HYDROGEN AND OXYGEN IN THE LIQUID AND SOLID PHASES*

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INTRODUCTION

There are many undetermined hazards associated with the use of the cryogenic hydrogen–oxygen propellant system at low pressures equivalent to high altitudes. Among these hazards are those which may be associated with rupture of tanks or feed lines, leakage, or venting. The conditioning and chilldown of systems during the preignition stages of engine operation provide other potentially dangerous situations.

The purpose of the present program was to determine the nature and extent of the hazards associated with the ignition of the various condensed-phase hydrogen–oxygen systems. During the program, studies were conducted under various conditions of total pressure, mixture ratio, ignition source, and confinement. The ambient pressure levels of interest were 55 to 75 mm Hg for the phase system liquid hydrogen–liquid oxygen, 10 to 45 mm Hg for the liquid–solid system, and below 2 mm Hg for the solid–solid system. The sources of ignition investigated were hot-surface, hot-wire, flame, spark, and impact. The fuel–oxidant ratio varied from 0.2 to 5 times equivalence, and the experiments were performed under both confined and unconfined conditions. Equivalence is defined as the actual fuel–oxidant ratio over the stoichiometric fuel–oxidant ratio.

EXPERIMENTAL APPARATUS

The apparatus used for this study is shown schematically in Fig. 1. It consisted of a 4 ft × 10 ft cylindrical vacuum tank with a ½-in. thick wall. There were 10 ports for viewing and instrumentation. A 750 ft³/min vacuum pump evacuated the chamber to the desired pressure. Propellants were transferred to small glass flasks from dewars located on opposite sides of the tank. Various cutting or crushing devices were used to break the flasks. The freed propellants were then subjected to the ignition sources being investigated. The ignition sources were as follows:

1. Hot surface—a 4 in. × 4 in. × 0.003 in. nickel sheet heated to 700–1000°C in about 5 sec.
2. Hot wire—a grid of heating element wire strung at ½ in. separation, and stretched on insulators fixed to a 4 in. × 4 in. Teflon sheet.

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Fig. 1. Schematic arrangement of the apparatus.

Fig. 2. Schematic diagram of the instrumentation.

3. Spark—800 V at 20 mA repeated 60 times per second for unconfined runs and a continuous source of 15 kV at 15 mA for confined experiments.


5. Impact—air operated piston and 36-lb opposing lead weights to which a ½-in. hardened flat-faced pin was affixed. These weights were dropped 14½ in.

The apparatus for the confined experiments was similar to that used for the unconfined experiments, except for the capacity of the reaction container in which the propellants were mixed. The confining volume consisted of a 4½ in. x 4½ in. x 7½ in. box. Three sides of the box were closed in with aluminum, while the other three sides were covered