March 1971

Brief 71-10041

AEC-NASA TECH BRIEF

Space Nuclear Systems Office

AEC-NASA Tech Briefs announce new technology derived from the research and development program of the U.S. AEC or from AEC-NASA interagency efforts. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

An Unconfined, Large-Volume Hydrogen/Air Explosion

During the development of the nuclear rocket, an experiment was conducted to measure acoustic sound levels during the release of hydrogen at high flow rates into the atmosphere. It was desirable to flow once with and once without the hydrogen flared in order to isolate combustion noise from flow noise. It was recognized that hydrogen autoignition might occur at any time, that such autoignition would require experiment abort, and that damage might result. Autoignition did in fact occur, the experiment was aborted, and attention was diverted to studying the possible sources and documenting the damage that resulted from the deflagration of 283 m^3 (10,000 ft^3) of gas.

Autoignition of the hydrogen occurred during the shutdown portion of the unburned hydrogen run, as flow was being reduced. Before the tests began, three potential causes of autoignition were recognized:

(1) Electrification of the gas,
(2) Electrification of the particles carried in the gas, and
(3) Incandescence of large particles.

After the explosion, a fourth possibility — and the one that appears most probable in this case — was discovered. A metal rod that was welded across the mouth of the nozzle through which the hydrogen was exhausted had torn loose at one end; the rending action may have been the ignition source.

The closest observers, 0.8 km (0.5 mi) away and in the open, detected no pressure wave. Yet others 3.2 km (2 mi) away and in or near control point buildings reported windows rattling. A shed 85.3 m (280 ft) away was damaged, and the immediate area suffered widespread, superficial damage, most of which appeared to have resulted from the negative phase of the shock wave. A reasonable engineering estimate was that overpressure and negative pressure were about 3.4 and 1.7 kN/m^2 (0.5 and 0.25 psi), respectively. The photographs taken during the explosion indicated a pressure-wave velocity of about 335 m/sec (1100 ft/sec).

Calculations based on the physical size of the explosion revealed that only about 90 kg (200 lb) or 10%, of the hydrogen exploded. Evidently, this was attributable to the gas being too dilute, which was probably promoted by the high discharge rate of the gas 1.2 km/sec at 54 kg/sec (4000 ft/sec at 120 lb/sec).

It was concluded that, in the release of a large quantity of hydrogen into the atmosphere, autoignition would produce an "explosion" which could be described as a deflagration of explosive velocity, with a shock wave of about sonic velocity, with minor damage potential. This test constitutes the only known measured observation of such a great volume of exploding hydrogen, and should be of interest to suppliers and users of the gas.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
AEC-NASA Space Nuclear Systems Office
U.S. Atomic Energy Commission
Washington, D.C. 20545
Reference: TSP71-10041

Patent status:

No patent action is contemplated by the AEC or NASA.

Source: R. Reider, H. J. Otway, and H. T. Knight of
Los Alamos Scientific Laboratory
under contract to
AEC-NASA Space Nuclear Systems Office
(NUC-11000)
Category 03