NASA TECHNICAL NOTE

NASA TN D-3965

NASA TN D-3965

N67-26544

(ACCESSION NUMBER)

8

(PAGES)

(NASA CR OR TMX OR AD NUMBER)

(THRU)

1

(CODE)

11

(CATEGORY)

FACILITY FORM 602

# NITROGEN TETROXIDE DISPOSAL UNIT COMBUSTION PRODUCTS

*by Irwin D. Smith*

*Manned Spacecraft Center*
*White Sands Test Facility*
*Las Cruces, New Mexico*

GPO PRICE $ ______

CFSTI PRICE(S) $ 3.00

Hard copy (HC) ______

Microfiche (MF) .65

ff 653 July 65

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • MAY 1967

NASA TN D-3965

# NITROGEN TETROXIDE DISPOSAL UNIT COMBUSTION PRODUCTS

By Irwin D. Smith

Manned Spacecraft Center
White Sands Test Facility
Las Cruces, New Mexico

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

For sale by the Clearinghouse for Federal Scientific and Technical Information
Springfield, Virginia 22151 – CFSTI price $3.00

## ABSTRACT

A test program was conducted to determine the identity of the combustion products released to the atmosphere by the units utilized to dispose of nitrogen tetroxide. Samples of the combustion products were collected and analyzed by infrared spectroscopy. The samples obtained when the unit was operated in the normal, slightly fuel-rich mode showed the detectable combustion products to be carbon dioxide, water vapor, and unburned propane or other carbon-hydrogen bond-containing materials.

# NITROGEN TETROXIDE DISPOSAL UNIT COMBUSTION PRODUCTS

By Irwin D. Smith
White Sands Test Facility

## SUMMARY

The White Sands Test Facility utilizes vapor disposal units to dispose of nitrogen tetroxide by burning with propane. A test program was conducted to determine the identity of the combustion products released to the atmosphere during normal operation of the units. Samples were collected at various oxidizer-to-fuel ratios and analyzed by infrared spectroscopy. The samples obtained when the unit was operated in the normal, slightly fuel-rich mode showed the detectable combustion products to be carbon dioxide, water vapor, and unburned propane or other carbon-hydrogen bond-containing materials.

## INTRODUCTION

The White Sands Test Facility utilizes a nitrogen-tetroxide disposal unit to dispose of excess nitrogen tetroxide resulting from various test operations conducted on site. The units are used to dispose of nitrogen tetroxide in the oxidizer storage area, in the command service module test area, and in the lunar module test area. Prior to the introduction of the disposal units, it was sometimes necessary to suspend operations in one area while venting nitrogen tetroxide in another. The units were also installed in an effort to reduce the amount of toxic material released into the atmosphere during the testing.

During the 1966 spring meeting of the Aerospace Propulsion Testing Association, numerous questions were raised concerning the identity of the combustion products emitted from the disposal units. A short series of tests was conducted during June and July 1966; the tests were designed to identify the combustion products emitted by the disposal units.

## DESCRIPTION OF DISPOSAL UNIT

The location of the disposal unit in the lunar module test area is shown in figure 1; the area is across the arroyo from the main test site. This particular unit is controlled from the blockhouse to dispose of nitrogen tetroxide that has been dumped into the vent

Figure 1. - Location of disposal unit in lunar module test area.

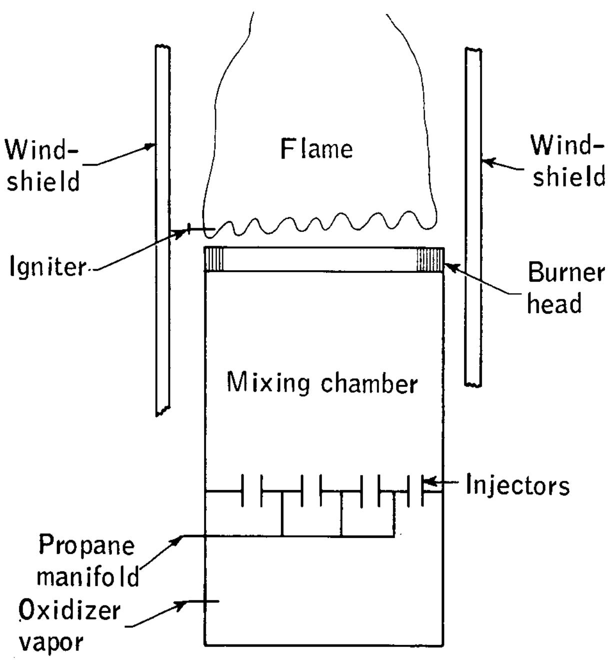


Figure 2. - Schematic of burner.

system from any of the three test stands or the holding tank. A typical installation consists of the burner unit, the control unit, the propane fuel tank, and the vent system leading to the unit.

A schematic of the burner unit is shown in figure 2. The burner consists of an injector system for the propane and the nitrogen tetroxide, a mixing chamber, a burner head constructed to minimize flashback, a spark-plug igniter system, and windshield. The rate of propane and nitrogen-tetroxide injection is controlled by remotely operated valves. Typically, the burner is started by opening the fuel valve to approximately 40 percent of full flow; by activating the spark-plug igniter system; and then by adjusting the fuel and oxidizer flows to the normal operational mode of a slightly fuel-rich flame that does not visually show the presence of red nitrogen dioxide.

The units are designed to dispose of at least 10 pounds of nitrogen tetroxide per minute.

Certain conditions, such as a complete liquid-nitrogen-tetroxide feed or a combination of high-pressure/high-nitrogen-content/low-nitrogen-tetroxide-content feed, will cause the burner flame to be extinguished. Normally, precautions are taken to prevent the occurrence of such conditions.

## THEORETICAL COMBUSTION PROCESS

Before the tests were conducted, some theoretical consideration was accorded the combustion process. Theoretically, the units dispose of nitrogen tetroxide through the equation

$$5N_2O_4 + 2C_3H_8 \longrightarrow 6CO_2 + 8H_2O + 5N_2$$

From this stoichiometric equation, the oxidizer-to-fuel ratio was calculated to be 5.2 to 1.

Assuming that the total feed to the unit were nitrogen-tetroxide rich, then incomplete combustion would occur; and such products as nitrogen dioxide, nitrogen tetroxide, nitric oxide, and nitrous oxide, in addition to the normal combustion products, could be found in the exhaust. If the oxidizer-to-fuel ratio were fuel-rich, that is less than 5.2 to 1, then such products as unburned propane, methane, ethane, and carbon monoxide, in addition to the normal combustion products, could be found in the exhaust.

These predictions do not consider the fact that the hot gases are expelled into the atmosphere. Subsequently, a portion of the unburned propane and its degradation products would be burned with the oxygen in the air rather than with the nitrogen tetroxide.

## SAMPLING

All tests of the nitrogen-tetroxide disposal unit were conducted utilizing the unit located in the oxidizer storage area. For these tests, the oxidizer storage system was modified to provide a fairly constant source of nitrogen-tetroxide vapor (mixed with gaseous nitrogen) to the disposal unit.

Figure 3 shows the technicians preparing to obtain a sample during a fuel-rich run. With the burner adjusted to the oxidizer-to-fuel ratio desired for a specific test, the samples were obtained simply by holding an inverted funnel which was connected to a flex hose leading to an evacuated 3-liter pressure bottle over the most dense portion of the flame; the sample valve on the bottle was then opened to pull in the sample. The sample system, constructed of stainless-steel or Teflon-lined components, did not appear to have reacted with the sample gases. The samples obtained with this sampling system were diluted with approximately 160 milliliters of air, due to the volume of the flex hose used to connect the sample bottle and the funnel. No attempt was made to obtain samples that could be quantitatively analyzed to determine the exact output of the unit. Since wind conditions at the White Sands Test Facility are very erratic, sampling for precise quantitative analysis would be difficult and impractical.

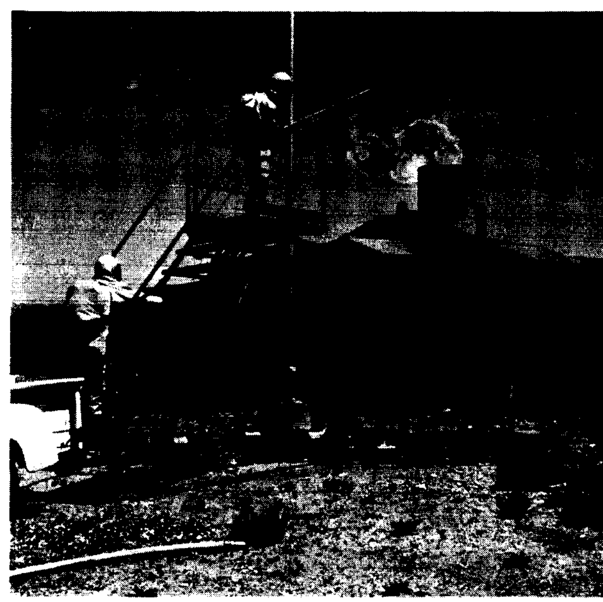

Figure 3. - Technicians preparing to obtain a sample during a fuel-rich run.

## ANALYSIS

Preliminary study of possible exhaust products indicated that the most convenient method for analysis of the samples would be an examination utilizing infrared spectroscopy. Examination by this method would not show the presence of nitrogen or oxygen since both of these gases do not absorb in the infrared-wavelength region.

Table I presents the detection limits for a number of postulated and real combustion products that absorb in the 2.5- to 15-micron infrared-wavelength region (ref. 1). The table includes several compounds not predicted by the preliminary study but postulated by some parties to be present in the exhaust from the unit.

TABLE I. - DETECTION LIMITS OF VARIOUS GASES

| Gas | Limit of detection, ppm |
|---|---|
| Nitric oxide | 1.0 |
| Nitrogen dioxide | .04 |
| Nitrous oxide | .1 |
| Hydrogen nitrate | .01 |
| Hydrogen cyanide | .04 |
| Cyanogen | .5 |
| Carbon monoxide | 1.0 |
| Carbon dioxide | .1 |
| Propane (carbon-hydrogen bond) | .1 |
| Water | 100.0 |

The laboratory examinations were conducted by transferring the gas sample to infrared gas cells having path lengths of either 10 centimeters or 10 meters, and by obtaining the infrared absorption of the samples in the wavelength region from 2.5 to 15 microns utilizing an infrared spectrophotometer.

## RESULTS AND DISCUSSION

Examination of the infrared spectra of samples obtained when the unit was operated with an oxidizer-rich feed indicated incomplete combustion by the presence of nitric oxide, and of nitrogen dioxide and its dimer nitrogen tetroxide. The spectra of the samples obtained when the unit was operated with a fuel-rich feed, or the normal operational mode, indicated the presence of water vapor, carbon dioxide, and unburned propane or other carbon-hydrogen bond-containing materials.

Cyanogen, nitrous oxide, hydrogen nitrate, hydrogen cyanide, and carbon monoxide were not detected in any of the samples.

## CONCLUSIONS

The study of the combustion products emitted by the disposal unit indicates that if the burner is operated with the mixture ratio slightly propane-rich, the combustion products do not, at least to the detection limits of the analysis method, contain any materials which present toxicity problems. The combustion products consist of carbon dioxide, water vapor, nitrogen, and unburned propane or other carbon-hydrogen bond-containing materials. The hydrocarbon emission, which would be undesirable in a smog-prone area, can be controlled to some degree by proper adjustment of the propane feed. The propane adjustment becomes particularly important when disposing of an oxidizer feed that continuously diminishes in nitrogen-tetroxide content.

The White Sands Test Facility concludes that the disposal units, after more than a year of usage, provide a very convenient, rapid, and safe method for the disposal of excess nitrogen tetroxide.

Manned Spacecraft Center
National Aeronautics and Space Administration
Houston, Texas, March 14, 1967
914-80-05-02-72

## REFERENCE


1. Pierson, R. H.; Fletcher, A. N.; and Gantz, E. St. C.: Catalog of Infrared Spectra for Qualitative Analysis of Gases. Anal. Chem., vol. 28, Aug. 1956, pp. 1218-1239.