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Pantex Plant

# HE CALORIMETRY

SANL 601-004

J. Sandoval

April, May, June 1969

ATOMIC ENERGY COMMISSION
UNITED STATES OF AMERICA

DEVELOPMENT DIVISION

MASTER

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## ABSTRACT

The 48-inch detonation sphere confined the gaseous products resulting from the discharge of approximately one-half pound (225 g) of an HE (PETN) under investigation.

Product analysis, combined with calorimetric measurements will provide data regarding the detonation processes.

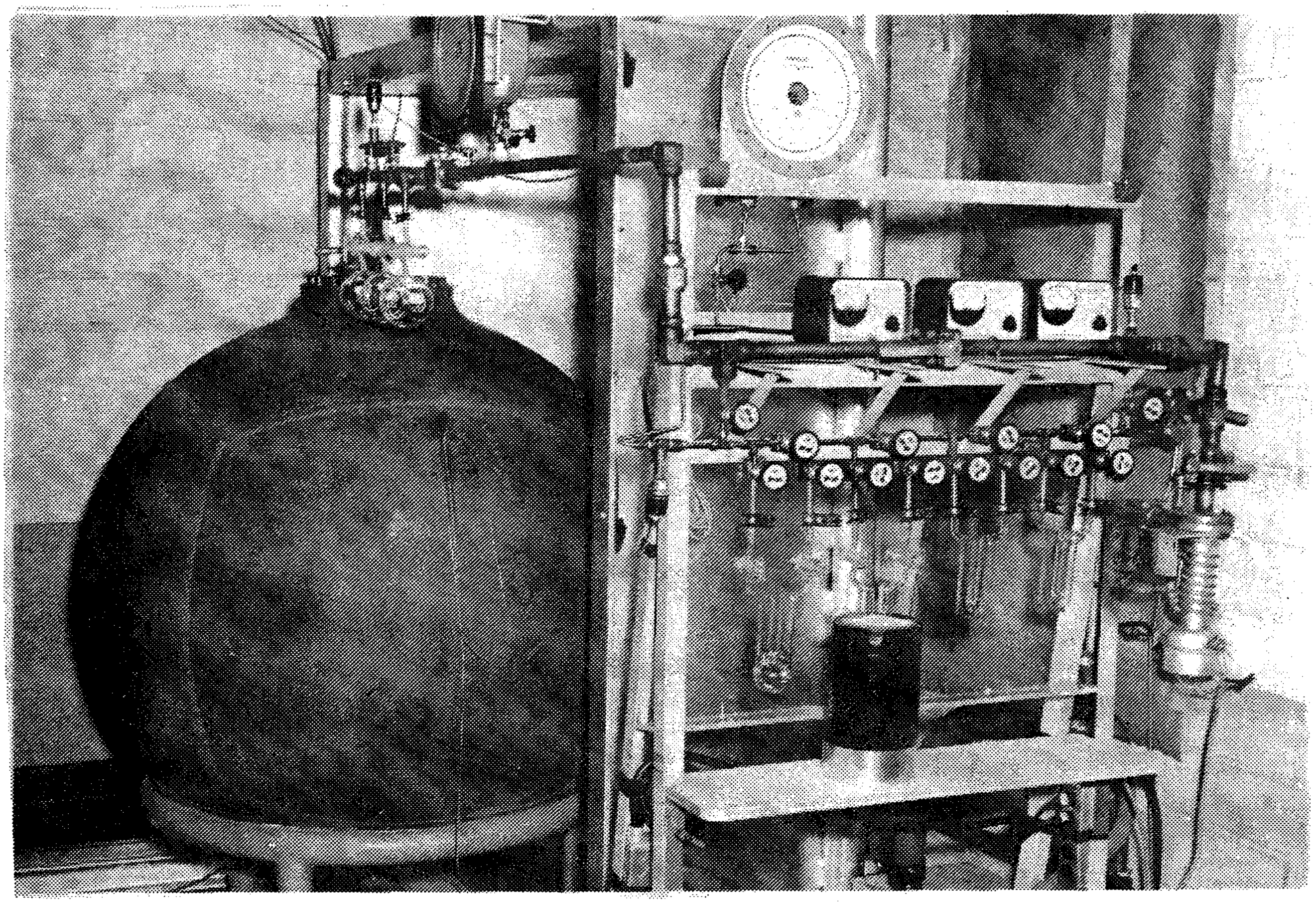
## DISCUSSION

The larger (48-inch ID) detonation sphere was designed and fabricated at Lawrence Radiation Laboratory (LRL) in Livermore, California, originally for installation at Bunker 340, Site 300. The vessel, along with its accompanying lid and stand, was shipped to Pantex and is now located in Building 11-19 (Fig. 1).

Varied explosive charges (pure CHNO explosives, and fluorine producing explosives), both confined and unconfined, of approximately one-half pound (225 g) are to be discharged in the confinement vessel; consequently, the sphere had to meet two requirements. It had to be sturdy enough to withstand repeated detonation and contain the debris and shrapnel resulting from the firing of heavily confined charges. Additionally, the vessel, as well as all auxiliary components, had to resist the corrosive effects of hydrogen fluoride produced by some explosives. Thus, the sphere was fabricated with one-inch walls. Monel was used exclusively in the construction of the sphere, auxiliary lines, and all related hardware.

On delivery of the sphere to Pantex, work was begun on the fabrication of vacuum, sampling and trapping lines. Monel tubing and valves were not readily available and considerable delay was encountered in obtaining construction supplies. Assembly of the testing facility was completed in January 1969.

The confinement sphere and all connecting lines were cleaned thoroughly, preparatory to making a volume determination. The unit was evacuated and checked



Pantex Detonation Sphere

Fig. 1

for leaks. Defective weld joints and faulty valves were discovered, and deficiencies corrected. In early March, the unit was again evacuated and a volume calibration was made. Dry carbon dioxide, 1210.12 g (27.5 moles) was introducted into the sphere (pressure: 0.692 atmosphere, temperature: 20.78°C). From the ideal gas law, PV = nRT, the calibration value,

$$V = \frac{(1210.12/44\ (0.082054)\ (293.93)}{0.692} = 958.45 \text{ liters}$$

The volume was also calculated using van der Waal's equation of state. For carbon dioxide, a = 3.592 x liters$^2$, while b = 0.04267 liters per mole. Hence,

$$(P + \frac{n^2a}{V^2})\ (V - nb) = nRT$$

$$PV^3 - PV^2nb + n^2aV - n^3ab = nRTV^2$$

$$PV^3 - (Pnb + nRT)V^2 + n^2aV = n^3ab$$

$$PV^3 - (Pnb + nRT)V^2 + n^2aV - n^3ab = 0$$

$$V = 955.52 \text{ liters}$$

Two additional volume calibrations were made since the above values disagreed. High purity gases were used: Argon {1504.657 g (37.665 moles), pressure 0.951 atmosphere, temperature 18.63°C} and Nitrogen {1014.314 g (36.208 moles), pressure 0.919 atmosphere, temperature 20.1°C}.

Calculations were made at LRL, using the Beattie-Bridgeman equation of state, and at Pantex, using van der Waal's equation. The average of these values is:

| | LRL | Pantex |
|---|---|---|
| Argon: | 947.94 liters | 947.39 liters |
| Nitrogen: | 948.21 liters | 947.44 liters |

947.74 liters has been accepted as the volume of the sphere.

Early in June preparations for the first detonation began. The sphere and all auxiliary lines and related hardware were cleaned and rechecked for vacuum and pressure stability. On June 11 the test unit was readied for the first shot. Water traps were affixed to the trapping lines and temperature sensing equipment (thermocouples, amplifiers, recorders) were calibrated and set in place.

It had previously been decided to use PETN as the initial HE to be detonated and the charge had been pressed at Pantex.

PETN Lot P-287-A

Charge No. 73055 Y 3101

Wt. = 212.8310 gm    density = 1.7645

Length = 4.1839 in.    dia. = 1.500 in.

Detonator Cavity:

depth = 0.300 ±0.001 in.

diameter = 0.270 ±0.001 in.

detonator resistance = 0.076 Ω

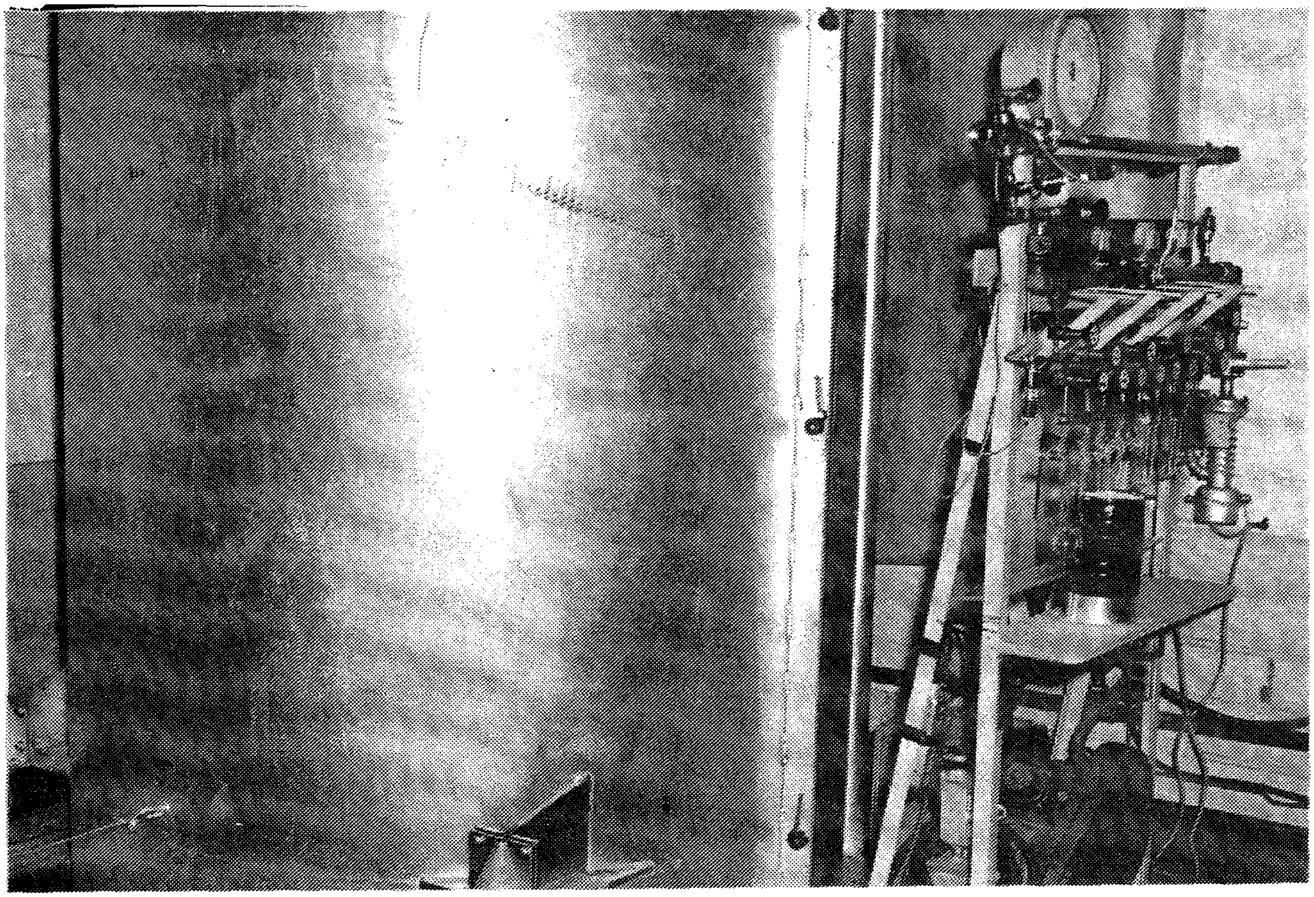
The detonator used to fire the charge was supplied by LRL and was fabricated in the following manner:

Bare 0.08 cm platinum leads were cast in an alumina body which was then sintered at 1400°C. A 0.005 cm gold bridgewire was soldered between the leads. The detonator cup, 0.64 cm ID and 1 cm in length was spun from 0.025 cm gold and was fixed to the alumina body and to the main charge with small amounts of cement. The detonator cup contained a 150 mg high density pellet of PETN next to the main charge and about 100 mg of powdered PETN packed around the bridgewire.[1]

The charge and detonator were brought into the test chamber, affixed to the HE test specimen, and the specimen was suspended centrally within the vessel by two stainless steel straps (1/16 inch thick, 3/8 inches wide, ~ 30 inches long) attached to the lid. The charge was held in position with SS wire (0.050 inch) tightened around the bent straps and charge. The external connector of the lid was shorted and the lid with the suspended charge was moved into position on the sphere and bolted. All lines and associated hardware were reassembled and evacuation of the test unit was commenced.

On the morning of June 12 final equipment adjustments were made. Pressure and temperature readings were recorded. The valve on the evacuated (to 2 μ) sphere was closed and the vacuum lines and hardware were dismantled to permit closing of the protective shield (Fig. 2). The external firing cable (shorted) was connected to the high voltage and ground terminals on the lid; the protective shield was moved into place and locked, and all personnel moved out of the restricted area. The extension firing cable was connected to the Capacitor Discharge Detonator firing Unit (CDU); the chamber door was locked, and the warning signal activated. The CDU was energized from the control room and the initial HE sample, PDS-1, was fired.

[1] *D. L. Ornellas, J. H. Carpenter, and S. R. Gunn, Rev. Sci. Instrum., 37, 907, 1966.*



Protective Shield, positioned around sphere and locked

Fig. 2

Immediately following the detonation, entry was made into the test chamber. The protective shield was removed and the vacuum and sampling lines reattached to the sphere. The sample collection flasks were affixed to the sampling line and evacuation of the same was affected.

The expected temperature rise was approximately 2.6°C:

| | |
|---|---|
| Weight sphere (incl. lid, stand) | 2300 lbs. |
| Weight stand (est.) | 100 lbs. |
| Weight sphere and lid | 2200 lbs. or 1,000,000 gm |

Sp Ht Monel = 0.13 cal/gm/°C
Approximately $C_p$ = 130,000 cal/°C

PETN, 225 gm @ 1490 cal/gm = 345,000 cal.

Expt. Temp. Rise = 345,000/130,000 = 2.6°C

From tables 10°CΔ ≅ + 0.50 mv

1°C = + 0.05 mv or 50 μv

2.6° = 125 μv

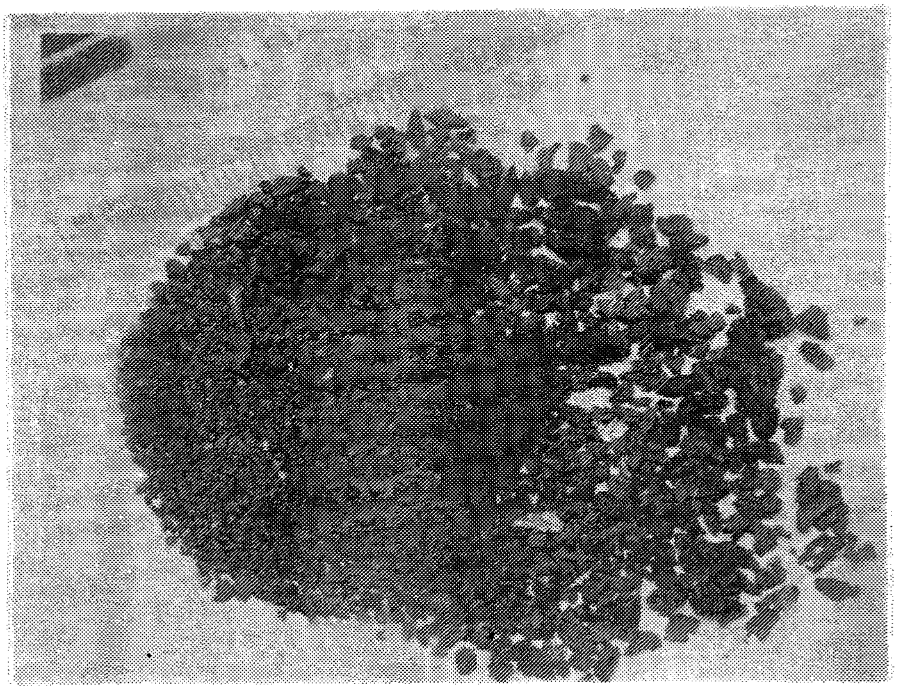
Temperature readings were taken from the strip chart recorder (μv converted to °C). The initial temperature at instant of detonation = $T_1$ = 24.47°C. The temperature at which maximum rise was recorded = $T_2$ = 25.64°C.

$$\Delta T = T_2 - T_1 = 1.17°C$$

Upon evacuation of the sampling line, the line manometer read -0.5 mm of mercury. After thermal equilibrium had been established the gaseous detonation products were admitted into the sampling line (Pr: 123.9 mm; temp.: 25.38°C) and two samples removed for analysis. One sample (PDS-1A) will be evaluated at LRL and the other (PDS-1B) will be handled at Pantex. Major components sought are $CO_2$, CO, $N_2$, $H_2$. Traces of $CH_4$, $NH_3$ and $H_2O$ are also expected. The volume (STP) of the water-free products is calculated at 114.215 liters or 5.095 moles.

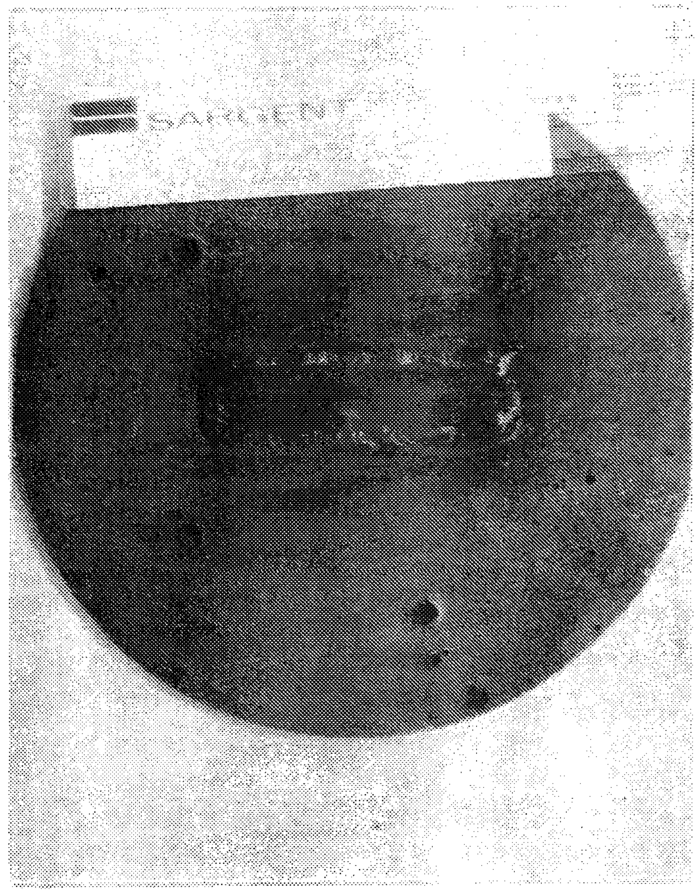
The gaseous detonation products were removed from the confinement vessel by expansion and pumping. Total time for this function was 26.5 hours. The water was collected in two in-line traps at -95°C. 40.7003 gm of the condensate was trapped. This, along with the trap rinsings, was submitted to the chemistry laboratory for determination of ammonia per Kjeldahl distillation. The total weight of ammonia was reported at 0.0112 gm, leaving a water balance of 40.6891 gm.

After extraction of all gaseous products from the containment vessel, the lines and associated hardware were dismantled and the lid removed. Examination of the vessel revealed that the explosive charge had been completely consumed. The relatively little debris in evidence (11.7 gm) was removed and collected by brushing it out through the drain port. The sweepings consisted of small irregular granular particles (Fig. 3). A light deposition of soot was noted on the walls. Some pitting was evidenced, but the scarring was confined to three small areas—at the bottom of the sphere and on the walls on opposite sides of the vessel. Pitting at the base was localized over the 6-inch diameter drain plug protective plate (Fig. 4). On the walls, the pitting was confined to small elliptical areas (approximately 8 X 20 inches) with some of the cavities measuring 0.350 inches in depth and a crater diameter of the same magnitude.



Debris resulting from first HE detonation

Fig. 3




Cavities in 1/2" monel drain plug
protective plate introduced
during first HE detonation

Fig. 4

Evaluation of the experimental data and observations is still in progress. The analyses of the gaseous products have not been completed. When all pertinent information gathered from the initial detonation is summarized, the potential as well as the limitations of the sphere will be better understood.

Originally, the sole function of the sphere was to confine the detonation products of HE for subsequent characterization and analysis. These, along with the calorimetric measurements made at LRL, were to be utilized in obtaining vital information on the detonation process.

Shortly before the initial detonation at Pantex, it was proposed that attempts be made at measuring the heats of detonation. Thus, temperature sensing devices were affixed to the walls of the sphere and temperature changes were recorded. The validity of these recordings is reliable only to the extent which conditions under which these recordings were made permit.

The building where the sphere is housed is not in a temperature-controlled area; consequently, the temperature variation in the room during a 24-hour period may be as much as ±15°F, depending on the season.

The walls of the sphere are bare and consequently affected by variations in room temperature. Insulation of the detonation sphere is being contemplated, along with the temperature controlling the room.

## FUTURE WORK; COMMENTS; CONCLUSIONS

Numerous explosives will be investigated in the Pantex detonation facility. These will consist of confined and unconfined charges, and liquid and solid explosives.

Results of the initial HE detonation are still in the process of evaluation and tabulation. The final summary of this information will be instrumental in the direction of future experimental endeavor. Investigation at Pantex will be in collaboration with and guided by the research in progress at LRL.

A new lid, still in the design stage, must be fabricated to make the detonation sphere compatible with the anticipated need in the testing of future explosives. This will necessitate the modification of the vacuum lines, but the extent of this modification is not known at this time.