In conclusion the writers desire to express their appreciation of the helpful suggestions of Major Wm. Lloyd Evans of the Chemical Laboratory of Edgewood Arsenal.

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[CONTRIBUTION FROM CHEMICAL LABORATORY, EDGEWOOD ARSENAL, EDGEWOOD, MD.]

DENSITY AND COEFFICIENT OF EXPANSION OF DICHLORO-ETHYL SULFIDE.[1]

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Received April 28, 1920.

One of the physical constants of dichloro-ethyl sulfide or mustard gas, which is of great importance in filling gas shells, is the density and the variation of this with changes in temperature. This last is of importance since upon it is based the calculations of the voids necessary to be left in filling the shells in order to prevent the development of leaks. The liquid expanding as the temperature rises completely fills the shells and crushes the threads on the adaptors which hold the boosters.

Since the density at different temperatures was desired, the determinations were made in a dilatometer tube. The same sample could be used to determine the density at the different temperatures and thus the coefficient of expansion could be calculated.

Preparation of Dichloro-ethyl Sulfide.

A sample of mustard gas supposed to be about 97% pure was first distilled by passing the vapor from a constant boiling hydrochloric acid solution through it. The heavier layer of the distillate was then extracted with ether and the ether layer dried over calcium chloride for 12 hours. It was then poured from the calcium chloride into a distilling flask and the ether evaporated off, and the residue distilled *in vacuo*, the middle portion being taken for the density determination. This liquid was almost water-white, having but a very faint yellow tinge. Its freezing point was 13.5°.

Determination of Density.

The stem of the dilatometer was calibrated before sealing to the bulb by weighing the amounts of mercury delivered by the different lengths of the capillary. The volume of the bulb was determined by weighing the dilatometer empty and filled to the zero mark with mercury.

The mustard gas was introduced into the dilatometer through a very fine capillary tube made by drawing out a piece of glass tubing. The dilatometer was immersed in a water bath at 15° and filled with mustard gas adjusting the level to the zero mark after equilibrium had been reached. The top of the dilatometer was then sealed off and it and the contents

[1] Published with the approval of Lt. Col. Amos A. Fries, Chief Chemical Warfare Service, U. S. A.

weighed. The increase in the weight over that of the empty dilatometer gave the weight of the mustard gas.

Data.

The values obtained are as follows:

Weight of mustard gas used..... 6.0835 g.
Volume of dilatometer..... 4.7564 cc.

$$\text{Density at } 15^\circ = \frac{6.0835}{4.7564} = 1.2790.$$

Coefficient of Expansion.

The dilatometer was then immersed in a tall glass vessel filled with water which served as a constant temperature bath. The temperature was raised slowly and the height of the meniscus in the capillary read by means of cathetometer. The following table gives the volume occupied by the 6.0835 g. of mustard gas at the different temperatures, and from these values are calculated the densities or specific gravities compared to water at 4° as unity. In the last column are the differences in density for each 5 degrees. Several readings being made at each point with both rising and falling temperatures.

The volume read on cooling to 15° after having raised the apparatus to 90° was exactly the same as it was before being heated. This showed that the apparatus recovered its original volume very quickly after being heated.

TABLE I.

Weight of Mustard Gas = 6.0835 g.

Volume Cc.	Temp., °C.	Density.	Diff.	
4.7564	15	1.2790	..	
4.7748	20	1.2741	0.0051	
4.7956	25	1.2686	0.0055	
4.8147	30	1.2635	0.0051	
4.8345	35	1.2584	0.0051	
4.8547	40	1.2531	0.0053	
4.8752	45	1.2479	0.0052	
4.8957	50	1.2426	0.0053	
4.9168	55	1.2373	0.0053	
4.9386	60	1.2318	0.0055	
4.9607	65	1.2263	0.0055	
4.9823	70	1.2210	0.0053	
5.0034	75	1.2158	0.0052	
5.0249	80	1.2106	0.0052	
5.0481	85	1.2051	0.0051	
5.0633	88	1.2015	0.0036	0.0055
5.0710	90	1.1996	0.0019	

The variation in density per degree between 15° and 90° is 0.001058. The variation in volume of one gram per degree between the same temperature is 0.0006895 cc. The variation in volume in cc. per cc. per degree is 0.000881 cc.

TABLE II.

Thermal Expansion of Dichloro-ethyl Sulfide.

Volume at 15° = 1.

Temperature, °C.	Vol.
15	1.00000
20	1.00324
25	1.00824
30	1.01226
35	1.01642
40	1.02067
45	1.02497
50	1.02901
55	1.03372
60	1.03830
65	1.04295
70	1.04747
75	1.05193
80	1.05648
85	1.06133
88	1.06452
90	1.06614

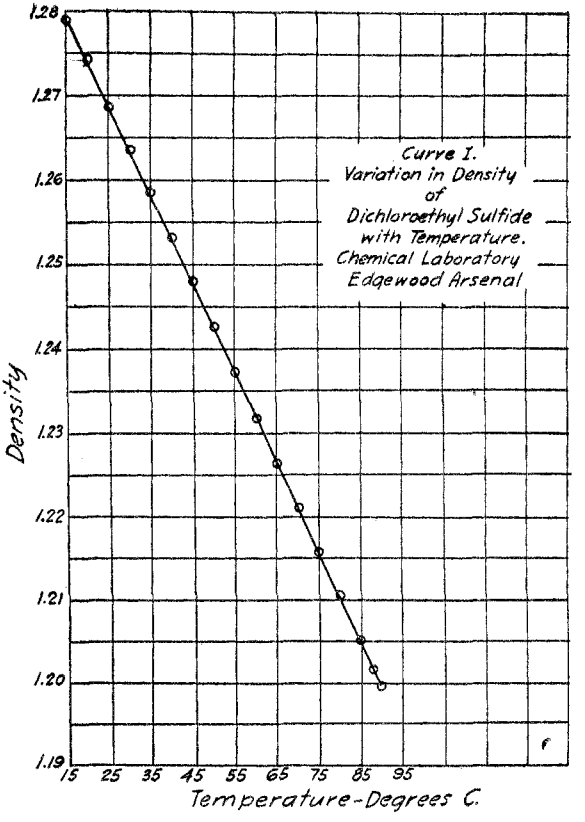

Fig. 1.

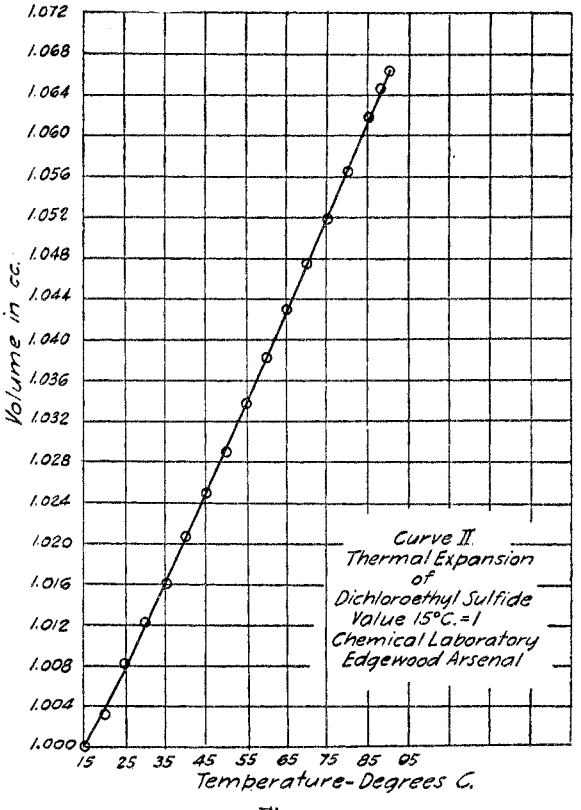

Fig. 2.

In the accompanying curves, I shows the relationship between density and temperature and II change in volume of one cc. of mustard gas with increase in temperature, *i. e.*, the coefficient of expansion.

Conclusions.

(1) The density of dichloro-ethyl sulfide at 15° is 1.2790 and at 90° it is 1.1996, a change of 0.001058 per degree.

(2) The coefficient of expansion of dichloro-ethyl sulfide between 15° and 90° is 0.06614 cc. per cc., an increase of 0.000881 cc. per degree.

(3) The expansion between these temperatures is practically uniform.

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