Manley

INTER OFFICE MEMORANDUM

June 12, 1945

TO: John Manley

FROM: J. O. Hirschfelder

SUBJECT: ENERGY OF BLAST WAVE AT TRINITY

The energy remaining in the blast wave is a good means of determining the original energy released by the explosion. Whereas the peak pressure is proportional to the 1/3 power of the energy released and the positive impulse is proportional to the 2/3 power, the energy remaining in the blast is proportional to the first power. The energy in the blast is given by the equation:

$$E_{blast} = \frac{2\pi R^2}{\rho_o c_o} \int p^2 dt$$

$$= \frac{5.52 \times 10^{13} \, (R/300)^2}{\left(\frac{\rho_o}{1.29 \times 10^{-3}}\right)\left(\frac{c_o}{3.47 \times 10^4}\right)} \int p(psi)^2 dt \quad \text{ergs}$$

In the second equation, R is in feet, p is in psi, t is in milliseconds, ρ_o is in grams/cm^3, c_o is in cm/sec.

To get the total energy in the blast it would be necessary to carry the integration over both the positive and negative phases of the pulse. However, for our purposes the energy in the positive pulse is just as good an indication of the energy of the explosion. If the blast wave has the normal shape proposed by G. I. Taylor:

$$p = p_{peak}(1 - t/\tau)e^{-t/\tau}$$

the energy in the negative pulse is only 13.5% of the total energy in the blast wave or practically negligible. At sufficiently large distances of course the pulse becomes linear and an equal amount of energy is carried in the positive and negative phases. The Taylor form should apply for $R/W^{1/3}$ less than 200 and the linear pulse should apply when $R/W^{1/3}$ reaches around 500. One definite advantage of the energy over the impulse is that the $\int p^2 dt$ is quite insensitive to changes in the base line.

At the present time we are trying to obtain a number of good pressure time curves from which we can obtain a reliable experimental norm for the $E_{blast}/E_{released}$.

In the meantime our best estimate in accord with the peak pressure and impulse data compiled by Sheard and Littler is

$R/W^{1/3}$ less than 25 $E_{blast}/E_{released} = .874$ Kirkwood for cast pentolite (NDRC A-318)

This is shown in Figure 1.

$R/W^{1/3}$ greater than 25 $E_{blast}/E_{released} = \frac{.0843}{\sqrt{\log_{10}(R/W^{1/3}) - 0.928}}$

The following results were obtained by integrating the blast pressures measured in the 107.6 ton Trinity shot:

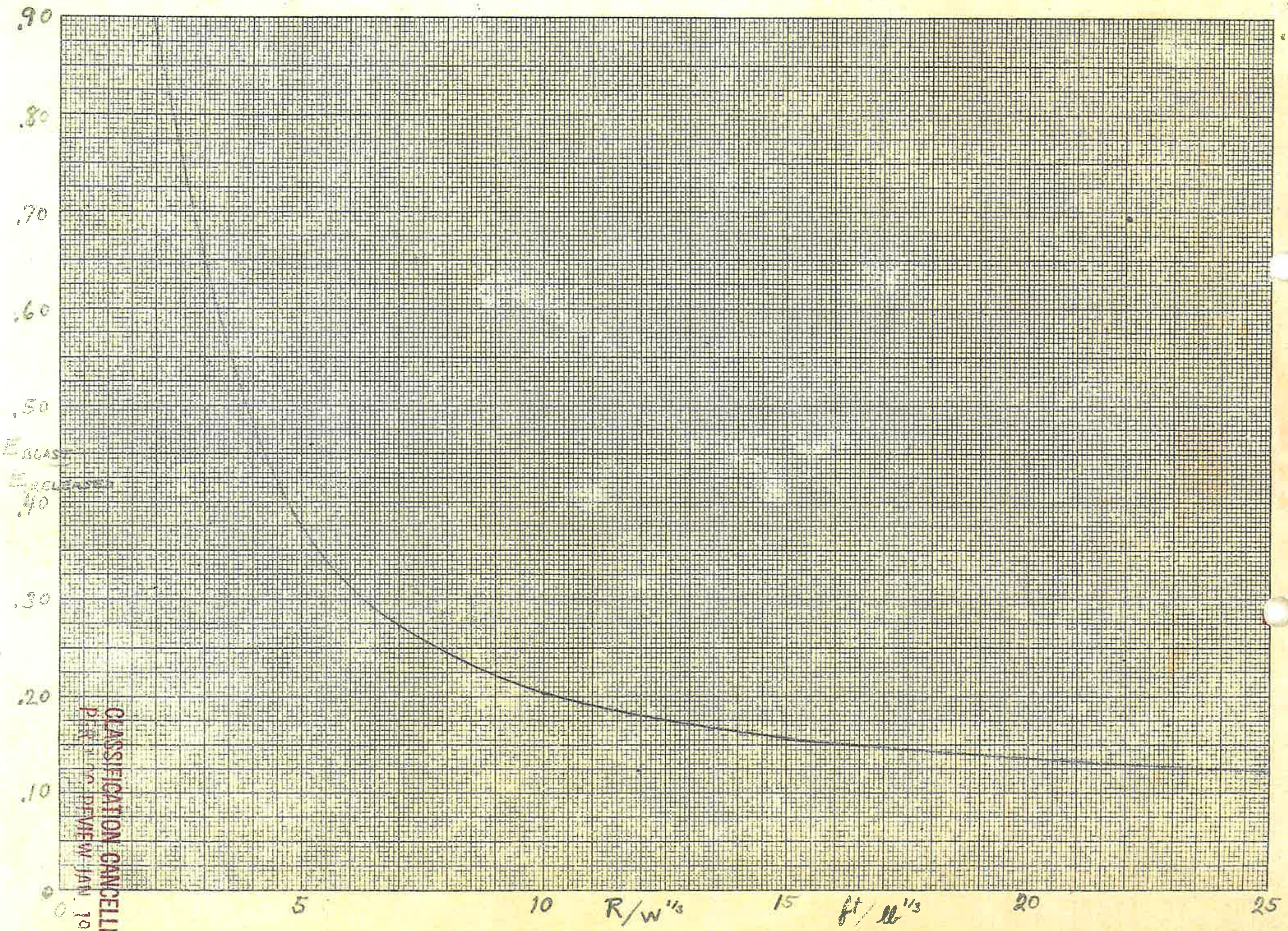
STATION	$R/W^{1/3}$ ft/lb$^{1/3}$	$\left(\frac{E_{pos.blast}}{E_{released}}\right)_{observed}$	$E_{pos.blast}$	$\left(\frac{E_{blast}}{E_{rel}}\right)_{expect}$	$\frac{E_{blast\ obs}}{E_{blast\ expect}}$
230 yd South	11.8	.175	7.9 × 10[17] ergs	.180	0.97
230 yd North	11.8	.149	6.73	.180	0.83
320 yd North	16.4	.159	7.18	.150	1.06
740 yd South	38.0	.113	5.10	.104	1.09
1500 yd North	76.9	.068	3.07	.086	0.79
9200 yd South	472	.106	4.8	.063	1.68
				Average	1.07

The only measurement definitely out of line is the 9200 yd South result. The blast pressure and the impulse at this point also seem to be too large.

J. O. Hirschfelder

cc: Bainbridge
Bethe
Penney
Sheard
Walker

$E_{released} = 4.2 \times 10^{16} \times 107.6 = 4.52 \times 10^{18}$ ergs



.90
.80
.70
.60
.50
E BLAST
E RELEASED
.40
.30
.20
.10
0
0
5
10
R/W1/3
15
ft/lb1/3
20
25