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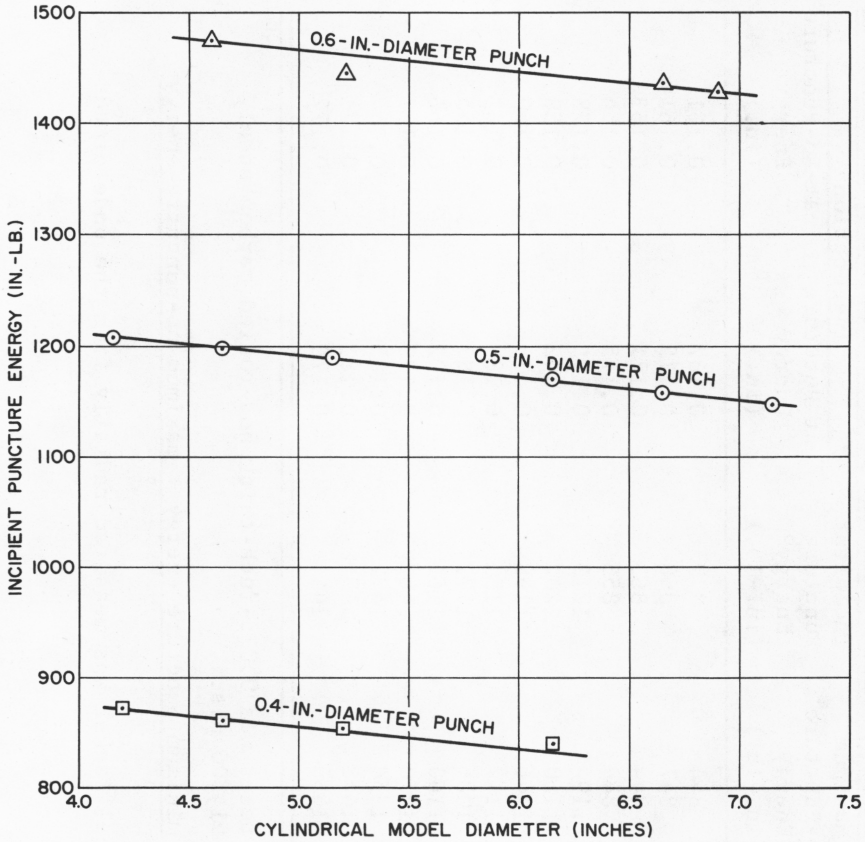

Figure 16. Incipient puncture energy for cylindrical models as a function of the diameter of the model.

The deformation that occurs when a model of a cylindrical cask impacts on a flat-ended punch is illustrated in Figures 17 and 18. As may be seen in these two illustrations, considerable deformation of both the jacket and the lead shielding occurs during the punching process. Along the direction of the longitudinal axis of the cask model, the dimension of the region that sustained permanent deformation was approximately three times the diameter of the punch. Perpendicular to the direction of the longitudinal axis of the model, the dimension of the region that sustained permanent deformation, measured as a chord of the cask diameter, was about 2 to 2.3 times the diameter of the punch for the range of model-to-punch-diameter ratios tested. There appeared to be a tendency for this dimension to decrease as the model-to-punch-diameter ratio decreased.

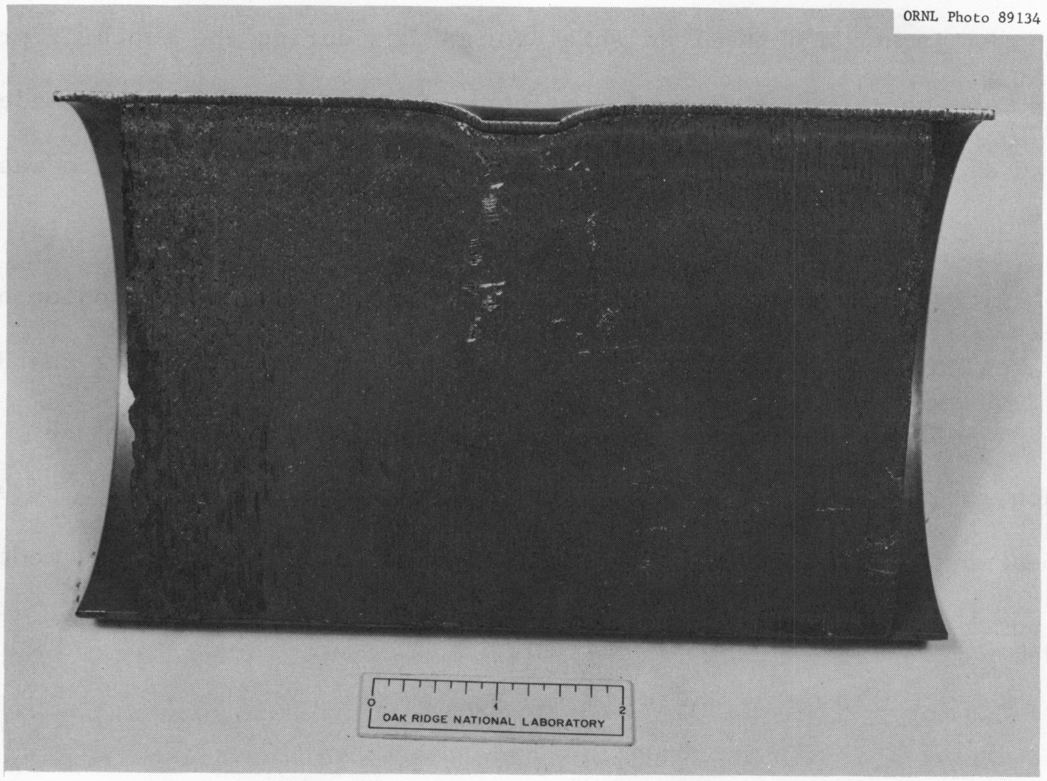

Figure 17. Longitudinally sectioned cylindrical model after impact.

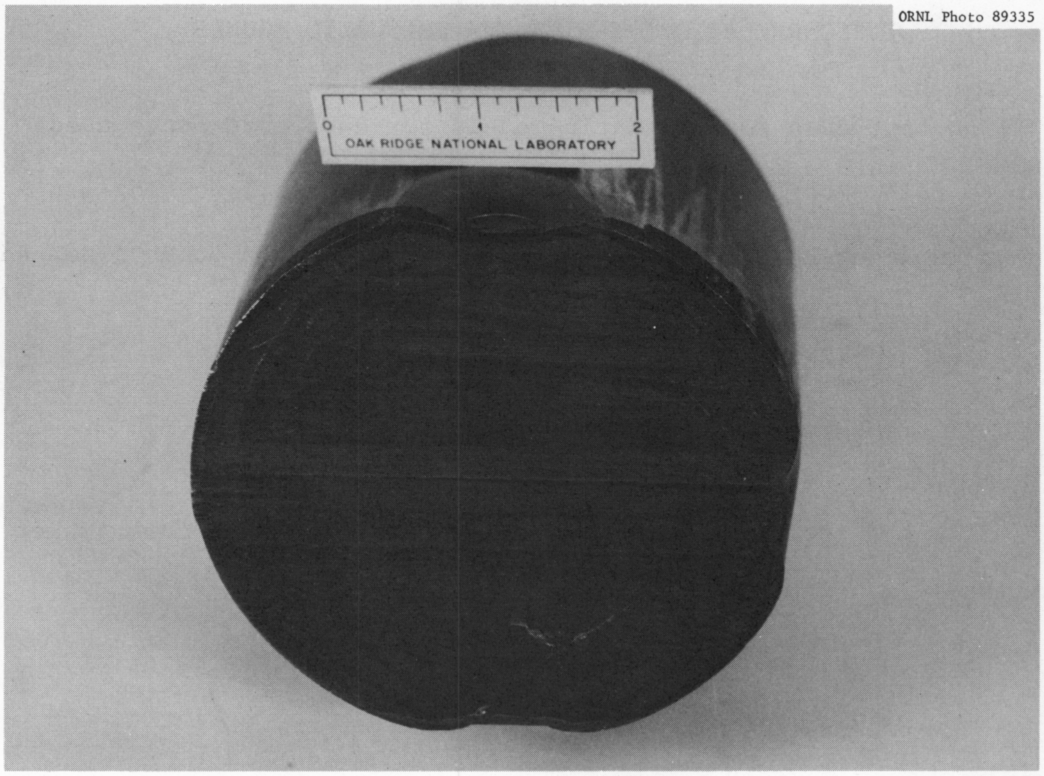

Figure 18. Circumferentially sectioned cylindrical model after impact.

CHAPTER V

CORRELATION OF DATA

I. CORRELATION OF DATA FOR PRISMATIC MODELS

The test data for prismatic models for each size punch used appear to fall along a straight line when plotted in a log-log graph, as shown in Figure 11. This suggests that for a given punch size, the data might be represented by an equation of the form

$$E_F/S = At^n \ , \qquad (6)$$

where

E_F = the incipient puncture energy of a prismatic cask jacket, inch-pounds,

S = the ultimate tensile strength of the jacket material, pounds per square inch,

A = a constant,

t = the thickness of the jacket material, inches, and

n = a constant.

Using the method of least squares to fit the data plotted in Figure 11, the equations found for the two punch sizes are

$$(E_F/S)_{0.5} = 0.70t^{1.37} \qquad (7)$$

and

$$(E_F/S)_{0.6} = 1.19t^{1.44} \ , \qquad (8)$$

where the subscript 0.5 in Equation 7 and the subscript 0.6 in

Equation 8 refer to the 0.5-inch-diameter and the 0.6-inch-diameter punches used in the prismatic model tests.

In the investigation (4) that produced the original data that were used to construct Table IV, the ultimate tensile strength, S, of the jacket material was not treated as a variable. When the ultimate tensile strength of the jacket material is treated as a variable, the data for each size punch appear to fall along a straight line on a log-log plot, as may be seen in Figure 13. This suggests that these data might also be described by an equation of the form given by Equation 6. If the data in Table IV are comparable with that reported here, sufficient data appear to be available to develop an equation that includes the size of the punch as a variable. The equation that is obtained by using the method of least squares to fit the 0.5-inch-diameter punch data in Table IV is

$$(E_F/S)_{0.5S} = 0.77t^{1.41} \ , \tag{9}$$

where the subscript 0.5S refers to the data for the 0.5-inch-diameter punch in Table III.

A comparison of Equations 7 and 9 indicates that the data reported here and that in Table III are in good agreement. Thus, it appears that an equation with the form of Equation 10 below might be obtained.

$$E_F/S = g(d)g_1(t) \ , \tag{10}$$

where

$g(d)$ = a function of the size of the punch, and

$g_1(t)$ = a function of the thickness of the jacket.

Since the exponents of t in Equations 7, 8, and 9 vary only slightly, the weighted average based on the number of data points represented by these equations, a value of 1.4, appears to be a suitable exponent of t in the $g_1(t)$ term of Equation 10. Thus,

$$E_F/S = g(d)t^{1.4} \quad . \tag{11}$$

If the value of t in Equation 11 is held constant at 0.072, Equation 11 can be rewritten as follows.

$$g(d) = 39.8E_F/S \quad . \tag{12}$$

The values of g(d) can now be determined for each size punch from the data in Table IV. A plot of these values of g(d) on a log-log graph shown in Figure 19 indicates that the function g(d) may be expressed as

$$g(d) = Bd^n \quad , \tag{13}$$

where B and n are constants determined from the test data. Values of B = 2.4 and n = 1.6 are obtained by using the method of least squares to fit the data. Equation 13 then becomes

$$g(d) = 2.4d^{1.6} \quad , \tag{14}$$

and Equation 12 can be written

$$E_F/S = 2.4d^{1.6}t^{1.4} \quad . \tag{15}$$

Equation 15 appears to adequately represent the data for the prismatic models. Of the thirty-eight data points listed in Tables II and IV, thirty are predicted by Equation 15 with a difference of only

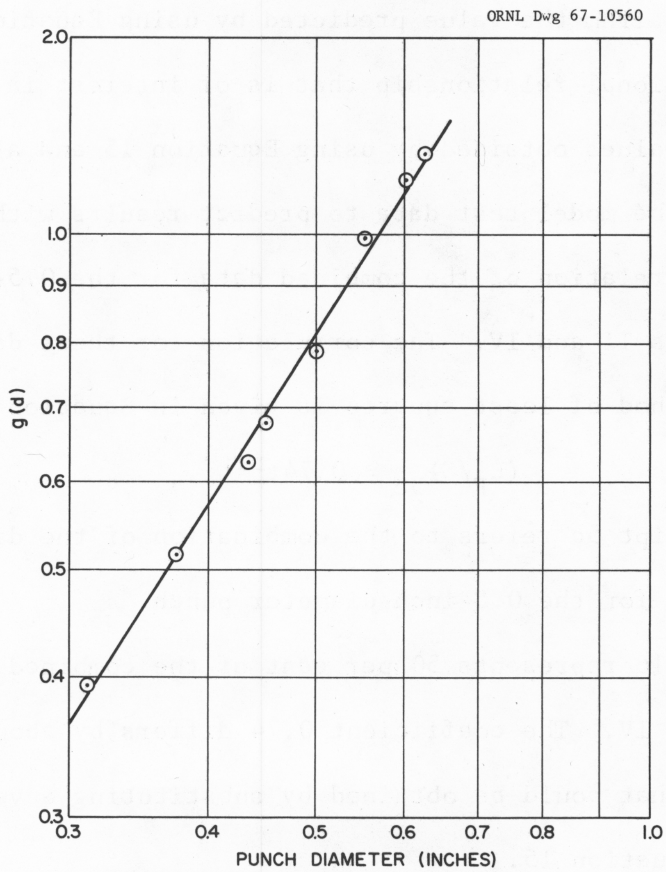

Figure 19. Calculated values of g(d) as a function of the punch diameter for the prismatic model test data.