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DISCUSSION

A. F. Conn[1]—In the oral presentation of this paper, the method was not described whereby, given a certain density of rainfall, the number of impacts per unit area can be calculated. As we have also made such calculations,[2,3] I think a brief description of the authors' method for estimating numbers of impacts would be useful for the record, if this procedure is not already in the written version of the paper.

G. S. Springer and C. B. Baxi (authors' closure)—The authors wish to thank Dr. Conn for suggesting that the method of estimating the numbers of impacts be included in the paper. The method is now shown in Eqs 1 to 4.

F. G. Hammitt[4]—The only way we can judge a new correlation is by its success in correlating the existing data. On this basis at any rate, the presently proposed correlation seems to represent a large backward step when compared with other published correlations over the past years, for example, at the last ASTM Symposium on this very subject.

Figure 7 of the present paper is a log-log plot of the final results. I note that for any value of the abscissa, the data spread is by a factor between 10^2 and 10^3, so that the standard deviation must be by $\times$ 10 or more. I would like to ask the authors what is the calculated standard deviation for this data fit?

Numerous correlations between mechanical properties and erosion resistance for similarly comprehensive data sets have been published by Hammitt et al[*10*], Heymann (discussion of Ref *10*), Rao et al,[5] and others. The

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[2] Conn, A. F., "Relating Dynamic Properties of Materials and Resistance to Damage by Rain Impact," Technical Report 905-1, HYDRONAUTICS, Incorporated, Laurel, Md., Jan. 1970.

[3] Conn, A. F. and Thiruvengadam, A., *Journal of Materials*, Vol. 5, No. 3, Sept. 1970, pp. 698–718.

[4] Professor, Department of Mechanical Engineering, Cavitation and Multiphase Flow Laboratory, University of Michigan, Ann Arbor, Mich. 48104.

[5] Rao, B. C. S., Rao, N. S. L., and Seetharamiah, K., *Transactions*, American Society of Mechanical Engineers, *Journal of Basic Engineering*, Sept. 1970, pp. 573–576.

TABLE 2—*Results for MDPR from Ref.* 10.

Correlating Relation	n (where applicable)	Sample Correlation Coefficient	95% Confidence Limits for Population Correlation Coefficients	Factorial Standard Error of Estimate
$\frac{1}{MDPR} = C(UR)^n$	0.998	0.811	0.64 to 0.91	2.52
$\frac{1}{MDPR} = C(UR)$	...	0.811	0.64 to 0.91	2.52
$\frac{1}{MDPR} = C(UR \times BHN)^n$	0.720	0.798	0.62 to 0.89	2.25
$\frac{1}{MDPR} = C(UR \times E^2)^n$	0.659	0.744	0.52 to 0.86	2.35
$\frac{1}{MDPR} = C(BHN)$	...	0.742	0.52 to 0.86	2.75
$\frac{1}{MDPR} = C(BHN)^n$	1.788	0.734	0.52 to 0.85	2.38
$\frac{1}{MDPR} = C(UR \times BHN)$	...	0.716	0.49 to 0.84	2.57
$\frac{1}{MDPR} = C(UR \times E^2)$	...	0.684	0.44 to 0.82	2.86
$\frac{1}{MDPR} = C(SE)^n$	0.738	0.517	0.21 to 0.73	3.24
$\frac{1}{MDPR} = C(SE)$	...	0.498	0.17 to 0.72	3.30

standard deviation for most of these is ~2-3, rather than ~10, as apparently is true in the present case. Much (though not all) of the material to which I refer comes from *Characterization and Determination of Erosion Resistance, ASTM STP 474,* 1970. Table 2 summarizes our previously published numerical work in this regard. Typical of these data fits is Fig. 3 of Ref *10*; also, see Fig. 4 of Heymann's discussion of the same reference.

In conclusion, why do the authors feel that their correlation is preferable even though it apparently produces much poorer results than the various correlations previously published?

G. S. Springer and C. B. Baxi (authors' closure)—We can discern no technical basis for the objections expressed by Dr. Hammitt. The correlation proposed by Hammitt et al applies only to the mean depth of penetration (MDPR). Unlike our model, it does not provide such very important and practical parameters as the incubation period (n_i), rate of mass removal after the incubation period (α), and the total mass loss (m).

Our model not only provides considerably more information than Hammitt's correlation but, apparently, it also gives more accurate results. The average standard deviations for our model are 1.2 for n_i, 1.7 for α, 2.0 for m. In comparison, Hammitt's correlation yields standard deviations in the range of 2 to 3, in spite of the fact that it is entirely empirical; is based on fewer data; covers a much narrower range of experimental conditions; and is restricted to MDPR, which is easier to determine from the experiments.

It is also worth noting that the available experimental data (with which our model is compared) are very widely scattered. The standard deviations about the mean of the data themselves are generally of the order of 1 to 2.