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INTRODUCTION

Two ISO tests involving the low-temperature disintegration of iron oxides are at the stage of draft international standards proposals[1, 2]. This report describes part of a program at MREC under the auspices of the Canadian Advisory Committee to ISO/TC 102 (Testing of Iron Ores) to determine the relationship between the two proposed ISO tests (static[1] and dynamic[2]). Although the entire study involves the disintegration of ores, pellets, and sinters this report only discusses the disintegration behaviour of the sinters. Eleven experimental sinters of varying basicity (base to acid ratios from 1.5 to 3.1) and their analyses were supplied by the Algoma Steel Corporation Limited, Sault Ste. Marie, for this study.

The proposed low-temperature disintegration tests involve the reduction (at 500°C) of a 500-g sample of sinters (12.7 - 9.51 mm in size) with a 20:20:60 mixture of CO, CO_2, and N_2. These conditions reduce hematite in the sample to magnetite and simulate the reduction processes that occur in the upper region of the blast furnace. The change in volume associated with the structural change from rhombohedral hematite to cubic magnetite during the anisotropic reduction process can cause some materials to break down.

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Materials that display poor low-temperature breakdown properties in the furnace can cause high flue dust loss and an increased pressure drop in the upper stack and also the bosh zone. As a result, furnace operation is impaired. It has been reported that the number of slips per day for some blast furnaces can be related to the low-temperature breakdown properties of the burden[3, 4].

METHOD

The static[1] test requires that the sample be heated to temperature under a nitrogen atmosphere in a stainless steel basket (75 mm ID) which is placed in a heat-resistant stainless steel (Type 310) reducibility retort. The reducing gas flow is set at a rate of 20 l/min and the reduction allowed to proceed for one hour. The sample is allowed to cool under a constant flow of nitrogen; then it is placed in a tumble drum (8 in. long, 5 in. ID) fitted with two lifters and rotated for 10 minutes at 30 rpm. The cumulative amounts of product retained on 6.35 mm, 3.26 and 0.50 mm sieves, and the amount passing a 0.50 mm sieve (fines) are reported.

The dynamic disintegration[2] test requires that the sample be heated to temperature under a constant flow of nitrogen in a modified Linder barrel (8 in. long, 5 in. ID) fitted with four lifters. The barrel is rotated at 10 rpm for 45 minutes during the heating process and for an additional hour during the reduction process. The flow of reducing gas mixture is 15 l/min. The sample is cooled under a nitrogen atmosphere and screened in the same manner reported for the static test.

RESULTS AND DISCUSSION

It was necessary in many cases to use a smaller amount of sample than the 500g required by the proposed ISO tests because of the limited supply of sinters. The dynamic test was made on only four (B/A 1.5, 1.6, 1.8, 1.9) of the samples. Single tests were made in all cases because of the lack of sample. The results are listed (Table 1) according to the basicity of the sample. Of the sieve analyses reported, the plus 6.35-mm and the minus 0.50-mm fractions are generally considered to be the most important because they reflect the disintegration ascribable to the chemical and physical forces, respectively. An examination of the results in Table 1 indicates that the sinters have a relatively low level of disintegration (when compared with various pellets and ores previously tested). More than 90 per cent of the product was retained on the plus 6.35-mm sieves while less than 2.5 per cent of the product was in the form of fines (for all samples). In the case of the static tests less than 1.3 per cent of the products were in the form of fines.

A comparison between the static disintegration and the basicities of the sinters appears to indicate a slight increase in the disintegration of the sinters which have medium basicities. (Results are shown in Figure 1). The deviations in their breakdowns, however, is slight (less than 1.0 per cent for the fines) and in view of the fact that the absolute percentage of the product in the form of fines is also small it appears that these deviations are of minor significance. All sinters, as judged by these tests, appear to be of acceptable quality.

Correlation of the dynamic and static results indicate that a linear relationship*, found previously for ores and pellets, also holds for the sinters (Figures 2-4). The minor deviations in the disintegration behaviour of the sinters is well illustrated in these graphs by all their points being grouped very closely together.

The relatively small amounts of disintegration of the sinters and the small weight losses observed after reduction to magnetite suggests that the original sinters already contain large amounts of magnetite and that only a small amount of reduction has occurred during the tests.

Satmagan (Saturation Magnetic Analyzer**) measurements on sinters before and after reduction verified that there is substantial magnetite in the original sinters which increases only slightly upon reduction. It is, therefore, not surprising that the amount of disintegration is small since there appears to be only a small change in the composition of the sinters upon low temperature reduction.

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*$S = 0.71\ D + 29.4$ for + 6.35 mm ($R^2 = 0.94$)
$S = 0.65\ D + 34.8$ for + 3.25 mm ($R^2 = 0.97$)
$S = 0.59\ D - 0.11$ for - 0.59 mm ($R^2 = 0.98$)

**Outokumpu Oy Instrument Division, Tapiola, Finland. Reproducibility: 0.2 per cent.

TABLE 1

Size Distribution of Products (by % wt) after Static and Dynamic Low Temperature Disintegration of Sinters

	STATIC											DYNAMIC			
B/A	1.5	1.6	1.7	1.8	1.9	2.1	2.3	2.5	2.7	2.9	3.1	1.5	1.6	1.8	1.9
Wt. Used	500	250.0	490	400.0	250.0	350.0	300.0	206.0	225	250	250	500	267	400	250
% Wt Loss	0.7	0.5	0.4	0.3	0.2	0.2	0.5	0.5	0.3	0.3	0.3	0.8	0.6	2.0	.3
+6.35-mm	95.4	95.6	98.2	96.2	95.3	94.5	95.5	94.9	95.9	95.6	96.4	93.9	94.9	93.3	94.4
+3.26-mm	97.4	97.7	99.1	98.0	97.6	97.2	97.4	97.4	97.9	98.0	97.4	96.4	96.4	96.2	96.4
+0.5-mm	99.1	99.1	99.8	99.1	99.0	98.9	99.1	99.2	99.3	99.3	98.8	98.1	97.9	97.9	98.1
-0.5-mm	0.9	0.9	0.2	0.9	1.0	1.1	0.9	0.8	0.7	0.7	1.2	1.9	2.1	2.1	1.9

TABLE 2

Per cent Magnetite as Determined by Satmagan

Basicity of Sample	1.5	1.6	1.7	1.8	1.9	2.1	2.3	2.5	2.7	2.9	3.1
% Magnetite (before)	46.1	43.4	46.9	40.5	43.8	43.2	37.6	32.1	33.4	27.5	
% Magnetite (after static)	48.9	46.3	48.6	44.5	45.7	46.7	41.5	41.6	37.2	34.6	
% Magnetite (after dynamic)	48.8	47.0		44.6	45.7						

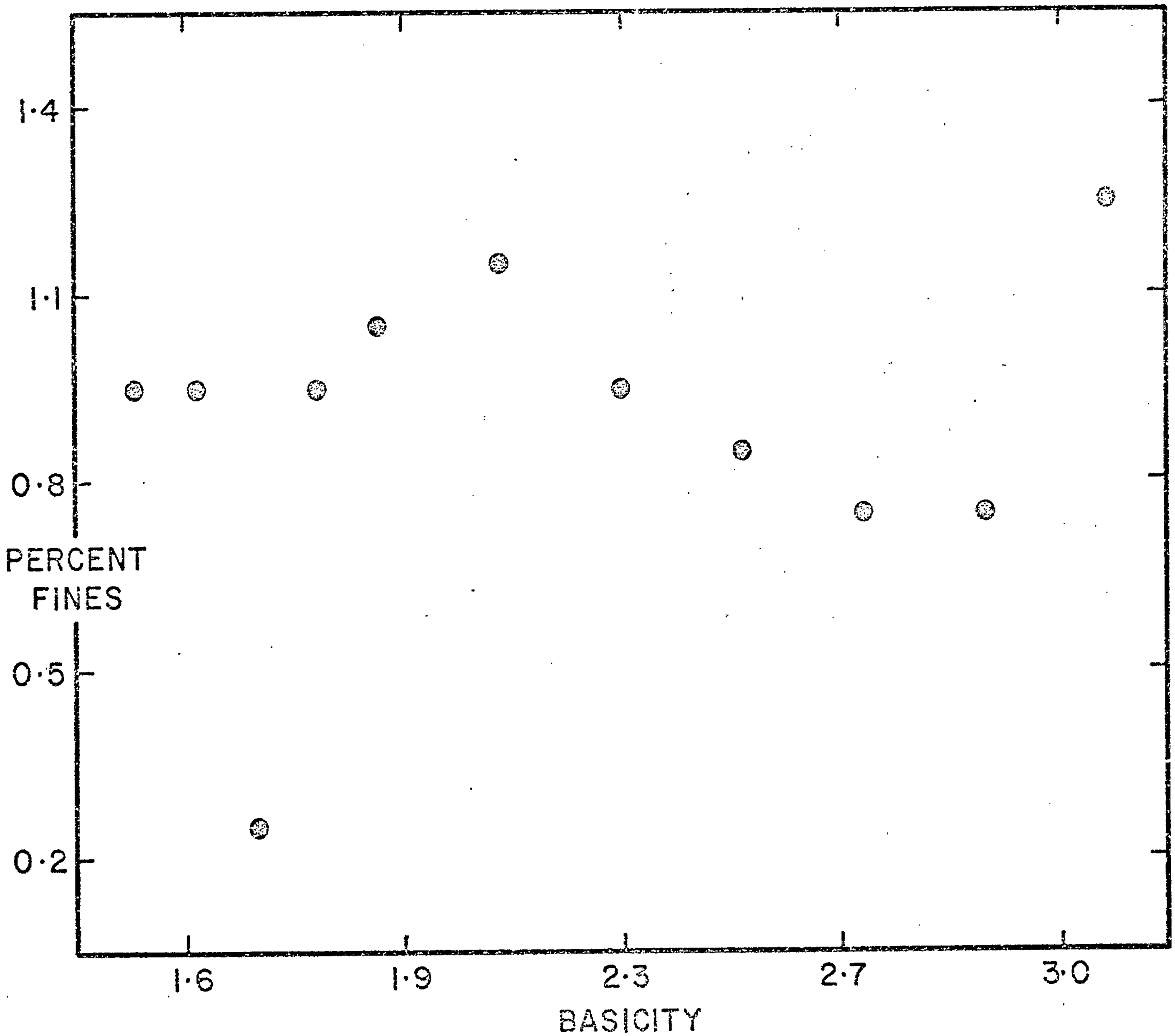

FIGURE I — Per Cent of Fines vs Basicity of Sinter.

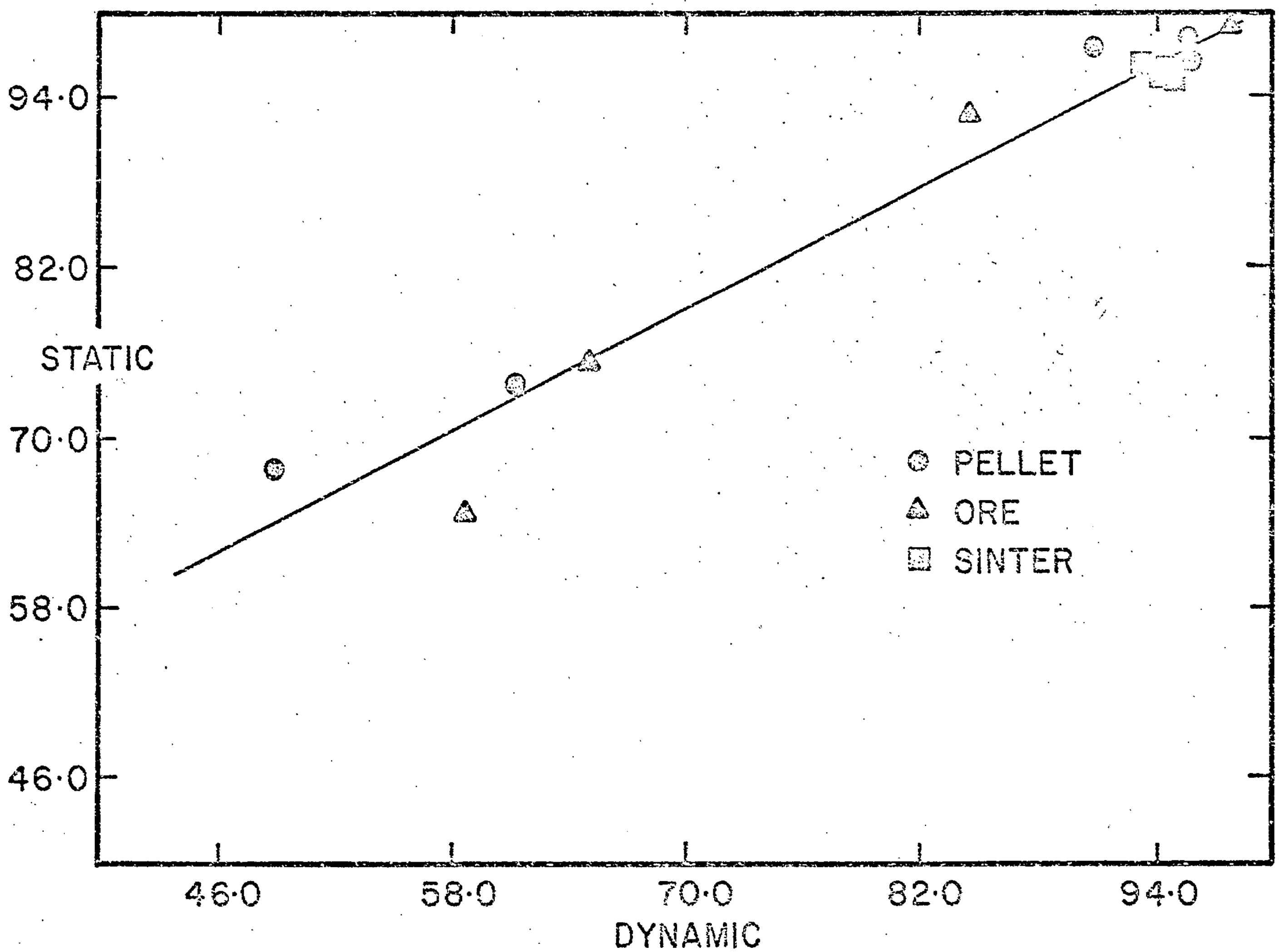

FIGURE 2 — Per Cent of Product + 6·35 mm (Static vs Dynamic).

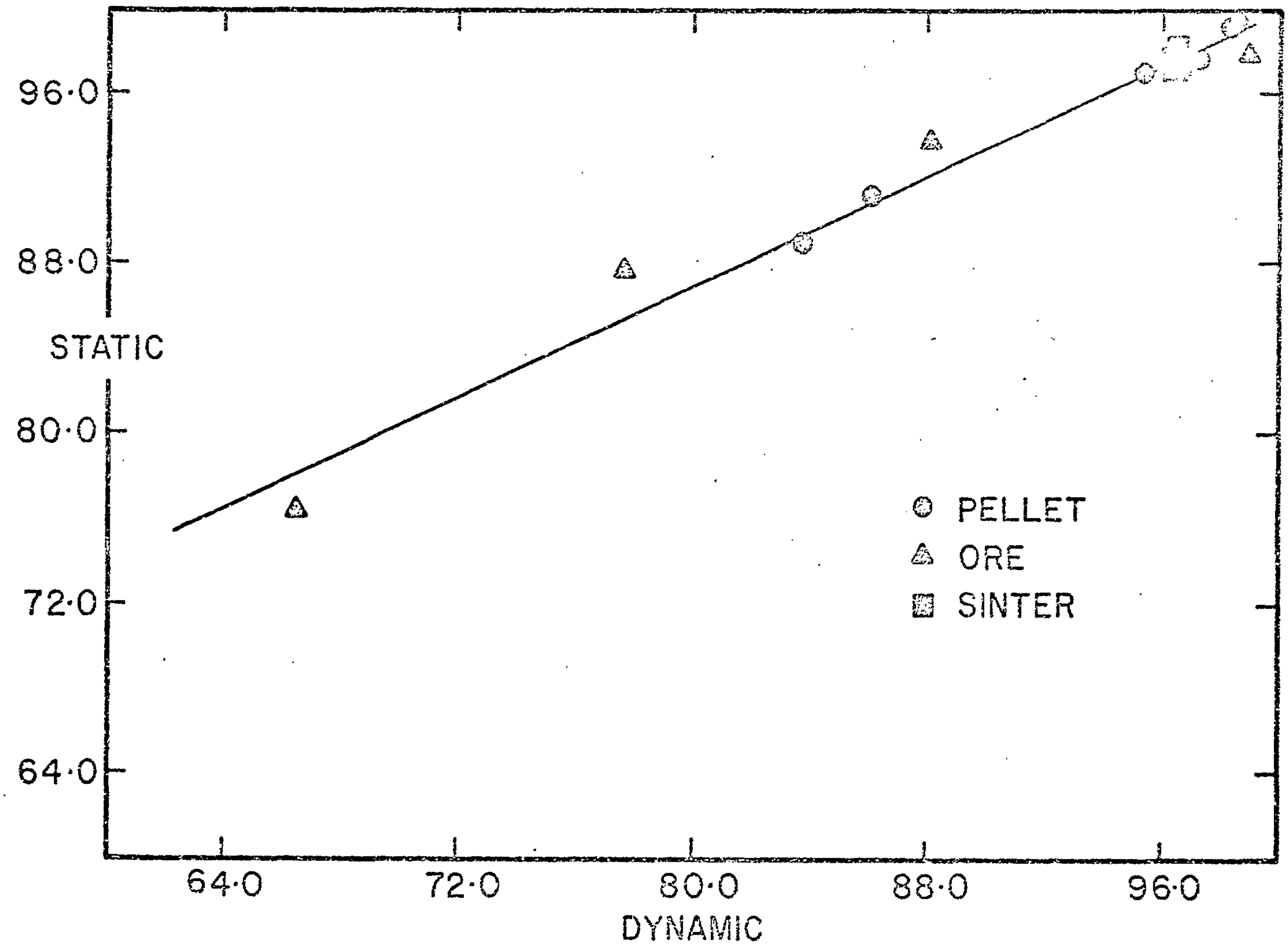

FIGURE 3 — Per Cent of Product + 3·26 mm (Static vs Dynamic).

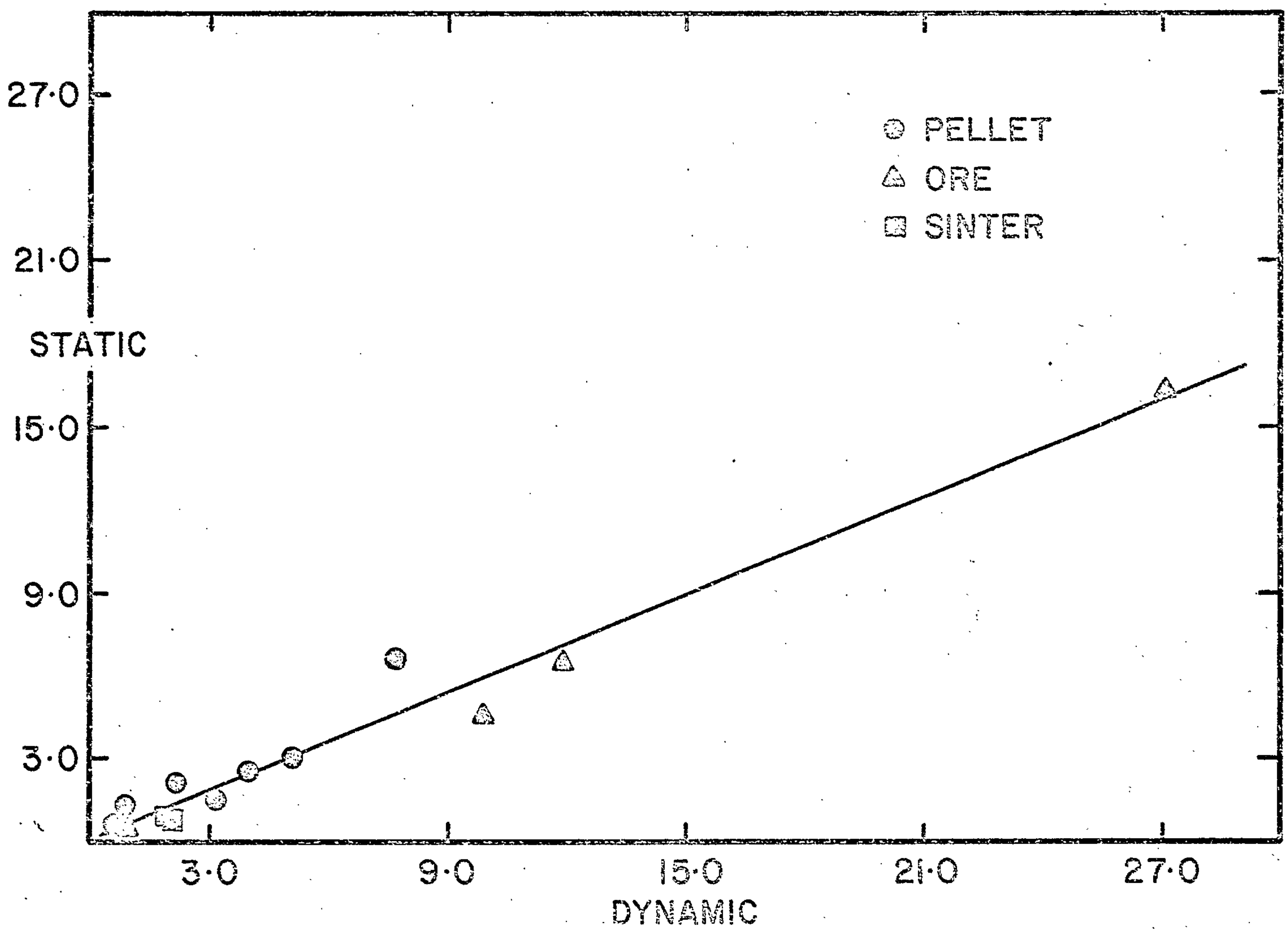

FIGURE 4 — Per Cent of Product -0·5mm (Static vs Dynamic).

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