File

FILE COPY

OTTAWA May 1st, 1943.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1395.

Field Trial Interpretation.

(Copy No. 13.)

Bureau of Mines
Division of Metallic
Minerals
—
Ore Dressing
and Metallurgical
Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

OTTAWA May 1st, 1943.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES

Investigation No. 1395.

Field Trial Interpretation.

Origin of Request:

On April 15th, 1943, Lt.-Col. A. V. Golding, Assistant Director of Inspection (Technical) (M), Inspection Board of United Kingdom and Canada, Ottawa, Ontario, requested that statistical analysis be applied to the field trials of tank tracks and track pins.

Proposed Method:

It was decided that a set of charts would be supplied to those familiar with the field trials so that they could apply statistical methods. A knowledge of all the conditions of test is prerequisite before data can be judged. If the testing procedure is not constant, then engineering judgment should be relied upon for an evaluation of different materials. If test procedure has become standardized, then it may be worthwhile to have an analysis made of the test data.

The purpose of this report is to provide a tool for measuring the importance of test results. Those conducting field tests are the most competent to decide when and where this tool can be applied.

Accuracy of Percentages:

A percentage becomes more accurate as it is derived from larger numbers of observations. If 10 units fail out of 200 on test, the percentage failing is 5 per cent. Supposing that 5 per cent of 10,000 units failed on test, is the first percentage as accurate as the second? It is generally realized that more confidence can be placed in a percentage when it is derived from a larger number of observations. Figure 1 shows how the accuracy of percentages is affected by the number of observations. The accuracy of a 5 per cent result on 200 observations is given at the intersection of these two lines as 4.5 per cent. The observed percentage should then be stated as 5 per cent ±4.5 per cent. If 10,000 units are tested and 5 per cent fail, the observed percentage should be stated as 5 per cent ±0.6 per cent.

The chart of Figure 1 may be used to determine within what limits results may be expected to occur if

(Accuracy of Percentages, cont'd) -

conditions remain the same. For the 200-unit test, these limits would be 5 per cent ± 4.5 per cent, or 1 to 18 failures. Thus, a quality control chart could be set up with limits of 1 to 18 failures for groups of 200.

Difference:

Suppose that 70 bogey wheels from producer "A" and 90 bogey wheels from producer "B" are on test. Seven failures are recorded for producer "A" and 12 failures for producer "B".

Table I.

	No. tested	No. of failures	Percentage failures
Producer A	70	7	10.0
"	90	12	13.3

Are these results significantly different?

From Figure 1 the accuracy of the percentages is derived,-

	Per cent
"A"	10 (± 11%)
"B"	13.3 (± 11%)

On Figure 2, at the intersections of 11 per cent accuracy we read Standard Error of Difference to be 5 per cent.

On Figure 3, the base line reads in standard error and the vertical scale in percentage difference. For a difference of 3.3 per cent and a standard error of 5 per cent, we read, odds are 1 out of 2 that a difference exists. The bogey wheels from producer "A" have not been proven significantly different from producer "B" when

(Difference, cont'd) -

judged statistically.

The above difference in test results (Table I), if left to unaided human judgment, might be interpreted in different ways, depending upon the observer. The statistical method provides a "yardstick" for measuring differences between ratios. Two further examples are given to assist in understanding the use of the charts:

EXAMPLE I.

		Product D	Product E
No. on test	-	50	50
No. of failures	-	18	22
Percentage failures	-	36%	44%
Difference	-	8%	
Accuracy of per cent (from Figure 1),	-	25%	27%
Standard error of difference (from Figure 2),	-	12%	
Significance of difference (from Figure 3),	-	Odds are 1 out of 2 that a difference exists.	
Conclusion	-	No significant difference.	

EXAMPLE II.

		Product G	Product H
No. on test	-	130	200
No. of failures	-	2	10
Percentage failures	-	1.5%	5%
Difference	-	3.5%	
Accuracy of per cent (from Figure 1),	-	3%	4.5%
Standard error of difference (from Figure 2),	-	2%	
Significance of difference (from Figure 3),	-	Odds are 9 out of 10 that a difference exists.	
Conclusion	-	Product G is superior to product H.	

HHF:GHB.

ooo888888ooo

(The next three pages contain Figures 1, 2, and 3)

ACCURACY OF PERCENTAGE

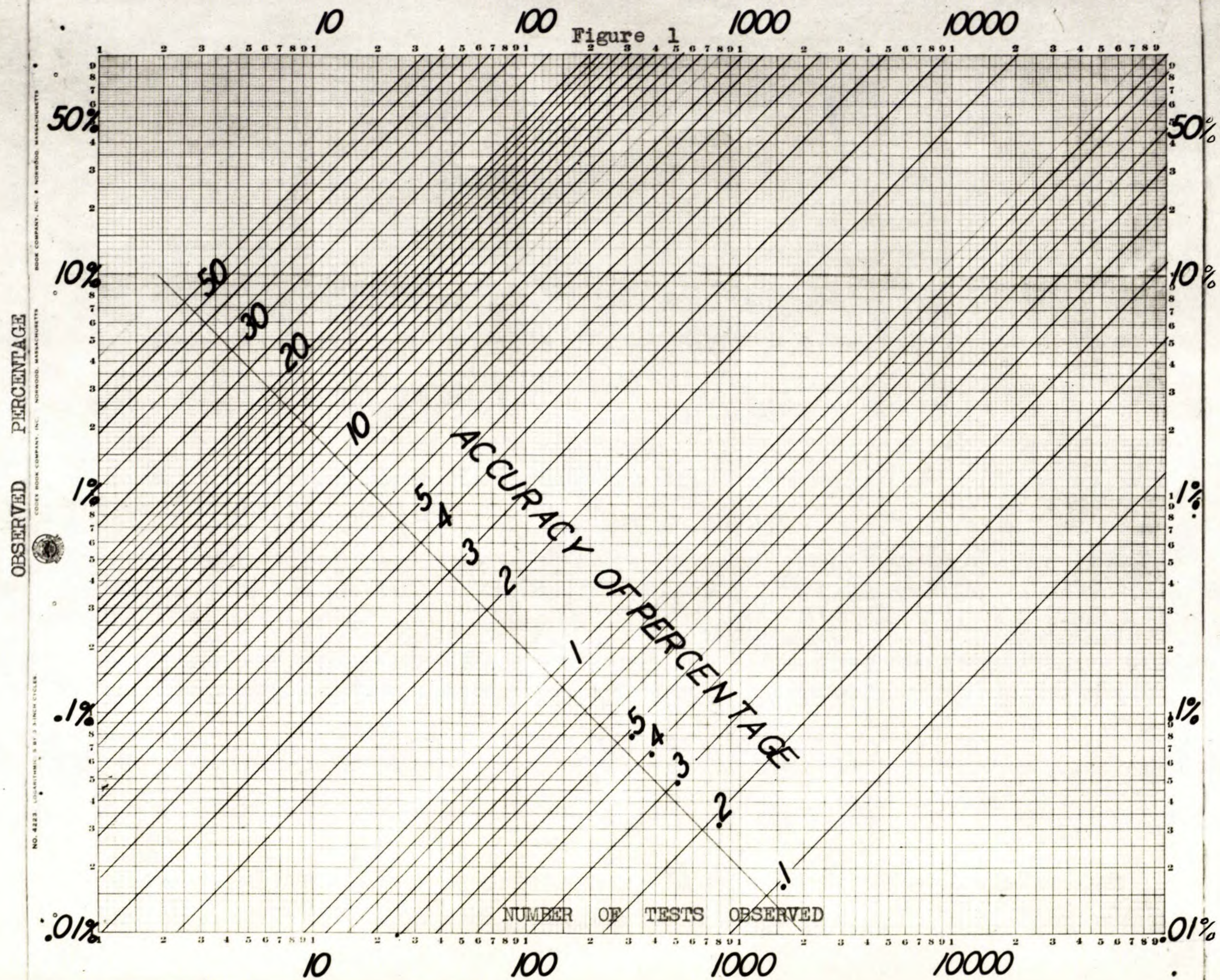

Figure 1

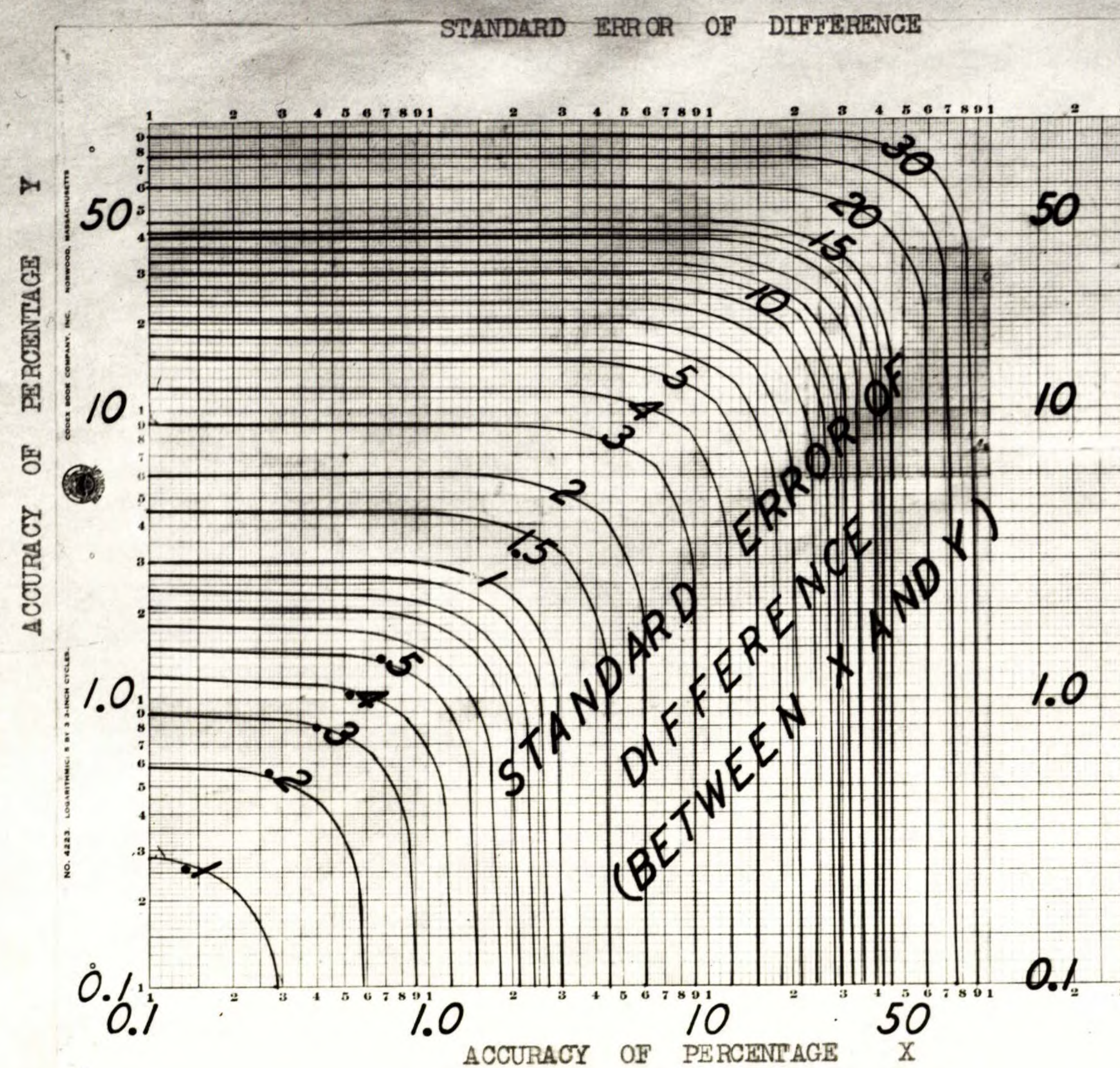
STANDARD ERROR OF DIFFERENCE
ACCURACY OF PERCENTAGE Y
ACCURACY OF PERCENTAGE X
50
10
1.0
0.1
0.1
1.0
10
50
30
20
15
10
5
4
3
2
1.5
1
.5
.4
.3
.2
.1
STANDARD ERROR OF DIFFERENCE (BETWEEN X AND Y)
NO. 4223. LOGARITHMIC, 5 BY 3 3-INCH CYCLES.
CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS

Figure 2.

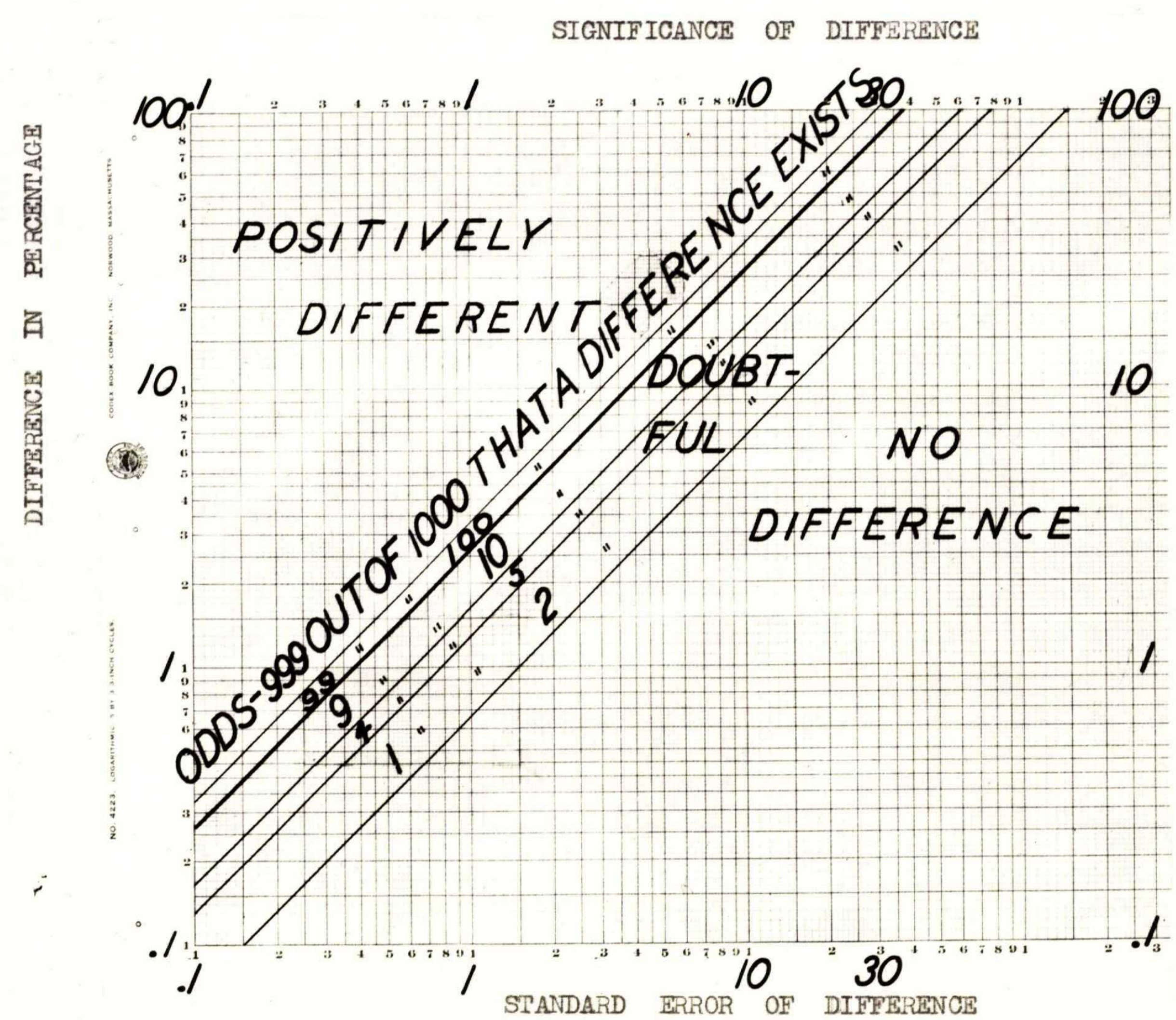
SIGNIFICANCE OF DIFFERENCE
DIFFERENCE IN PERCENTAGE
STANDARD ERROR OF DIFFERENCE
POSITIVELY
DIFFERENT
ODDS-999 OUT OF 1000 THAT A DIFFERENCE EXISTS
99
9
4
1
10
5
2
DOUBT-
FUL
NO
DIFFERENCE
100
10
1
.1
30

Figure 3.

APPENDIX.

Accuracy of Percentage:

The standard error of a percentage is given as

$$\sigma_p = \sqrt{\frac{pq}{n}}$$

p = Fraction defective.
q = 1.00 - p.
n = No. of results.

$\pm$3 standard errors includes 99.7 per cent of the possible results.

Standard Error of Difference:

From the standard error of two percentages, the standard error of their difference may be calculated:

$$\sigma_{p_1 - p_2} = \sqrt{\sigma_{p_1}^2 + \sigma_{p_2}^2}$$

Significance of a Difference:

$$t = \frac{x}{\sigma} = \frac{p_1 - p_2}{\sigma_{p_1 - p_2}} = \frac{\text{Difference}}{\text{Standard error of difference}}$$

The difference divided by the standard error of difference gives a value t.

If t = 3, odds are 997 out of 1,000 that a difference exists.
t = 2, " " 995 " " 1,000 " " " "
t = 1, " " 682 " " 1,000 " " " "

and so on.

A complete description of these equations and their

(Appendix, concluded) -

use will be found in the following:

APPLIED GENERAL STATISTICS - by Croxton and Cowden. Published by Prentice-Hall, Inc., New York.

INTERPRETING OBSERVATIONS. - Report of Investigation No. 1341, Ore Dressing and Metallurgical Laboratories, Bureau of Mines, Ottawa, Canada.

May, 1943.
HHF:GHB.