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DEPARTMENT OF MINES AND RESOURCES
BUREAU OF MINES
CANADA

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Ottawa, October 7, 1946.

R E P O R T
of the
ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2115.

Corrosion and Abrasion Resistance
of Four Pie Plates.

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(Copy No. 8.)

O T T A W A

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Background:

On July 4, 1946, W/C J. M. Macoun, A/Director,
Interservice Research and Development (Clothing and Equipment),
Department of National Defence, 299 Bank Street, Ottawa,
Ontario, submitted for examination four pie plates: one of
perforated and tin-coated steel, one of vitreous enameled
steel, one of aluminium, and one of stainless steel. In a
letter (File No. DIRD(P)-105-36/D.5) accompanying the material,
it was requested that the samples be subjected to the following
tests to simulate ordinary kitchen wear and abuse:

- (a) Resistance to impact.
- (b) Resistance to abrasion and
knife cuts.
- (c) Corrosion resistance.

(Continued on next page)

(Background, cont'd) -

Investigation Report No. 2099 from these Laboratories, dated August 30, 1946, gave data regarding chemical composition and tensile, hardness, bend, ductility and impact properties. The present report gives data regarding the corrosion-resisting and abrasion-resisting properties of the plates.

INVESTIGATION:

This part of the investigation was performed on the different pie plates under the following headings:

1. Resistance to abrasion.
2. Shear hardness.
3. Resistance to corrosion by salt solution.
4. Resistance to high temperature corrosion.
5. Thickness of tin and enamel coatings.
6. Porosity of tin coating.

I. Resistance to Abrasion.

Samples of the aluminium, stainless steel, tin-coated steel and enameled steel plates were tested for resistance to abrasion by the Taber Abraser. A 1,000-gram load and No. CS 10 abrasive wheels were used for all tests.

The vitreous enamel showed such great resistance to abrasion that the test was discontinued after 100 cycles with no scratching or surface wear detectible.

The results obtained on the stainless steel, aluminium, tin coating, and the steel under the tin, are given in Table I. In the case of the tin-coated plate, the tin was worn through in certain places after 100 cycles, and was worn through over the entire test area after 200 cycles.

(Table I appears)
(on next page.)

(Investigation, cont'd) -

TABLE I. - Abrasion Resistance of
Pie Plates.

Material	Duration of Test (wear cycles)	Average Penetration (inches/100 cycles)
Stainless steel:	5,500	0.000,0014
Aluminium	5,500	0.000,0088
Tin coating	100	0.000,026
Steel under tin:	100	0.000,0063

II. Shear Hardness.

Samples of the four different plates were tested for shear hardness by the Taber Abraser shear hardness attachment.

The vitreous enamel was not subjected to this test because of its high hardness.

The tin coating could not be done separately because the standard tool, even on the low loads, cut through the tin into the steel underneath.

Table II gives the results that were obtained on the stainless steel, aluminium, and tin-coated mild steel plates. The shear hardness values given are calculated by the formula,

$$\text{Shear Hardness} = \frac{\text{Load in grams} \times 100}{\text{Width of groove in mils}}$$

TABLE II. - Shear Hardness of Pie Plates

Material	Load, grams	Shear Hardness
Stainless steel:	1,000	2,703
Aluminium	1,000	1,333
Tin-coated steel	1,000	1,886 [®]

[®]This obviously is close to the value for the steel alone.

III. Resistance to Corrosion by Salt Solution.

Samples of the four different plates were tested by the intermittent immersion method for resistance to corrosion

(Investigation, cont'd) -

by salt solution. A 20 per cent solution of salt (sodium chloride) was used as corroding agent, the temperature was maintained at 95° F., and the relative humidity was maintained at 45 per cent throughout the test, which lasted for 32 days.

Results:

At the end of the test all samples except the enameled steel showed evidence of corrosion. The aluminium sample had corroded fairly uniformly over the surface. The stainless steel sample had corroded at certain points along the cut edges, and the tinned steel had corroded at a number of spots, particularly around the edges of the perforations. The loss in weight of the various samples is given in Table III.

TABLE III. - Loss in Weight of Pie Plate
Samples After Corrosion
in Salt Solution.

	Loss in Weight(grams)
Aluminium	0.0023
Stainless steel:	0.0226
Tinned steel	0.0268
Enameled steel :	No appreciable loss.

IV. Resistance to Corrosion at
High Temperature.

Samples of each one of the four pie plates were placed in an oven at 210° C.(410° F.), to determine the effect of comparatively high temperatures.

Results:

After 48 hours
at 210° C. - The tin-coated steel was darkened until it resembled ordinary cold-rolled low carbon steel.

(Continued on next page)

(Investigation, cont'd) -

The other three samples remained unchanged.

After 96 hours
at 210° C. - No further change.

After an additional 48
hours at
250° C. (482° F.) - No further change.

V. Thickness of Protective Tin and Enamel Coatings.

The thickness of the tin and enameled coatings on the ordinary steel pie plates was determined by the Aminco-Brenner Magne-Gage. The values obtained are given in Table IV.

TABLE IV. - Thickness of Coatings on Steel (inches).

	Maximum	Minimum	Average
Enamel coating	0.017, 6	0.011, 8	0.014, 4
Tin coating	0.000, 150	0.000, 035	0.000, 089

VI. Porosity of Tin Coating.

The porosity of the tin coating was determined, by the ferroxyl test, on six samples taken from different parts of the pie plate. Three of the samples showed no porosity by this test. There were a few quite small pores in each of the others.

Conclusions:

On the basis of the above experimental data, the following conclusions may be drawn:

1. In regard to resistance to ordinary abrasion, the materials may be arranged in the following order:
enameled steel (best), stainless steel, steel under the tin coating, aluminium, tin coating alone (worst).
2. In regard to shear hardness (i.e., resistance

(Conclusions, cont'd) -

to scratching), the materials may be arranged in the following order: enameled steel (best), stainless steel, steel with tin coating, aluminium, tin coating alone (worst).

3. In regard to resistance to aqueous salt solutions, the materials may be arranged in the following order: enameled steel (best), aluminium, stainless steel, tinned steel (worst). It should be noted that the comparatively poor rating of the stainless steel sample was due to its tendency to corrode at cut edges.

4. In regard to resistance to corrosion at comparatively high temperatures, all of the metals except the tin-coated steel remained unaffected.

5. In regard to thickness of coating, the coating of vitreous enamel is much thicker than that of tin.

6. In regard to porosity of coating, the vitreous enamel is non-porous and the tin coating has a certain small amount of porosity.

7. To sum up, the resistance of the vitreous enameled steel to the different types of abrasion and corrosion investigated is superior to that of the other materials.

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