DEPARTMENT OF MINES AND RESOURCES

BUREAU OF MINES

CANADA

FILE COPY

Ottawa, August 30, 1946.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2099.

Examination of the Mechanical Properties of Three Pie Plates.

(Copy No. 6.)

Bureau of Mines
Division of Metallic
Minerals

Physical Metallurgy
Research Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

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Origin of Material and Object of Investigation:

On July 4, 1946, W/C J.M. Macoun, A/Director, Inter-Service Research and Development (Clothing and Equipment), Department of National Defence, 299 Bank Street, Ottawa, Ontario, submitted for examination two steel pie plates (one of perforated tinned steel and the other of enamelled steel) and one aluminium pie plate. 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 (after subjection to (a) and (b)).

It was also requested that the quality and gauge of the

(Origin of Material and Object of Investigation, cont'd) -

aluminium plate, the thickness of the tin plating, and the composition of the steel be determined. A sample of stainless steel was also submitted and similar tests on this material were requested.

After discussion it was agreed to carry out the following tests, the data obtained to be used in writing a specification for pie plates:

1. Chemical Analysis -

   (a) Aluminium.
   (b) Steel plate.
   (c) Stainless steel sheet.

2. Mechanical Tests -

   (a) Tensile.
   (b) Hardness.
   (c) Bend.
   (d) Ductility (Erickson cup test).
   (e) Impact.

3. Corrosion Tests -

   (Note: The results of the corrosion tests will be given in a separate report.)

TEST RESULTS:

Chemical Analysis -

The results of chemical analysis of the tinned steel, stainless steel and aluminium pie plate materials are given in Table I.

TABLE I. - Chemical Analyses.

Tinned Pie Plate -

		Per cent
Carbon	-	0.08
Manganese	-	0.40
Silicon	-	Trace
Sulphur	-	0.039
Phosphorus	-	0.015

Stainless Steel -

		Per cent
Carbon	-	0.10
Manganese	-	0.69
Silicon	-	0.54
Chromium	-	19.89
Nickel	-	10.14

(Test Results, cont'd) -

Aluminium (3-S -

		Per cent
Manganese	-	1.13
Silicon	-	0.23
Copper	-	0.04
Magnesium	-	0.02
Iron	-	0.40
Aluminium	-	Remainder.

MECHANICAL TESTS -

Tensile Properties -

Tensile, proof stress and elongation determinations were carried out in duplicate on each of the three samples. The results are tabulated in Table II.

TABLE II.

	Tinned Steel Plate	Stainless Steel Sheet	Aluminium Pie Plate
Ultimate stress, p.s.i.	49,000	144,600	15,800
" " "	49,000	164,400	15,000
0.2% proof " , "	30,100	130,100	12,200
" " , "	30,200	149,500	11,800
Elongation, per cent	35.0	10.0	26.0
" , "	25.0	12.5	26.0
Size of test piece, inch	.498 x .010	.182 x .019*	.496 x .0265
" " , "	.496 x .010	.176 x .019*	.497 x .0265

* Micro-tensile specimen.

Hardness Tests -

The hardness values shown in Table III were determined by the Vickers method.

TABLE III.

Material	Load, kg.	Hardness Numbers Vickers	Brinell (converted)
Tinned steel	1	159	159
Stainless steel	5	345	322
Aluminium plate	1	34	34

(Continued on next page)

(Test Results, cont'd) -

Bend Test -

The bend test was carried out on strips ½" wide, the edges being filed to remove any roughness. The test pieces were bent back and forth through 180 degrees until failure over a radius equal to three times the thickness of the material. The following results (Table IV) were obtained on duplicate samples:

TABLE IV.

Material	Gauge, inches	Number of Bends to Failure
Tinned steel	0.010	14, 15
Stainless steel	0.019	2, 1
Aluminium	0.0265	6, 6

Ductility (Erickson cup test) -

In the Erickson machine the specimen of the sheet metal is clamped between two dies and held in such a way that the metal has "play" and can flow, while a tool having a rounded end is moved forward against the sheet until fracture occurs. The outside surface of the cup can be seen in a mirror during the operations and the first fracture observed. The depth of the impression or cup required to cause fracture can be read directly from a micrometer scale and represents the "Erickson value" of the material, which is taken as an index of the workability of the material for manufacturing purposes.

Erickson cup tests were carried out on the tinned steel and the aluminium pie plate materials. However, due to lack of sample no tests were made on the stainless steel sheet. The results are listed in Table V.

(Continued on next page)

(Test Results, cont'd) -

TABLE V.

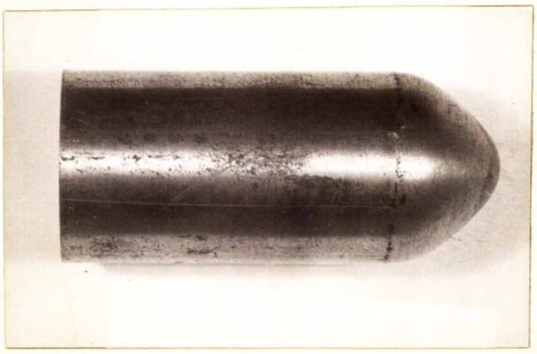
Material Tested		Gauge, inches	Depth of Cup, inches
Tinned steel	-	0.010	0.035
Aluminium sheet	-	0.0265	0.040

Impact Tests -

Test "A". A section of the metal was laid on a soft wood block and a steel weight (see Figure 1) weighing 1½ pounds was dropped through a 1¼" steel tube from a height of 3 feet onto the sheet materials.

Test "B". A similar impact test was carried out upon each plate, the plates being turned upside-down and unsupported except on the outer rim. The results of these tests are recorded in Table VI.

Figure 1.



STEEL WEIGHT USED.
(Actual size.)

TABLE VI.

Material		Depth of Impression, inches	
		Test "B"	Test "A"
Tinned steel	-	0.247	0.015
Stainless steel	-	0.063	0.010
Aluminium sheet	-	0.149	0.015

DISCUSSION OF RESULTS:

The composition of the materials submitted may be classified as follows:

Tinned steel plate - SAE 1010 steel.
Stainless steel sheet - Type 301 18-8 stainless steel.
Aluminium sheet - Alcoa 3-S.

Mechanical Properties -

The results of mechanical tests indicate that the tinned steel and aluminium alloy metal were in the soft temper condition. The high tensile properties of the stainless steel sheet were obtained by a half temper heat treatment. The greater hardness of the stainless steel sheet would undoubtedly increase its resistance to abrasion and therefore would give longer service life than the other two materials.

The bend and ductility tests show that the two materials, which are in the annealed condition, have better ductility and bend properties than the stainless steel. The impact test results indicate quite definitely that the stainless steel would withstand severe service better than either the tinned steel or the aluminium alloy sheet metal. The impact properties as determined by "A" method are identical for the two latter materials.

CONCLUSIONS:

1. The draft of a specification for pie plates will depend entirely upon the material specified.

2. The material used in making the tinned steel pie plate was a low-carbon steel of SAE 1010 composition. An A.S.T.M. specification for Light Gauge Structural Steel (A-245-44T) is fully described on pages 1223 to 1230, inclusive, in A.S.T.M. Standards 1944, Metals, part I.

3. For a full description of A.S.T.M. specification (A-177-44) for High Strength Corrosion-Resisting Chromium-Nickel Steel Sheet and Strip, see pages 486 to 489, inclusive, in the

(Conclusions, cont'd) -

same edition.

4. A tentative specification (B-79-44T) for aluminium manganese alloy sheet and plate is also described on pages 1481 to 1485, inclusive, of the A.S.T.M. Standards 1944, part I, Metals, edition.

5. From the results of mechanical tests, the stainless steel sheet would give better wear. However, the selection of this material may be governed by other factors.

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