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OTTAWA July 17th, 1944.

# REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1680.

## Comparative Tests of Joining Methods for Oerlikon Gun Feeder Levers.

(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals

Physical Metallurgy
Research Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

OTTAWA July 17th, 1944.

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### Origin of Request and Object of Investigation:

On July 5th, 1944, the Director of Technical Research, Department of National Defence, Naval Services, Ottawa, Ontario, requested the assistance of these Laboratories in determining the most suitable method of salvaging Oerlikon gun levers. These gun levers were the subject of a previous investigation (Report of Investigation No. 1607, dated March 7th, 1944), a brief abstract of which follows:

> Salvage of the gun levers is accomplished by oxy-acetylene welding a low-carbon extension strip to the end of a lever. Tests of salvaged levers resulted in a high percentage rejection and considerable doubts as to the serviceability of those not tested. The sample submitted showed evidence of faulty welding technique and a coarse-grained structure adjacent to the weld. Impact resistance would be low with such a structure. It was recommended that welding be done from both sides and that the levers be normalized at 1550° F. for 1¼ hours after welding. Two operations, normalizing and securing the desired gun metal finish, would be combined by oil quenching from 1100° F.

As demonstrated by tests in these Laboratories, levers salvaged and treated in this way show excellent

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

impact strength and ductility. It would appear, however, that the firm doing the salvaging operation (Creighton & Smith Motors, Fredericton, New Brunswick) is not suitably equipped. In addition, the production rate and salvaging costs are unsatisfactory.

These Laboratories have been requested to devise a testing program designed to show the relative merits and costs of silver and bronze brazing, oxy-acetylene welding, and arc welding. Six samples of salvaged and heat-treated levers from Creighton & Smith Motors were submitted for tests. Also submitted were 24 levers and extension pieces for joining and testing and one brass or bronze lever. The latter was submitted for a chemical analysis to determine its composition. It is understood that there are some twenty five (25) of the latter type to be salvaged and approximately 25,000 of the steel levers.

PROCEDURE:

1. Six levers were brazed with Easy-Flo (Handy & Harman, Toronto), using Handy Flux. The ends of the gun levers and extension pieces were cut at a 45° angle to the length of the lever. Both ends to be joined were ground smooth and pressed lightly together. Brazing was done in as short a time as possible and the lever allowed to cool slowly. When cold the extension pieces and joints were machined to the same section as the end of the original lever. All samples were then subjected to impact tests. The table below lists the results secured:

(Continued on next page)

(Procedure, cont'd) -

Silver-Brazed Levers.

| Test No. | Energy absorbed, foot-pounds | Comments |
| --- | --- | --- |
| 1 | 50 | Joint cracked but not completely broken. |
| 2 | 40 | Extension piece broken off. |
| 3 | 45 | Joint not cracked; right angle bend. |
| 4 | 48 | Joint not cracked; right angle bend. |
| 5 | 40 | Extension piece broken off. |
| 6 | 45 | " " " " |

Average - 44.66 foot-pounds.

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2. Six levers were bronze-brazed, using Oxweld No. 25M (high strength and ductility, Dominion Oxygen Co., Toronto) bronze rod. The ends of the levers and extension pieces were cut at an angle of 45° to the length of the lever. In addition, the extension piece was bevelled to a 45° angle to permit easy penetration of the molten bronze. The lever extension pieces and joints were machined to the proper section and subjected to impact tests. The table below lists the results secured;

Bronze-Brazed Levers.

| Test No. | Energy absorbed, foot-pounds | Comments |
| --- | --- | --- |
| 1 | 25 | Extension piece broken off. |
| 2 | 32 | " " " " |
| 3 | 25 | " " " " |
| 4 | 20 | " " " " |
| 5 | 22 | " " " " |
| 6 | 20 | " " " " |

Average - 24 foot-pounds.

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(Procedure, cont'd) -

3. Six levers were oxy-acetylene welded, using Oxweld No. 7 rod (nearly pure iron; Dominion Oxygen Co., Toronto). The ends of the levers and extension pieces were cut at an angle of 45° to the length of the lever. In addition, the extension piece was bevelled to a 45° angle to permit ready penetration to the bottom of the V. After welding, the levers were normalized at 1550° F. for 1¼ hours and cooled in air. The lever extension pieces and joints were machined to the proper section and subjected to impact tests. The table below lists the results secured:

Oxy-Acetylene Welded Levers.

| Test No. | Energy absorbed, foot-pounds | Comments. |
|---|---|---|
| 1 | 50 | Joint cracked but not completely broken. |
| 2 | 68 | Joint not cracked; right angled bend. |
| 3 | 65 | Joint not cracked; right angled bend. |
| 4 | 66 | Joint cracked but not completely broken. |
| 5 | 96 | Joint not cracked; right angled bend. |
| 6 | 65 | Joint not cracked; right angled bend. |

Average - 68.33 foot-pounds.

4. Six levers were arc-welded (AC., 95 amps., 3/32 inch electrode) using Fleetweld No. 7 electrode (Lincoln Electric Co., Toronto). The ends of the levers were cut at an angle of 45° to the length of the lever. In addition, the extension pieces were bevelled to a 45° angle to permit ready penetration to the bottom of the V. The pieces were lightly pressed together and welded. Considerable difficulty was encountered due to the 'burn-through' of the lever proper. After welding, the levers were normalized at 1550° F. for 1¼ hours and cooled in air. The extension pieces and joints were machined to the proper section and subjected to impact tests. The table below lists the results secured:

(Continued on next page)

(Procedure, cont'd) -

Arc-Welded Levers.

| Test No. | Energy absorbed, foot-pounds | Comments |
|---|---|---|
| 1 | 22 | Incomplete penetration; complete break. |
| 2 | 30 | Poor fusion; joint cracked, not broken off. |
| 3 | 18 | Poor fusion; complete break. |
| 4 | 18 | Poor fusion; complete break. |
| 5 | 35 | Poor fusion; complete break. |
| 6 | 35 | Poor fusion; complete break. |

Average - 26.33 foot-pounds.

5. The six levers salvaged by Creighton & Smith were subjected to impact tests. In the case of these levers, the joint is at a 90° angle to the length of the lever. It is understood that the levers were also normalized at 1350° F. for $1\frac{1}{4}$ hours after welding. The table below lists the results secured:

Levers Welded by Creighton & Smith Motors.

| Test No. | Energy absorbed, foot-pounds | Comments |
|---|---|---|
| 1 | 68 | Joint not cracked; right angled bend. |
| 2 | 75 | Joint not cracked; right angled bend. |
| 3 | 60 | Joint not cracked; right angled bend. |
| 4 | 70 | Joint not cracked; right angled bend. |
| 5 | 92 | Joint not cracked; right angled bend. |
| 6 | 65 | Joint not cracked; right angled bend. |

Average - 71.5 foot pounds.

(Procedure, cont'd) -

6. The non-ferrous lever submitted for determination of composition was subjected to chemical analysis. The table below lists the results secured and, for the purpose of comparison, the closest specification:

| | | Gun Lever Analysis. | Specification D.T.D. 174A. |
|---|---|---|---|
| | | - Per Cent - | |
| Aluminium | - | 10.19 | 7.5-10.5 |
| Iron | - | 5.18 | 1.5-3.5 |
| Nickel | - | 2.08 | 4.0 max. |
| Manganese | - | 0.92 | 3.5 max. |
| Silicon | - | 0.07 | 0.30 max. (total impurities). |
| Other elements | - | 0.57 | |
| Copper | - | 80.99 | Remainder. |

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Discussion:

On the basis of physical tests only, the order of merit for the various joining methods would be as follows; oxy-acetylene welding, silver brazing, arc welding, and, finally, bronze brazing. Since, however, costs are important this factor must be given due consideration.

Arc welding on very thin sections, such as the levers, could not be recommended, due to severe difficulties of 'burn-through'. In addition, the use of this process would require a subsequent normalizing operation to reduce the hardness in the heat-affected zone and to secure a ductile structure. Oxy-acetylene welding must also be followed by a normalizing treatment, for the same reasons.

The second best joining method, silver brazing, need not, and indeed cannot, be followed by a normalizing treatment. This is due to the fact that the melting point of this silver alloy is 1175° F., which is approximately 100° Fahrenheit degrees below the lower critical of the gun lever steel. This

(Discussion, cont'd) -

being the case, the temperature of brazing cannot have a detrimental effect upon the structure of the steel and, consequently, normalizing is not necessary.

The most expensive single operation in the salvaging of a lever is the machining after the joining operation. From all of the above tests it is estimated that the machining costs of a large number of salvaged levers should not exceed $1.30 per lever. The time, materials, and labour of joining would raise this figure to roughly $1.50 per lever. It can be readily seen that if the necessity for normalizing is eliminated the costs will be closer to the figure quoted and the salvaging process considerably accelerated. The process offering the most economical means of salvaging the levers would seem to be silver brazing.

The impact resistance and ductility shown by the silver-brazed levers should be more than sufficient to ensure satisfactory service. The joint preparation is simple and rapid. In salvaging a large number of levers, a simple holding jig should be used, to ensure proper alignment and close contact between the mating surfaces. It will be noted, in the table listing the results of the impact tests, that in some cases the extension piece broke off completely through the joint. This is due to insufficiently close contact between mating surfaces and resultant too-great joint thickness. The samples were not jigged but merely placed together and no special care taken. Joint thickness is critical, in that it is characteristic of this process that the greatest joint strength is developed when the silver alloy film ranges from 0.0015 to 0.003 inch in thickness. Above or below this thickness the joint strength drops off rapidly.

In the case of the modified aluminium-bronze levers, (Discussion, cont'd) -

the joint preparation and brazing process would be the same, with the exception that Sil-Fos (silver, 15 per cent; copper, 80 per cent; phosphorus, 5 per cent) brazing alloy should be used instead of Easy-Flo. The strength and ductility would be comparable to the results secured with the steel levers.

The elimination of a normalizing treatment involves an additional operation of blueing, to ensure good corrosion resistance of the machined joint and extension piece to salt air. A low-cost, rapid treatment used by gunsmiths* is recommended. This treatment is detailed as follows:

(1) Degrease part after machining, using benzine wash or any good commercial degreasing compound.

(2) Immerse for 10 minutes in a bath at boiling temperature containing -

(a) 3 pounds 1 oz. of sodium hydroxide (flakes).
(b) 1 pound trisodium phosphate.
(c) 3 ounces sodium chloride.
(d) 5 pounds, 1 ounce of sodium nitrate.
(e) 10 pounds of water.

Replace water evaporated, to maintain a constant bath level.

(3) Rinse in hot water.

(4) Dip in oil and swab off.

Two sample steel levers were blued by the above treatment and then subjected to a salt-spray corrosion test. The test was conducted at 95° F. in a 3 per cent salt solution spray for a period of 24 hours. At the end of that time the levers were removed and scrubbed with hot water and carefully examined. There was no evidence of corrosive attack through the blued surfaces. From the results of this test it is reasonable to expect good corrosion resistance from the blueing process.

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* "The Modern Gunsmith" - James V. Howe.

CONCLUSIONS:

1. On the basis of physical tests the order of merit of the various joining methods is as follows: oxy-acetylene welding; silver brazing; arc welding; and, finally, bronze brazing.

2. Silver brazing offers the most economical means of salvaging the levers.

3. A simple, rapid blueing treatment, as recommended, should reduce costs and salvaging time.

4. The physical properties of silver-brazed joints are sufficient to ensure good service life.

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