Report 1874

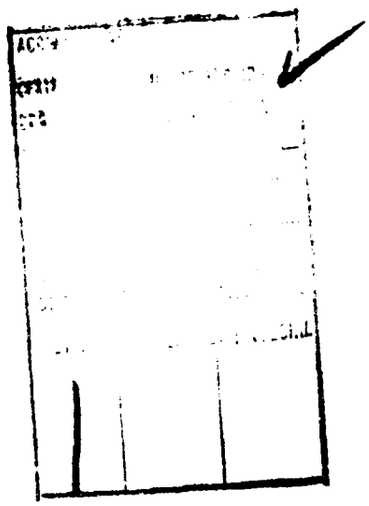
EVALUATION OF MUFFLER MATERIAL SAMPLES

by

Dario A. Emeric

October 1966

U. S. ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA



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SUMMARY

A practical heat-corrosion test, with respect to time, was designed to evaluate the corrosion resistance of various coated and noncoated muffler materials. Basically, the test is a modification of the Chrysler test used by industry. The duration of the test was shortened from 250 hours to 8 hours. Other variables, such as the salt fog spray test and the addition of hydrochloric acid to the corrosive medium, were evaluated. Stronger or weaker corrosive media than the one suggested by the Materials Research Laboratory were found impractical. The results obtained were in close agreement with the available data from the longer Chrysler test and from field performance.

The report concludes that the test designed by the Chemistry Branch can be used to evaluate the corrosion resistance of all muffler material samples presently available. It is superior to all heat-corrosion tests presently available with respect to time (8 man-hours, as against 240 man-hours). The results obtained are in close agreement with those of other published tests.

FOREWORD

The investigation was performed by Dario A. Emeric, under the supervision of Sidney Levine, Chief, Chemistry Branch, as directed by A. W. Van Heuckeroth, Chief, Materials Research Laboratory.

The author acknowledges the assistance of the following firms: U. S. Steel Corp., Bethlehem Steel Corp., Inland Steel Co., and the Republic Steel Corp.

CONTENTS

EVALUATION OF MUFFLER MATERIAL SAMPLES

I. INTRODUCTION

1. Statement of the Problem. The problem was to design a practical muffler test (heat corrosion), with respect to time, to evaluate the corrosion resistance of coated and noncoated muffler materials. The test is required for paragraph 4.5.2.8 (combination heat and corrosion) of the proposed Military Specification "Muffler, Exhaust, Internal Combustion Engine."

2. Background. This investigation was undertaken because an evaluation of the accelerated muffler corrosion tests used by industry found them to be impractical with respect to time (200-250 man-hours). These tests were the Chrysler (Republic-Inland) heat-corrosion test and the Chevrolet (Arvin) half immersion test (corrosion only). Inasmuch as the consensus was that the results obtained with the heat-corrosion test were more representative of muffler deterioration in the field, we decided to modify the Chrysler test to make it more practical with respect to time (a maximum of 8 man-hours) and to improve correlation with the available performance data (see Table I). It was felt that such a test would be meaningful to and acceptable by industry.

Table I. Performance Test*

Muffler Sample	No. of Miles	No. of Months
304 stainless steel	50,000	50
Alphatized steel	36,000	36
Chromized steel	36,000	36
Aluminized steel	18,000	18
Galvanized steel	12,000	12
Cold-rolled steel	9,000	9

* Based on information furnished by Inland Steel Co.

II. EXPERIMENTAL PROCEDURE

3. Approach to the Problem. All the parameters, such as immersion time, suspension time, number of immersions per cycle, corrosive medium, concentration and temperature, muffle furnace temperature, and the number of cycles of the heat-corrosion tests were examined closely and modified in order to shorten the duration of the test. The severity of the test was characterized by testing different types of muffler materials in different acid concentrations of the corrosive medium and by increasing the number of cycles. Other variables, such as the salt fog spray test and the addition of hydrochloric acid to the corrosive medium, were added to the test cycle and the results were evaluated. Study of the corrosion resistance of the different muffler materials obtained from industry, with modifications of the parameters, was made and compared with the available field performance data. The heat-corrosion laboratory procedure which produced the data correlating most closely with field performance was chosen for inclusion in the proposed Military Specification. The test appears in the Appendix to this report.

III. RESULTS AND DISCUSSION

4. Analysis of Test Results. It was found that strong corrosive media (acid concentrations greater than the 0.05N HBr and 0.10N H_2SO_4 suggested for the Materials Research Laboratory test) were impractical for the evaluation of the corrosion resistance of coated muffler materials. A weaker corrosive medium than the one suggested by the Materials Research Laboratory test was also found impractical because of the rapid loss in activity, especially during the evaluation of materials with active coatings, such as galvanized steel (see Table II).

Table II. Loss in Weight for Galvanized Steel in Grams Per Square Foot

Corrosive Medium	1st Cycle	2nd Cycle	3rd Cycle	4th Cycle	Total Weight Loss
Fresh solution	0.6	6.6	4.7	6.2	18.1
Depleted solution	0.9	3.2	2.5	3.3	9.9
Depleted solution	0.9	5.7^{z}	2.4^{x}	6.1^{z}	15.1
Followed by fresh solution	0.7	2.5^{x}	4.0^{z}	10.8	18.0

z fresh solution
x depleted solution

The addition of the salt fog spray test to the test cycle did not cause any pitting nor did it increase the weight loss of the test panels. The introduction of hydrochloric acid to the test cycle did not cause any pitting on any of the metals tested. A slight increase in weight loss was noted on some of the tested materials (see Table III). The data obtained (Table IV) show that the rate of corrosion of galvanized steel is dependent on the strength of the corrosive medium, while the corrosion rate of the cold rolled steel was almost independent of it. The results obtained (Table V) were in close agreement with the field performance data available and with the longer Inland test data (Table VI) for different muffler materials. The only materials whose laboratory test data did not correlate well with field performance was aluminized steel, Type I. The same problem, however, is encountered with the Chrysler test and was also reported by Allegheny Ludlum Steel Corp.

Table III. Loss in Weight Per Test Panel in Grams Per Square Foot

Test Panel[a]	1st Cycle	2nd Cycle	3rd Cycle	4th Cycle	Total Weight Loss
430 stainless steel	0.4	0.9	0.9	0.8	3.0
Chromized steel[b]	0.8	1.3	0.9	1.1	4.1
Alphatized steel	0.5	1.3	1.0	0.7	3.5
Aluminized steel	0.0	0.5	0.6	0.5	1.6
Galvanized steel	0.9	9.2	6.8	5.0	21.9
Cold rolled steel	1.7	4.3	4.0	3.5	13.5

(a) Acid concentration of the corrosive medium: 0.02NHBr, 0.03NHCl, 0.10NH_2SO_4.

(b) Polished surface.

Table IV. Total Loss in Weight Per Test Panel in Grams Per Square Foot

Concentration of Corrosive Medium	Sample Galvanized Steel	Cold-Rolled Steel
0.1NHBr, $0.5NH_2S0_4$	28.0	12.7
0.05NHBr, $0.25NH_2S0_4$	27.1	13.5
0.05NHBr, $0.10NH_2S0_4$	17.7	13.6
0.05NHBr, $0.05NH_2S0_4$	9.2	12.9
0.01NHBr, $0.05NH_2S0_4$	4.9	9.7

Table V. Loss in Weight Per Test Panel in Grams Per Square Foot

Test Panel[a]	1st Cycle	2nd Cycle	3rd Cycle	4th Cycle	Total Weight Loss
430 stainless steel[b]	0.0	0.3	0.3	0.3	0.9
Chromized steel[c]	1.2	1.2	1.4	1.5	5.3
Alphatized steel[d]	0.2	0.9	0.8	0.6	2.5
Aluminized steel[b]	0.0	0.8	0.6	0.4	1.8
Galvanized steel[b]	0.5	5.3	5.5	6.4	17.7
Cold-rolled steel[b]	2.3	3.9	2.8	3.6	12.6
Muffler-type 100[b]	0.1	0.7	0.6	0.7	2.1
Enduro-stainless steel[e]	0.0	0.9	0.9	0.7	2.5

(a) Acid concentration of the corrosive medium: 0.05N HBr, $0.10NH_2S0_4$.

Material supplied by:

(b) U. S. Steel Corp.
(c) Bethlehem Steel Corp.
(d) Inland Steel Co.
(e) Republic Steel Corp.

Table VI. Loss in Weight Per Test Panel in Grams Per Square Foot[a]

Test Panel [b]	Weight Loss
430 stainless steel	1.0
Alphatized steel	2.0 (Edges protected)
MF-1	3.2
Galvanized steel	17.5
Carbon steel (16 times)	26.5

(a) Based on information furnished by Inland Steel Co.
(b) Acid concentration of the corrosive medium: 0.01NHBr, 0.05NH_2S0_4.

IV. CONCLUSIONS

5. Conclusions. It is concluded that:

a. The test designed by the Chemistry Branch can be used to evaluate the corrosion resistance of all muffler material samples presently available.

b. It is superior to all heat-corrosion tests presently available with respect to time (8 man-hours, as against 240 man-hours).

c. The results obtained are in close agreement with those of other published tests.

APPENDIX

SUGGESTED PROCEDURE FOR EVALUATION OF MUFFLER MATERIALS

15 June 1966

1. Prepare two test panels of the test material 2 inches by 3 inches, and punch a 3/16-inch hole in the 2-inch side. Be sure that test panels are free from corrosion products.

2. Degrease the panel with fresh acetone (spray bottle) and do not handle with bare hands.

3. Air dry the test panels and let them come to equilibrium in the balance room for 15 minutes.

4. Weigh the panels and record their weight to the nearest milligram (0.001 gram).

5. Dip weighed panels for 60 seconds in an aqueous solution of 0.05N hydrobromic acid and 0.10N sulfuric acid at 200° F (94° C).

6. Raise panels out of solution and leave them suspended 1 inch over the hot solution for 15 minutes.

7. Repeat steps (5) and (6). Place panels in muffle furnace at 1100° F (593° C) for 1 hour.

8. Remove the panels from the furnace and let them cool.

9. Brush the panels with a brass brush to remove loose corrosion products.

10. Repeat steps (5) to (9) three more times.

11. Repeat steps (2) to (4). inclusive.

12. Multiply all losses in weight by 12. to convert weight loss to grams per square foot.

13. The loss in weight between the two test panels (high-low) of the test material should not be greater than 3 grams per square foot. Report the average of the two test panels.

NOTE:

a. Panels must be spaced with glass spacers (or any other nonmetal spacer that can withstand the environment) on a glass rod.

b. The test beaker must be covered during the test for condensation of vapors.

c. Use 1500 ml of the aqueous acid solution in a 3000-ml Pyrex or Vycor Griffin beaker.

d. The aqueous acid solution should be changed every four cycles.

e. Do not run duplicates of active metals, such as zinc and iron, in the same corrosive bath.

f. Iron and zinc can be run together in singles, if desired.

g. A minimum specific ratio of 25 ml of the corrosive medium, per square inch of specimen surface area, should be used.

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