AD-777 790

STRESS CORROSION OF CHAPARRAL FIN RETAINERS

John H. Honeycutt

Army Missile Command
Redstone Arsenal, Alabama

25 January 1974

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

ACCESSION for		
NTIS	White Section	☒
DDC	Buff Section	☐
UNANNOUNCED		☐
JUSTIFICATION		
BY		
DISTRIBUTION/AVAILABILITY CODES		
Dist.	AVAIL. and/or SPECIAL	
A		

DISPOSITION INSTRUCTIONS

DESTROY THIS REPORT WHEN IT IS NO LONGER NEEDED. DO NOT RETURN IT TO THE ORIGINATOR.

DISCLAIMER

THE FINDINGS IN THIS REPORT ARE NOT TO BE CONSTRUED AS AN OFFICIAL DEPARTMENT OF THE ARMY POSITION UNLESS SO DESIGNATED BY OTHER AUTHORIZED DOCUMENTS.

TRADE NAMES

USE OF TRADE NAMES OR MANUFACTURERS IN THIS REPORT DOES NOT CONSTITUTE AN OFFICIAL INDORSEMENT OR APPROVAL OF THE USE OF SUCH COMMERCIAL HARDWARE OR SOFTWARE.

UNCLASSIFIED
Security Classification

AD-777790

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Ground Equipment and Materials Directorate, US Army Missile Res, Dev and Eng Laboratory, US Army Missile Command, Redstone Arsenal, Alabama 35809	2a. REPORT SECURITY CLASSIFICATION Unclassified; 2b. GROUP

3. REPORT TITLE

STRESS CORROSION OF CHAPARRAL FIN RETAINERS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Technical Report

5. AUTHOR(S) (First name, middle initial, last name)

John H. Honeycutt

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
25 January 1974	18	

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) RL-74-4
b. PROJECT NO.	
c. AMC Management Structure Code No. 4210.18.0810.1	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Same as No. 1

13. ABSTRACT

An investigation of the stress-corrosion characteristics of two materials proposed for use as fin retainers for the CHAPARRAL missile system was made. The two materials were 17-7PH stainless steel and QQ-S-777 carbon spring steel.

Retainers made from these two materials were mounted on a test fixture, which simulated the static loading conditions, and subjected to a salt fog environment per MIL-STD-151-B.

It was concluded that the retainers manufactured from the spring steel (QQ-S-777) were superior to those manufactured from the 17-7PH stainless steel.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Stress-corrosion						
17-7PH stainless steel						
QQ-S-777 carbon spring steel						

CONTENTS

1. INTRODUCTION

The CHAPARRAL Project Office, having received reports of fin retainers failing under normal environmental storage conditions, requested an investigation to determine the cause of these failures. All retainers that had failed were fabricated from the 17-7PH steel, heat treated to the RH950 condition.

No documented manufacturing procedure was available, except as called out on NAVAIR drawing 1562660. However, telephone communications between the CHAPARRAL Project Office and the manufacturer of the 17-7PH retainers revealed that the as-received material was cold rolled prior to forming. Exposure to a temperature of 950°F followed the cold forming operation. The manufacturer stated that this process was necessary to obtain the proper thickness of the material before retainer production started.

A stress-corrosion test program was established for the 17-7PH retainers and some special retainers made from QQ-S-777 spring steel. This program included reheat treatment of the 17-7PH retainers to lower stress levels, baking for hydrogen embrittlement relief, and testing in the as-received condition. See Tables 1, 2, 3, and 4.

One each of the specimens in the above conditions was subjected to a load deflection test. See Table 5.

After receiving the specimens, a metallurgical examination was conducted on the 17-7PH specimens. Inclusions and cracks were noted in the failed and unfailed specimens. These inclusions were caused by a titanium impurity, probably introduced during the alloying process (Figures 1-3). The titanium carbide inclusions develop stress risers, which are detrimental to the life of the retainer, especially when they emerge at the retainer surface and come in contact with a corrosive media such as a marine environment.

Figures 4, 5, and 6, as-received retainers, and Figure 7, a failed retainer, show cracks and voids. Figure 7 represents a section of the retainer away from the failed area.

2. TEST SPECIMENS

Specimens for this test were manufactured from 17-7PH and spring steel (QQ-S-777). Both types of specimens were subjected to identical test procedures.

The test conditions of the 17-7PH and of the QQ-S-777 specimens were as called out in Tables 1 through 5.

The 17-7PH material was reduced in thickness by cold rolling. A reduction in thickness of this material has the disadvantage of lowering its ductility. The ductility, as measured by elongation, is 5% for a 60% reduction and 10% for a 30% reduction. This reduction in ductility makes intricate parts more susceptible to cracking during the forming operation.

3. TEST PROCEDURE

Load-deflection data were generated on each type of specimen to be tested. Table 5 shows the different types of specimens and the resulting loads for a given deflection. Only the as-received specimens exhibit load capabilities as required by the NAVAIR drawing 1562660. Note 10 of this drawing requires that the load shall be 12.5 ±0.5 pounds for all deflections from 0.328 to 0.378 inch.

These data were generated using an Instron testing machine. The test setup is shown in Figure 8.

Stress-corrosion tests were conducted on four groups of retainers, as listed in Tables 1, 2, 3, and 4.

All specimens were prepared as called out in Tables 1 through 5 and were then mounted on the same type of material as the missile body. The shape of the mounting fixture was fabricated in accordance with NAVAIR drawing 2192625, sheet 3 of 3. Fasteners were 100° flat head, 10-32UNF-3A machine screws per BUWEPS drawing 1556725.

Each retainer was secured to its mounting fixture by applying 35-40 inch-pounds of torque to the fasteners (see Figure 9). After mounting, the retainers were subjected to salt fog test per Federal Test Method Standard 151B, except those in Table 4. These three retainers were loaded and tested at room temperature conditions.

4. TEST RESULTS

The load-deflection data generated on each different type of specimen showed that only the "as received" specimens exhibited the required load (12.5 ± 0.05 lb) for a given deflection. The specimen that was baked at 400°F for one hour was marginal at 11.7 lb. See Table 5.

Table 1 shows results of 17-7PH specimens in four different conditions: 1) as-received (RH-950); 2) baked at 400°F for one hour for hydrogen embrittlement relief; 3) reheated to 1000°F for 15 minutes (UTS = 214 ksi); and 4) reheated to 1050°F for 15 minutes (UTS = 205 ksi). The reheat procedure was an attempt to lower the existing ultimate tensile stress (222 ksi) to prevent stress cracking. There were failures in each of the specimen conditions except the reheat to 1050°F group, in which there were no failures. Testing of the group of specimens was terminated after 666 hours.

Figures 10 and 11 show a typical specimen failure for this group. All of the specimens exhibited blistering of the dry film lubricant. The first evidence of blistering was G_2-1-4 after 144 hours of testing. After 312 hours, all specimens showed blistering of the dry film lubricant. See Figure 12.

Table 2 represents a continuation of stress-corrosion testing of the as-received 17-7PH (RH950) specimens. After 163 hours, this test was terminated and 10 of the 12 specimens had failed. Figure 13 shows a typical stress-corrosion failure, specimen G_4-1. Note the large ferrite stringer at the top of this photograph.

Three specimens of this group were chosen at random for metallographic examination in the as-received condition. Two of the specimens were found to have cracks in the countersunk portion of the retainers (Figures 5 and 6). No cracks were noted in the third specimen. However, all three specimens did show inclusions of titanium carbide.

Table 3 shows results of stress-corrosion tests of retainers fabricated from 17-7PH and QQ-S-777 carbon steel. All of these specimens were tested in the as-received condition, except G_1-1, 2, and 3. These three specimens were modified by reducing the width of dimension "A" in Figure 14 by 0.010 inch.

This test was terminated after 144 hours. There were no failures of the QQ-S-777 specimens. However, all three of the 17-7PH specimens had failed at the end of 44 hours. See Table 3, G_3-1, 2, and 3.

There was some red rust on each of the QQ-S-777 specimens around the countersunk area and also around the edges of the specimens. See Figure 15.

Table 4 shows no specimen failures when stressed at the required load and tested at room temperature conditions for 155 days. Only the 17-7PH retainers were tested under these conditions.

5. CONCLUSION

Based on the data obtained from the stress-corrosion study, it was concluded that the 17-7PH specimens were inferior to the QQ-S-777 specimens. Poor alloying and fabricating processing were probably major factors contributing to the failure of the 17-7PH specimens.

6. RECOMMENDATIONS

As a result of test data, it is recommended that the CHAPARRAL fin retainer be fabricated from QQ-S-777 steel.

TABLE 1. STRESS-CORROSION TEST RESULTS
(Test Duration: 666 Hours)

Specimen No.	Specimen Material	Specimen Condition	Environmental Condition	Time To Failure (Hrs)
G_1 - 1	17-7PH	As Received	Salt Fog	NF*
- 2		As Received	↑	33
- 3		As Received		NF*
- 4		As Received		NF
G_2 - 1	17-7PH	Hydrogen Relief Baked at 350-400°F 400°F (1 hr)		NF
- 2		Baked at 350-400°F (1 hr)		NF
- 3		Baked at 350-400°F (1 hr)		9
- 4		Baked at 350-400°F (1 hr)		NF
G_3 - 1	17-7PH	Reheated to 1000°F (15 min)		NF
- 2		Reheated to 1000°F (15 min)		NF
- 3		Reheated to 1000°F (15 min)		NF
- 4		Reheated to 1000°F (15 min)		9
G_4 - 1	17-7PH	Reheated to 1050°F (15 min)		NF
- 2		Reheated to 1050°F (15 min)		NF
- 3		Reheated to 1050°F (15 min)	↓	NF
- 4		Reheated to 1000°F	Salt Fog	NF

*NF: Did not fail.

TABLE 2. STRESS-CORROSION TEST RESULTS
(Test Duration: 163 Hours)

Specimen No.	Specimen Material	Specimen Condition	Environmental Condition	Time To Failure (Hrs)
G_2 - 1	17-7PH	As Received	Salt Fog	73
- 2				NF*
- 3				117
- 4				NF
G_3 - 1	17-7PH			42
- 2				42
- 3				20
- 4				20
G_4 - 1	17-7PH			163
- 2				20
- 3				20
- 4		As Received	Salt Fog	139

*NF: Did not fail.

TABLE 3. STRESS-CORROSION TEST RESULTS
(Test Duration: 144 Hours)

Specimen No.	Specimen Material	Specimen Condition	Environmental Condition	Time To Failure (Hrs)
G_1 - 1	QQ-S-777	Modified End	Salt Fog	NF*
- 2		Modified End		NF
- 3		Modified End		NF
G_2 - 1	QQ-S-777	As Received		NF
- 2				NF
- 3				NF
- 4				NF
G_3 - 1	17-7PH			14
- 2				44
- 3				22
- 4	QQ-S-777	As Received	Salt Fog	NF

*NF: Did not fail.

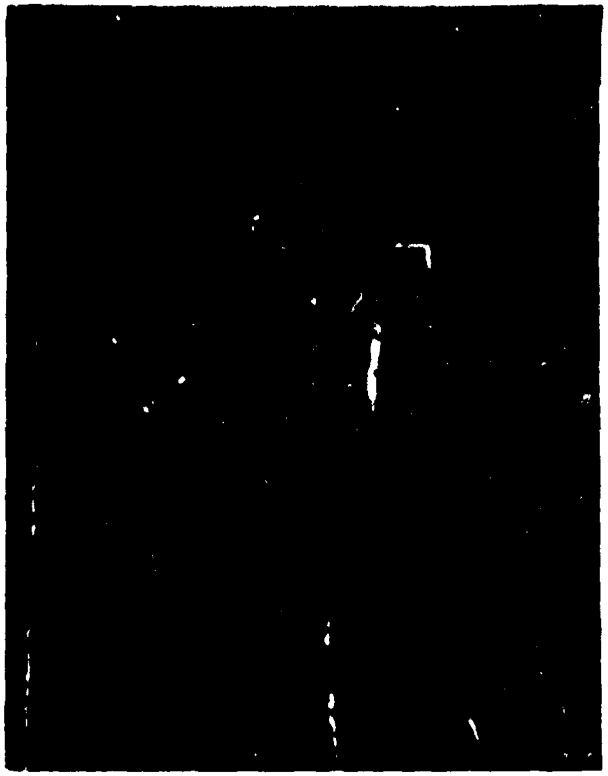
TABLE 4. STRESS-CORROSION TEST RESULTS
(Test Duration: 155 Days)

Specimen No.	Specimen Material	Specimen Condition	Environmental Condition	Time To Failure (Hrs)
G_4 - 1	17-7PH	As Received	Room Temp	NF*
- 2		As Received	Room Temp	NF
- 3		As Received	Room Temp	NF

*NF: Did not fail.

TABLE 5. LOAD-DEFLECTION

Specimen Material	Specimen Condition	Load (Lb.)	Deflection (In)
QQ-S-777	As received	13.1	0.375
17-7PH	Baked for H_2 relief (400°F for 1 hr.)	11.7	0.375
17-7PH	Reheated to 1000°F for 15 minutes; finished per MIL-L-46010	10.9	0.375
17-7PH	Reheated to 1050°F for 15 minutes; finished per MIL-L-46010	10.4	0.375
17-7PH	As received	12.8	0.375



F·gure 1. Titanium carbid· inclusion, 250X.

Figure 2. Titanium inclusions, 400X.

Figure 3. Titanium carbide inclusion, 2000X. (scanning electron microscope micrograph)

Figure 4. Cracks in untested retainer, 500X.

Figure 5. Untested as-received, retainer, 700X.
(scanning electron microscope micrograph)

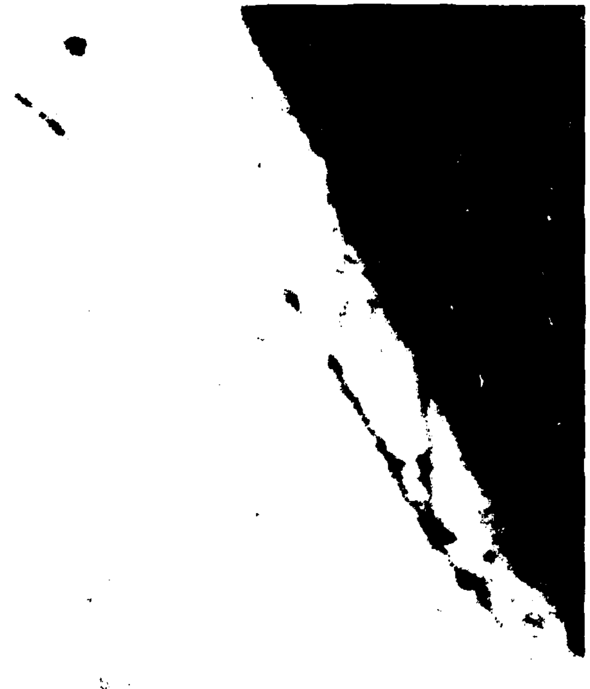


Figure 6. Cracks in untested retainer, 1000X.

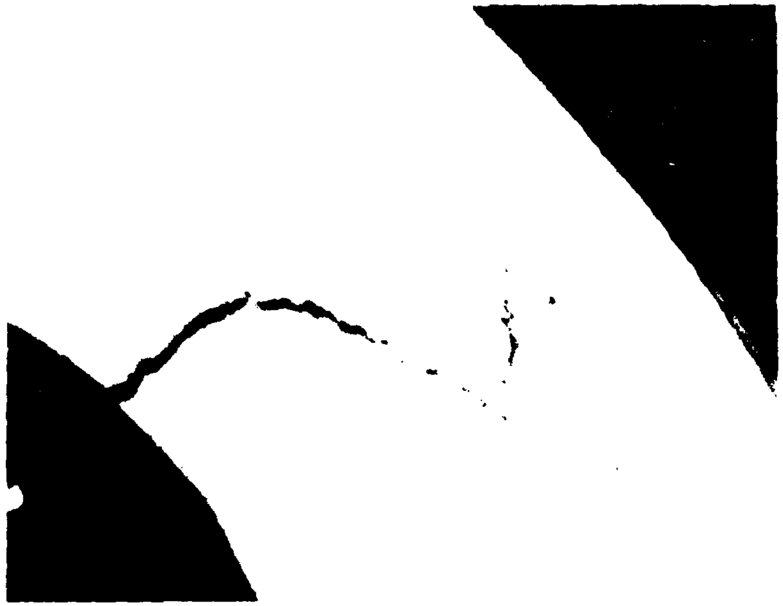


Figure 7. Failed retainer, 75X.

Figure 8. Load deflection test setup.

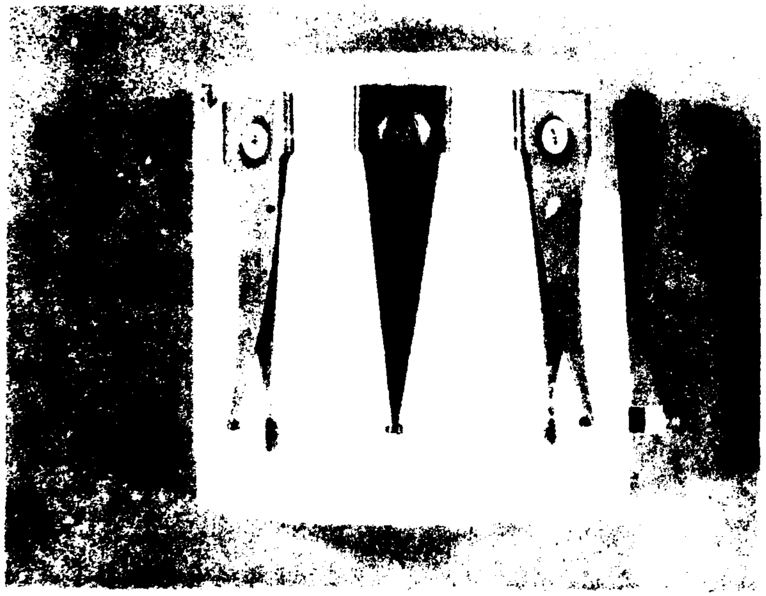


Figure 9. Specimens mounted on test fixture G_2.

Figure 10. Typical specimen failure (G_3-4 Table 1, first test).

Figure 11. Typical failure.

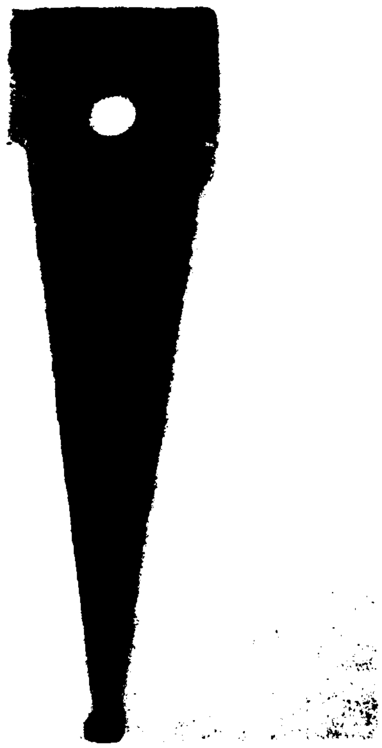


Figure 12. Blistering dry-film lubricant.

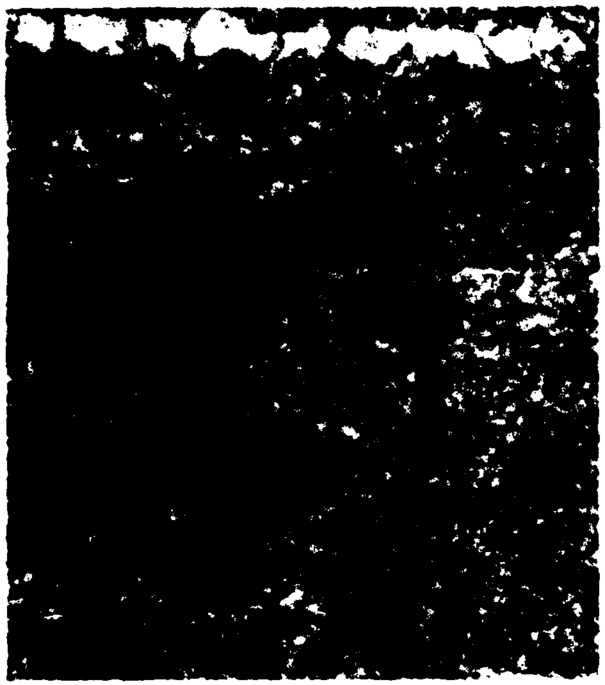


Figure 13. Typical stress-corrosion failure, 500X.

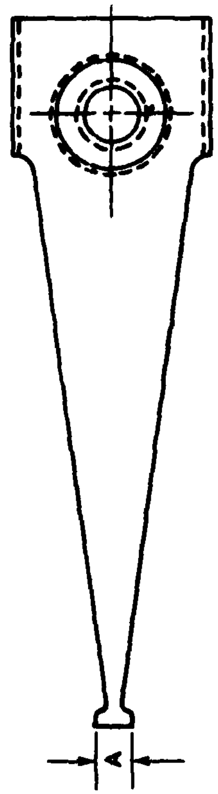


Figure 14. Modified retainer.

Figure 15. Typical rust on QQ-S-777 specimen.