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TECHNICAL NOTE

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ARTIFICIAL AGING OF RIVETED JOINTS MADE IN ALCLAD 24S-T SHEET USING A17S-T, 17S-T, AND 24S-T RIVETS

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INTRODUCTION

Artificial aging of 24S-T and 24S-RT sheet to improve their mechanical properties has been developed to the point that it is finding considerable commercial application (reference 1). Ordinarily the sheet is artificially aged before it is assembled into a structural part, but some manufacturers have expressed an interest in the artificial aging of complete assemblies. Since most aircraft structural assemblies are riveted, such a procedure would involve artificially aging the driven rivets which might or might not be of 24S alloy. It seems desirable, therefore, to obtain some information on the effect of artificial aging on the strengths of driven rivets of the alloys used commercially for rivets: namely, A17S-T, 17S-T, and 24S-T.

OBJECT

The object of this investigation was to study the effect of artificial aging on the shear strength of joints prepared from alclad 24S-T sheet using A17S-T, 17S-T, and 24S-T rivets.

MATERIAL

The sheet used in this investigation was 0.064-inch-thick alclad 24S-T produced in accordance with specification AN-A-13

(amended Oct. 11, 1943). The rivets were 1/8 by 5/16-inch button head and of the alloys commonly employed in airplane construction: A17S-T, 17S-T, and 24S-T.

PROCEDURE

The effect of the artificial aging treatment on the rivets was measured by the changes produced in the shear strength of the rivets. The details of the specimens are shown in figure 1.

A total of 40 specimens was prepared, with all rivets headed by using the driving load necessary to give flat driven heads 3/16 inch in diameter. Ten specimens were prepared for each of the following conditions:

(1) A17S-T rivets, driven as received with approximately 2000 pound driving load for each rivet

(2) 17S-T rivets, reheat-treatment, quenched, refrigerated, and driven immediately with 1800 pound driving load per rivet

(3) 17S-T rivets, reheat-treated, quenched, and allowed to age 6 days at room temperature before being driven with 2400 pound driving load per rivet

(4) 24S-T rivets, reheat-treated, quenched, refrigerated, and driven immediately with 2400 pound driving load per rivet

The rivets were driven with the aid of a sub-press in a 40,000-pound capacity Amsler testing machine (type 20, ZBDA, Serial No. 4318). None of the rivets in this investigation developed any head cracks.

Of the 10 specimens prepared for each condition, 5 were artificially aged for 10 hours at 375° F, and 5 were left unaged for comparison. The aging treatment, 10 hours at 375° F, was selected to represent the type of treatment that probably would be used on complete assemblies involving various alloys and tempers.

After completion of the necessary operations, all the specimens were tested in a 40,000-pound capacity Amsler testing machine (type 20, ZBDA, Serial No. 4318). The test results are given in table 1.

DISCUSSION OF RESULTS

A study of table 1, especially the last column headed "Percent Change in Strength," indicates that the artificial aging treatment applied had various effects on the different rivets.

The 24S-T rivets increased in shear strength by 6.1 percent while the others suffered either a decrease in strength or were practically unchanged. The A17S-T rivets exhibited the greatest loss of shear strength due to artificial aging: namely, 10.3 percent. The 17S-T rivets driven before room temperature aging (refrigerated) showed practically no change in shear strength after artificial aging; while 17S-T rivets driven after room temperature aging showed a decrease in strength of 7.5 percent. The shear strength of the 17S-T rivets driven in the full "T" temper was greater than that of the 17S-T rivets driven refrigerated, whether artificially aged or not.

The results from the 24S-T riveted joints can be compared to the results from a previous study also given in table 1. In the previous investigation, the artificial-aging treatment was 11 hours at 375° F (as compared to 10 hours at 375° F in this investigation). In one case the rivets were aged before driving,[1] and in the other the completed specimens containing driven rivets were aged. Final strength values obtained in these previous tests are in good agreement with those obtained in the present tests. The data indicate that there is practically no difference in the shear strength of the 24S-T rivets whether aged after driving or before driving.

The average shear strengths of the rivets in this investigation are compared to the Army-Navy allowable design values given in table 5-14 of reference 2 in the following tabulation:

Rivet alloy	Driving condition	Allowable design values, (psi)	Average shear strength, (psi) (from table 1)	
			Not artificially aged	Artificially aged
A17S-T	As received	30,000	34,000	30,500
17S-T	Refrigerated	34,000	36,800	36,900
17S-T	Room temperature aged*	38,000	41,100	38,000
24S-T	Refrigerated	41,000	44,200	46,900

*17S-T rivets driven in the room temperature aged condition are referred to as "17S-T-A" rivets in ANC-5.

[1]A U.S. patent application is pending on this treatment.

It can be seen that the average shear strengths of the rivets not artificially aged are 8 to 13 percent greater than the allowable design values given in ANC-5. The average shear strengths of the rivets artificially aged after driving are 0 to 14 percent greater than the allowable values.

PRELIMINARY CORROSION TESTS

In connection with this investigation several joints consisting of 1/8-inch A17S-T, 17S-T, and 24S-T rivets driven in 0.064-inch-thick 24S-T and Alclad 24S-T sheet were prepared, some of which were exposed after being aged 10 hours at 375° F and some of which were exposed in the unaged condition. The exposure was alternate immersion for one week in sodium chloride-hydrogen peroxide solution. These preliminary tests indicate that the rivets in the artificially aged joints are attacked considerably more rapidly than those in the joints not artificially aged and that the attack is most rapid on the driven heads of the rivets.

CONCLUSIONS

On the basis of data and discussion in this report on the artificial aging of riveted lap joints in alclad 24S-T sheet using A17S-T, 17S-T, and 24S-T rivets, the following conclusions seem warranted:

1. The change in shear strengths resulting from the artificial aging treatment of 10 hours at 375° F applied to the driven rivets is as follows:

   (a) 24S-T rivets increased about 6 percent in strength.

   (b) 17S-T rivets driven refrigerated showed practically no change in strength.

   (c) 17S-T rivets driven in the full T temper decreased about 8 percent in strength.

   (d) A17S-T rivets decreased about 10 percent in strength.

2. The shear strength of the 17S-T rivets driven in the full T temper is higher than that of 17S-T rivets driven refrigerated whether artificially aged or not.

3. The average shear strengths of the A17S-T, 17S-T, and 24S-T rivets in the specimens not artificially aged are from 8 to 13 percent higher than the corresponding Army-Navy allowable design values given in reference 2.

When artificially aged after driving, the rivets showed average shear strengths 0 to 14 percent higher than the allowable values just mentioned.

Aluminum Research Laboratories,
Aluminum Company of America,
New Kensington, Pa. January 18, 1944.

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2. Anon.: Strength of Aircraft Elements. Army-Navy-Civil Committee on Aircraft Design. Amendment No. 1, Oct. 22, 1943.

TABLE 1

RESULTS OF ARTIFICIAL AGING OF JOINTS MADE WITH A17S-T, 17S-T AND 24S-T RIVETS
All rivets were 1/8 in. in diameter
Aging treatment was 10 hours at 375°F
All rivets driven in Alclad 24S-T sheet
Average driven head-size for all cases = 3/16 in.
All failures were by shearing the rivets

Type of Rivets	Driving Conditions	Average Driving Load per Rivet, lb	Unaged Specimens		Aged Specimens		Per Cent Change in Strength†
			Ultimate Load,* lb	Average Shear Strength,** psi	Ultimate Load,* lb	Average Shear Strength,** psi	
A17S-T	Driven as received	2005	895 875 880 874 886 882	34 000	785 793 804 785 783 790	30 500	-10.3
17S-T Soft	Heat treated, put on ice, and driven immediately	1805	960 942 956 961 952 954	36 800	939 955 961 958 969 956	36 900	+ 0.3
17S-T hard	Heat treated, room temperature aged 6 days, then driven	2400	1075 1056 1055 1069 1073 1066	41 100	987 987 988 979 990 986	38 000	- 7.5
24S-T	Heat treated, put on ice, and driven immediately	2400	1145 1136 1158 1151 1141 1146	44 200	1204 1210 1226 1230 1212 1216	46 900	+ 6.1
24S-T	Previous Test*** (aged after driving)	2500		45 900		47 000	+ 2.4
24S-T	Previous Test**** (aged before driving)	2480				46 300	

* Individual and average values given are total loads for two rivets.
** Shear Area = 2 x π/4 $(0.1285)^2$ = 0.02594 sq in.
† + sign indicates increase in strength due to aging, - sign indicates decrease in strength due to aging.
*** Driving conditions same as for 24S-T above. Specimens were aged 11 hr at 375°F after driving rivets. Results are average of three specimens.
**** Rivets were heat treated, quenched, kept at room temperature for 6 days, and were aged 11 hr at 375°F before driving. Results are average of three specimens. No artificial aging after rivets were driven.