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Material - Aluminum - 2024-T81 and 2024-T31 - Stretcher Levelled Plate

Stress Corrosion Susceptibility From Rivet Swelling

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Abstract:

The tendency for the swelling of 2024-T31 aluminum alloy rivets, caused by gun driving them into holes in 2024-T81 stretcher levelled aluminum alloy plates, to induce stress corrosion susceptibility in the plate material was checked by means of salt spray exposure and synthetic sea water alternate immersion tests. Stress corrosion cracking was not observed during testing, and stretcher levelling thus did not appear to induce stress-corrosion susceptibility in 2024-T81 plates.

Reference: Turner, H. S., Sutherland, W. M., "Stress Corrosion Cracking Test of 2024-T81 Aluminum Alloy Plate," General Dynamics/Convair Report MP57-506, San Diego, California, 17 September 1958, (Reference attached).

CONVAIR

A DIVISION OF GENERAL DYNAMICS CORPORATION

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STRUCTURES-MATERIALS LABORATORIES

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MODEL F-106A

TITLE

REPORT NO. 57-506
STRESS CORROSION CRACKING TEST
OF 2024-T81 ALUMINUM ALLOY PLATE

MODEL F-106A
CONTRACT NO. AF33 (600)-30169

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INTRODUCTION:

This report describes a test program conducted with the cooperation of the Aluminum Research Laboratories of Alcoa, New Kensington, Pa. Convair exposed two sets of test specimens in the standard salt spray test cabinet. Aloca agreed to subject other Convair specimens to exposure in their alternate immersion and sea atmosphere facilities. Since their Point Judith exposure station has been undergoing reconstruction, the sea atmosphere test results are not yet available. However, it is unlikely that the latter tests will yield contradictory data.

OBJECT:

To evaluate the susceptibility of 2024-T81, stretcher leveled plate, to stress corrosion cracking when stressed in the short transverse direction due to the installation of either 2024-T31 or stainless steel rivets.

CONCLUSION:

Stress corrosion cracking was not observed in Convair salt spray exposure tests or in Alcoa alternate immersion tests.

TEST SPECIMENS:

Specimens were taken from a 2 in. thick plate of 2024-T4 stretcher leveled plate. Four pieces 2 3/4 in. x 8 1/4 in. were cut from this plate with the longitudinal dimension parallel to the grain direction. Each of these was machined to a channel section, heat treated, drilled, and riveted in accordance with Figure 1.

Rivet holes were drilled in accordance with Convair Standard 32001. This requires that the holes for the 5/32 in. universal head 2024-T31 rivets be $.161^{+.006}_{-.000}$ in. diameter and the holes for the 1/8 in. flat head stainless steel rivets be $.128^{+.006}_{-.000}$ in. diameter. The diameter of the 5/32 in. rivets is $.156^{+.004}_{-.001}$ and of the .125 in. rivets is $.125^{+.003}_{-.001}$. Rivets were driven with a gun rather than a squeezer.

Two of the channels were sent to Alcoa. One was for alternate immersion tests in 3 1/2% sodium chloride solution and the second for seaside exposure at Point Judith. The other two were retained by Convair for salt spray exposure tests.

The latter two Channels were split lengthwise and placed in a salt spray cabinet operated in accordance with Federal Test Method Standard 151, Method 811. They were placed so that there was a slight incline beneath the spray. In this way the run-off was directly on the surfaces with the rivet heads. Observations were made daily except for weekends for two weeks; after this period, observations were made every week. Specimens were removed after two months exposure.

RESULTS AND DISCUSSION:

At the end of two months no stress corrosion cracks were observed. All test panels were severly pitted. The Channel halves with the stainless steel rivets appeared to be slightly worse than those with the aluminum rivets. The rivets appeared to be free of corrosion. These specimens are shown in Figure 2.

Alcoa's test results on specimens exposed to alternate immersion in a 3 1/2 % sodium chloride solution for twelve weeks are noted in their report No. XA-105. Results of microscopic examination are also recorded. Their conclusions were:

1. The relatively anodic potential, -0.812 volts, of the 2024-T81 alloy machined channel indicated a good resistance to stress corrosion cracking.
2. The 2024-T81 alloy machined Channel containing hoop stresses caused by the expanding force of the stainless steel rivets did not stress corrosion crack.
3. There was no evidence of appreciable galvanic corrosion of the 2024-T81 alloy plate caused by the relatively cathodic rivets of stainless steel and 2024-T31 alloy.

The results of specimens exposed at Point Judith are not yet available.

A cover letter to Alcoa's report contains the following recommendation:

> The satisfactory performance of these riveted channels of 2024-T81 does not necessarily mean that the locked-in stresses were low enough that equal performance would be obtained with other high strength aluminum alloys. From the stress corrosion standpoint, we would much prefer to see the channels fabricated to size as as extrusion or forging, if such is feasible.

In a previous instance, where rivets were installed so as to cause stresses in the short transverse direction in 7075-T6 plate stock, cracks were developed. This is described in Materials and Processes Laboratory Report No. 944. Here, the material was subjected to a more severe condition including contact with a large area of stainless steel, mismatch of the two parts resulting in bending stresses, and overdriving of the rivets. This case is mentioned to show the need for caution when parts must be machined from aluminum plate and riveted in a manner causing stresses in the short transverse direction.

Note: The data from which this report was written are recorded in Materials and Processes Laboratory Notebook No. 893.

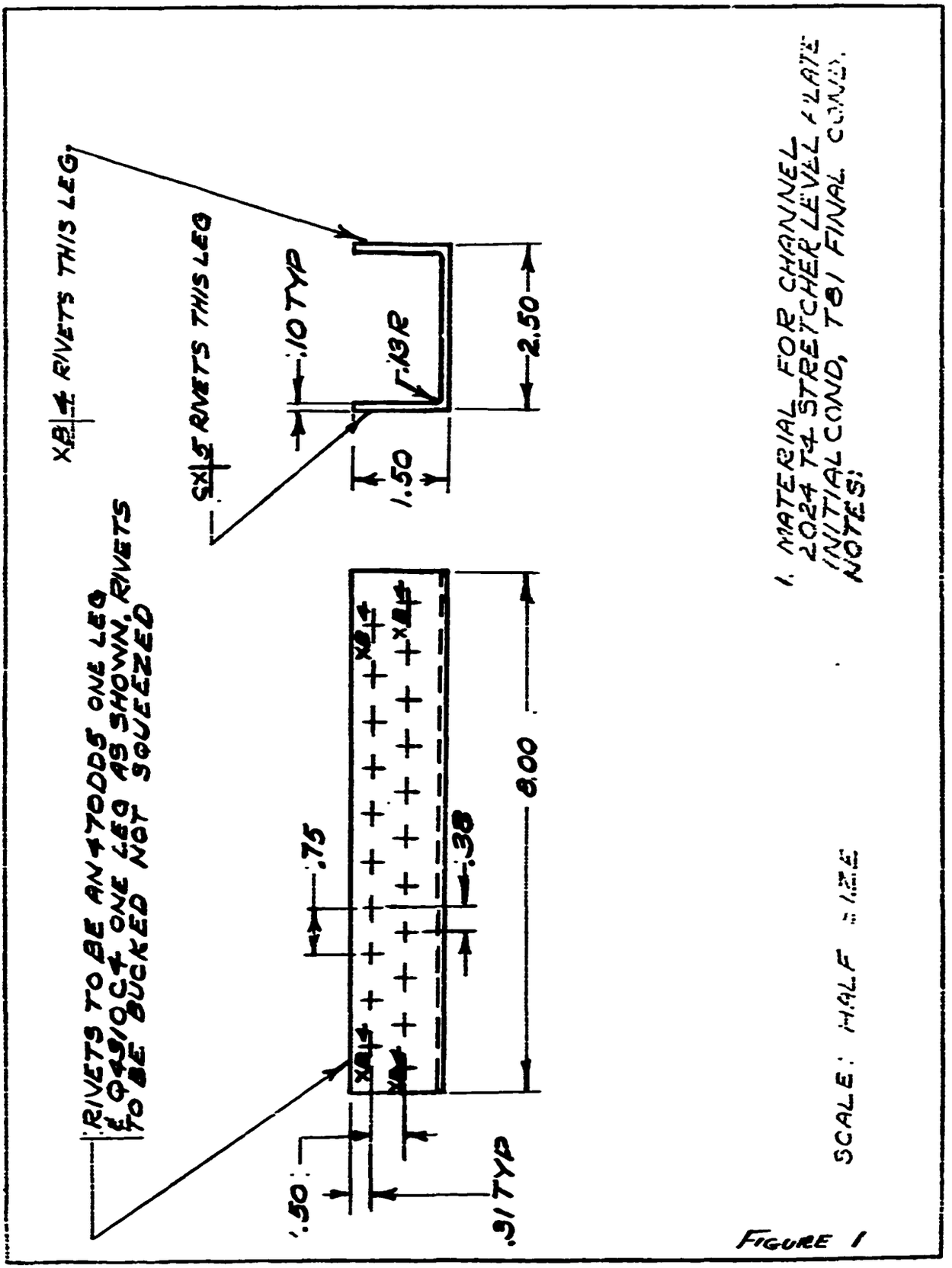

FIGURE 1

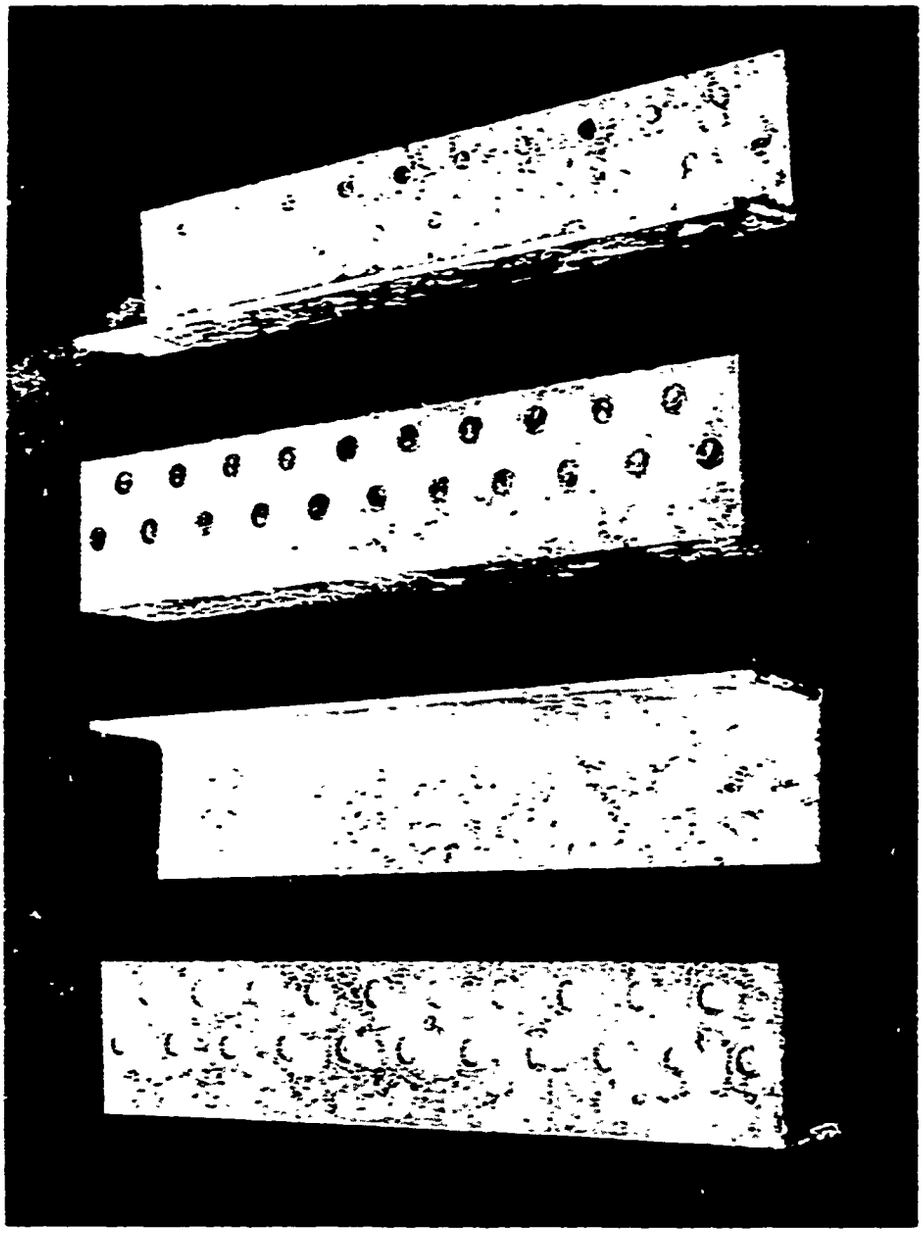

FIGURE 2. Corrosion Test Specimens of 2024-T81 Aluminum Alloy Plate after two months in the salt spray cabinet. Specimens with 2024-T31 rivets are shown at left and those with stainless steel rivets at right.