A Brief Study of the Suitability of Titanium and a Titanium Alloy as Firewall Material

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A BRIEF STUDY OF THE SUITABILITY OF TITANIUM AND A TITANIUM ALLOY AS FIREWALL MATERIAL*

FOREWORD

The investigation covered by this report was conducted at the Civil Aeronautics Administration's Technical Development Center, Indianapolis, Indiana, under WADC Contract No. AF33(616)54-15, Amendment No. A2(56-1935), and RDO No. R-523-369SR1Z.

SUMMARY

Tests were conducted on several grades of commercially pure titanium and one alloy to determine their strength at elevated temperatures and their resistance when exposed to a 2,000° Fahrenheit flame. Similar tests of stainless steel were conducted to provide a basis for comparison since stainless steel has a long record of service in high temperature and fireproof construction.

The test results indicate that the strength of titanium and titanium alloy decreased as the temperature of the metal increased. Stainless steel, with a higher ultimate strength than titanium, remained stronger than titanium throughout the temperature range of the tests, namely, 1,000° to 1,800° Fahrenheit. However, stainless steel decreased in strength at a more rapid rate than did titanium, until at 1,800° Fahrenheit the difference in their strengths was not as pronounced as it was at 1,000° Fahrenheit.

Panels of commercially pure titanium as thin as 0.016-inch resisted the 2,000° Fahrenheit flame for a minimum of 15 minutes without any visible deterioration. When a pressure differential of 5 pounds per square inch across the panel imposed a strain, deformation or creep occurred. A 15-pound-per-square-inch differential pressure caused a greater deformation and brought about the rupture of two panels. The stainless steel panels also underwent some deformation but to a lesser degree than the titanium panels. The one titanium alloy panel deformed less than commercially pure titanium panels of the same thickness.

INTRODUCTION

The use of commercially pure titanium and titanium alloy in the construction of aircraft powerplant firewalls, ducts, and shrouds has resulted in a need for information on the structural strength and behavior of these materials under exposure to elevated temperatures and fire. In order to meet this need in part, the testing described in this report was accomplished.

TEST PROCEDURE

Test specimens of commercially pure titanium and a titanium alloy of the size and shape shown in Fig. 1 were mounted in a tensile-testing apparatus and heated electrically to a predetermined temperature. A tensile load was applied until failure of a specimen occurred. The specimen was strained at a rate of 1.5 inches per second. The tensile-testing apparatus and transformer used for heating the test specimens are shown in Fig. 2. Eleven 24- by 24-inch sections of titanium sheets were subjected for 15 minutes to a 2,000° Fahrenheit (F.) flame from a conversion oil burner which consumed 2 gallons of kerosene per hour. The flame contact area was elliptical in shape, having a major axis of 12 inches and a minor axis of 6 inches. The tests were conducted under the following conditions

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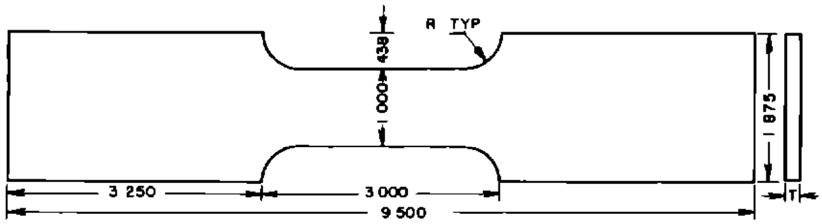

SPECIMEN	*T DIMENSION (INCHES)
MST GRADE III, COMMERCIALLY PURE TITANIUM	0 035
TI75A, COMMERCIALLY PURE TITANIUM, HEAT L131	0 026
TI75A " " , HEAT L153	0 024
REM-CRU A-70 TITANIUM ALLOY	0 018
REPUBLIC STEEL CORP ENDURO TYPE 302 STAINLESS STEEL	0 020
18-8 STAINLESS STEEL	0 018

Fig. 1 Test Specimen Dimensions

(1) equal pressure on each side of the firewall, (2) a pressure differential of 5 pounds per square inch (psi) across the firewall, and (3) a pressure differential of 15 psi The arrangement for mounting the titanium sheets and providing the differential air pressure is shown in Fig. 3. Six panels of two approved stainless steel firewall materials were subjected to the same test conditions to obtain comparative data.

RESULTS

The data obtained from the tensile strength tests conducted with specimens at elevated temperatures are plotted in Fig. 4. Figure 5 shows the high-temperature strength of two stainless steel materials compared with that of two titanium materials. Each point plotted in the figures represents the strength-temperature conditions at which a specimen failed. The following were noted

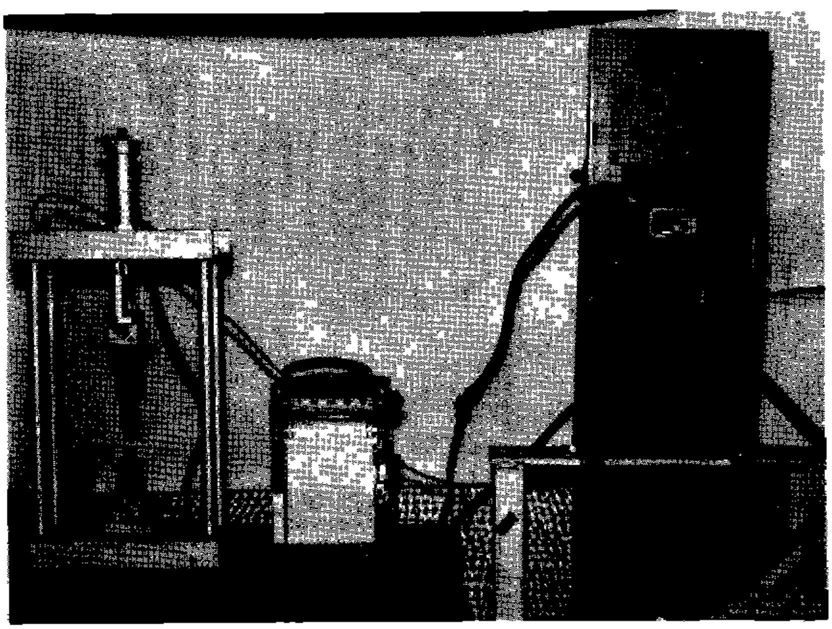

Fig. 2 Tensile Testing Apparatus and Transformer

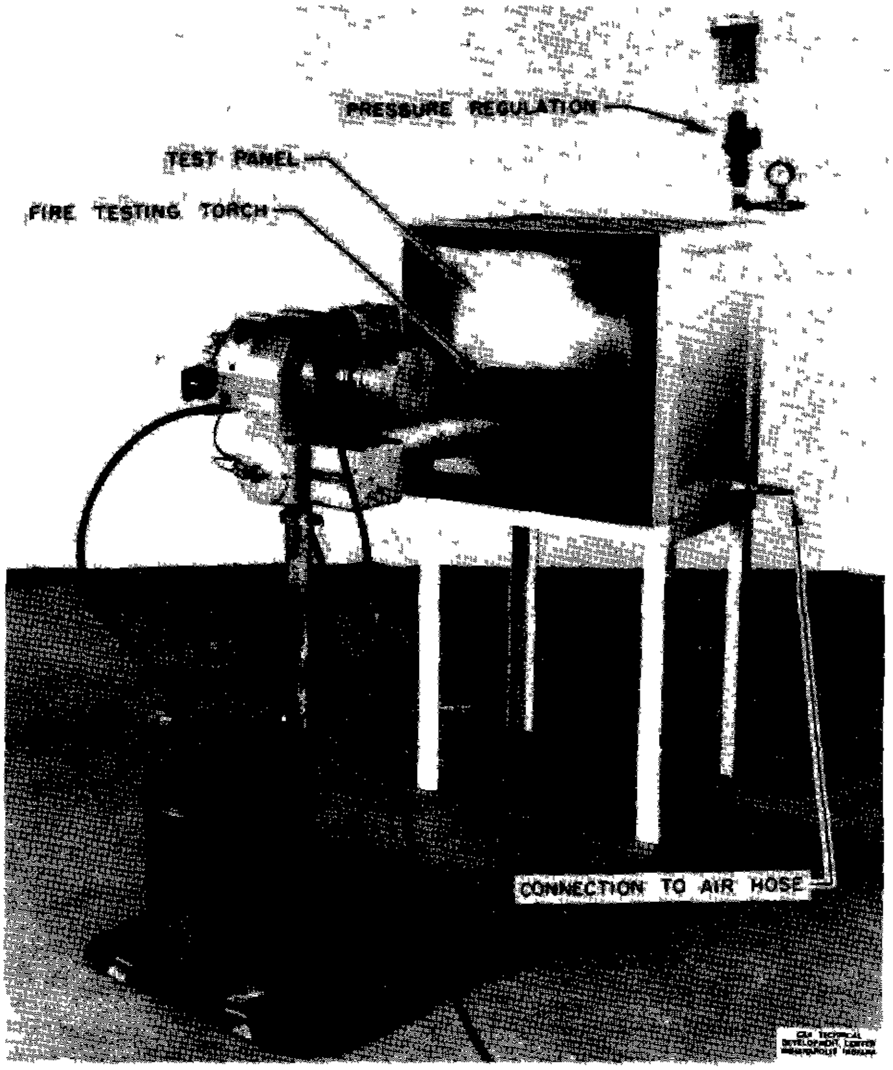

Fig. 3 Firewall Testing Arrangement

1. Between the temperature limits of these tests (1,000° to 1,800° F.), titanium decreased in strength quite rapidly with increasing temperature.

2. In the temperature range of these tests, the titanium had less strength than the stainless steel. This is reasonable because at lower temperatures the strength of stainless steel is considerably higher than titanium, however, this difference in strength of the two materials decreased considerably as the temperature approached the upper limit of the range of these tests.

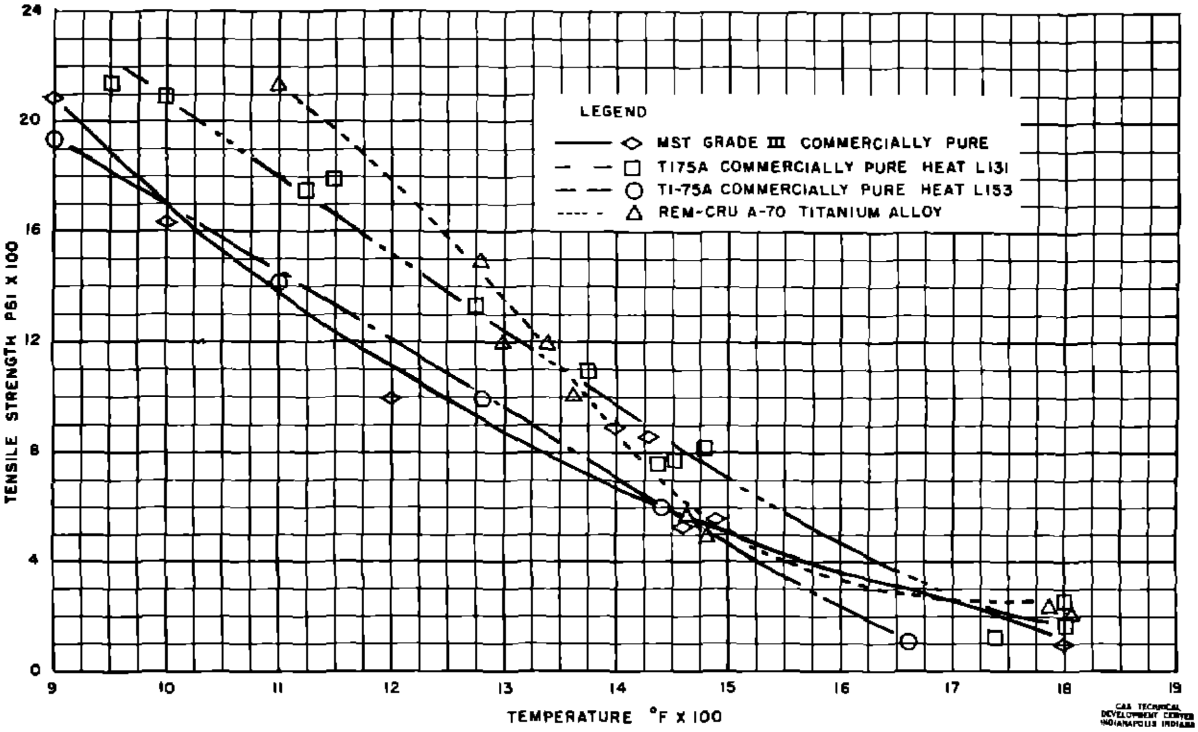

Fig. 4 Effect of Temperature on Tensile Strength of Titanium and Titanium Alloy

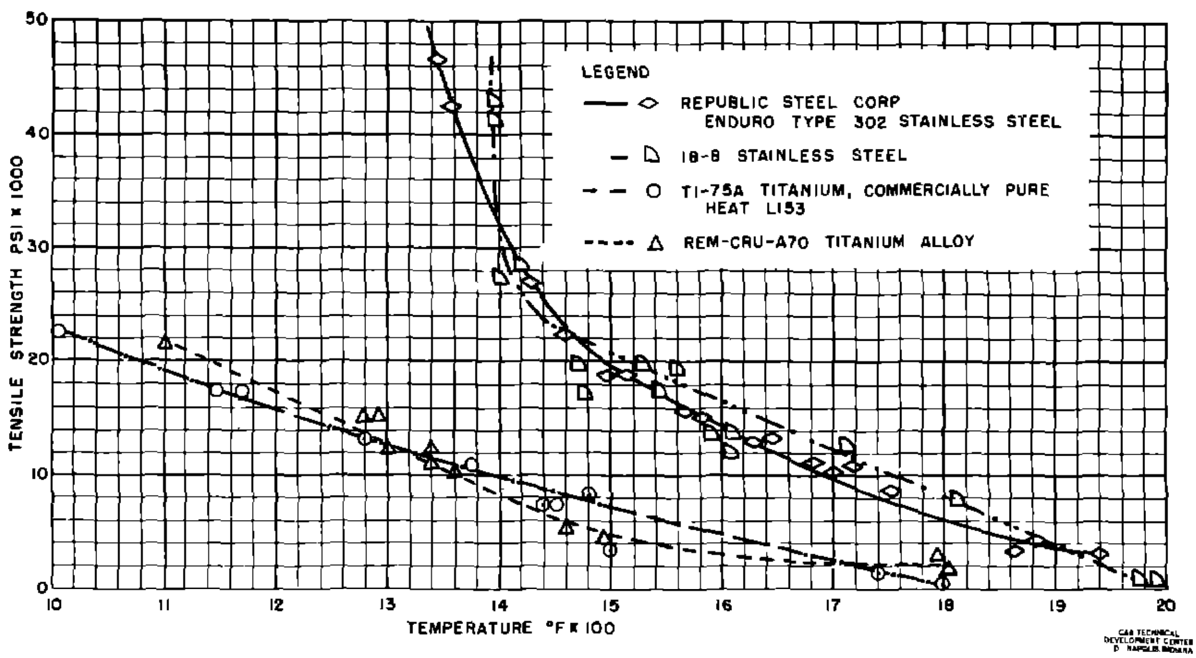

Fig. 5 Effect of Temperature on Tensile Strength of Stainless Steel as Compared to Titanium and Titanium Alloy

The data obtained from the tests in which the 24- by 24-inch titanium sheets were subjected to a 2,000° F. flame are given in Table I. The specimens tested under no applied load served as an effective firewall. Considerable distortion occurred to the specimens tested when a differential pressure of 5 psi exerted force on one side. A 15-psi differential caused two specimens to fail. Table II contains the data obtained when 18-8 stainless steel panels were tested under the same conditions as the titanium panels. The deformation which occurred to the titanium panels was greater than that of the stainless steel panels.

TABLE I

RESULTS OF 2,000° F. FLAME TESTS
ON 24- BY 24-INCH TITANIUM PANELS

Sheet Thickness (inches)	Material	Differential Pressure (psi)	Results of Exposure To Flame (15 minutes)
0.032	TI-65A Heat M2620*	None	No visible damage to metal.
0.025	RC-70 Annealed 303883*	None	No visible damage to metal.
0.020	MST-Grade III Heat 24204*	None	No visible damage to metal.
0.016	TI-65A Heat M20240*	None	No visible damage to metal.
0.020	MST-Grade III Heat 24204*	5	Deformation began at 6 minutes. Panel contained bulge of 1 5/8-inch displacement at end of test.
0.016	TI-65A Heat M29240*	5	Deformation began at 5 1/2 minutes. Panel contained bulge of 2 1/8 inches after completion of test.
0.016	TI-65A Heat M29240*	15	Deformation began at 5 minutes. Panel bulged 3 7/8 inches and split after 3 minutes 12 seconds of testing.
0.020	MST-Grade III Heat 24204*	15	Deformation began at 5 minutes. At 10 minutes 15 seconds panel bulged 3 3/4 inches and failed. Failure consisted of a split 1 1/4 by 1/16-inch.
0.032	TI-65A Heat M2620*	5	Deformation began at 9 1/2 minutes. Panel contained bulge of 1 1/8-inch displacement at end of test.
0.025	TI-75A Cold Rolled Heat L131*	15	Deformation began at 5 minutes. At 7 minutes panel bulged 4 3/4 inches. At 8 minutes 2 seconds after start of test blow hole occurred which relieved pressure.
0.025	RC-A110-AT ANN 040161**	15	Deformation began at 10 minutes. Material contained bulge of 1 1/2-inch displacement at end of test.

* Commercially pure titanium
** Titanium base alloy

TABLE II

RESULTS OF 2,000° F. FLAME TESTS
ON 24- BY 24-INCH STAINLESS STEEL PANELS*

Sheet Thickness (inches)	Differential Pressure (psi)	Results of Exposure To Flame (15 minutes)
0.020	None	No visible damage to panel.
0.020	5	Deformation began at 9 minutes Panel contained a bulge of 1-inch displacement at end of test
0.020	15	Deformation began at 11 minutes. Panel contained a bulge of 1 1/4-inch displacement at end of test.
0.015	None	No visible damage to panel.
0.015	5	Deformation began at 8 minutes Panel contained a bulge of 1-inch displacement at end of test
0.015	15	Deformation began at 10 minutes. Panel contained a bulge of 1 1/2-inch displacement at end of test

* 18-8 stainless steel, Type 302, 1/2 hard AN-QQ-772, Allegheny Ludlum Steel Corporation.