TECHNICAL DEVELOPMENT REPORT NO. 196

THE FIRE RESISTANCE OF ALUMINUM-ALLOY CONTROL RODS PROTECTED BY ALBI-RX FIRE-RETARDANT COATING

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By
J. J. Gassmann

Aircraft Division

March 1953

CIVIL AERONAUTICS ADMINISTRATION
TECHNICAL DEVELOPMENT
AND EVALUATION CENTER
INDIANAPOLIS, INDIANA

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SUMMARY

Tests were conducted on stressed primary control rods to determine the amount of protection against fire offered to the rods by a fire-retardant coating. Aluminum-alloy control rods were covered with various weights of Albi-RX oil-base coating and were subjected to simulated accessory-section fires at approximately 2,000° F. Results indicate that a rod under compression and covered with 50 grams per square foot of Albi-RX coating will withstand the fire four times as long as an uncoated rod. Tests conducted on rods subjected to torsion and bending were inconclusive because of the limited number of test specimens and because the specified loadings imposed before and during fire exposure resulted in excessive stressing.

INTRODUCTION

In order to determine whether aluminum-alloy rods protected by Albi-RX[1] oil-base coating would comply with certain fireproofing requirements, the Office of Aviation Safety of the Civil Aeronautics Administration requested the Technical Development and Evaluation Center to conduct a series of tests in which rods were subjected to various amounts of compression, torsion, and bending while being exposed to simulated accessory-section fires.

CAA Safety Regulation Release No. 259 states that a component located in a potential fire zone is considered fireproof when it will withstand for a period of 15 minutes fire likely to occur in that zone. It further states that a similar component is considered fire-resistant when it retains its ability to operate after five minutes of exposure to such a fire.

[1]Albi-RX is a fire-retardant coating manufactured by the Albi Chemical Corporation, Hartford, Connecticut. This material has now been superseded by Albi Temp-Kote 99, a similar material of greater fire resistance.

DESCRIPTION OF TEST EQUIPMENT

Stress was applied to the simulated primary control rods by the machine shown in Figs. 1, 2, and 3. This machine is of the dead-weight loading type. Compression was produced by a bell crank having a ratio of two to one. Bending moment, or compressive stress, and torsion were produced by loading the 24-inch horizontal arms.

The flame producer consisted of a gun-type conversion oil burner with a No. 2 eighty-degree oil nozzle, 5 one-inch diameter holes for air intake, and the return relief valve set at 85 pounds per square inch (psi). Kerosene was used as fuel. A barrel extension was added to the burner, extending ten inches beyond the end of the barrel and having an opening six inches high and eleven inches wide. The flame producer was located so that the rod to be tested was four inches beyond the end of the barrel extension and the flame passed equally above and below the rod.

PROCEDURE

Primary control rods were made of 24-ST aluminum-alloy tubing. A number of these rods were uncoated and were used for obtaining basic test data for unprotected rods. The remainder of the rods were primed with zinc chromate and covered with Albi-RX oil-base fire-retardant coating. The weights of coating varied up to 50 grams per square foot of rod surface. The sizes of the rods varied from 1/2 to 1 1/2 inch OD with the wall thicknesses ranging from 0.035 inch to 0.120 inch. The lengths of the rods were 12 inches and 36 inches, excluding the portion in the clamp or in the socket of the test machine.

Stresses of various types as specified by CAA were imposed on the rods. The stressed rods were then subjected to fire, and the time for failure of each rod counted from the incidence of fire was noted. The specific dimensions of each rod, the type of stress, and the amount of load applied are given in Table I. These were as specified in the request.

RESULTS AND DISCUSSION

The results of the tests in which the rods were covered with various weights of Albi-RX fire-retardant coating and in which they were subjected to fire while under compression are shown in Figs. 4A and B. Each curve expresses the relationship between the weight of fire-retardant coating and the length of time from the incidence of fire until failure. The curves in Fig. 4A show the effect of size on various rods which were subjected to fire under the same load. The curves in Fig. 4B show the effect of various loads on the same size rod.

TABLE I

DIMENSIONS OF TEST SPECIMENS AND LOADS APPLIED

Rod Size			Load		
Diameter (inches)	Wall (inches)	Length (inches)	Amount (pounds)	(inch-pounds)	Type
1/2	0.035	12	280		Compression
3/4	0.065	12	765		Compression
1	0.083	12	280		Compression
1	0.083	12	765		Compression
1	0.083	12	1080		Compression
1	0.083	36	765		Compression
1 1/2	0.120	12	765		Compression
1 1/2	0.120	36	765		Compression
1 1/2	0.083	36		5470	Torsion
1 1/2	0.083	36		5560	Bending

These results show that a rod covered with 50 grams per square foot of Albi-RX coating will withstand a 2,000° F flame approximately four times as long as a similar uncoated rod. This relationship existed for all the rods tested under compression, including the rods of smaller diameter. The smallest of these rods, which was 1/2 by 0.035 by 12 inches, was subjected to 280 pounds of compression. It failed in seven seconds when uncoated and in thirty seconds when coated with 53 grams per square foot of Albi-RX.

This relationship did not exist in the case of the rods tested in torsion and in bending. Fifty grams of Albi-RX per square foot barely doubled the life of these rods. It is reasonable to believe, however, that this was due to the unusually high loading imposed upon the rods. For example, 5470 inch-pounds of torsion caused the loaded end of the 36-inch-long rod to rotate 20°. An additional 10° of rotation was considered to be failure. The loads imposed on the rods were so high that at a relatively

TABLE II

RESULTS OF FIRE TEST ON STRESSED ALUMINUM-ALLOY RODS

Rod Size			Weight of Coating	Compression	Time Until
Diameter (in.)	Wall (in.)	Length (in.)	(gm per sq. ft)	Load (lb)	Failure (seconds)
1/2	0.035	12	0	280	7
1/2	0.035	12	15	280	13
1/2	0.035	12	53	280	30
3/4	0.065	12	0	765	19
3/4	0.065	12	20	765	31
3/4	0.065	12	30	765	45
3/4	0.065	12	41	765	64
3/4	0.065	12	51	765	67
3/4	0.065	36	0	280	21
3/4	0.065	36	12	280	29
3/4	0.065	36	25	280	50
3/4	0.065	36	37	280	59
1	0.083	12	0	280	37
1	0.083	12	19	280	73
1	0.083	12	38	280	118
1	0.083	12	50	280	160
1	0.083	12	0	765	30
1	0.083	12	11	765	55
1	0.083	12	27	765	61
1	0.083	12	27	765	80
1	0.083	12	30	765	80
1	0.083	12	30	765	89
1	0.083	12	38	765	91
1	0.083	12	38	765	95
1	0.083	12	50	765	109
1	0.083	12	0	1080	29
1	0.083	12	19	1080	55
1	0.083	12	27	1080	68
1	0.083	12	30	1080	63
1	0.083	12	42	1080	89
1	0.083	12	42	1080	98
1	0.083	12	42	1080	102
1	0.083	12	50	1080	133
1	0.083	36	0	765	26
1	0.083	36	23	765	58
1	0.083	36	33	765	70
1	0.083	36	39	765	87
1	0.083	36	51	765	97
1 1/2	0.120	12	0	765	63
1 1/2	0.120	12	43	765	242
1 1/2	0.120	12	51	765	278
1 1/2	0.120	36	0	765	38
1 1/2	0.120	36	33	765	173
1 1/2	0.120	36	33	765	178

TABLE IIB

RESULTS OF FIRE TEST ON STRESSED ALUMINUM-ALLOY RODS

Rod Size			Weight of Coating	Torsion Load	Bending Load	Time Until Failure
Diameter (in.)	Wall (in.)	Length (in.)	(gm per sq ft)	(in-lb)	(in-lb)	(seconds)
1 1/2	0.083	36	0	5470		17
1 1/2	0.083	36	24	5470		24
1 1/2	0.083	36	50	5470		35
1 1/2	0.083	36	0		5560	32
1 1/2	0.083	36	24		5560	36
1 1/2	0.083	36	28		5560	37

low temperature (300° to 400° F), creep occurred in the metal. This creep rendered the rods unfit to serve as primary controls. Additional tests on rods subjected to torsion and to bending were not conducted because the limited quantity of aluminum-alloy tubing available had already been consumed. Results of all the tests conducted are given in Tables IIA and IIB.

CONCLUSIONS

It is concluded that:

1. A control rod under compression, covered with 50 grams per square foot of Albi-RX oil-base coating, will withstand fire about four times as long as a similar uncoated rod.

2. Aluminum control rods located in potential fire zones even though protected by a coating of Albi-RX do not conform to the fire-resistance requirements as outlined in the CAA Safety Regulation Release No. 259, since failure occurred in less than five minutes after incidence of fire.

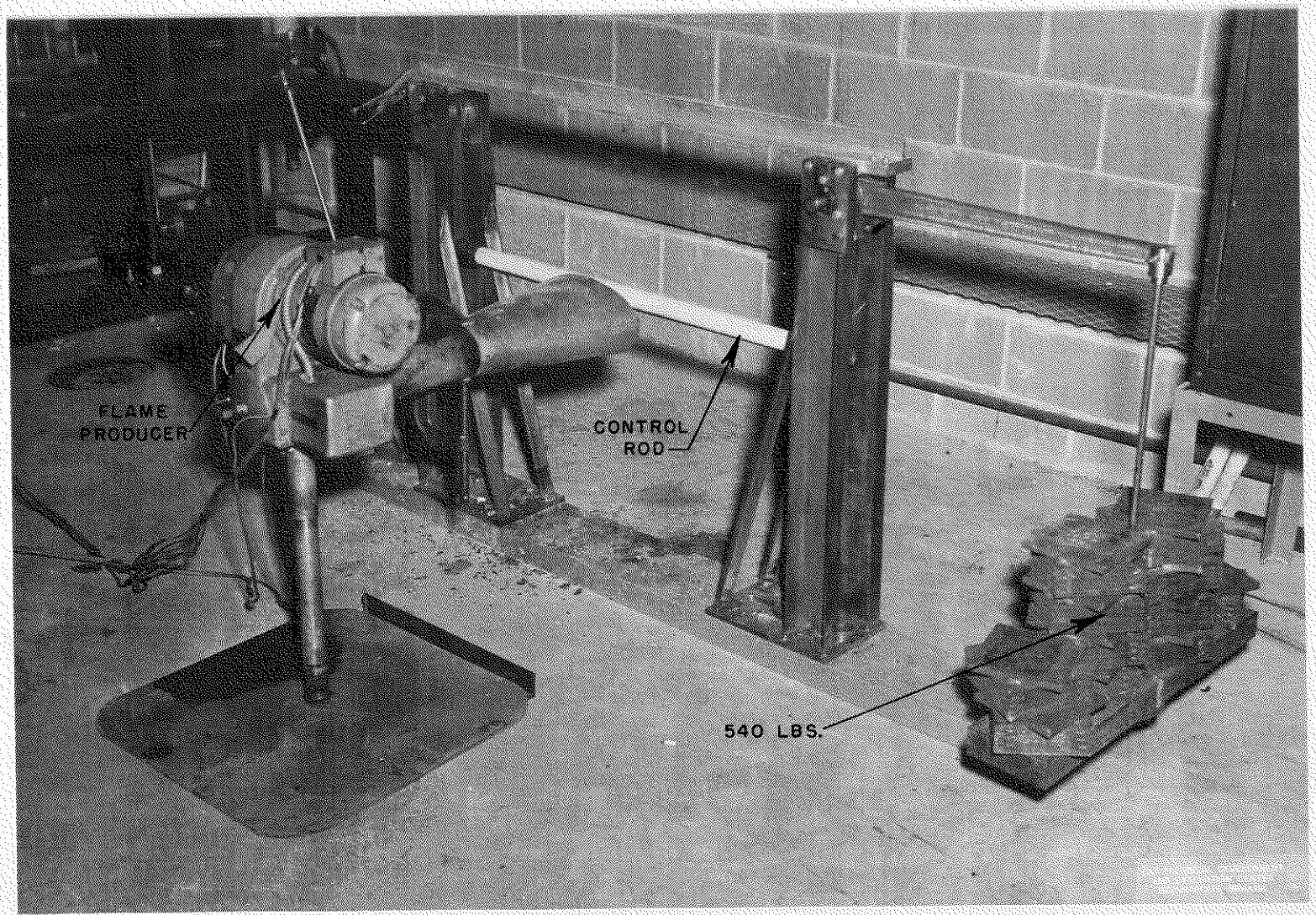


FIG. 1 CONTROL ROD, COATED, SUBJECTED TO COMPRESSION

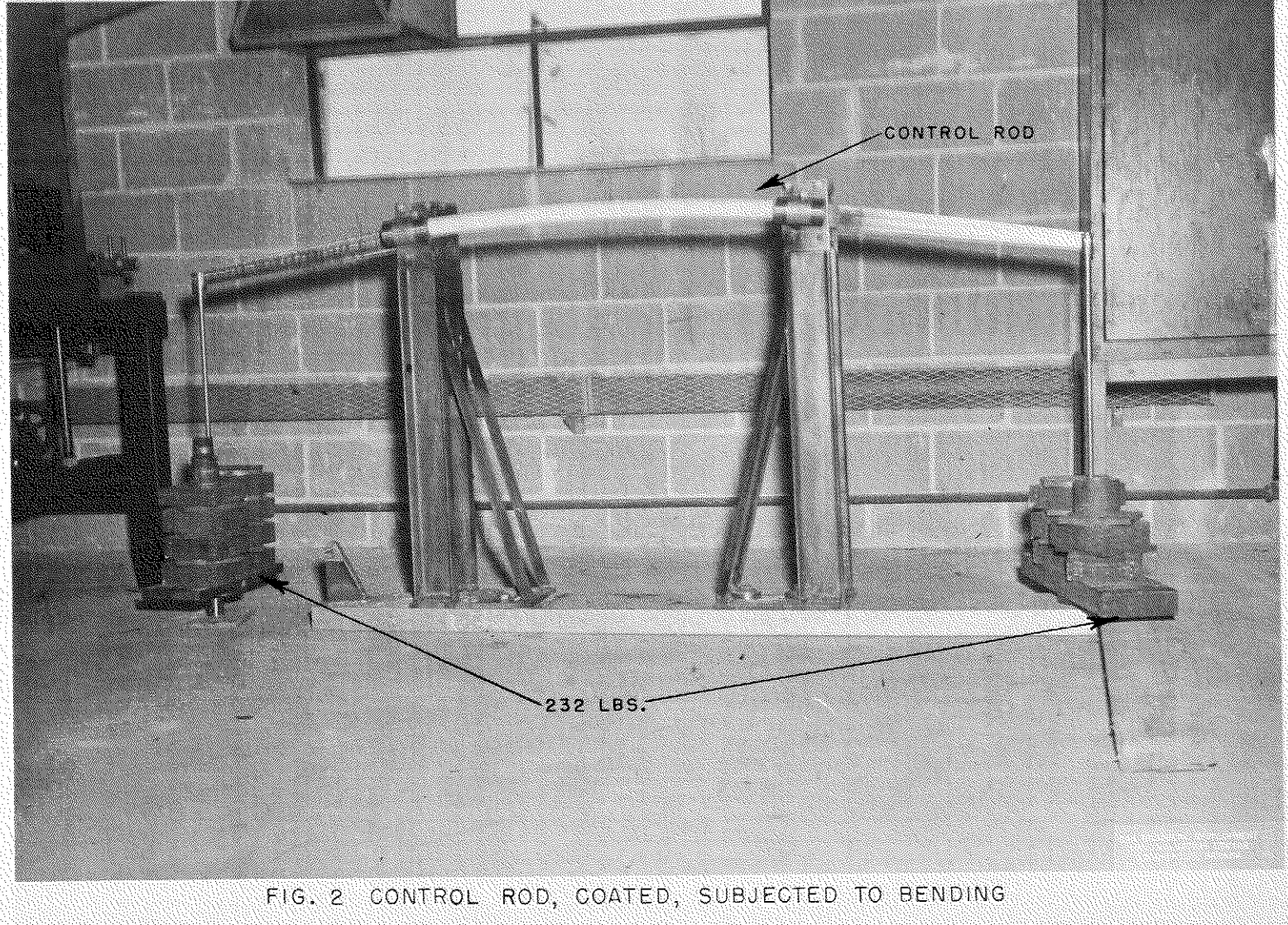


FIG. 2 CONTROL ROD, COATED, SUBJECTED TO BENDING

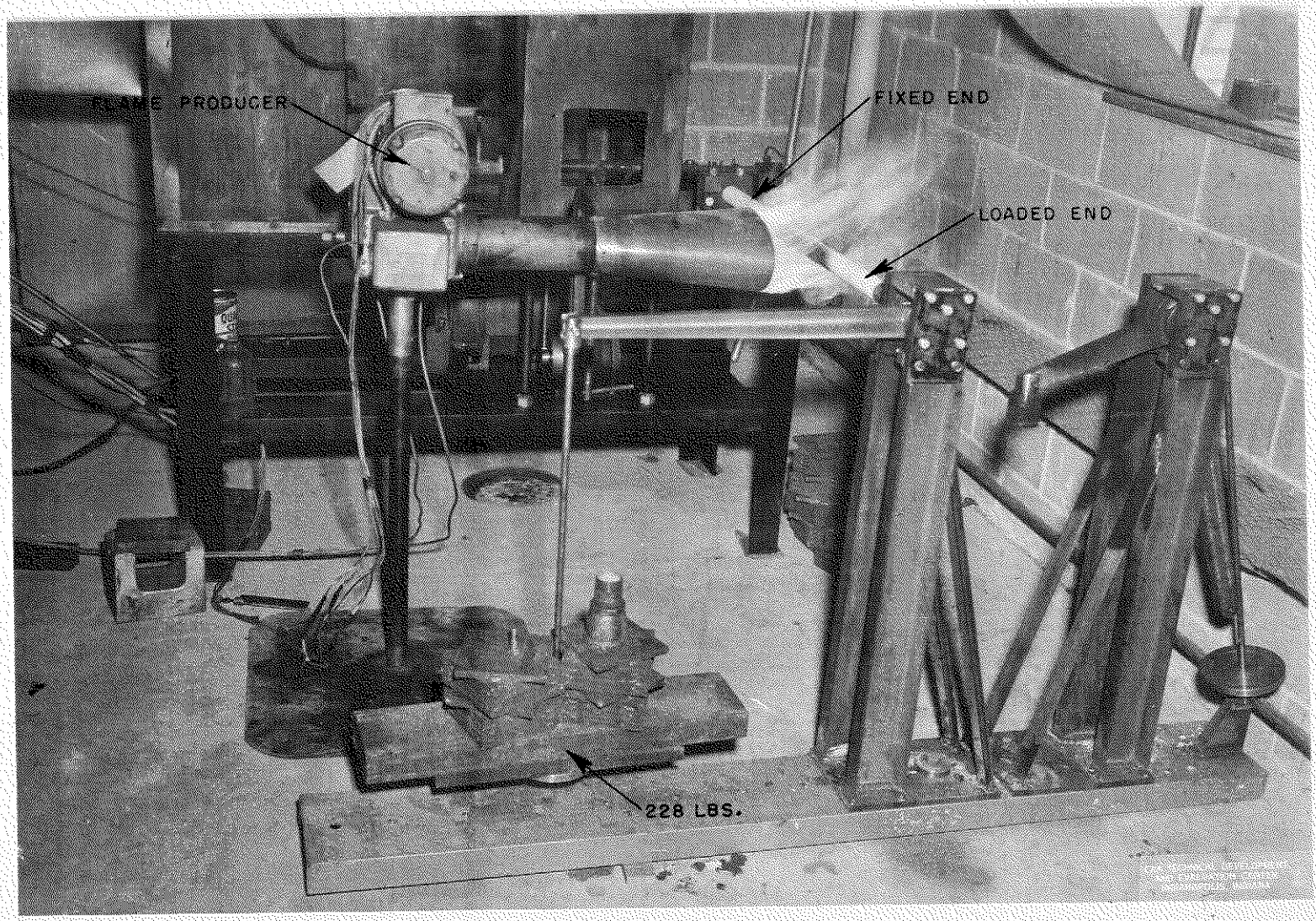
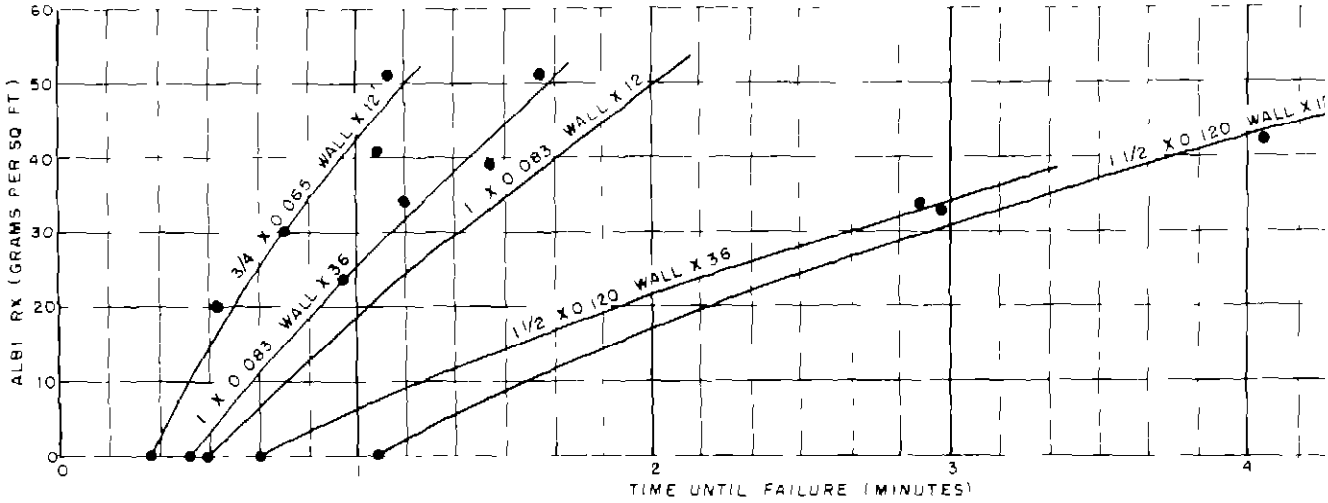
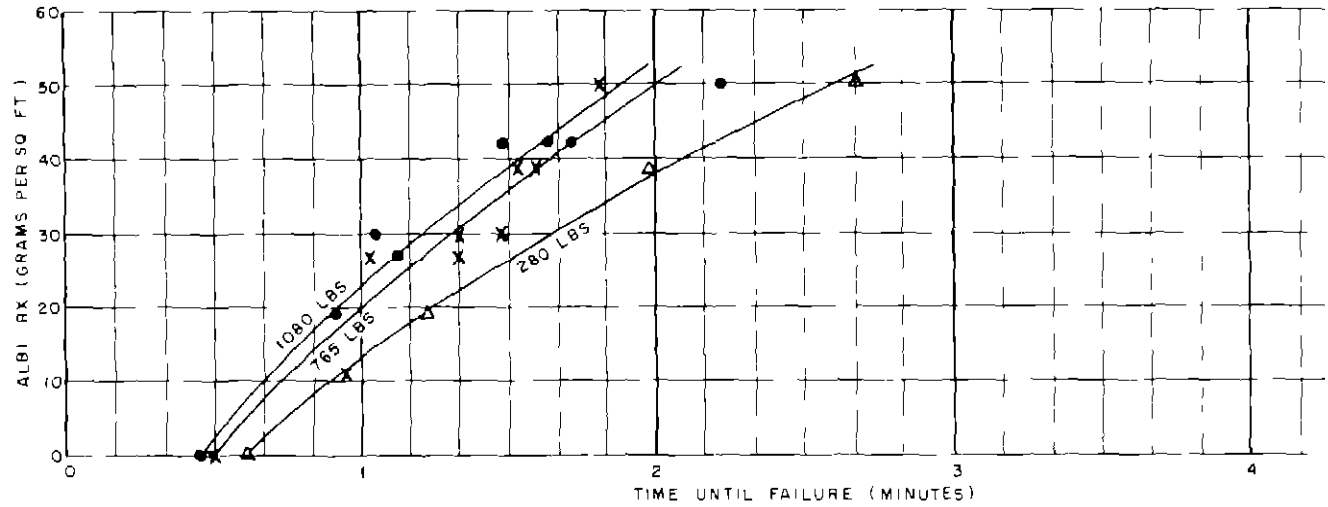


FIG. 3 CONTROL ROD, COATED, SUBJECTED TO TORSION



(A) VARIOUS SIZE RODS WITH 765 POUNDS COMPRESSION



(B) 1 X 0.083 WALL X 12 RODS WITH VARIOUS AMOUNTS OF COMPRESSION

FIG 4 TIME-WEIGHT CURVES SHOWING THE AMOUNT OF PROTECTION AGAINST FIR
AFFORDED ALUMINUM-ALLOY CONTROL RODS BY ALBI-RX FIRE-RETARDANT PA