

MATERIALS RESEARCH & PROCESS ENGINEERING

LABORATORY REPORT

SERIAL NO. LR-AD-1463
Addendum #1
DATE 7/16/62

TITLE **FIREWALL INSULATION FOR 3500°F. FLAME
IMPINGEMENT**

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ABSTRACT:

Preliminary screening flame impingement tests with temperature adjusted to 3500°F. at impact surface from an oxygen acetylene torch was applied to a number of additional materials since issuance of LR-AD-1463 on 3-16-62. Results of these tests are reported in this addendum.

PR-1965, from Product Research Co. is still the only material tested to date that has fully met all of the screening test requirements.

OBJECT:

Preliminary evaluation of materials suitable for DC-8 Firewall insulation for resistance to direct flame impingement of 3500°F.

MATERIALS:

1.	PR-1965 A/B	Product Research
2.	PR-1902 Prime	Product Research
3.	69 F	Thermo Resist
4.	#25	Organoceram
5.	#27	Organoceram
6.	#29	Organoceram
7.	X-711 - Sample 12	Thermoresist
8.	X-34-65	Swedlow
9.	X-34-43	Swedlow
10.	RF-192	Rez Coat
11.	Korotherm Delta 6000	Desoto Chemical Coatings
12.	Korotherm Delta 5500	Desoto Chemical Coatings
13.	Thermolag T-500	Emerson Electric
14.	Korotherm Delta 5500 798-009	Desoto Chemical Coatings
15.	Korotherm Delta 5500 798-010	Desoto Chemical Coatings
16.	Thermolag T-500 Laminate	Emmerson Electric
17.	#31	Organoceram
18.	#30	Organoceram
19.	#33	Organoceram
20.	XA-48-16-6	U. S. Polymeric
21.	#28	Organoceram
22.	XA-48-16-4	U. S. Polymeric
23.	XA-48-16-2	U. S. Polymeric
24.	HT-5	American Latex
25.	#127	Organoceram
26.	#128	Organoceram
27.	XA-48-16-1B	U.S. Polymeric
28.	XA-48-16-6A	U.S. Polymeric
29.	#90	Organoceram
30.	XA-48-16-3	U.S. Polymeric
31.	#26	Organoceram
32.	Fiberfrax 37D	Carborundum
33.	17-7 Ph Steel	Commercial
34.	Titanium Sheet	Commercial

EQUIPMENT:

1. Oxyacetylene Equipment
 2. Welding Torch Victor Type 310
 3. Welding Torch tip Type 12-A-11
 4. Welding Torch tip Type 6
 5. Optical Pyrometer Model #8622
- Leeds & Northrup, Co.

PROCEDURES:

1. Ablative test specimens were prepared on 6"x6"x.045 17-7 ph CRES steel backing plates unless specified otherwise.
2. All test specimens except PR-1965 were prepared by the manufacturer of the material. PR-1965 specimens were prepared in the sealant laboratory identical to Procedure 3a of LR-AD-1463.
3. The specimens were mounted in a vertical position in front of an oxygen acetylene torch. The torch was mounted for flame impingement of 25° from perpendicular to the surface of the specimen. A single action cutoff for oxygen and acetylene was arranged to eliminate valve adjustment between tests.
4. Specimens recorded in Table I, II and IV were tested by normal procedure. A fire brick was placed in the direct flame impingement area, the gas pressure stabilized and the distance of the torch from the fire brick was adjusted for a temperature reading through an optical pyrometer of 3500°F. This distance was 2 7/16 inches. The torch was ignited and time recorded for the flame to penetrate the ablative coating and backup plate. A temperature reading was taken with the optical pyrometer during the flame impinging test for most specimens.
5. Specimens recorded in Table III were tested in an identical manner except that the test temperature was an estimated temperature. A fire brick was placed in the direct flame impingement area 2 7/16" from the tip of the torch. The gas pressure was adjusted so a cavity would be formed in the fire brick, the brick would "boil" in the hot spot, but the drops of molten brick would not fall away from the test area. A check of this procedure recorded temperatures between 3300°F and 3700°F. with the optical pyrometer.

Note: The optical pyrometer had to be borrowed from Santa Monica Process for each test. The temperature estimate was established to reduce costs of preliminary testing and still have confidence in these results to screen materials for future tests.

6. Specimens recorded in Table V were tested in an identical manner except the test temperature was estimated to be 2900°F. A fire brick was placed in the direct flame impingement area 2 7/16" from the tip of the torch. The gas pressure was adjusted so a cavity would not form, but the surface of the brick just began to boil. The specimen was then located 2 7/16" from the torch and tested.

PROCEDURES: (Cont.)

6. The construction of the sandwich specimen was RF-192 laminated skins and a Fiberfrax 371D insulation batting core. The .062 and .040 RF-192-28 skins were cured under vacuum bag pressure for 1/2 hours at 300°F. plus 1/2 hour at 350 and post cured 3 hours at 400°F. One layer of Fiberfrax 371D batting was located between the RF-192-28 skins, separated by 1/4" spacers and bolted in the four corners.

RESULTS:

1. Results of tests conducted with non water cooled torch tip #6 and tip A 12-11A on Thermoresist 69F at 3500°F per optical pyrometer readings are recorded in Table I.
2. Results of tests conducted with water cooled torch tip #6 at 3500°F. per optical pyrometer readings recorded in Table II.
3. Results of tests conducted with water cooled torch type #12-11A at estimated 3500°F are recorded in Table III.
4. Results of tests conducted with water cooled torch tip #12-11A at 3500°F. per optical pyrometer readings are recorded in Table IV.
5. Results of tests conducted with water cooled torch tip #12-11A at estimated temperature of 3000°F. on RF-192 - Fiberfrax sandwich are recorded in Table V.

TABLE I
 3500°F FLAME IMPINGEMENT

Material Name	Manufacturer	Time For Penetration	Remarks
Thermo Resist 69F	Thermo Resist	See Remarks	12-11A torch tip. Test stopped in 3'35" when torch back fired. Specimen about 1/2" burned through. Material flaked away to form typical cavity. At 3 minutes cavity became deep enough to cause air to blow back and overheat the torch. There was after burn. Temperature averaged 3630°F. Specimen was 9/16" thick and unsupported (not on steel plate)

Table I (Cont.)
3500°F. Flame Impingement

Material Name	Manufacturer	Time for Penetration	Remarks
Thermo-Resist 69F	Thermo Resist	5'	#6 torch tip. Penetration occurred in typical cavity in 5' exposure. Several voids were obvious in specimen that caused early failure. There was after burn. Temperature averaged 3360°F. Specimen was 9/16" thick and unsupported.

TABLE II (See Next page)

TABLE II
 3500°F Flame Impingement
 #6 Torch Tip - Water Cooled

Material Name	Manufacturer	Time for Preparation	Remarks
R-1965 R-1902 Prime	Products Research	10' stopped	Test stopped in 10 minutes without penetration. A deep crack appeared almost immediately in upper area of hot spot. Lower edge of specimen started to loose bond although entire mass of covering remained in place. Temperature averaged 3450°F. Specimen had some after burn.
25	Organoceram	10' stopped	Test stopped in 10 minutes without penetration. Thin top layer peeled away and then material expanded and formed a hard ceramic like surface with no cracks. Temperature averaged 3450°F. There was no afterburn.
27	Organoceram	5'50"	One side of specimen lost adhesion and curled in towards flame. Impingement area remained intact and formed crust. Test was stopped in 5'50" when material completely lost adhesion and tipped forward into torch.
29	Organoceram	10' stopped	There was slightly more smoke than others. The material expanded or foamed in hot spot and formed a hard crust. Temperature averaged 3450°F. Test stopped after 10' exposure.
Thermo Resist X-711 Sample #12	Thermo Resist	10' stopped	Material expanded and formed a hard ceramic like crust. There was no loss of adhesion. Temperature averaged 3450°F. Test stopped after 10' exposure.

TABLE III
 3500°F Flame Impingement
 12-11A Torch Tip - Water Cooled -
 Temperature Estimated

Material Name	Manufacturer	Time for Penetration	Remarks
X-34-65	Swedlow	2' 30"	Cracks formed immediately altho there was no smoke. After 1½ minutes sparks began to shower off. Penetration occurred at 2' 30". There was continued after burn. Specimen did not lose adhesion.
X-34-65	Swedlow	3' 10"	Identical appearance as above.
X-34-43	Swedlow	1' 6"	Specimen yellow color and 3/16" thickness. Outside ply peeled away immediately. Failure progressed layer by layer. Penetration occurred after 1' 6". Material lost adhesion and continued to burn. Temperature appeared to be above 3500°F.
RF-192	Rez Coat	4' 40"	Material burned crater layer by layer. Penetration occurred in 4' 40". There was no after burn. This was third test on specimen and adhesion had already failed. Temperature was obviously high as material had previously withstood 3500°F. temperature, recorded by an optical pyrometer without penetration.
PR-1965 PR-1902 Prime	Product Research	7' 56"	Temperature was also high as samples have repeatedly withstood 3500°F controlled flame exposure for 10 minutes without penetration. Deep cracks appeared around edge of center crust. Penetration occurred through a crack only in 7' 56". The material lost adhesion upon penetration.
Korotherm Delta 6000 (200°F/40 min)	Desoto Chemical Coatings	3' 21"	Specimen black color. The material formed cracks, peeled away in hot spot layer by layer, and lost adhesion after 3'. Penetration occurred in 3' 21". There was slight after burn. Temperature appeared to be above 3500°F.

TABLE III (Cont.)

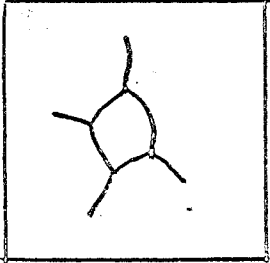
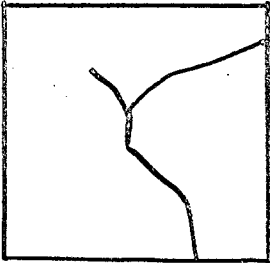
Material Name	Manufacturer	Time For Penetration	Remarks
Korotherm Delta 5500 - Bake (2000F/ 40 min)	Desoto Chemi- cal Coatings	3' 52"	<p>Material formed immediate deep cracks. Penetration occurred in cracks only after 3' 52". Remaining coating in hot spot was only 20% eroded. There was little sign of bubbling and specimen may have lasted 10 minutes except for cracks. There was considerable after burn.</p> <p>Crack Pattern</p> 
Korotherm Delta 5500 Air Dry	Desoto Chem- ical Coatings	2' 45"	<p>Material formed immediate cracks that continued to deepen with exposure time. Penetration occurred in 2' 45" at a crack while the remaining material in the hot spot was only 20% eroded.</p> <p>Crack Pattern</p> 

TABLE III (Cont.)

Material Name	Manufacturer	Time For Penetration	Remarks
Thermo Lag T-500 Casting	Emmerson Electric	8'	Specimen 3/8" thick and 2 1/2" diameter. There was no bubbling, no fire and no cracking. A cavity gradually eroded in hot spot. However, there was considerable washing of flame around back side of small specimen. There was almost as much depth of damage on back side as on the front erosion side. Had the back side been protected, the test would have gone much longer. Penetration occurred in 8 minutes. The temperature appeared to be near 3500°F.
Thermo Lag T-500 Casting	Emmerson Electric	9' 20"	Specimen 5/8" thick and 2 1/2" diameter. Failure identical to first test. Penetration occurred in 9' 20". There was no after burn.
Korotherm Delta 5500 798-009 Air Dry	Desoto Chem- ical Coatings	4'30"	Thin top ply peeled away. Deep crack appeared across hot spot at 30 seconds. After 3' time the crack had healed itself. The material ablated away to form a crater in the hot spot. A few sparks continuously flew away throughout the test. Penetration occurred in 4'3. There was after burn but no smoke. The temperature may have been slightly below 3500°F.
Korotherm Delta 5500 Bake 798-010	Desoto Chem- ical Coatings	3'9"	The material ablated away ply by ply and cracks formed immediately away from hot spot. At 2'30" a deep crack appeared in center of hot spot. At that time the ply by ply penetration stopped and a crust formed. The deep center crack continued to widen. Penetration occurred through the crack 3'9". There was after burn. temperature may have been

TABLE III (Cont.)

LR-AD-1463

Addendum #1

Date: 7/16/62

Pg. 10

Material Name	Manufacturer	Time For Penetration	Remarks
Thermo Lag T-500 Laminate	Emmerson Electric	1' 53"	Specimen was 2 3/4"x6" x .17" bolted in four corners to steel plate. Many tiny cracks appeared immediately over hot spot. The support plate bowed towards heat source and the temperature went far above 3500°F. Ablation, or sub- limation formed a typical crater. Penetration occurred in 1' 53". There was no after burn.

TABLE IV

3500°F. Flame Impingement Test
12-11A Torch Tip - Water Cooler

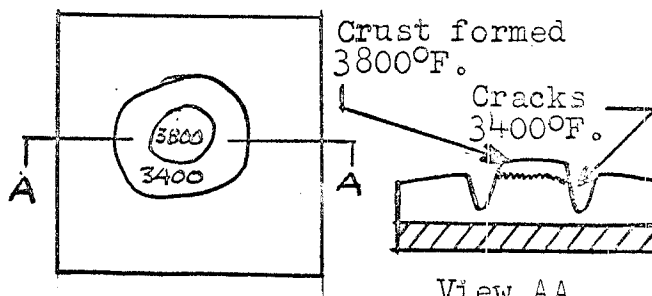
Material	Manufacturer	Time For Penetration	Remarks
PR-1965 1902 Prime	Product Research	10'	<p>Typical deep cracks appeared mainly in ring around hot spot. The material expanded and formed a crust. The specimen was still not red color on back side after six minutes. Temperature over heated as shown in sketch. Test stopped after 10 minutes with no penetration. There was slight after burn.</p> 

TABLE IV (Cont.)

Material	Manufacturer	Time For Penetration	Remarks
#25	Organoceram	2'	Outer ply peeled away. Small beads formed and rolled outwards to form cavity. Layers fell forward. Penetration occurred in 2 minutes. There was heavy after burn. Area away from burn spot still had good adhesion. The temperature in hot spot was 3350°F.
Steel 17-7 PH .040" thick	Commercial	4 to 5 seconds	Set up was identical to above test. Penetration occurred in 4 to 5 seconds.
#31	Organoceram	3' 10"	Outer ply peeled away. Small beads formed and rolled outwards to form cavity. Penetration occurred in 3' 10" and material fell forward. There was heavy afterburn. The Temperature in the hot spot was 3390°F.
#30	Organoceram	5'	There was considerable overall expansion of the material, but no sign of delamination or cracking. Small beads flew out to form a cavity. It did not form a crust. Penetration occurred in 5 minutes. There was heavy after burn. The remaining material did not lose adhesion. The temperature in the hot spot was 3320°F.
#33	Organoceram	4' 10"	The appearance of the material during test was identical to the #30 reported above. Penetration occurred in 4' 10".

Table IV (Cont.)

LR-AD-1463
 Addendum #1
 Date: 7/16/62
 Pg. 12

Material	Manufacturer	Time For Penetration	Remarks
X-711	Thermo Resist	2' 42"	Sample coating on 2024T-3 aluminum plate was originally .200" thick and later increased to .250" by vendor. The top .050 ply peeled away in 1 minute. A typical cavity was formed with no cracks, that seemed to be layer by layer. Penetration occurred in 2'42". There was some after burn.
Experimental	Thermo Resist	3'25"	Specimen coating was 5"x10" x 3/8". The coating cracked immediately. A typical cavity was formed. The cracks did not seem to harm the test. Penetration occurred in 3'25".
25	Organoceram	7'50"	Specimen with 10 minute exposure with #6 torch-given added time with 12-11A tip. The crust formed from first test slowly eroded away. Penetration occurred in 7'50".
Steel 17-7 Ph .064" thick	Commercial	5"	Set up was identical to above test. Penetration occurred in 5 seconds.
Titanium .025" thick	Commercial	2"	Set up was identical to above test. Penetration occurred in 2 seconds.
#30	Organoceram	6'56"	The material did not crack, expand or foam. A cavity gradually formed by eroding or ablating away the coating. There was no excess smoke. Penetration occurred in 6'56". There was some after burn. The temperature in the hot spot was 3450°F.

Table IV (Cont.)

Material	Manufacturer	Time For Penetration	Remarks
Desoto Coating 4094 Prime	Desoto Chemical Coatings	3'20"	Top thin layer flaked off The material gradually eroded or ablated to form a cavity. Several bubble appeared in the body of the coating. Penetration occurred in 3' 20". There was no loss of adhesion but considerable after bur The remains were hard.
XA-48-16-6	U.S.Polymeric	3'25"	The material formed a har appearing crust and began to ablate away to form a typical cavity. A few sparks or hot bead popped away during test. There appeared to be a number o small air pockets in material. Penetration occ curred in 3'25".There was no loss of adhesion but considerable after burn. Except for the surface crust the material was stillm soft. The tempera ture _o in the hot spot was 3400 F.
#28	Organoceram	Fire	Top layer immediately de laminated and burned wit excess smoke fire and fl up. Test stopped in 20 seconds. Material remain ing below burned spot wa still soft and intact.
XA-48-16-4	U.S.Polymeric	2'12"	The material was tan col of rubbery consistency a had a wire screen imbedd in the coating. The mat ial formed a typical cavity. The top layer o char almost fell away. Penetration occurred in 2'12". There was very ba after burn with excess so and smoke.

Table IV (Cont.)

LR-AD-1463
 Addendum #1
 Date: 7/16/62
 Pg. 14

Material	Manufacturer	Time for Penetration	Remarks
XA-48-16-2	U.S. Polymeric	4'15"	The specimen was 3"x6" with a 1/4" thick coating. The material formed a typical cavity. Penetration occurred in 4'15". The coating fell away from surface when test stopped. There was after burn.
HT-5	American Latex	1'15"	The material was very soft and rubber and did not appear completely cured. The material formed a typical cavity with no cracks. Little beads formed and rolled outwards from the center of the cavity. Penetration occurred in 1'15".
#127	Organoceram	Aluminum Melted	The specimen was 2"x4" with a 1/4" thick coating. The material started to form a typical cavity. The flame washed around the sides of the specimen and melted the aluminum in 1'40". This stopped the test. The sample was too small.
#128	Organoceram	2'30"	The specimen was 2"x4" with a 1/4" thick coating. The material formed a typical cavity by bubbling and spreading sideways in tiny balls. Penetration occurred in 2'30". The sample was too small and the aluminum backup plate melted prior to penetrations.
XA-48-16-1B	U.S. Polymeric	2'35"	The material formed a typical cavity with no cracks. Full top ply of char delaminated in 20" but did not fall off. The cavity continued to boil in usual manner. Penetration occurred in 2'35".

Table IV (Cont.)

Material	Manufacturer	Time for Penetration	Remarks
XA-48-16-6A	U.S. Polymeric	2'13"	The material formed a typical cavity with no cracks. Penetration occurred in 2' 13". The top char layer fell off when test stopped. There was no afterburn.
#90	Organoceram	1' 32"	The specimen was 3"x6" with a 1/4" thick coating. The material formed a typical cavity with no cracks. Penetration occurred in 1'32". There was considerable smoke and flame after test stopped.
XA-48-16-3	U.S. Polymeric	3'58"	The specimen was 4"x4" with a 1/4" thick coating. The material expanded or foamed around the hot spot where a typical cavity without cracks formed. Penetration occurred in 3'58". There was no loss of adhesion but considerable after burn. A brittle crust was formed around the burned area.
#26	Organoceram	Test stopped 1' 50"	The specimen was 3"x6" with a 1/8" thick coating. The material formed a cavity by flaking away in small layers. A top layer of char formed around the hot spot that fell into the torch flame and the test was stopped in 1'50". The remaining material under the hot spot was still rubbery and showed only 1/2 depth penetration.

TABLE V
3000°F FLAME IMPINGEMENT
RF-192 - FIBERFRAX 3710 SANDWICH

Material	Manufacturer	Time For Penetration	Remarks
RF-192-.062 Fiberfrax 3710 RF-192 .040	Rez Coat Carborundum Rez Coat	15 min stopped	9"x9" panel with flame impinging on .045 side of sandwich was stopped after 15 minute exposure with no flame penetration. The temperature was estimated to be between 2900 and 3100°F. The skin bulged toward the flame and temperature may have been higher. Fiberfrax turned black on inside of panel in hot spot. This was probably from byproducts of charring resin in RF-192
17-7 Ph Steel .064" thick	Commercial	21 Seconds	17-7 Ph steel plate same distance (6") from flame as above test penetrated in 21 seconds.

REMARKS:

1. The test results reported with the #6 torch tip in Table I and Table II are not considered to be comparable to all previous tests with the larger #12-11A torch tip. Even though the temperature was stabilized at approximately the same 3500°F, the smaller #6 tip does not give near the flame impingement velocity. This greatly reduces the washing or eroding effect of the test.

REFERENCE:

1. LR-AD-1463. Firewall Insulation for 3500°F. Flame Impingement.
2. Materials Research and Process Engineering Laboratory Record Book #37, Page 76.

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