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EVALUATION OF A-7E AIRCRAFT THERMAL RADIATION CLOSURE FOR LIGHT--ETC(U)
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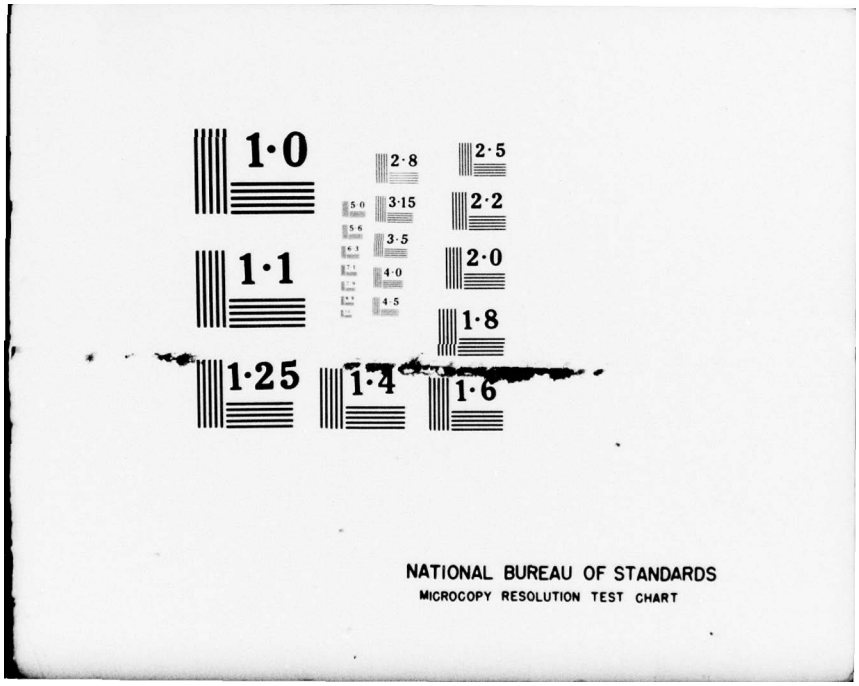
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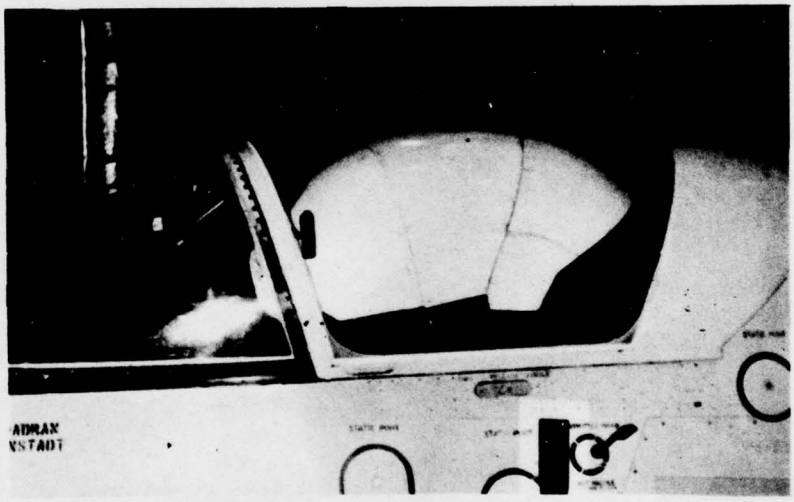
NWEF REPORT 1079

EVALUATION OF A-7E AIRCRAFT THERMAL RADIATION CLOSURE FOR LIGHT LEAKAGE



NAVAL WEAPONS EVALUATION FACILITY
ALBUQUERQUE, NEW MEXICO 87117

Enclosure (1)

NWEF Report 1079

NAVAL WEAPONS EVALUATION FACILITY

CAPT W. W. STRONG, USN
Commanding Officer

EVALUATION OF A-7E AIRCRAFT THERMAL RADIATION CLOSURE FOR LIGHT LEAKAGE

by

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and

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Albuquerque, New Mexico

20 April 1971

FOREWORD

Tests conducted during BIS A-7E-03 nuclear weapons trials at the Naval Weapons Evaluation Facility, Kirtland Air Force Base, Albuquerque, New Mexico, in November 1969 revealed deficiencies which reduced thermal radiation closure (TRC) effectiveness due to light leaks into the cockpit. This report presents results of tests to evaluate TRC modifications being incorporated in A-7E aircraft No. 318 and subsequent which were intended to eliminate light leaks previously defined.

These studies were conducted under AIRTASK 340340B/206B/IF32-523-401 dated 7 August 1970 from Naval Air Systems Command (AIR-530323).

ABSTRACT

Tests detailed in this report were conducted by the Naval Weapons Evaluation Facility to evaluate effectiveness of thermal radiation closure (TRC) modifications developed by LTV to eliminate light leaks defined during BIS-A7E-03 nuclear weapons trials. Leakage evaluations were made before TRC modification, after TRC modification, and following 100 repetitive TRC actuations. Results indicated that the modification did eliminate leak paths present at corners of the cowling, but high-transmissivity areas exist along the interface between the aft movable segment and the fixed segment which are not considered in the modification. Further, pinpoint light leaks were observed at the HUD cowling interface which allowed light to shine directly into the pilot's eyes, a most undesirable situation. Measurements of ambient light levels in the cockpit were well within specification in spite of the high transmission areas along the fixed segment interface. It was demonstrated that a seal along this interface can reduce transmitted light to specification tolerances. Through proper seal installation and elimination of light leaks from sources other than the TRC, the level of all light transmitted to the cockpit area can be brought within specification tolerances.

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INTRODUCTION

Thermal radiation closure (TRC) tests conducted in November 1969 during BIS A-7E-03 revealed deficiencies which reduced effectiveness of the TRC because of light leaks in the cockpit area. These deficiencies were defined on BIS Yellow Sheet NWEF-14 dated 26 November 1969. To alleviate problems defined, the Vought Aeronautical Division of LTV Corporation proposed modifications, which are being installed in aircraft No. 318 and subsequent. A review of proposed modifications by NWEF personnel on 5 November 1970 at LTV Corporation, Dallas, Texas, was inconclusive since test conditions were not imposed and the aircraft inspected was not fully modified. It was recommended that changes being installed in A-7E aircraft No. 318 and subsequent be incorporated in A-7E aircraft BuNo 156739 (No. 6), assigned to NWEF, for futher evaluation. On 30 December 1970, parts and marked drawings as required for retrofit were sent to NWEF for modification of BuNo 156739.

Prior to modification and testing, the aircraft was flown to NAS Cecil Field for incorporation of Airframe Change (AFC) 111 by the LTV mod team. At this time, the pressure regulator valve was changed to ensure TRC actuation at 200 psi rather than 445 psi. Following AFC 111 installation, the aircraft returned to NWEF on 22 March 1971. An attempt was made to eliminate all light leaks from sources other than the TRC. Specifically, both access panels located forward of the Heads Up Display (HUD) on the cowling were resealed, and adjustments were made to the rubber seals around the HUD.

PURPOSE

The purpose of this test was to determine if modifications of the TRC proposed by LTV Vought Aeronautics Division enable the A-7E TRC to meet A-7E Aircraft Detail Specification SD-555-5-1, Paragraph 3.7.1.3.1.6(6). This paragraph stipulates: "(6) VISIBLE LIGHT TRANSMISSION - When the closed system is exposed to bright light, no direct transmission of light to the cockpit shall be permitted. Penetration of light through the shield shall not exceed 0.01% of the outside light level."

DISCUSSION

PHASE I TESTS

Phase I tests were conducted on 23 March 1971 in the NWEF hangar to identify light leaks existent prior to retrofit. Four 1,000-watt quartz-iodide photo floodlamps, two on each side of the aircraft, were positioned on maintenance stands as shown in Fig. 1. Lamps were positioned so that a uniform ambient light intensity of approximately 3,000 footcandles was measured in the cockpit.

The TRC was marked off into 5-inch square segments as illustrated by Fig. 2 so that exact position of any leaks observed could be specifically defined. All closure actuations were made pneumatically and a motion picture record of each actuation was made. To preclude activation of cockpit white floodlights, circuit breaker CB3043 was pulled. All instrumentation lights were covered with black tape.

Visual observation revealed the following leakage points:

1. Major transmission areas on both left and right sides at positions 5-6 and 6-6 (Fig. 2) along the interface between the fixed segment and the movable segment, with particular emphasis on the area around the metal-slider hinge.

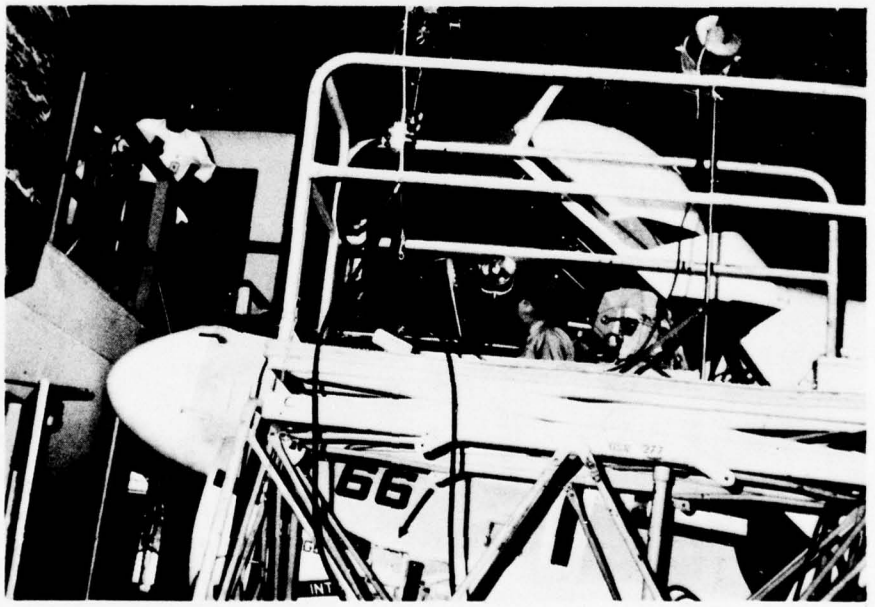
2. Major transmission area directly aft of the pilot's seat along the rear edge of the aft movable segment at positions L-1-10 and R-1-10.

3. Major light leaks, apparently direct, at left and right corners of the cowling with the right-hand leak directly above the standby compass. The left-hand leak appeared slightly worse than the right. Another cowling leak on the left-hand side was attributable to a hole in the cowling.

4. Major transmission area at positions L-5-2 and L-6-2 (Fig. 2) along the interface between the forward and center movable segments.

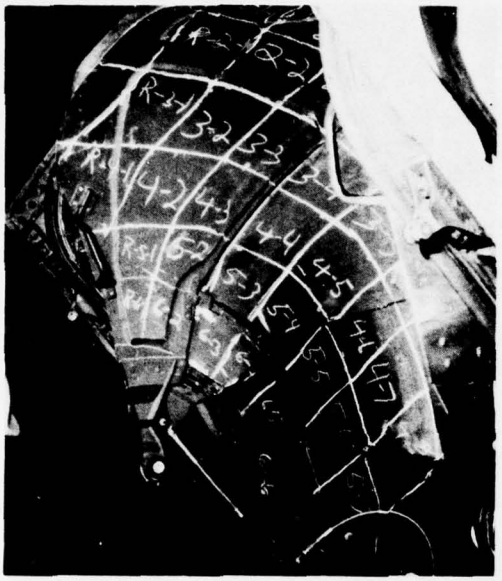
5. Numerous scratches visable in the closure material. The forward movable segment appeared slightly more translucent than the center and aft movable segments.

RIGHT SIDE VIEW

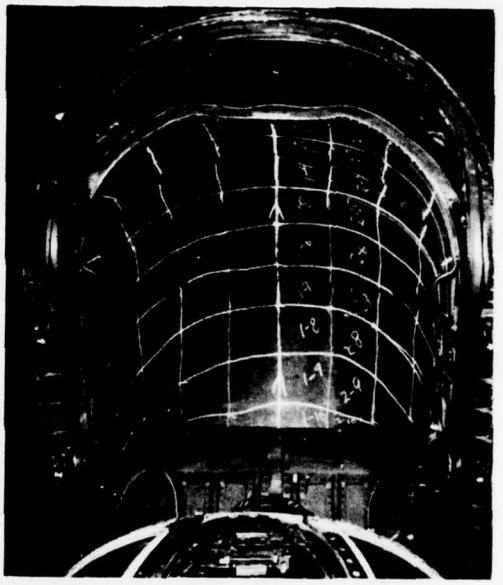


LEFT SIDE VIEW

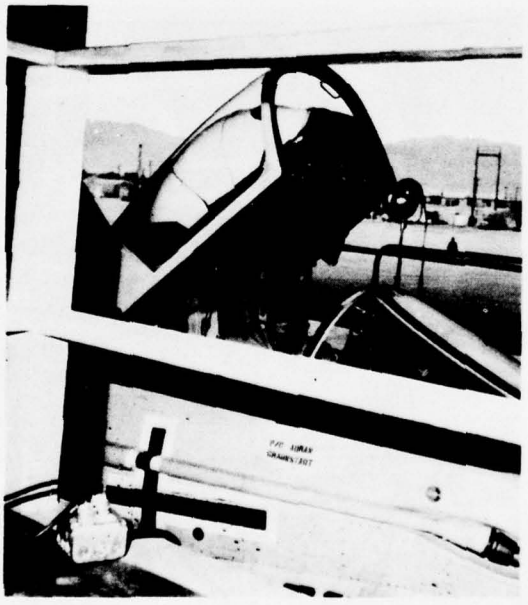
FIGURE 1. LAMP POSITIONING, PHASE I TESTS



RIGHT SIDE



FRONT



LEFT SIDE

FIGURE 2. SEGMENT MARKINGS FOR POSITION IDENTIFICATION

6. Major light leaks noted along HUD seal areas on left and right sides of the HUD at its interface with the cowling.

Ambient internal light levels were not measured during Phase I tests. Nor was any attempt made to measure the magnitude of leaks observed. Seal areas along the interfaces of the movable segments revealed no unacceptable leakage except as previously noted. Following visual observations, the TRC was pneumatically cycled ten times from the READY position (Fig. 3). No significant changes in leakage characteristics were noted.

PHASE II TESTS

Phase II was initiated 25 March 1971 and entailed incorporation of retrofit changes defined by LTV letter 2-51830/0L-3584 dated 30 December 1970. Concurrent with retrofit operations, investigations were conducted to establish sources of light leaks observed and to determine if these leaks would be corrected by retrofit.

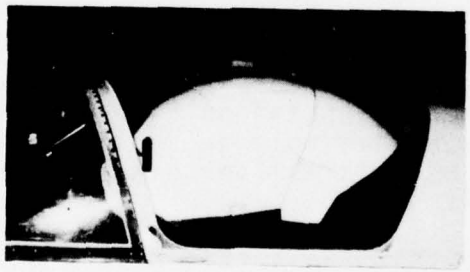
The gross leak area aft of the seat along the rear edge of the aft movable segment was traced to lack of a seal for a length of approximately 12 inches along the top periphery of the fixed segment (Fig. 4). LTV was contacted to determine if for some reason lack of a seal at this point was limited to aircraft BuNo 156739. It was established that the only seal along the interface between the aft movable segment and the fixed segment is provided by the absorber (LTV part No. 215-21136-9), and that this condition is common to all A-7E aircraft.

Lack of a seal along the forward edge of the fixed segment (Fig. 4) was also determined to be the cause of light transmission noted at positions 5-6 and 6-6 along the interface between the aft movable segment and the fixed segment in the area of the metal-slider hinge on both left- and right-hand sides.

It was noted that seals (LTV part Nos. 218-21136-7 and -8) at left and right corners of the cowling had not been installed during incorporation of AFC 111 (Fig. 5). These seals were installed as part of the retrofit operation (Fig. 6). Figure 5, sheet 5 of 6, of AFC 111 shows the 218-21136-7 and -8 seals as rectangular, while the marked drawing (218-21136, sheet 3) furnished NWEF indicates that these seals should be cut to fit. Difficulties encountered during seal installation revealed that a hand-fit operation

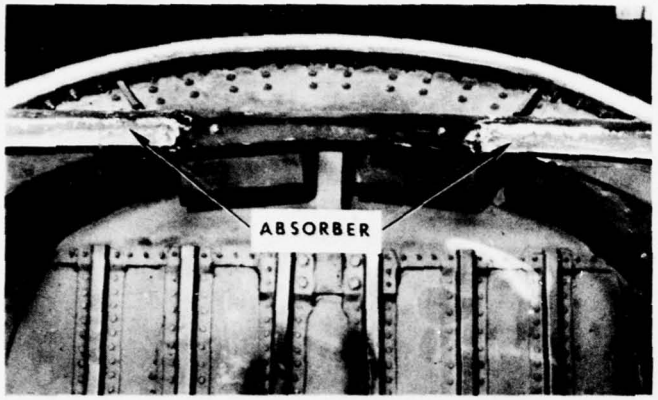
OPEN

READY

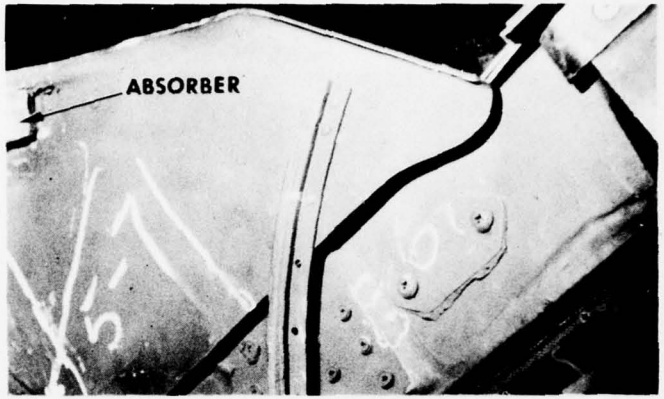


CLOSED

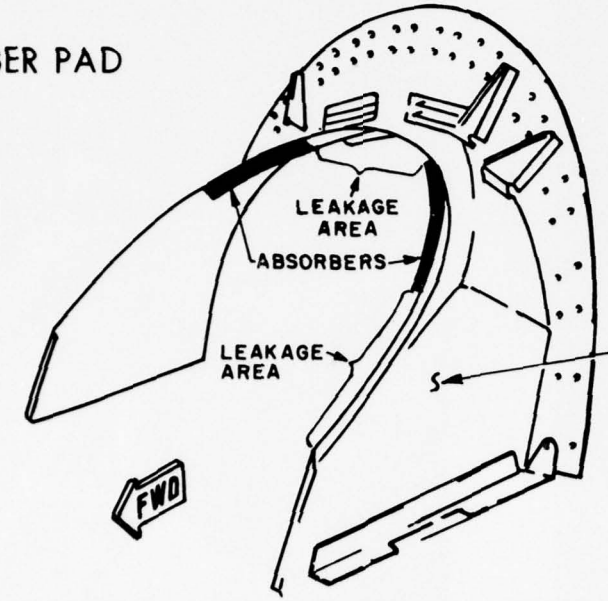
FIGURE 3. THERMAL RADIATION CLOSURE POSITIONS



MISSING SEAL
FWD OF ABSORBER PAD



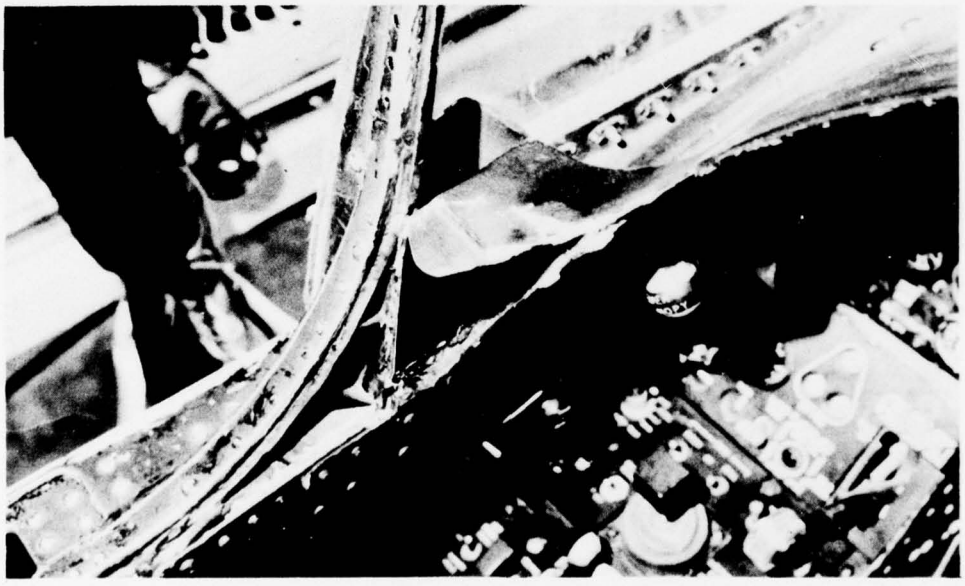
MISSING SEAL
AFT OF ABSORBER PAD



FIXED SEGMENT
ABSORBER POSITION

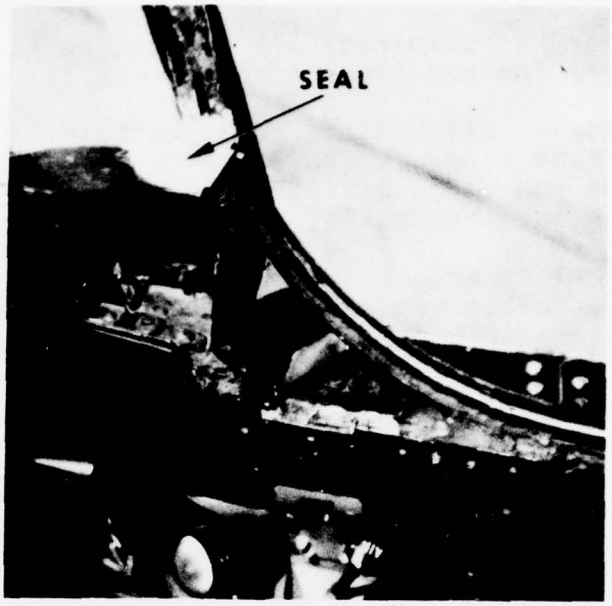
FIGURE 4. CAUSE OF LIGHT LEAKS ALONG AFT-MOVABLE SEGMENT AND FIXED SEGMENT

RIGHT SIDE



LEFT SIDE

**FIGURE 5. COWLING SEAL LOCATIONS-
BEFORE SEAL INSTALLATION**



RIGHT SIDE

LEFT SIDE

FIGURE 6. COWLING SEAL LOCATIONS- SEALS INSTALLED

is necessary to eliminate all leakage paths. AFC 111 does not specify the requirement for a hand fit operation.

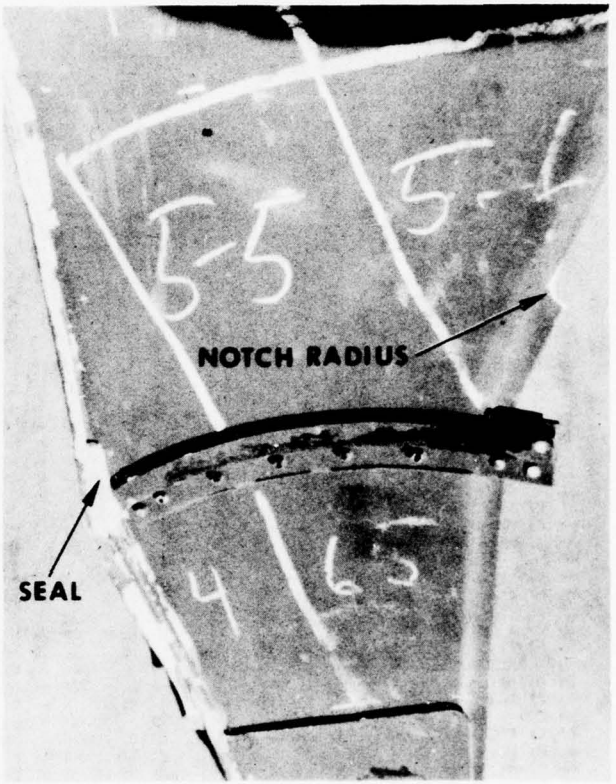
An attempt was made to seal the hole in the cowling on the left-hand side, as indicated by the seal material visible to the right of LTV part 218-21136-7 up approximately 4 inches along the cowling (Fig. 6).

No problems were encountered either with installation of the sponge rubber wedges (LTV part No. 218-21704), installation of seals (LTV part Nos. 215-21136-58 and -127) as shown in Fig. 7, or with rounding notch corners (LTV drawing 218-21136, sheet 2) on the aft movable segment (Fig. 7). The radius of the notch corner was not defined specifically, but was determined to be 0.3125 inch by scaling from the drawing. A gauge of this radius was used.

Adhesive was allowed to dry overnight, and Phase II measurements were made 26 March 1971 at approximately 1000 hours. The aircraft was positioned on the flight line facing north in direct sunlight. Ambient light level in the cockpit with the TRC open measured a uniform 8,000 footcandles. After manual closure, ambient internal levels at pilot eye level were determined in four quadrants (left fwd, left aft, right fwd, and right aft). Meter readings indicated 0.13 footcandle in the fwd quadrants, and 0.13 to 0.26 in aft quadrants. Since the transmission specification defines 0.01% of external incident light as acceptable, a maximum internal level of 0.8 footcandle was within specification. Light transmission values ranged from 0.13 to 0.26 footcandle depending upon position measured and existence of external scratches. All metered readings of light directly transmitted through the material were well within specification values. Meter readings at left and right cowling seals indicated a transmission level of 0.5 footcandle. Therefore, the retrofit to the cowling seals (LTV part No. 218-21136-7 and -8) reduced the transmitted light level below specification values.

Considerable leakage was still noted along the seam between the center and aft movable segments on both left- and right-hand sides through positions 6-5, 5-6, and 4-8. Measurements indicated a value well in excess of 1 footcandle along each interface. Further, the leak aft of the seat along the rear edge of the aft movable segment measured greater than 1 footcandle at a distance of approximately 16 inches.

SEGMENT BEFORE REWORK



SEGMENT AFTER REWORK

FIGURE 7. MOVABLE SEGMENT REWORK TYPICAL

Leakage points were still noted at the HUD seals, even though further adjustments had been made following Phase I tests. Following readings taken after manual closure, the TRC was pneumatically actuated twice with a different observer in the cockpit. Along with the leaks previously noted, this observer noted considerable light transmission along the metal-slider hinge in positions 6-3, 6-4, and 6-6 (Fig. 2) on both left- and right-hand sides. The seal of the hole in the cowling was ineffective and again resulted in a high transmission area approximately 3 to 4 inches up along the cowling on the left side.

PHASE III TESTS

Prior to Phase III testing, an attempt was made to eliminate leakage areas at the interface between the aft movable segment and the fixed segment (Fig. 4). Seal material available at NWEF was bonded to the fixed segment both forward and aft of the absorber (LTV part No. 215-21139-91) to complete the seal pattern around the fixed segment edge. Severe interference problems were encountered with the materials used. Particular problems involved the seal aft of the absorber along the periphery of the fixed segment. Because of clearance variations during closure operation, severe interference necessitated removal of the aft seal installation. These problems could be minimized if the seal were positioned on the outside edge of the aft movable segment rather than the fixed segment. There would then be no interference during closure, and a seal would result as the aft segment completed its motion. Installation of seals along this interface was intended to demonstrate that a complete seal along the fixed segment could eliminate all remaining leakage paths yielding out-of-specification values, and not as a proposed fix in lieu of an engineering evaluation by LTV.

Phase III measurements were made 2 April 1971 with the aircraft positioned on the flight line in sunlight and facing north. Three sets of measurements were made. Initial measurements were taken after manual closure with the seals bonded to the fixed segment forward of the absorber as installed after Phase II. Then, these seals were removed, the TRC was manually closed and measurements were repeated. A third set of measurements was taken after a manual closure following 100 cycles of the TRC. Data are tabulated in Tables 1, 2, and 3 respectively.

TABLE 1

A-7E AIRCRAFT THERMAL RADIATION CLOSURE TESTS
PHASE III LIGHT LEAKAGE MEASUREMENTS
DATA SHEET, BEFORE SEAL REMOVAL

Date: 2 April 1971 Aircraft BuNo.: 156739

Location: Flight line, south of Bldg 1002

Aircraft Position: Facing north

Weather Condition: Clear, bright sunlight

Ambient External Light Level: 8,000 footcandles

First Set of Measurements - 1000 Hrs to 1130 Hrs:

Ambient Internal Levels

Fwd right quadrant	0.13 footcandle
Fwd left quadrant	0.13 footcandle
Directly over pilot's head	0.13 footcandle
Aft right quadrant	0.13 to 0.26 footcandle
Aft left quadrant	0.13 to 0.26 footcandle

Areas of Maximum Light Transmission

Left side at cowling seal, left corner	0.7 footcandle
Left side at slider hinge	0.7 footcandle
Left side at notch cutout (aft segment)	0.7 footcandle
Right side at cowling seal, right corner	0.7 footcandle
Right side at slider hinge	4.6 footcandles
Right side at notch cutout	4.0 footcandles
Right side at pushed-out seam (in general area of R-6-5) . . .	180 footcandles
Right side (ambient in location over SEL ENABLE on right console)	16 footcandles
Direct leaks (four small pinpoints) in HUD seal	No reading

TABLE 1 - CONTINUED

Areas of Maximum Light Transmission (Continued)

Hole in cowling (left side) . . . 4 footcandles
Leak directly behind seat
(R-1-10 and L-1-10) . . . . . 130 footcandles

Material Transmissivity Measurements

Left Side

Square	L-1	L-2	L-3	L-4	L-5	L-6
1	0.32	0.35	0.35	0.32	0	0
2	0.32	0.35	0.35	0.32	0	0
3	0.32	0.35	0.37	0 - Hinge	0.18	0
4	0.20	0.20	0.20	0.20	0.20	0
5	0.20	0.20	0.20	0.20	0.20	0
6	0.20	0.20	0.20	0.20	0.20	0
7	0.20	0.20	0.20	0.20	0	
8	0.25	0.20	0.20	0.20		
9	0.30	0.26	0.30			
10	0.30					

Right Side

Square	R-1	R-2	R-3	R-4	R-5	R-6
1	0.32	0.32	0.32	0.32	0	0
2	0.32	0.32	0.32	0.32	0	0
3	0.30	0.32	0.36	0.33	0.18	0
4	0.20	0.20	0.20	0.20	0.18	0
5	0.20	0.20	0.20	0.20	0.20	0-180
6	0.20	0.20	0.20	0.20	0.20-8	
7	0.20	0.20	0.20	0.20		
8	0.20	0.20	0.20	0.20-4		
9	0.20	0.26	0.20			
10	3.5					

NOTES:

1. Manual closure to prevent damage due to stiff seals installed along fwd portion of fixed segment.

2. Seam on right-hand side open due to inflexibility of seal installed along fwd portion of fixed segment. Left-hand seal is satisfactory.

TABLE 2

A-7E AIRCRAFT THERMAL RADIATION CLOSURE TESTS
PHASE III LIGHT LEAKAGE MEASUREMENTS
DATA SHEET, AFTER SEAL REMOVAL

Date: 2 April 1971 Aircraft BuNo.: 156739

Location: Flight line, south of Bldg 1002

Aircraft Position: Facing north

Weather Condition: Clear, bright sunlight

Ambient External Light Level: 8,000 footcandles

Second Set of Measurements - 1150 Hrs to 1230 Hrs

Ambient Internal Levels

Fwd right quadrant	0.58 footcandle
Fwd left quadrant	0.40 footcandle
Directly over pilot's head	0.32 footcandle
Aft right quadrant	0.32 to 0.45 footcandle
Aft left quadrant	0.32 to 0.45 footcandle

Areas of Maximum Light Transmission

Left side at cowling seal (left corner)	Not taken
Left side at slider hinge	4.0 footcandles
Left side at notch cutout	4.0 footcandles
Left side (ambient in location over left console below hinge)	65.0 footcandles
Right side at cowling seal (right corner)	0.84 footcandle
Right side at slider hinge	8.0 footcandles
Right side at notch cutout	4.0 footcandles
Right side (ambient in location over SEL ENABLE on right console)	65.0 footcandles
Direct leaks in HUD seal area (4 points)	No reading

TABLE 2 - CONTINUED

Areas of Maximum Light Transmission (Continued)

Direct leak on right-hand side, approximately a 0.25-inch diameter beam of light located close to hinge	260 footcandles
Leak directly behind seat	750 footcandles

NOTES:

1. Left- and right-hand seals along fwd portion of fixed segment removed.
2. Binding no longer present.
3. Material transmissivity measurements not repeated.

TABLE 3

A-7E AIRCRAFT THERMAL RADIATION CLOSURE TESTS
PHASE III LIGHT LEAKAGE MEASUREMENTS
DATA SHEET, AFTER 100 CYCLES

Date: 2 April 1971 Aircraft BuNo.: 156739

Location: Flight line, south of Bldg 1002

Aircraft Position: Facing north

Weather Condition: Clear, bright sunlight

Ambient External Light Level: 8,000 footcandles

Third Set of Measurements - 1500 Hrs

Ambient Internal Levels

Fwd right quadrant	0.32 footcandle
Fwd left quadrant	0.48 footcandle
Directly over pilot's head	0.32 footcandle
Aft right quadrant	0.32 to 0.65 footcandle
Aft left quadrant	0.45 to 0.70 footcandle

Areas of Maximum Light Transmission

Left side of cowling seal (left corner)	0.7 footcandle
Left side at slider hinge	4.0 footcandles
Left side at notch cutout	3.6 footcandles
Left side (ambient in location over left console at hinge)	65.0 footcandles
Right side of cowling seal (right corner)	Not measured
Right side of slider hinge	1.0 footcandle
Right side of notch cutout	0.78 footcandle
Right side (ambient in location over SEL ENABLE on right console)	65.0 footcandles
Direct leak in HUD (four points)	No reading

TABLE 3 - CONTINUED

Areas of Maximum Light Transmission (Continued)

Direct leak on right-hand side previously noted now highly diffused	No reading
Leak directly behind seat	600 footcandles
Leak on cowling at radius located up approximately 4 inches from edge on right side	36 footcandles

NOTES:

1. Sun positioned west of aircraft (left side)
2. Ambient external light level - 8,000 footcandles
3. Measurements made after 100 actuations of closure (30 were pneumatic).

Because of considerable binding from the seals installed on the fixed segment, the TRC was initially closed manually to prevent damage to the closure mechanism. It was noted that the right seal (Fig. 8) was pushing against the closure to such an extent that an excessive leak measuring 180 footcandles appeared along the interface between the aft movable segment and the fixed segment at positions R-6-5, R-5-6, and R-4-8. Conversely, the seal on the left side worked properly, and reduced all light transmission to a level of 0.7 footcandle which is within specification limits. The second set of measurements repeated after removal of these seals (Table 2) revealed that the reduction in light-transmission levels was directly attributable to presence of the seal material. Further, after seal removal, a direct light leak approximately 0.25 inch in diameter and measuring 260 footcandles was noted on the right side near the hinge.

Considerable change was noted between light intensity readings aft of the seal along the edge of the aft movable segment in positions L-1-10 and R-1-10 from the initial to the second set of measurements. Readings varied from an initial value of 130 footcandles to a second value of 750 footcandles in the same location. Presence of the side seals may have helped maintain a more uniform contour in the aft movable segment during initial measurements. With the seals removed, the aft movable segment probably relaxed, increasing the clearance between the aft movable segment and the fixed segment, resulting the observed change in transmitted light.

Ambient internal light levels are the average of four measurements made in each quadrant. The increase in ambient internal light levels after removal of the side seals previously discussed was probably caused by the increase in transmitted light both aft of the seat and along the hinge areas. The ambient light differences between the second and third readings was caused by the movement of the sun to the left of the aircraft. All internal ambient measurements were within specification tolerances.

Material transmission measurements were made with the meter in contact with the material at each position. Recorded values indicate material transmission limits to be well within specification tolerances.

Although the seals added at the corners of the cowling reduced intensities at those points to acceptable levels, a high transmission area was present along the cowling on

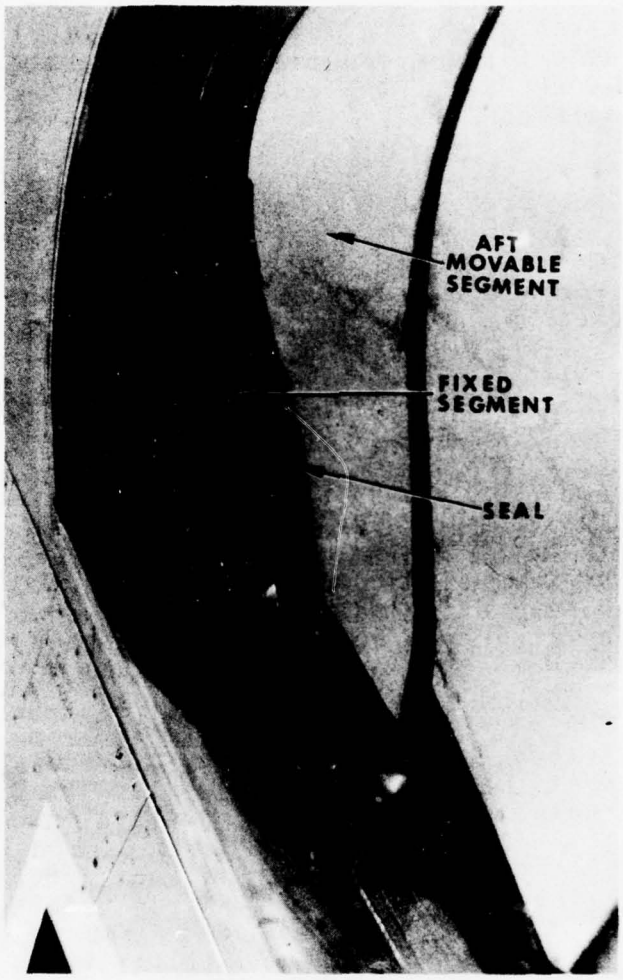


FIGURE 8. FIXED-SEGMENT SEAL INSTALLATION RIGHT SIDE

both left and right sides at the curved section immediately above the patched hole as shown in Fig. 6. There was an apparent mismatch between radius of the cowling and radius of the fwd movable segment of the TRC. Measurements of this area indicated a transmission level of 36 footcandles on the right radius during the third set of readings taken. It was not as severe earlier and seems to be reduced significantly when the TRC is closed pneumatically.

Four direct light leaks, which allow light to shine directly in the pilot's eyes, were noted throughout this test series. Although they are not attributable to any fault of the closure, these direct leaks must be eliminated because of their position. Figure 9 defines these leak locations. A shield attached to the fwd movable segment could be positioned so that as the TRC closed, pinhole leaks would be eliminated from the direct view of the pilot; or a permanent seal could be added to the top portion of the HUD control panel to eliminate leakage paths

Following completion of NWEF tests, two fleet aircraft of VA-147, NAS Lemoore, were checked visually. This inspection revealed the same problems with seals along the aft fixed segment and direct light leaks along the HUD seals. Neither aircraft had the 200 psi pressure-regulator valve, and both revealed significant leaks at corners of the cowling. No form-fitting of seals was noted. According to the aircraft logbooks, AFC 111 was installed at the factory prior to delivery. However, two features of AFC 111 (the 200 psi value and LTV part Nos. 218-21136-7 and -8 seal installation) were not installed in either of the aircraft inspected. Considerable light transmission along the metal-slider hinge at the interfaces of all movable segments, and smaller transmissions along the cowling radius approximately 3 to 4 inches up from the corners on each side were also noted. In general, the same light transmission problems were noted at NAS Lemoore as were noted at NWEF. Overall transmitted light to the cockpit area appeared greater than observed on the NWEF aircraft.

CONCLUSIONS

1. Seals (LTV part Nos. 218-21136-7 and -8) added to left and right corners of the cowling reduce transmitted light at these points to specified tolerance levels.

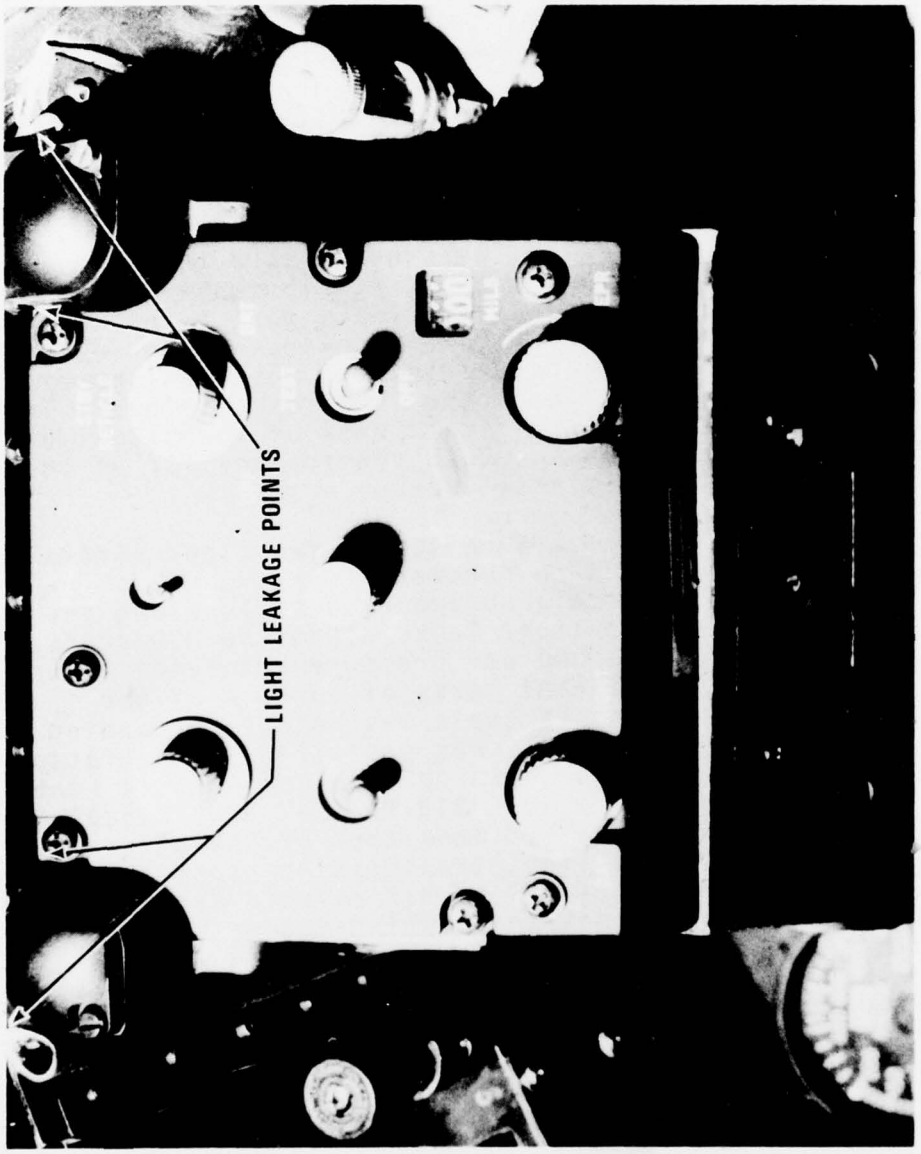


FIGURE 9. DIRECT LIGHT LEAKAGE POINTS ALONG HUD SEALS

2. Rounding of corners of the notch in the aft movable segment (LTV part No. 215-21136-121) is an acceptable method of relieving stress concentrations at notch corners.

3. No light leaks were noted between the movable segments in the areas protected by side seals (LTV part Nos. 215-21136-58 and -127) either before or after retrofit.

4. Wedge-shaped sponge rubber blocks (LTV part No. 218-21704), added to the forward seal to prevent the seal lip from collapsing and not extending over the cowl when closed, perform this function effectively as installed. However, the sponge rubber blocks also indicate a tendency to attain a "set" under long-term storage which may eventually reduce their effectiveness.

5. Severe light leaks exist at the interface between the fixed segment (LTV part No. 215-21136-86) of the segment assembly (LTV part No. 215-21136-90) and the external face of the aft movable segment. Although the absorber (LTV part No. 215-21136-91) acts as an effective seal along part of this interface, the observed leaks are directly attributable to lack of a seal forward and aft of the absorber along the interface length.

6. Direct light leaks, which are supposed to be eliminated by seal assemblies (LTV part Nos. 215-20078-187, -188, and -240), exist along the edges of the HUD. However, adjustments of these seals failed to remove four pinpoints of direct light which shine into the pilot's eyes. These leaks are not attributable to a fault of the TRC per se, but are definitely serious because of their position.

7. Measurements of ambient light level inside the cockpit and away from the leakage points defined above indicate ambient levels to be well within specification limits.

RECOMMENDATIONS

1. Install a seal along the entire interface between the fixed segment of the segment assembly and the aft movable segment to ensure a reduction to specification levels of all light transmitted to the cockpit, either directly or indirectly.

2. Eliminate direct light leaks to the pilot's eyes from positions along the HUD.

3. Modify Fig. 5, sheet 5 of 6, of AFC 111 to show that cowling seals (218-21136-7 and -8) must be cut to fit as required to eliminate leaks.

4. Require LTV to define the radius dimension for the radius to be added to the notch cutout shown in LTV drawing No. 218-21136, sheet 2.

APPENDIX A

DETAILED TEST PROCEDURE, LIGHT LEAKAGE TEST OF A-7E THERMAL RADIATION CLOSURE

APPENDIX A

6 April 1971

DETAILED TEST PROCEDURE
LIGHT LEAKAGE TEST OF A-7E THERMAL RADIATION CLOSURE

1. Test Plan No.: 71-5

2. Project Officer: LCDR J. E. Fordice, Ext 3151

3. Project Engineer: L. L. Langdon, Ext 3151

4. Other Key Personnel:

   LT E. O'Dell (Maintenance Department)
   PH1 Lenhoff (Photo Laboratory)
   Mr. D. M. O'Connor (Aircraft Projects Department)

5. TA No.: A340340B/206B/IF32-523-401

6. Allotment No.: 246

7. Segment (Charge) No.: 1102

8. Test Dates: 22-25 March 1971

9. O.D. No.: N/A

10. Hazard Form No.: N/A

11. Test Location: NWEF Hangar Area Bldg 1002

12. Test Items: Modifications of A-7E aircraft thermal radiation closure (TRC) as defined by:

    a. LTV Drawing No. 215-21136
    b. LTV Drawing No. 218-21136
    c. LTV Drawing No. 218-21704
    d. Parts package w/218-21136-7 and -8 seals, 218-21704 wedge, 215-21136-58 seal, and Dow-Corning sealant/adhesive

    These items are intended to correct TRC light-leak discrepancies as defined by NWEF BIS Yellow Sheet Report No. NWEF-14 of 26 November 1969.

13. Test Purpose: To determine whether or not the TRC modifications defined above meet the requirements of Model A-7E Aircraft, Detail Specification SD-555-5-1, Para. 3.7.1.3.1.6(6) which stipulates: "(6) VISIBLE LIGHT TRANSMISSION - When the closed system is exposed to bright light, no direct transmission of light to the cockpit shall be permitted. Penetration of light through the shield shall not exceed 0.01% of the outside light level."

14. Test Description:

General. The test will be conducted in three phases. Phase I will entail evaluation of the TRC system as presently installed in A-7E aircraft BuNo 156739. Phase II will entail installation and adjustment of proposed modifications by NWEF maintenance personnel. Phase III will entail evaluation of the modified TRC assembly to include repetitive testing.

Test Procedure. Prior to initiation of Phase I tests, a complete inspection of the TRC installation is required to ensure that proper installation and maintenance have been accomplished, and to verify elimination of all light leaks into cockpit area other than those along the closure seals. AFC 111 will be incorporated prior to test initiation.

a. Phase I, Premodification Testing

Step 1. Assemble four quartz-iodide photo floodlamps around the cockpit as required to attain an ambient uniform light intensity of 3,000 footcandles in the cockpit.

Step 2. Photograph test setup (overall view).

Step 3. Mark off closure into 5-inch squares with aircraft centerline as dividing point between left and right sides of the TRC. Photograph identification markings.

Step 4. Pneumatically close TRC (motion picture of actuation is required).

Step 5. Maintain TRC in closed position until observer's eyes become accustomed to the dark (approximately 30 minutes) or until direct light leaks can be visually observed.

Step 6. Mark and record locations of all light leaks visually observed. Photograph leakage areas as applicable.

Step 7. Open TRC.

Step 8. Pneumatically cycle TRC open/closed/open for a total of ten actuations (motion picture of each actuation is required). Record any changes to visual light leaks in cockpit. Photograph as applicable.

Step 9. Measure and record ambient light intensity in the cockpit area.

Step 10. Phase I complete.

b. Phase II, Modification Installation and Adjustment

Step 1. Install and adjust rubber tabs in accordance with LTV drawings 218-21136-7 and -8 using adhesive provided. Sheet 3 of the drawing shows a half-size pattern of parts. Close canopy and closure before adhesive cures to check for fit and light seal. Move or trim as required to eliminate light. Photograph tab locations before and after installation.

Step 2. Install wedge-shaped sponge rubber block (LTV drawing 218-21704) per LTV drawing 218-21136, sheet 2. Blocks are to be bonded on one side only to the riveted retainer strip. A heated probe may be used to indent sponge to allow space for rivet heads. Photograph installation procedures.

Step 3. With the TRC extended, check for light leaks between sides of the segments. If present, ensure side seals 215-21136-58 and -127 extend to each other. The ends may be bonded to each other. Enclosed with modification kit is a length of seal material. Ensure that the seal is depressed 1/16 to 1/32 inch when closure segments are assembled. Use adhesive to build up under seal as required to gain required deflection. Photograph installation procedures to include positioning of side seals.

Step 4. Round corners of notch in rear of aft movable segment 215-21136-121 as shown on 218-21136, sheet 2. Photograph notch area after removal operation.

Step 5. Allow adhesive to cure fully before proceeding with further testing.

Step 6. Position aircraft in bright sunlight on flight line.

Step 7. Measure and record ambient light intensity in the cockpit area with TRC open.

Step 8. Manually close TRC while observer in cockpit.

Step 9. Maintain TRC in closed position until observer's eyes become accustomed to the dark (minimum 35 minutes) or until direct light leaks are observable.

Step 10. Record position of light leaks usually observed. Photograph leakage areas as applicable.

Step 11. Measure and record ambient light intensity levels in the cockpit at eye level in left fwd, right fwd, left aft, and right aft quadrants. Average a total of four readings from each quadrant.

Step 12. Measure and record intensity of light transmitted directly through TRC material.

Step 13. Measure and record intensity of light transmitted at each visual leak observed.

Step 14. Open TRC and record ambient level of incident light.

Step 15. Pneumatically close TRC with observer in cockpit (motion picture of actuation is required).

Step 16. Record position of light leaks visually observed. Photograph leakage areas as applicable.

Step 17. Open TRC and record ambient level of incident light.

Step 18. Phase II complete.

b. Phase III, Post-Modification Testing (Repetitive Testing)

Step 1. Install seals along edge of fixed segment

on left and right sides forward of absorber. Allow adhesive to dry thoroughly. Photograph seal installation.

Step 2. Position aircraft in bright sunlight on flight line.

Step 3. Measure and record ambient light intensity in the cockpit area with TRC open.

Step 4. Manually close TRC while observer in cockpit.

Step 5. Maintain TRC in closed position until observer's eyes become accustomed to the dark (minimum 35 minutes) or until direct light leaks are observable.

Step 6. Record position of light leaks visually observed. Photograph leakage areas as applicable.

Step 7. Measure and record intensity of light transmitted directly through the TRC material.

Step 8. Measure and record ambient light levels in the cockpit at eye level in left fwd, right fwd, left aft, and right aft quadrants. Average a total of four readings from each quadrant.

Step 9. Measure and record intensity of light transmitted at each visual leak observed.

Step 10. Open TRC and record ambient level of incident light.

Step 11. Remove seals installed on fixed segment during Step 1.

Step 12. Repeat Steps 4 through 10.

Step 13. Cycle TRC open/closed/open for a total of 100 actuations (70 manual, 30 pneumatic). Complete cycles in groups of ten. After each group of ten cycles, record any changes in system or indications of light leaks as observed visually (motion pictures of each pneumatic actuation are required).

Step 14. Record position of light leaks visually observed. Note particularly any changes in leaks which occurred during cycling operation.

Step 15. Open TRC and record ambient level of incident light.

Step 16. Repeat Steps 4 through 10.

Step 17. Phase III complete.

15. Anticipated Behavior of Test Items During Test: Phase I tests should reveal presence of light leaks in existing TRC installation. If modifications installed during Phase II function as anticipated, all light leaks should be eliminated. Penetration of light through the shield shall not exceed 0.01% of the outside light level (2,000 footcandles minimum).

16. Data Requirements: All data indicated are required. Data sheets are to be completed during testing. Data sheets will be furnished by the project engineer. Documentary photography is required as indicated.

17. Instrumentation Requirements: Light intensity meter - Luna Pro by Gossen. Range 0.016 through 32,000 footcandles.

18. Test Equipment and Material Requirements:

a. Floodlight array to be located in hangar area. Four 1,000 watt quartz-iodide lamps.

b. TRC modification kit.

c. Drop cords - 100 feet long - 4 each.

d. Clipboards for data collection as required.

e. Cue-board for photo identification.

f. Data sheets.

19. Storage Requirements: N/A

20. Handling Requirements: N/A

21. Assembly Requirements: Phase II requires maintenance personnel for TRC rework.

22. Loading Requirements: N/A

23. Flight Requirements: N/A

24. Recovery Requirements: N/A

25. Safety Precautions:

a. Use caution in actuating TRC. Ensure all personnel clear before actuation.

b. Do not look into quartz lamps when on, or eye damage may result.

26. Services Required:

a. Photographic coverage by Photo Branch as required.

b. Installation of retrofit kit and operation of closure by Maintenance personnel.

27. Reports Required by Project Officer and/or Engineer: Complete data sheets and exposed film strips.

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1 Naval Plant Representative Office, Dallas
1 Senior Member, Navy Board of Inspection and Survey