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TAC TEST 70A-057F

AD902273

# Final Report

# FOAMED-IN-PLACE HELMET

JULY 1972

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TACTICAL AIR COMMAND

USAF TACTICAL AIR WARFARE CENTER

EGLIN AFB, FLORIDA 32542

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TAC TEST 70A-057F

# FOAMED-IN-PLACE HELMET

FINAL REPORT

July 1972

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TACTICAL AIR COMMAND
USAF TACTICAL AIR WARFARE CENTER
EGLIN AIR FORCE BASE, FLORIDA

## FOREWORD

This operational test and evaluation (OT&E) was conducted by authority of AFR 80-14, TACR 55-10, and TAC Test Order Number 70A-057F, June 1970. Active testing began 15 September 1970 and ended 28 April 1972. The OT&E was managed by the Tactical Air Warfare Center and conducted by the Tactical Fighter Weapons Center/57th Fighter Weapons Wing, Nellis Air Force Base, Nevada.

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The assistance by personnel of the following organizations is gratefully acknowledged:

57th Fighter Weapons Wing
27th Tactical Fighter Wing
4410th Special Operations Training Group
4500th Air Base Wing

## SUMMARY

The present HGU-2A/P helmet is unsatisfactory because of discomfort, lack of retention during ejections, and restricted upward visibility. This is reflected in several unsatisfactory reports submitted by units of the Tactical Air Command. During the USAF Life Support Conference conducted in Las Vegas, Nevada (20 November - 1 December 1967), it was determined that a form-fitting helmet is the best solution to present helmet problems. The modified HGU-17/P liner previously evaluated in TAC Test 67-178 proved unsatisfactory because it was difficult to fit, the foam liner hardened during cold weather, and the liner was covered with a material that was considered a fire hazard. The commercial method of providing individually molded helmet liners also evaluated previously in TAC Test 68-202 revealed possible logistic problems should that method be accepted for Air Force-wide application.

The Foamed-In-Place process evaluated in this OT&E was conducted in conjunction with routine flying/training missions. Testing began on 15 September 1970 but was suspended on 8 October 1970 due to defective molds. After extensive modification of the liner molds, testing was resumed on 10 November 1971 and terminated on 28 April 1972. Due to the modification of liner molds after the first testing period, only results obtained in the last testing period are discussed in this report.

It was determined that life support technicians are capable, with practice, of local fabrication of acceptable Foamed-In-Place helmets. Most of the material and equipment provided were satisfactory; however, some were unacceptable and considerable supplies were required that were not provided. Aeronautical Systems Division (ASD) instructions for the helmet liner foaming process, after revision by Nellis Air Force Base personnel, were found to be adequate, although they should be refined and photographs/illustrations should be added. Instructions for helmet fabrication were inadequate. Participating aircrews rated the test helmet superior to helmets used previous to this test in the areas of comfort (82 percent) and stability (80 percent). No significant difference was noted in restrictions to visibility, and noise attenuation was rated acceptable.

It is recommended that immediate action be taken to adopt the Foamed-In-Place helmet process for Air Force use and that ASD/SAAMA take expeditious action to accomplish the following:

a. Develop, procure, and provide comfortable acoustical earcups for retrofit on all Foamed-In-Place helmets.

b. Develop, procure, and provide comfortable, adhesive-backed, leather covered edge rolls for retrofit on all Foamed-In-Place helmets.

c. All leather and sponge rubber be precut and furnished in a press-on/self-adhesive backing.

d. Talon adhesive (FSN 8040 754 2685) be used in lieu of the Bostik adhesive furnished with the test units.

e. The chemicals should be packaged and controlled to insure exact portions (measures) are available and shelf life is guaranteed.

f. Evaluate the effects of humidity and temperature on the quantity of catalyst required during foaming process.

g. Prepare appropriate technical orders with the assistance of test project officers and technicians.

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## ABBREVIATIONS AND SYMBOLS

ABWg..... Air Base Wing

AFB..... Air Force Base

AFSC..... Air Force Specialty Code

AFLC..... Air Force Logistics Command

ASD..... Aeronautical Systems Division

F..... Fahrenheit

FWWg..... Fighter Weapons Wing

G..... gravitational force

HQ..... Headquarters

hrs..... hours

OT&E..... Operational Test and Evaluation

PE..... Personal Equipment

SOTGp..... Special Operations Training Group

TAC..... Tactical Air Command

TAWC..... Tactical Air Warfare Center

TFWC..... Tactical Fighter Weapons Center

TFWg..... Tactical Fighter Wing

USAF..... United States Air Force

UR..... unsatisfactory reports

vs..... versus

FINAL REPORT

TAC TEST 70A-057F

FOAMED-IN-PLACE HELMET

1. INTRODUCTION.

a. Background.

(1) A number of units of the Tactical Air Command (TAC) have generated a requirement for a new flying helmet and/or liner. Several unsatisfactory reports (UR) have been submitted on the current HGU-2A/P helmet and fitting pad combination. Aircrews have noted the lack of capability of the helmets to reduce the high noise level associated with some types of aircraft. In addition, the present helmet is unsatisfactory in the areas of comfort, retention during ejections, and visibility in the upper vertical plane.

(2) During the USAF Industry Life-Support Conference which convened in Las Vegas, Nevada, 28 November - 1 December 1967, it was determined that the best solution to the inadequate helmet problem was a form-fitting helmet for crews of high performance aircraft. It was recommended that a study be conducted to develop a new form-fitting helmet. Such a study would consider new protection criteria for different crew positions, as well as advanced materials and design considerations which would insure comfort, stability, retention, and adequate visibility, while providing the degree of protection required for the particular crew position.

(3) TAC Test 67-178 was an attempt to use the HGU-17/P liner to solve the foregoing problems. However, it proved unsatisfactory because it was difficult to fit, the foam liner hardened during cold weather, and the liner was covered with a material which was considered a fire hazard.

(4) TAC Test 68-202 evaluated a commercial method of providing individually-molded helmet liners. Results, although successful, revealed possible logistic problems should this method be accepted for Air Force-wide application.

(5) The Foamed-In-Place Helmet Liner evaluated in this project was a further effort to provide aircrews with an improved helmet.

b. Description.

(1) The test helmets were assembled at base level. The helmet used a standard HGU-2A/P or 26/P helmet shell assembly and a supplementary package. This package provided materials and instructions for fabricating a custom-molded energy absorbing liner, ear pads, and helmet edge roll.

(a) The custom-molded liner was fabricated by pouring a liquid foam into a mold placed snugly over the subject's head. As the foam set, it conformed to the contours of the individual's skull. After the foam had set, the liner was removed from the mold and allowed to dry completely. It was attached to the inside of the helmet shell at a later time (Annex B).

(b) Ear pads for most helmets tested were made of foam rubber and covered by black sheepskin leather. Standard earphone motors were inserted into a cavity cut into the foam rubber. Due to the discomfort of the foam rubber ear pads, several helmets were built incorporating acoustical ear cups.

(c) Helmet edge rolls were of two types. The first was a rubber edge roll glued around the forward edge of the helmet shell. The second was a foam rubber edge roll, covered by black sheepskin leather, attached by sewing through holes drilled around the face opening of the helmet shell.

(2) When completely assembled, the basic components provided a custom-fit helmet configuration similar in appearance to the test items employed during TAC Test 68-202 and the custom-fit helmets fabricated at Wright-Patterson AFB (Figures 1 through 4, Annex C).

2. PURPOSE OF THE OT&E. The purpose of this OT&E was to determine if the Foamed-In-Place process could produce a helmet that provided satisfactory noise attenuation, visibility crew comfort, and stability. Specific test objectives were to determine:

a. Acceptability of materials, equipment, and instructions for local fabrication of helmet liners.

b. Capability of life support technicians to perform required tasks.

c. Aircrew acceptability of helmet comfort, visibility, stability, and noise attenuation.

3. METHOD OF CONDUCTING THE OT&E. This evaluation was conducted in conjunction with routine flying/training missions from 10 November 1971 to 28 April 1972 (exclusive of a short testing period from 15 September 1970 to 8 October 1970, results of which were discarded due to extensive redesign of the molds before the final testing period). The 57 FWWg, 27 TFWg, 4410 SOTGp, and the 4500 ABWg were each allocated chemicals and fabric for a minimum of 15 helmets.

a. Helmet Fabrication. Liners were fabricated locally by life support technicians in accordance with instructions developed by Nellis AFB life support personnel. Helmets were assembled in accordance with

instructions provided by ASD. Adequacy of the fabrication/assembly instructions was evaluated. When fabrication and assembly was complete, participating life support personnel completed the Life Support Technician Questionnaire #1 (Annex A, Appendix 2).

b. Service Evaluation. Inspection and maintenance of test items was in accordance with applicable technical orders and command directives. An additional inspection was performed at the conclusion of the evaluation. Required maintenance was recorded during the evaluation, and Life Support Technician Questionnaire #2 (Annex A, Appendix 2) was completed at the conclusion of the evaluation.

c. Aircrew Acceptability. Participating aircrews wore the test items on every flight during the evaluation period. Pertinent data were recorded after each flight and the Aircrew Questionnaire (Annex A, Appendix 1) was completed at the termination of the test. Test helmets were worn by F-4, F-111, A-37, T-33, F-105, and UH-1 aircrews.

4. CONCLUSIONS. Analyses of Aircrew and Life Support Technician Questionnaires and comments from project officers and technicians form the basis for the following conclusions.

a. Material, equipment, and instructions supplied for local helmet fabrication were acceptable except as noted below.

(1) The rubber edge roll provided in lieu of the leather and foam rubber edge roll was unacceptable.

(2) Acoustical ear cups provided to replace the leather and foam rubber custom earpads were unacceptable.

(3) Glue provided for the fabrication process was unacceptable.

(4) Installation of drill-and-sew leather and foam rubber edge rolls and leather and foam custom-made earcups is too time-consuming for local mass production.

(5) Instructions for the helmet liner foaming process were adequate; however, they could be improved by the addition of reference illustrations/photographs.

(6) Instructions for helmet fabrication were inadequate.

b. Life support technicians at the squadron level are capable, with practice, of completing the entire foaming and fabrication procedure.

c. Eighty-two percent of the participating aircrews rated the test helmet more comfortable than their previous helmet.

d. There was no additional restriction to visibility caused by custom fitting the helmet when comparing it to other custom-fit or standard issue helmets.

e. Eighty percent of participating aircrews rated the test helmet more stable during flight maneuvers than their previous helmet.

f. Noise attenuation provided by the leather and foam earcup was acceptable.

g. Noise attenuation provided by the acoustical earcup was satisfactory and superior to the leather and foam earcup; however, this earcup proved unacceptable due to aircrew discomfort.

5. RECOMMENDATIONS. Recommend immediate adoption of the Foamed-In-Place helmet process for Air Force use and that ASD/SAAMA take expeditious action to accomplish the following:

a. Develop, procure, and provide comfortable acoustical earcups for retrofit on all Foamed-In-Place helmets.

b. Develop, procure, and provide comfortable, adhesive-backed, leather covered edge rolls for retrofit on all Foamed-In-Place helmets.

c. All leather and sponge rubber be precut and furnished in a press-on/self-adhesive backing.

d. Talon adhesive (FSN 8040 754 2685) be used in lieu of the Bostik adhesive furnished with the test units.

e. The chemicals should be packaged and controlled to insure exact portions (measures) are available and shelf life is guaranteed.

f. Evaluate the effects of humidity and temperature on the quantity of catalyst required during foaming process.

g. Prepare appropriate technical orders with the assistance of test project officers and technicians.

6. OT&E RESULTS AND DISCUSSION. Prior to resumption of the test on 10 November 1971, the Nellis Project Officer and two life support technicians went on temporary duty for one week to ASD at Wright-Patterson AFB to become familiar with the equipment and practice using the revised molding procedures. In addition, they were given training in custom-fit helmet fabrication procedures used by the Physiological Training Branch of the USAF Medical Center. The project officers and technicians at the other participating units received the revised molding procedures but did not receive formal training.

a. Objective A. Acceptability of materials, equipment, and instructions for local fabrication of helmet liners.

(1) Acceptability of Materials and Equipment.

(a) The mold and its associated hardware (Figure 6, Annex C) was adequate. With proper instructions and practice, technicians had no problem fitting it to the aircrewman's head. Aircrewmen found the fitting and foaming process rather uncomfortable due to tightness of the sealer ring when in place on the head and because of the heat generated by the foaming process which was comparable to a hot shower. The whole procedure lasted only about 20-30 minutes. The addition of an extractor lever in later molds further reduced the time and effort required to get the foam liner out of the mold.

(b) The chemicals (polyol, isocyanate, and a catalyst) provided for the evaluation produced the desired polyurethane foam liner. The technique used to mix and pour the chemicals is critical; however, all technicians became capable after watching one or two pourings and practicing several of their own.

(c) Near the end of the test, several molds produced at Nellis took excessively long to "cure." According to ASD engineers, the isocyanate bottled in the Materials Laboratory at ASD probably deteriorated due to slight moisture content since bottling conditions at ASD could not be strictly controlled.

(d) The amount of catalyst required in the reaction varied with humidity. In the extreme humidity (80-90 percent) at England AFB, the foaming process failed until they used the "temperature vs drops of catalyst" guide provided in the old foaming instructions (issued by ASD) rather than the 14-15 drops specified in the foaming instructions revised by Nellis AFB personnel (Annex B).

(e) The Dow Dispersion Coating prevented liners from sticking to the Teflon and rubber parts.

(f) The leather and foam rubber initially provided for liner covering and edge rolls was satisfactory; however, it was not precut which caused waste and slowed fabrication.

(g) The Bostik glue provided was unacceptable. It reacted with the polyurethane foam to cause raised hard areas inside many of the liners resulting in "hot-spots" to the aircrews. The raised hard areas were difficult to remove and caused several aircrews to discontinue wearing the test helmet. A talon adhesive was tested and found to be an ideal substitute.

(h) A rubber edge roll (Figures 2, 3, and 5, Annex C) provided to replace the leather and foam edge roll was unacceptable. On individuals with wide faces or high cheekbones, it had to be cut down to the point where very little padding remained (Figure 3, Annex C). It was also necessary to cut the edge roll to allow for operation of the visor (Figure 2, Annex C). The rubber was difficult to cut and the cutting produced a most unsatisfactory appearance. Difficulty was also experienced with bayonet binding (Figure 2, Annex C) unless another portion was cut away.

(i) Acoustical earcups (Figure 3, Annex C) were provided part-way through the test to replace the leather and foam custom-made earcups (Figure 1, Annex C). The latter were time-consuming to build and provided marginal sound attenuation. While the acoustical earcups did provide the required sound attenuation, they were unacceptable due to aircrewmen discomfort. For numerous aircrewmen, the earcups were too tight (due to the thickness of the cup) to wear at all. Difficulty in placement, the small size of the ear opening, and an excessively thin comfort pad made them very uncomfortable for the majority of aircrewmen who evaluated them.

(j) Other equipment required, but not supplied, to complete all required foaming and fabrication tasks are:

1. Smocks (to protect clothing from foaming process overflow).

2. Scalpel, surgical scissors, razors, and large needles (for working with leather and foam rubber).

3. Thermometer.

4. Ruler.

5. Brush (for applying dispersion coating).

6. Grease pencil.

7. Paper cups and tongue depressors (for mixing chemicals).

8. Spatula (for loosening liner from mold before addition of the extractor assembly).

9. Knife and saw (for cutting liner).

(2) Acceptability of Instructions for Local Fabrication of Helmet Liners. The revised foaming and fabrication processes were viewed and practiced by the Nellis AFB personnel at ASD, Wright-Patterson AFB, just prior to test resumption. Both processes had changed appreciably. Instructions originally provided were obsolete and inadequate, but were the only written instructions available.

(a) Foaming process instructions (Annex B) were revised and updated by Nellis AFB Project Officer and technicians for use by other participating units. Figures 6 through 19 are photographs of the foaming process. Difficulty was encountered by England AFB, where numerous failures occurred until they began using the "temperature vs number of drops of catalyst" chart provided in the original foaming instructions. This deviation appeared to be the result of extreme humidity conditions (80-90 percent) and warrants additional investigation by ASD before instructions are finalized in a technical order. As a result of this discovery and the addition of an extractor tool assembly (Figure 6, Annex C) to the helmet mold hardware, the foaming instructions should be revised and rewritten. The addition of reference pictures/illustrations should be mandatory to facilitate use and understanding of these procedures by life support technicians.

(b) The helmet fabrications instructions were provided by the Physiological Training Branch of the USAF Medical Center. These instructions were found to be inadequate. They had not been revised to allow for the installation of the dual visor required on all F-111 aircrew helmets. No written instructions were received to cover installation of the rubber edge roll or the acoustical earcups provided later in the test. When the configuration of the edge roll and earcups is finalized, instructions for the entire fabrication process should be revised and rewritten.

b. Objective B. Capability of life support technicians to perform required tasks. No major problems were encountered in learning or performing the required tasks. Several of the tasks require considerable technique (such as when to pour the foam into the mold as it is rising in the cup), but all participating technicians enjoyed the challenge and mastered the techniques with minimum practice. The following technique problems did occur during conduct of the test:

(1) Fitting of the mold to the aircrewman's head was critical. Great care had to be taken in the fitting of the mold to achieve proper liner thickness, thus insuring that the aircrewman's head fit properly in the helmet once the fabrication was complete.

(2) The mixing of the chemicals and the "just-right" time to pour the rising foam from the cup into the mold was a problem at first (Figures 11, 15, and 16, Annex C). Four or five attempts were usually required to obtain proficiency in this technique.

(3) Fabricating the leather and foam earcups required considerable technique in determining and building overall thickness and earhole depth to achieve the desired aircrew comfort and sound attenuation.

(4) Attaching and adjusting the test acoustical earcups proved to be an almost impossible task, but this was determined to be an equipment problem rather than technician capability (paragraph 6a(1)(i)).

(5) The drill-and sew procedure used in the cutom fit helmet program produced a helmet edge roll superior in comfort and appearance but took two to three times longer than required for installation of the rubber edge roll (Figures 1 and 4, Annex C).

c. Objective C. Aircrew acceptance of helmet comfort, visibility, stability, and noise attenuation.

(1) Helmet Comfort. The majority of the participating aircrewmen rated the test helmets better than the standard HGU-2A/P and 26/P helmets in areas relating to helmet comfort (Annex A). It is significant that three out of seven aircrewmen who had previously been provided custom fit helmets preferred the test helmet. There were three problem areas that caused 41.2 percent of the participating aircrews to rate the test helmets WORSE THAN their old helmet during initial fitting.

(a) The original glue reacted with the polyurethane foam liner (especially true if the liner had only cured the minimum required period of 24 hours before the glue was applied) in a number of cases subsequently hardening and causing hot spots in the liner.

(b) Earcups, whether leather and foam or acoustical, presented a problem with the test helmets. With the leather and foam rubber models, initial complaints were of extreme tightness or looseness and poor sound attenuation. The technician's technique with construction was critical to success. The acoustical earcup, while giving very satisfactory sound attenuation, was unacceptable for reasons of comfort (see paragraph 6a(1)(i) for additional discussion).

(c) The leather and foam edge roll, while time-consuming to install, was vastly superior to the rubber edge roll for comfort since it was much softer and easier to modify to individual differences in the user's face (see paragraph 6a(1)(h) for additional discussion).

(2) Visibility. Visibility was not significantly changed from the HGU-2A/P, 26/P, or other custom-fit models. The aircrewman's head sits in virtually the same position inside the helmet with this liner as with previous custom and standard models. A benefit to upward visibility does occur due to the added stability of the liner preventing the test helmet from rotating forward under high G loads. Neither this nor

other existing helmets appear to be the ultimate answer for aircrew visibility in the F-15 and future generation fighters with improved cockpit visibility and extreme sustained G capability.

(3) Stability. Stability was improved with the test helmet, as evidenced by 80 percent of the participating aircrewmen. This benefits not only upward visibility, but should aid immensely in helmet retention in the event of bird strike, canopy loss, or ejection.

(4) Noise Attenuation. Noise attenuation with the test helmet was reported to be better than their previous helmet by 64.8 percent of participating aircrews. Problems with earcups, however, were the most pervasive difficulty in the entire test (see discussions in paragraphs 6a(1)(i), 6b(3), and (4), and Annex A). If a comfortable, easily-installed acoustical earcup can be procured, the entire earcup and noise attenuation problem can be quickly resolved.

# ANNEX A

## DATA AND ANALYSIS

1. AIRCREW COMMENTS.

a. A total of 51 aircrew members completed questionnaires rating the test helmets with their previous helmet. A sample of the aircrew questionnaire is included as Appendix 1. Table 1 shows the overall results of this survey. The results are presented as either the number of aircrew members in a particular category (base, rank, etc.) or as a percentage of the total aircrew members answering each question in a particular way. Table 1 also shows that, in general, aircrews rated the test helmet as being "better than" their previous helmet in areas having to do with fit, comfort, stability, and noise suppression, while they rated the test helmet essentially the "same as" their previous helmet for fit of the oxygen mask, chin strap, and for peripheral vision. Most significant is that 80.5 percent of the aircrew members rated the test helmet as being overall "better than" their previous helmet and 84.5 percent elected to continue to use the test helmet rather than their previous helmet.

b. To analyze why 15.5 percent of the aircrew members (8) chose not to continue using the test helmet, their questionnaires were examined separately from the remaining 43. Table 2 has the same breakout of data as Table 1 but shows the results separated for the groups who did and did not "like" the test helmet. The information in Table 2 does not support any definite conclusions. However, in general, those aircrew members rejecting the test helmet rated it low in those areas in which the remaining crew members rated it high. Both groups generally agreed on those items rated as the "same as" their previous helmet (as noted above). One factor that is probably significant in the choice of helmets was the type of helmet previously in use. Seven of the total crewmembers surveyed were previously supplied with custom fit helmets, while the remainder had the standard HGU-2A/P or 26/P. Four of the seven with custom helmets were in the group of eight who rejected the test helmet.

2. LIFE SUPPORT TECHNICIAN COMMENTS. Twelve of the life support technicians who were involved with fitting/fabricating the test helmets completed questionnaires. A sample of the Life Support Technician Questionnaire is included as Appendix 2. Due to confusion as to how the questionnaire was to be used, the technicians at locations other than Nellis AFB completed only one questionnaire regardless of how many helmets they had fitted. Consequently, numerical analysis of information contained on these questionnaires was not appropriate.

Table 1. Overall Aircrew Questionnaire Results.

| | |
|---|---|
| Total Questionnaires Completed | 51 |
| Nellis AFB | 20 |
| Langley AFB | 11 |
| Cannon AFB | 13 |
| England AFB | 7 |
| **Rank of Aircrewmen Completing Questionnaire** | |
| Sgt | 1 |
| Captain | 23 |
| Major | 22 |
| Lt Colonel | 3 |
| Colonel | 1 |
| Squadron Leader | 1 |
| **Type of Aircraft** | |
| F-111 | 22 |
| T-33 | 7 |
| F-4 | 9 |
| F-105 | 3 |
| A-37 | 7 |
| UH-1 | 3 |

Time Test Helmet Used (hrs):

| | Minimum | Average | Maximum |
|---|---|---|---|
| Total hours used | 4.0 | 44.3 | 300 |
| Longest single period used | 1.5 | 3.0 | 8.0 |

Type of Helmet Previously Used (48 reported):

| | |
|---|---|
| HGU-2A/P | 41 |
| Custom Fit | 7 |

Table 1. Overall Aircrew Questionnaire Results (Continued).

| Question | Test Helmet Comparison with Previous Helmet: Better Than (%) | The Same As (%) | Worse Than (%) | No. Who Answered Question |
|---|---|---|---|---|
| 1. Initial fit | 52.9 | 5.9 | 41.2 | 51 |
| 2. Final fit | 82.0 | 12.0 | 6.0 | 50 |
| 3. Earphone location | 47.2 | 29.4 | 23.5 | 51 |
| 4. $O_2$ mask fit | 33.3 | 60.5 | 6.2 | 48 |
| 5. Chin strap fit | 11.8 | 88.2 | 0 | 51 |
| 6. Nape strap fit | 17.6 | 72.5 | 9.8 | 51 |
| 7. Stability during maneuvers | 80.0 | 18.0 | 2.0 | 50 |
| 8. Discomfort due to heat | 34.0 | 46.0 | 20.0 | 50 |
| 9. Noise suppression | 64.8 | 23.5 | 11.8 | 51 |
| 10. Radio/intercommunication system | 59.2 | 32.6 | 8.2 | 49 |
| 11. Left/right peripheral vision | 22.0 | 72.0 | 6.0 | 50 |
| 12. Upward peripheral vision | 26.0 | 58.0 | 16.0 | 50 |
| 13. Helmet weight | 18.0 | 62.0 | 20.0 | 50 |
| 14. Overall evaluation | 80.5 | 3.9 | 15.7 | 51 |
| | Yes | No | | |
| 15. Was skullcap adequate | 93.2 | 6.8 | | 44 |
| 16. Did helmet roll interfere with visor | 8.2 | 91.8 | | 49 |
| | Test | Previous | | |
| 17. Which helmet do you desire to use | 84.5 | 15.5 | | 51 |

Table 2. Comparison of Those Who Desired to Continue to Wear Test Helmet with Those Who Did Not.

| | | | |
|---|---|---|---|
| Questionnaires Completed | | | *43/8 Total |
| Nellis AFB | | | 16/4 |
| Langley AFB | | | 10/1 |
| Cannon AFB | | | 10/3 |
| England AFB | | | 7/0 |
| Aircrew Ranks | | | |
| Sgt | | | 1/0 |
| Captain | | | 21/2 |
| Major | | | 18/4 |
| Lt Colonel | | | 3/2 |
| Colonel | | | 1/0 |
| Squadron Leader | | | 1/0 |
| Type Aircraft | | | |
| F-111 | | | 16/6 |
| T-33 | | | 6/1 |
| F-4 | | | 9/0 |
| F-105 | | | 2/1 |
| A-37 | | | 7/0 |
| UH-1 | | | 1/0 |
| Time Test Helmet Used (hrs) | | | |
| | Minimum | Average | Maximum |
| Total | 4.0/10.0 | 47.9/25.4 | 300/57.0 |
| Longest Period | 1.5/2.0 | 3.0/3.0 | 8.0/4.5 |
| Type of Helmet Previously Used | | | |
| HGU-2A/P | | | 37/4 |
| Custom | | | 3/4 |

*Numbers preceding the slash refer to aircrews who stated desire to continue use of the test helmet. The second number applies to those who did not.

Table 2. Comparison of Those Who Desired to Continue to Wear Test Helmet with Those Who Did Not (Continued).

| Question | Test Helmet Comparison with Previous Helmet: Better Than (%) | The Same As (%) | Worse Than (%) | No. Who Answered Question |
|---|---|---|---|---|
| 1. Initial fit | 62.8/0* | 4.7/12.5* | 32.6/87.5* | 43/8* |
| 2. Final fit | 93.0/14.3 | 7.0/42.9 | 0/42.9 | 43/7 |
| 3. Earphone location | 51.1/25.0 | 30.2/25.0 | 18.6/50.0 | 43/8 |
| 4. $O_2$ mask fit | 35.0/25.0 | 62.5/50.0 | 2.5/25.0 | 40/8 |
| 5. Chin strap fit | 11.6/12.5 | 88.4/87.5 | 0/0 | 43/8 |
| 6. Nape strap fit | 18.6/12.5 | 72.1/75.0 | 9.3/12.5 | 43/8 |
| 7. Stability during maneuvers | 88.1/37.5 | 11.9/50.0 | 0/12.5 | 42/8 |
| 8. Discomfort due to heat | 40.5/0 | 45.2/50.0 | 14.3/50.0 | 42/8 |
| 9. Noise suppression | 69.8/37.5 | 25.6/12.5 | 4.7/50.0 | 43/8 |
| 10. Radio/intercommunications system | 63.4/37.5 | 31.7/37.5 | 4.9/25.0 | 41/8 |
| 11. Left/right peripheral vision | 23.8/12.5 | 71.4/75.0 | 4.8/12.5 | 42/8 |
| 12. Upward peripheral vision | 28.6/12.5 | 54.8/75.0 | 16.7/12.5 | 42/8 |
| 13. Helmet weight | 16.7/25.0 | 64.3/50.0 | 19.0/25.0 | 42/8 |
| 14. Overall evaluation | 95.3/0 | 4.7/0 | 0/100.0 | 43/8 |
| | Yes | No | | |
| 15. Was skullcap adequate | 91.7/100 | 8.3/0 | | 36/8 |
| 16. Did helmet roll interfere with visor | 7.3/12.5 | 92.7/87.5 | | 41/8 |
| | Test | Previous | | |
| 17. Which helmet do you desire to use | 100.0/0 | 0/100.0 | | 43/8 |

*Number preceding the slash refer to aircrews who stated desire to continue use of the test helmet. The second number applies to those who did not.

3. MAINTENANCE COMMENTS. Maintenance records were maintained for 35 of the helmets. Eighteen of the 35 helmets required corrective maintenance after the initial fitting, and a total of 28 actions was recorded. Twenty-two of these were for adjustment and/or replacement of the earphones, two for relief of hot spots, and four for cutting down the edge roll/beading.

# APPENDIX 1

## ANNEX A

## SAMPLE AIRCREW QUESTIONNAIRE

## AIRCREW QUESTIONNAIRE

GENERAL INSTRUCTIONS. This questionnaire will be completed in detail upon completion of test period, or in the event the helmet becomes unusable for reasons of safety. It is suggested that notes be made following each use of the test item to assure that all pertinent information is properly recorded. Any significant problems encountered which are not adequately covered by this questionnaire should be completely described and attached hereto. A questionnaire will be completed for each test helmet and submitted to the unit project officer.

I. IDENTIFICATION:

1. Name _____ 2. Rank _____

3. Squadron _____ 4. Base _____

5. Aircraft Type _____ 6. Crew Position _____

II. HELMET SIZE (MEASUREMENTS TO BE FILLED IN BY TECHNICIAN):

1. Head circumference _____, head length _____, head breadth _____.

2. Helmet size used: MED ____ _____, SMALL _____ _____.

3. Type helmet used prior to test: HGU-2A/P _____ Other _____

III. AMOUNT OF USE:

1. How many total hours did you wear the helmet? _____ _____

2. What was the longest period you wore the helmet? _____ _____

3. What was the average period of wear? _____ __

IV. COMPARISON. Complete the following statements to show how you compare the test helmet with your prior helmet. Comments are solicited, especially when the test helmet is rated "worse."

1. During initial fitting, the test helmet liner fit _____ my previous helmet.

BETTER THAN? SAME AS? WORSE THAN?

2. At the conclusion of the test, the test helmet liner fit _____ my previous helmet.

BETTER THAN? SAME AS? WORSE THAN?

3. The earphone location in the test helmet was _____ my previous helmet.

BETTER THAN? SAME AS? WORSE THAN?

4. The oxygen mask on the test helmet fit _____ my previous helmet.

BETTER THAN? SAME AS? WORSE THAN?

5. The chin strap on the test helmet fit _____ my previous helmet.

BETTER THAN? SAME AS? WORSE THAN?

6. The nape strap on the test helmet fit _____ my previous helmet.

BETTER THAN? SAME AS? WORSE THAN?

7. During flight maneuvers, the test helmet remained stable on my head _____ my previous helmet.

BETTER THAN? SAME AS? WORSE THAN?

8. Discomfort due to heat while wearing the test helmet was _____ my previous helmet.

BETTER THAN? SAME AS? WORSE THAN?

9. The test helmet suppressed objectionable noise _____ my previous helmet.

BETTER THAN? SAME AS? WORSE THAN?

10. Radio and interphone communication while wearing the test helmet was _____ my previous helmet.

BETTER THAN? SAME AS? WORSE THAN?

11. Peripheral vision, left and right, while wearing the test helmet was _____ my previous helmet.

BETTER THAN? SAME AS? WORSE THAN?

12. Peripheral vision upward, while wearing the test helmet, was _____ my previous helmet.

BETTER THAN? SAME AS? WORSE THAN?

13. The weight of the test helmet is _____ my previous helmet.

BETTER THAN? SAME AS? WORSE THAN?

14. My overall evaluation is that the test helmet is _____ my previous helmet.

BETTER THAN? SAME AS? WORSE THAN?

15. Was the skullcap adequate for absorbing perspiration?

YES ( ) NO ( )

16. Did the helmet edge roll interfere with visor operation?

YES ( ) NO ( )

17. Which helmet do you desire to wear? _____

TEST HELMET PREVIOUS HELMET

18. Comments _____

_____

_____

_____

_____

_____

_____

_____

# APPENDIX 2

## ANNEX A

## SAMPLE LIFE SUPPORT TECHNICIAN QUESTIONNAIRES

## LIFE SUPPORT TECHNICIAN QUESTIONNAIRE 1

INSTRUCTIONS. This questionnaire will be used by each life support technician to document significant information concerning the fabrication of test helmets. Discrepancies or deficiencies should be explained in detail, and include the aircrew name, if applicable. This questionnaire will be completed when all helmets have been fabricated and given to the unit project officer for forwarding to the TFWC.

I. PERSONAL DATA:

1. Name _____ Rank _____

2. Organization _____ AFSC _____

3. List any previous training or experience in helmet liner fabrication.

_____

_____

II. HELMETS FABRICATED: Estimate man-hours required for fabrication of last helmet _____.

| | AIRCREW NAME | RANK | DATE MOLD TAKEN | DATE HELMET READY FOR FITTING |
|---|---|---|---|---|
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| 5. | | | | |
| 6. | | | | |
| 7. | | | | |
| 8. | | | | |
| 9. | | | | |
| 10. | | | | |

III. FITTING PROCESS (LINER FABRICATION):

1. Did the lower section of helmet liner mold fit properly to test subject's head? Yes ( ) No ( ) (If no, specify problems encountered):

_____

_____

_____

_____

_____

2. Did top section of liner mold properly seal (leak proof) to bottom section? Yes ( ) No ( )

3. Was the splash shield adequate to contain overflow during the liner foaming process? Yes ( ) No ( )

4. Did the liner release easily from mold sections after the foaming process? Yes ( ) No ( ) (If no, specify problem encountered):

_____

_____

_____

_____

5. Were there any voids in the liner after forming? Yes ( ) No ( ) Which helmets?

6. Was there an excessive amount of unexpanded resin on liner surface after forming? Yes ( ) No ( )

7. Was it necessary to perform more than one attempt to obtain a properly formed liner? Yes ( ) No ( )

8. Were the instructions for forming the helmet liner adequate? Yes ( ) No ( )

(If no, specify any problems or unusual situations encountered which were not adequately covered):

_____

_____

_____

9. List any technique which will improve the molding process:

_____

_____

_____

IV. HELMET FABRICATION:

1. Were all necessary facilities, equipment, and materials not supplied in helmet kits readily available to perform the required fabrication and assembly processes? Yes ( ) No ( )

(If no, specify below what is required that is normally not on hand in the base PE facility):

_____

_____

_____

2. Were the instructions for fabrication, finishing, and assembly of the helmet components clearly stated: Yes ( ) No ( ) (If no, specify problems encountered):

_____

_____

_____

3. Did all helmet components properly fit together and function properly after final assembly? Yes ( ) No ( ) (If no, specify problem encountered and what corrections were made):

_____

_____

4. List techniques which would improve helmet fabrication:

_____

_____

_____

## LIFE SUPPORT TECHNICIAN QUESTIONNAIRE 2

INSTRUCTIONS. This form will be maintained in unit life support sections and be used to record all test helmet discrepancies and corrective actions. After test completion, this form will be given to the unit project officer for forwarding to the TFWC.

AIRCREW NAME _____ DATE _____

LIFE SUPPORT TECHNICIAN'S NAME _____

REASON FOR ACTION:

ROUTINE INSPECTION _____

END OF TEST INSPECTION _____

AIRCREW COMPLAINT _____

DISCREPANCY AND CORRECTIVE ACTION:

_____

_____

_____

AIRCREW NAME _____ DATE _____

LIFE SUPPORT TECHNICIAN'S NAME _____

REASON FOR ACTION:

ROUTINE INSPECTION _____

END OF TEST INSPECTION _____

AIRCREW COMPLAINT _____

DISCREPANCY AND CORRECTIVE ACTION:

_____

_____

_____

AIRCREW NAME _____ DATE _____

LIFE SUPPORT TECHNICIAN'S NAME _____

REASON FOR ACTION:

ROUTINE INSPECTION _____

END OF TEST INSPECTION _____

AIRCREW COMPLAINT _____

DISCREPANCY AND CORRECTIVE ACTION:

_____

_____

_____

AIRCREW NAME _____ DATE _____

LIFE SUPPORT TECHNICIAN'S NAME _____

REASON FOR ACTION:

ROUTINE INSPECTION _____

END OF TEST INSPECTION _____

AIRCREW COMPLAINT _____

DISCREPANCY AND CORRECTIVE ACTION:

_____

_____

_____

# ANNEX B

## HELMET LINER FOAMING PROCESS

1. GENERAL. The instructions outlined in this Annex apply to the helmet liner foaming process only and were revised by Nellis AFB personnel from the originally provided instructions from ASD. These are the unaltered instructions forwarded to other participating units for their use in conducting this test and do not represent finalized instructions to be issued by ASD. Original, unaltered helmet fabrication instruction issued by ASD were used by all participating units.

2. PROCEDURES FOR USE OF HELMET MOLD AND FOAMING PROCESS.

a. The procedures for use of the improved mold are outlined in step-by-step procedures below. With a little practice (say 4 to 5 fittings and foamings), the average technician should be ready to turn out usable liners.

b. There are four basic parts to the helmet mold assembly: The teflon-covered mold, adjusting ring, spacer cap and spacer ring. (These last two must be coated with Dow Corning Dispersion Coating 92-009 to prevent the polyurethane foam from sticking to the rubber fabric and causing the fabric to deteriorate. The procedure for repeating this process on these items will be outlined later.)

(1) Fitting the Mold:

(a) Place the ring over the subject's head with the strap adjusting screws (labeled ADJ and LOCK) to the rear. It should be carefully centered on his head so the ring covers his eyes. The Height of the ring is controlled by the strap. To adjust the strap, first loosen the screw, marked "LOCK", adjust with the "ADJ" screw, then retighten "LOCK" screw. Now place the teflon-covered mold on the ring, tighten the corresponding lock nuts loosely, and with a ruler measure the distance from the top of the head to the mold. It should be approximately 1-1/4 inches. Adjust the strap to achieve the desired distance, if necessary.

(b) Remove the mold and put a spacer cap on the man's head over the straps. (The front of the skull cap is where the seams on the inside come together.) Pull it down very tightly and fasten under the chin with the velcro. Smooth out all air under the cap, and recheck that the ring is still covered.

(c) Now tighten the ring spacer, adjusting the screws so that the bars exert equal and gentle pressure against the spacer cap. The ring should be approximately equidistant from the spacer cap all around.

This step insures that the ring will not move during the foaming process.

(d) Next is the sealer ring. (It, like the spacer cap, should be coated with the dispersion coating. See procedure at end of this discussion.) It has no "top" or "bottom" and either side can have the coating. The narrower end is the front. Push it down evenly over the head all the way to the ring, being careful not to disturb the centering.

(e) Recheck the centering and spacer cap fit one last time and then put the mold on the ring and tighten the fasteners finger tight. NOTE: The inside of the mold has a line drawn around it. This will indicate where to cut the foam after curing. It should be traced with a red grease pencil before the mold is locked in place. Heat of the foaming process will transfer the red to the foam.

(2) The Foaming Operation:

(a) Supplies required: Tongue depressors for mixing, paper cups (12 or 16 ounce and not lined with wax or plastic) and a thermometer (room temperature should be maintained at 75°F ideally, but 70-80 will do. The chemicals should be stored at these temperatures.) Two "doctor's coats" or smocks are to be worn by the subject and technician during the foaming process. The foam and chemicals are not really caustic, but will ruin your clothes, since it cannot be washed off. A well-ventilated working area is necessary because of the isocyanate gas produced by the reaction.

(b) Pour the contents of a bottle of polyol (light-colored) liquid into the paper cup. Add 13-14 drops of catalyst from the eye dropper. NOTE: Practice using the eye dropper. The drops should be "full" with no air to insure proper volume of catalyst. Also, avoid getting catalyst into the bulb of the dropper as it will deteriorate it in a short time. Flush the bulb with water and dry before using again. Use your extra dropper in the meanwhile.

(c) Add the contents of a bottle of isocyanate (dark-colored) liquid and stir immediately with the wooden tongue depressor. Continue stirring rapidly until the mixture changes to a very dark brown, almost black, liquid. Rapidly discard the stirring stick and hold the cup tilted above the opening in the mold. In about 6-8 seconds the mixture will start to froth rapidly. When it has risen about 1/4 inch above the level of the liquid pour it rapidly but smoothly into the mold opening, starting at the front and pouring toward the back and working to the front again using all the liquid. Discard the cup and rotate the subject's head slightly to distribute the liquid evenly.

(d) The foam should rise rapidly (about 20 seconds) filling the entire mold. It should expel a small amount through each vent hole

and rise 1-3 inches out of the large opening. (The process generates some heat - it feels about like taking a hot shower.) After about 1 minute you can start to wipe away the excess from the small vent holes with paper towels. All but 1/4 inch of the top excess can be cut away before taking the foam out of the mold. Leave the mold on the subject's head for 5 minutes, then carefully remove it by loosening the chin strap, backing off the ring spacer bars, and lifting the mold straight up. Let it "set" for 10 more minutes.

(e) Carefully remove spacer cap from the mold, unfasten finger locks, lift the mold from the ring and peel off the sealer ring. Cut excess off the top and using a plastic kitchen spatula or similar tool start to loosen the foam from the mold a little at a time going around the mold sliding the spatula in between the mold and the foam. After going around about twice or more you can "pop" the foam out by forcing the spatula toward the bottom of the mold all the way around.

(f) Put the spacer cap back into the foam liner and replace it on the subject's head pushing it down very firmly for a few minutes to make sure it gets reshaped to the subject's head. Carefully remove it, mark it, and set it aside to cure for 24 hours. NOTE: There should be a red "cut" line around the outside of the foam that transferred from the grease pencil you put inside the mold before the foaming process.

(g) Clean the mold of all foam by wiping or peeling it away. Be careful not to scratch the teflon with anything sharp.

(3) Quality Control:

(a) The finished product should be uniform in color and texture. It should have no obvious deformities such as cavities or hollow spots where the foam failed to fill. Holding the mold up to a strong light should indicate a consistent structure throughout.

(b) A "skin" inside the liner that may be slightly or completely loose from the foam itself is a normal product of the reaction.

(c) If the first attempt turns out an inferior product, the most likely causes are:

1. Too much catalyst - indicated by a dark brown area under the sealer ring, heat fissures, and inconsistent cellular formation.

2. Too little catalyst - foam may or may not fill the mold, but the product will appear very thin when held up to a strong light. In this case you may have had air bubbles in the drops of catalyst - more practice with the dropper is required. (Practice with water or the catalyst itself.)

3. Pouring the chemicals into the mold too early or too late either case will result in an incomplete fill of the mold. Moral: If you don't succeed the first time try something different - differing temperature and humidity conditions can cause slightly different reactions from day to day, but the real reasons for failure usually are because of technique.

(4) Dispersion Coating Procedure:

(a) It will be necessary to recoat the skull cap and sealer ring after about 5-6 foamings. This will insure their easy release from the foam after each attempt.

(b) In addition to the Dow Corning Dispersion Coating #92-009 you will need a #3 acid brush.

(c) Place the cap on the head-form in the box. Coat the cap with a layer of the coating, wait several minutes for it to become tacky, then coat again. Repeat once more for a total of three coats and wait 4-5 hours to dry before using.

(d) Use the same procedure on the sealer ring - any flat surface will do for it.

(5) Safety Procedures Summary:

(a) A well-ventilated room at about 72-75° and low humidity (50% of less) should be used if possible.

(b) Do the foaming process in an area where the vapors produced are positively removed. Fans blowing the vapors away from the working area is an additional aid.

(c) If the chemicals or reactant comes in contact with the skin, wash off immediately with soap and water.

(d) The subject and technician should both wear smocks to protect them from spilled chemical reactants.

(e) The subject should be seated during the process - two technicians helping each other makes the process not only safer but also easier.

(f) Have a large waste basket with plastic liner nearby to dispose of stirrers, cups, paper towels, etc.

(g) No one with a history of recurrent respiratory problems should work with this process.

# ANNEX C

## PHOTOGRAPHS

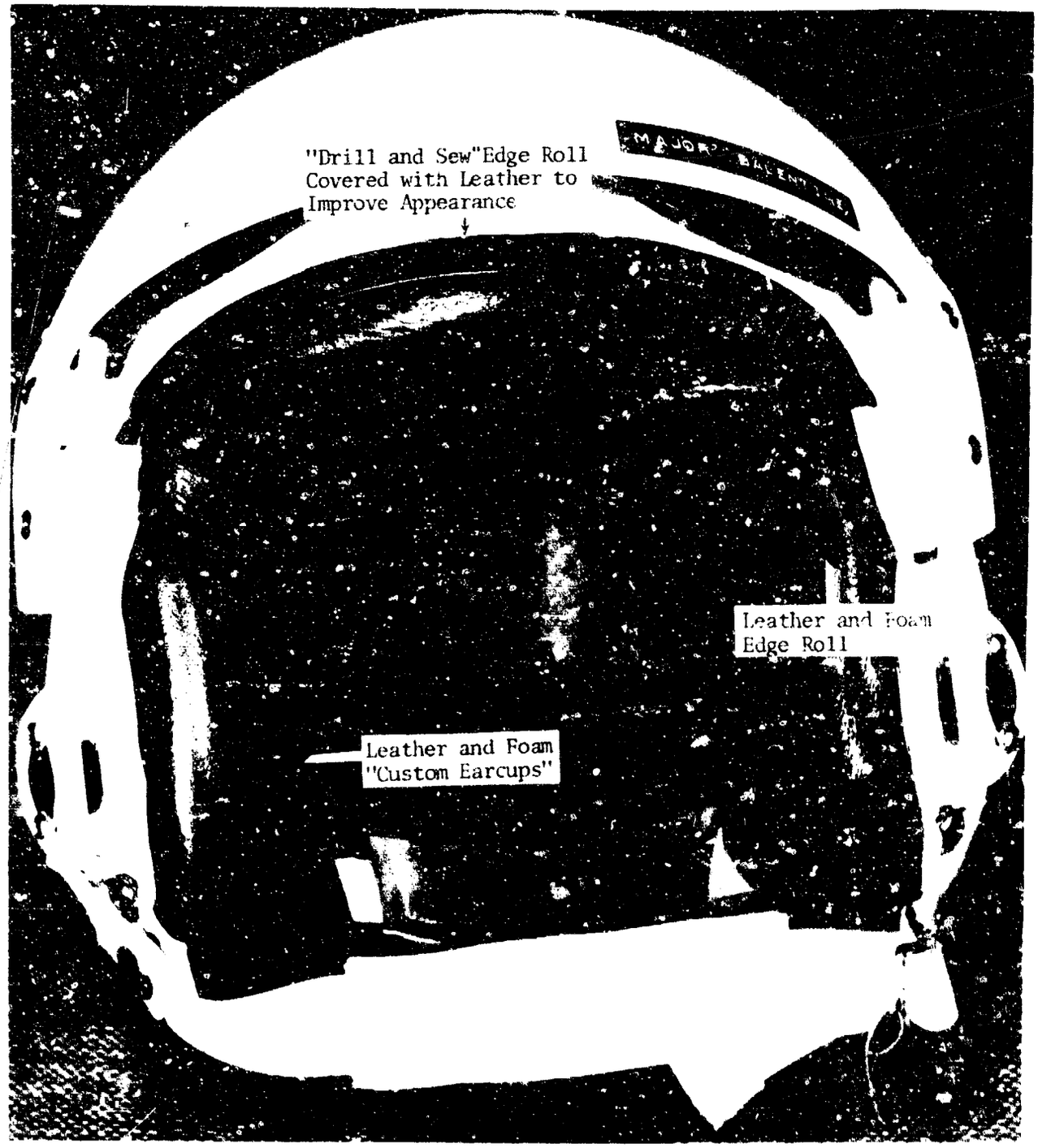


Figure 1. Finished Product with Leather and Foam Edge Roll and Earcups.

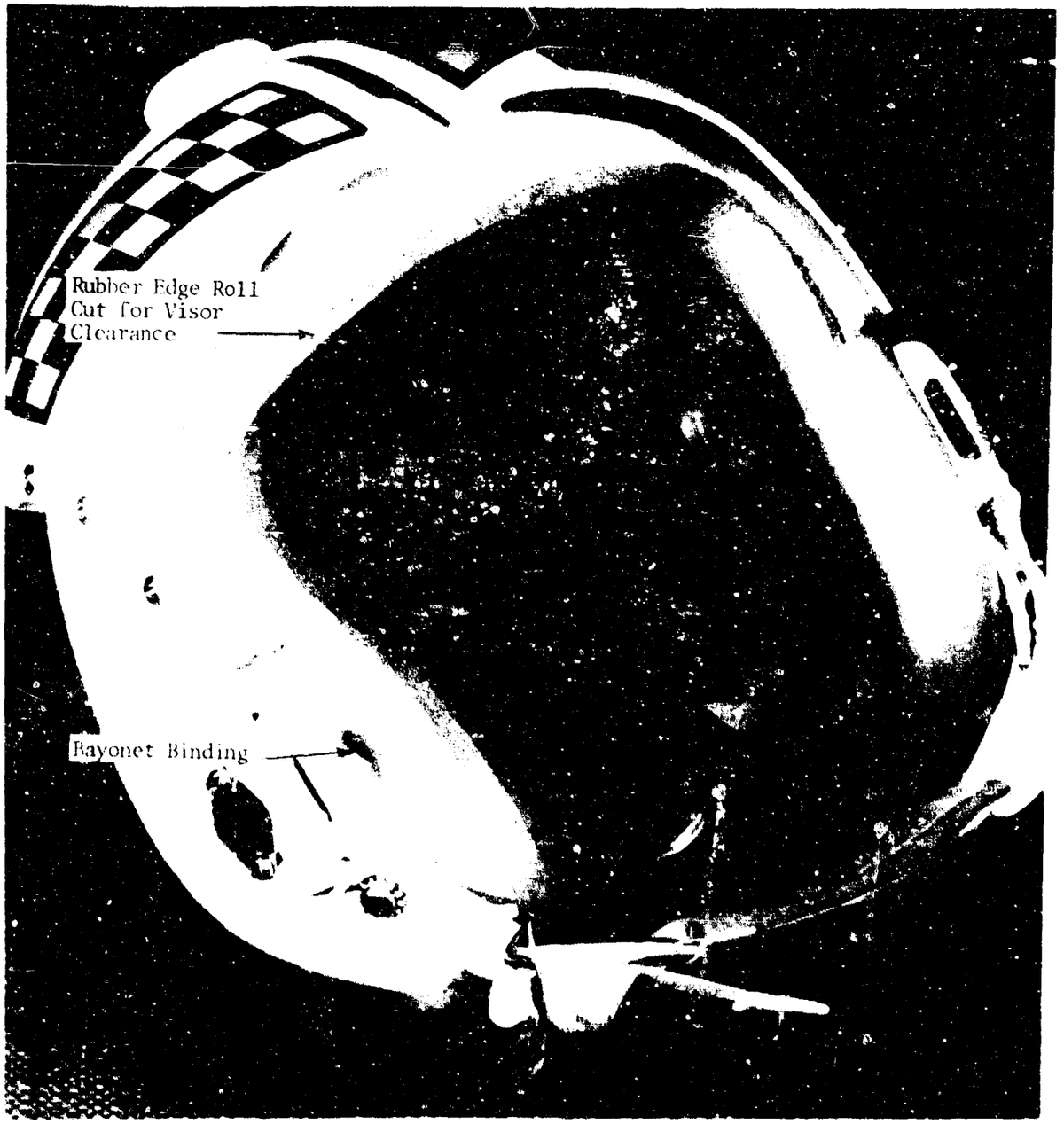


Figure 2. Finished Product with Rubber Edge Roll.

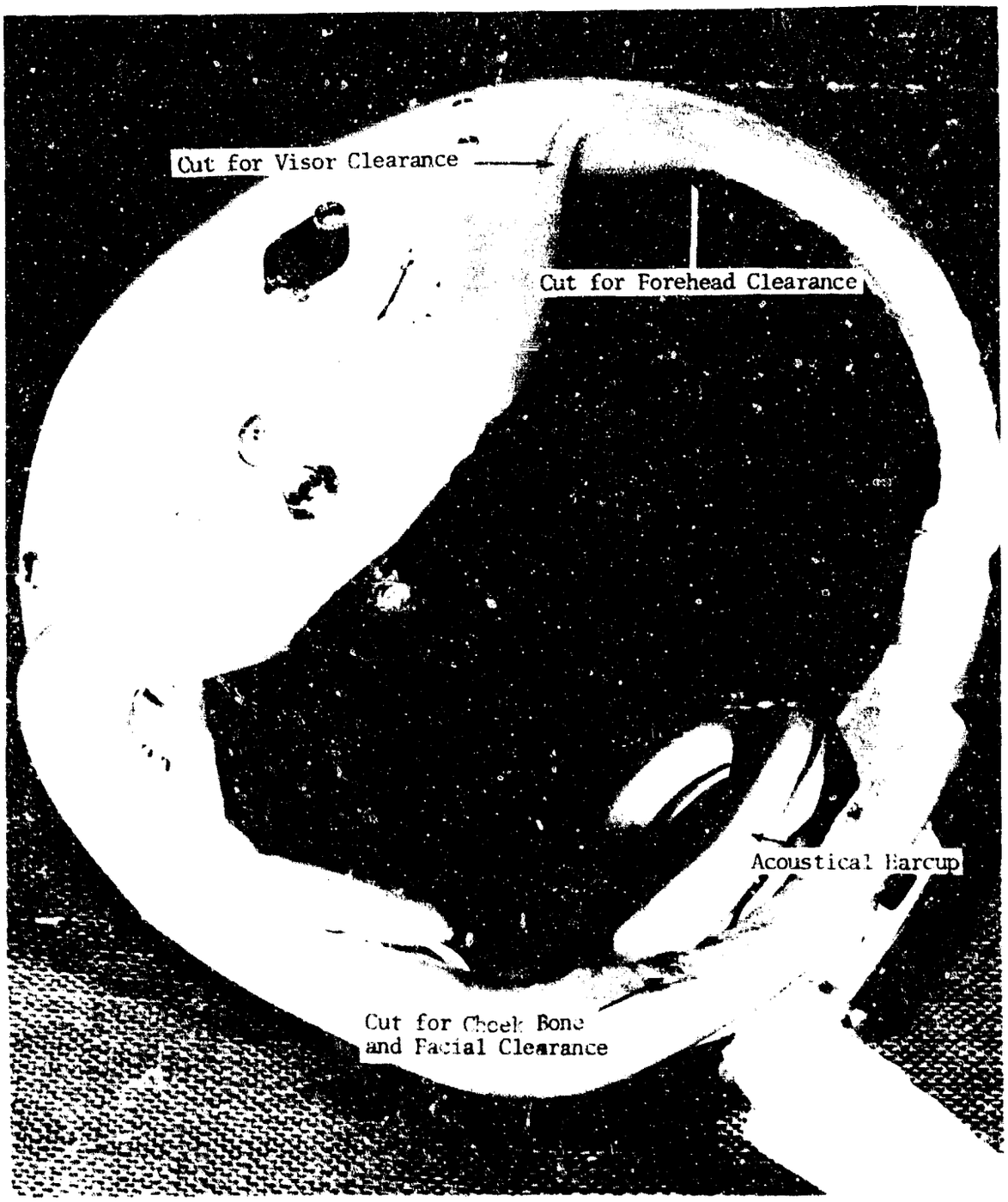


Figure 3. Example of Difficulties Encountered with one Rubber Edge Roll.

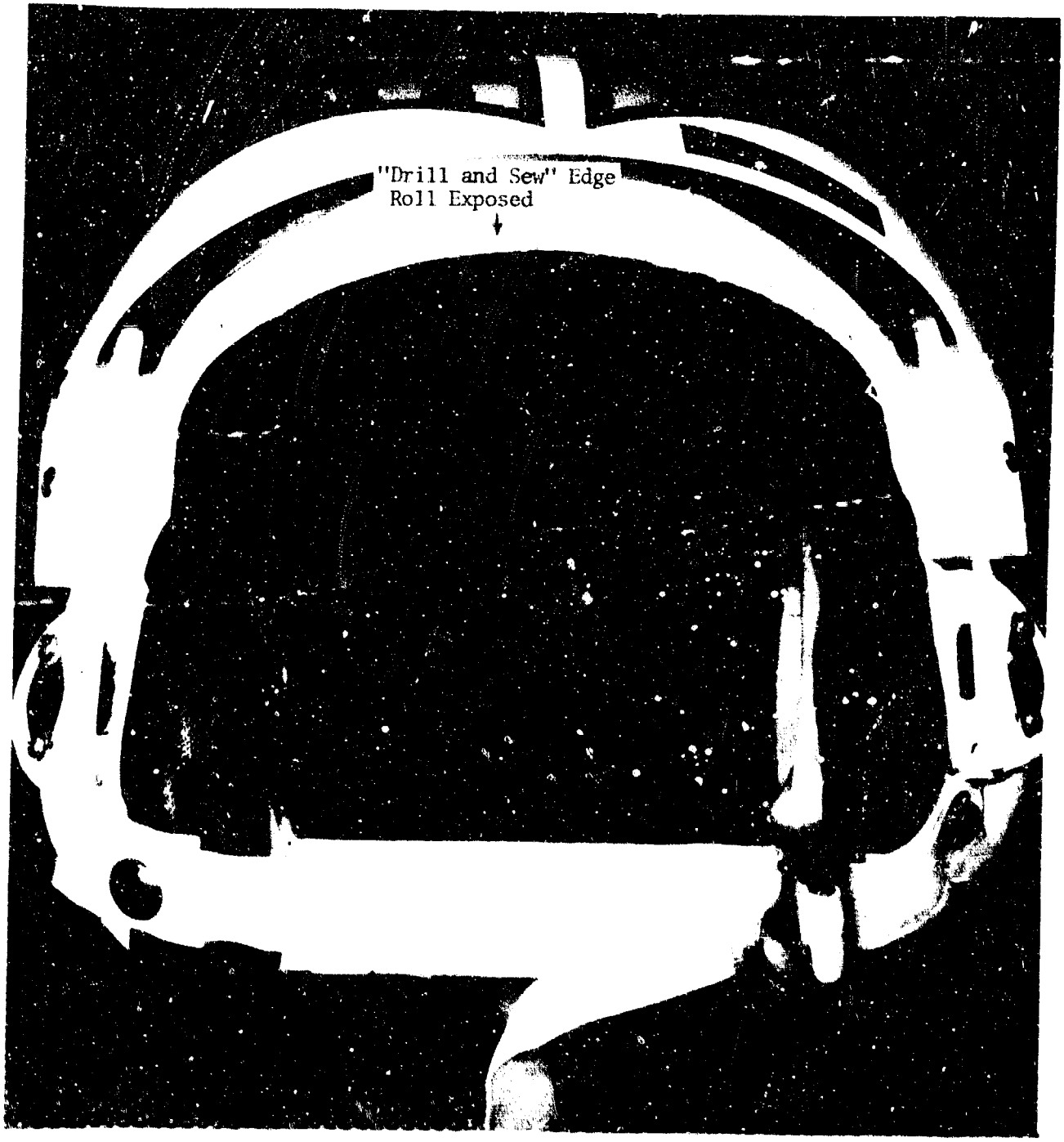


Figure 4. Finished Product with Leather Edge Roll and Acoustical Earcups.

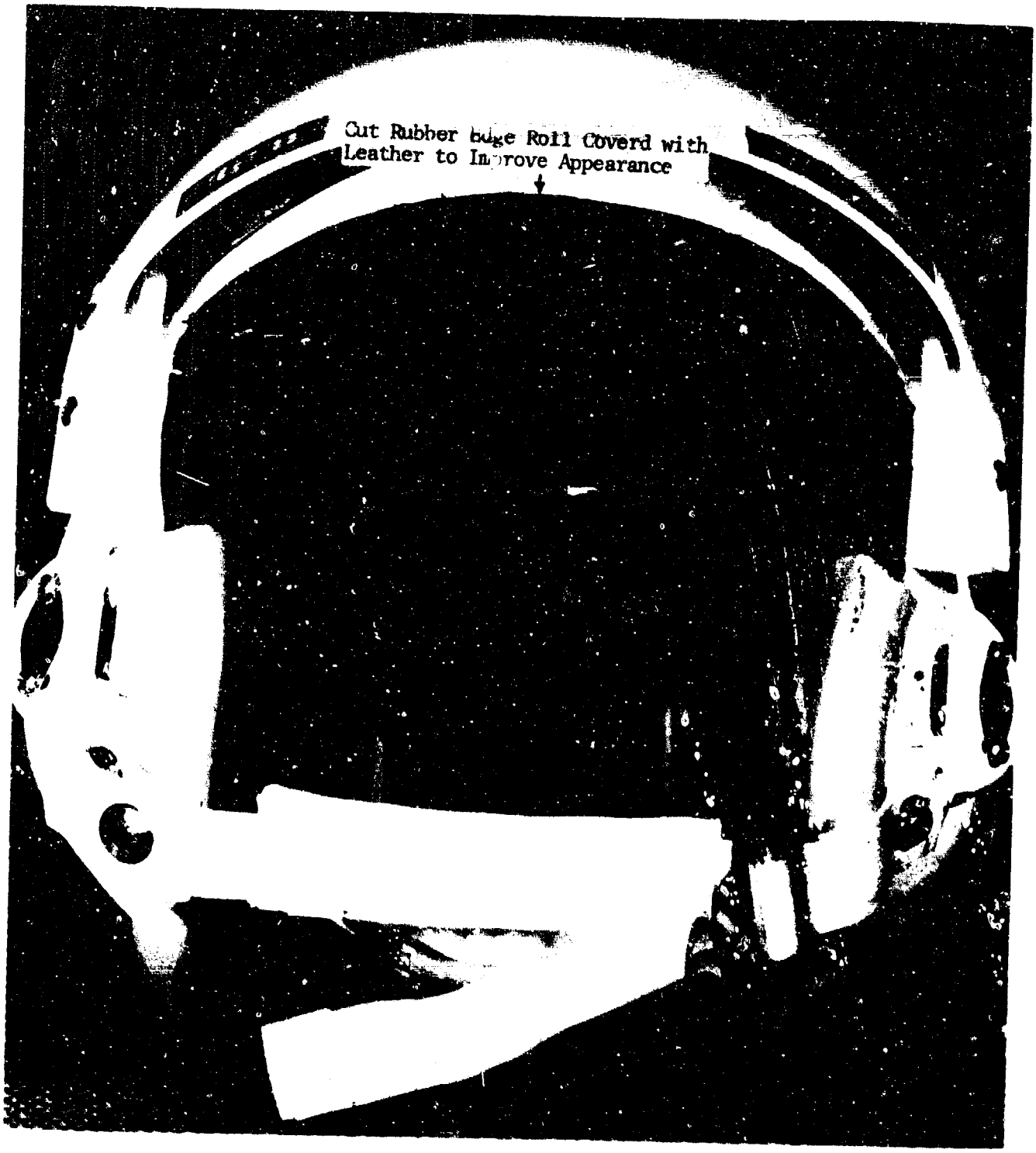


Figure 5. One Effort to Improve Rubber Edge Roll Appearance.

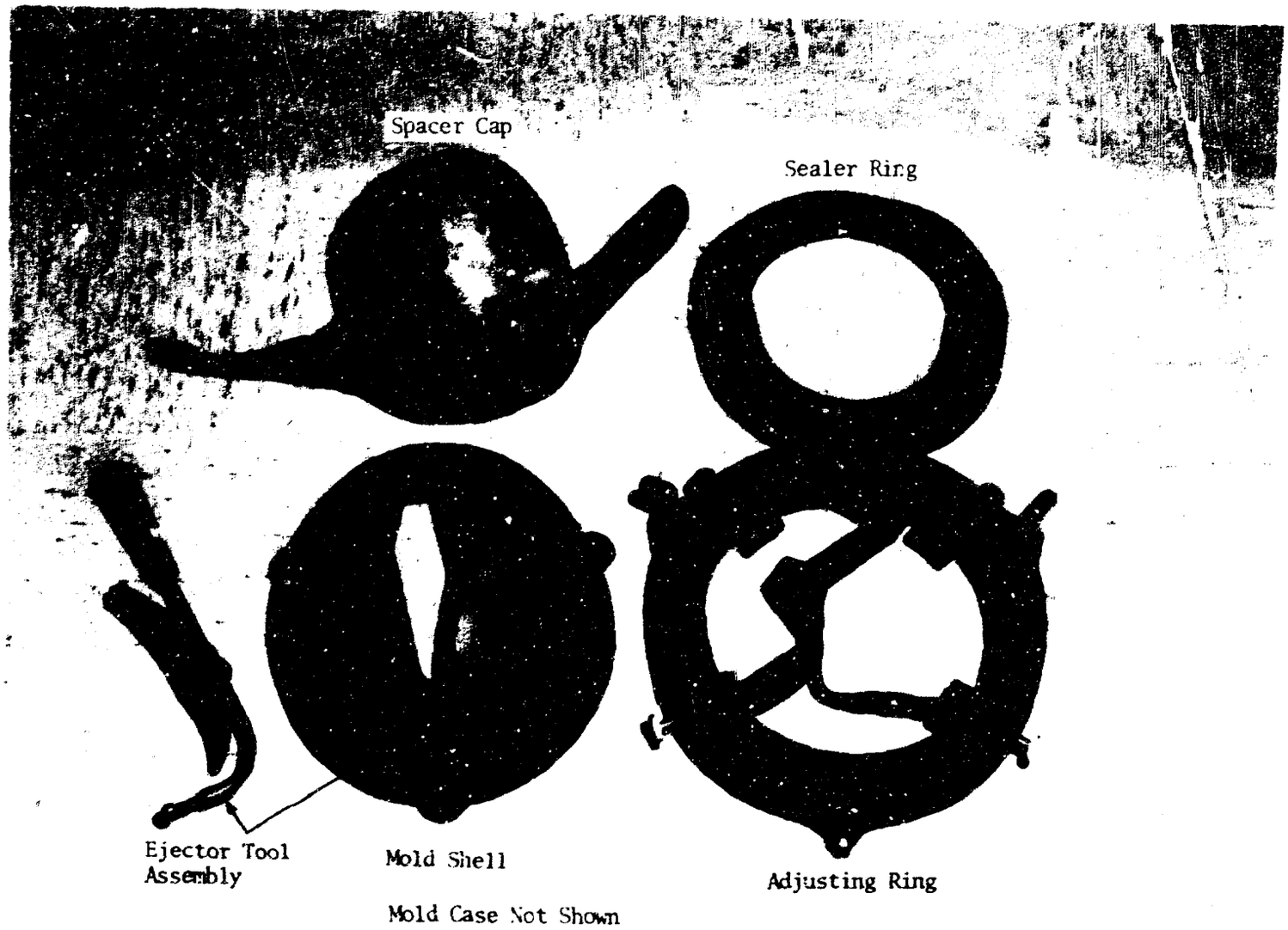


Figure 6. Mold Hardware.

Figure 7. Adjusting Ring In-Place.

Figure 8. Spacer Cap In-Place.

Figure 9. Sealer Ring being Placed Over Spacer Cap.

Figure 10. Mold Shell being Tightened In-Place.

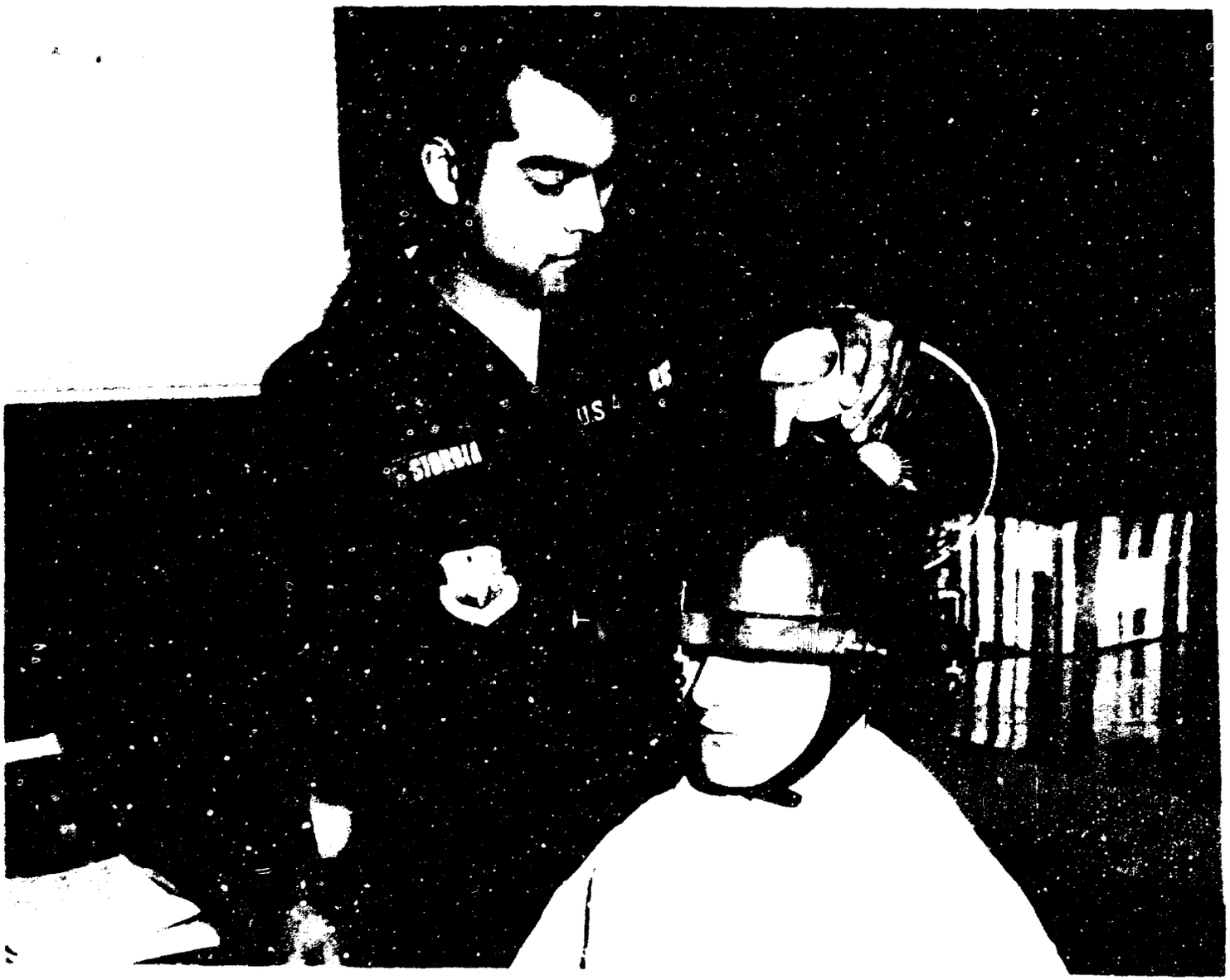

Figure 11. Foam being Poured into Mold.

Figure 12. Foam Rising and Filling Mold Shell.

Figure 13. Mold Shell and Foam Liner Removed from Aircrewman's Head.

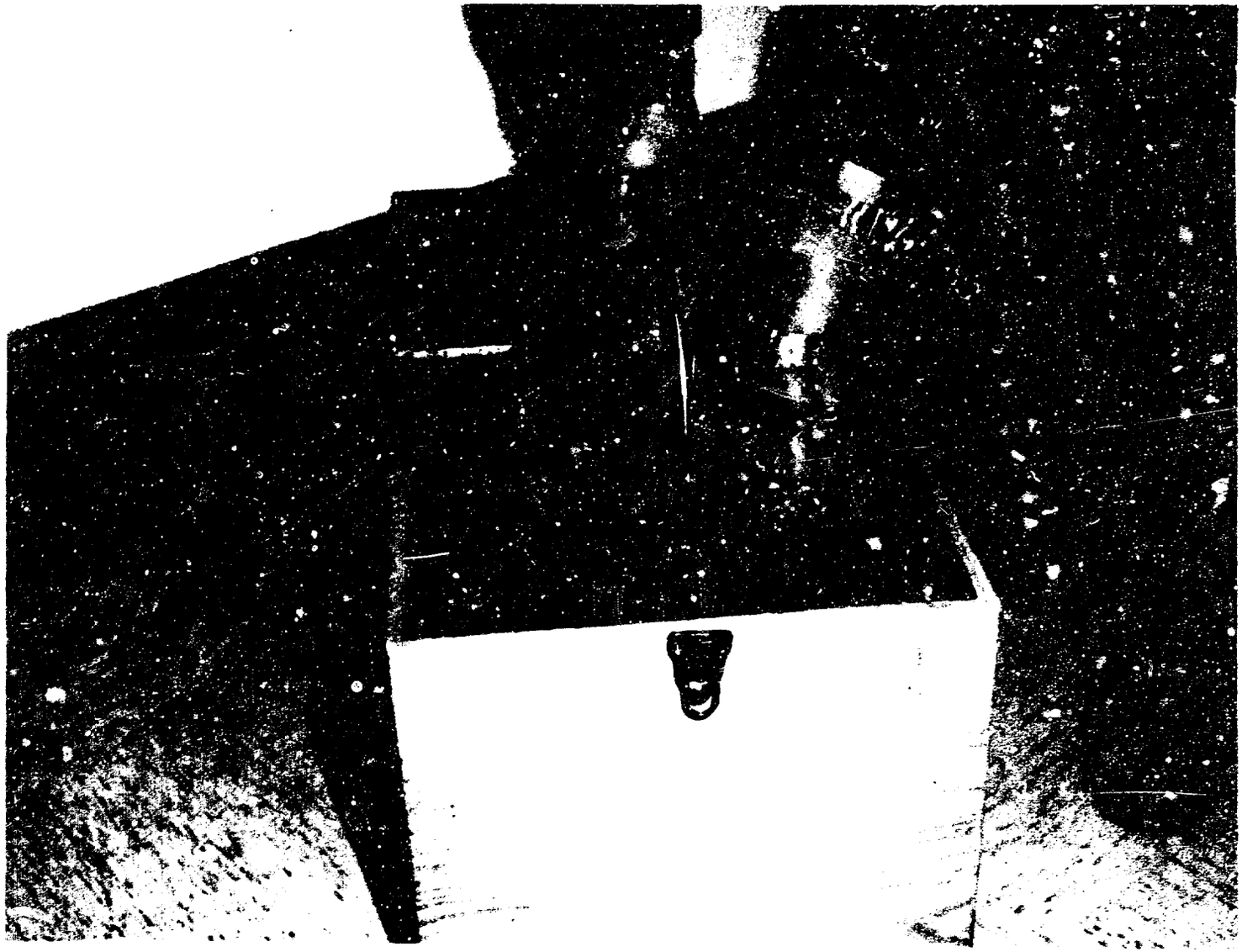

Figure 14. Extractor Mechanism and Mold Case being used to Remove Liner from Shell.

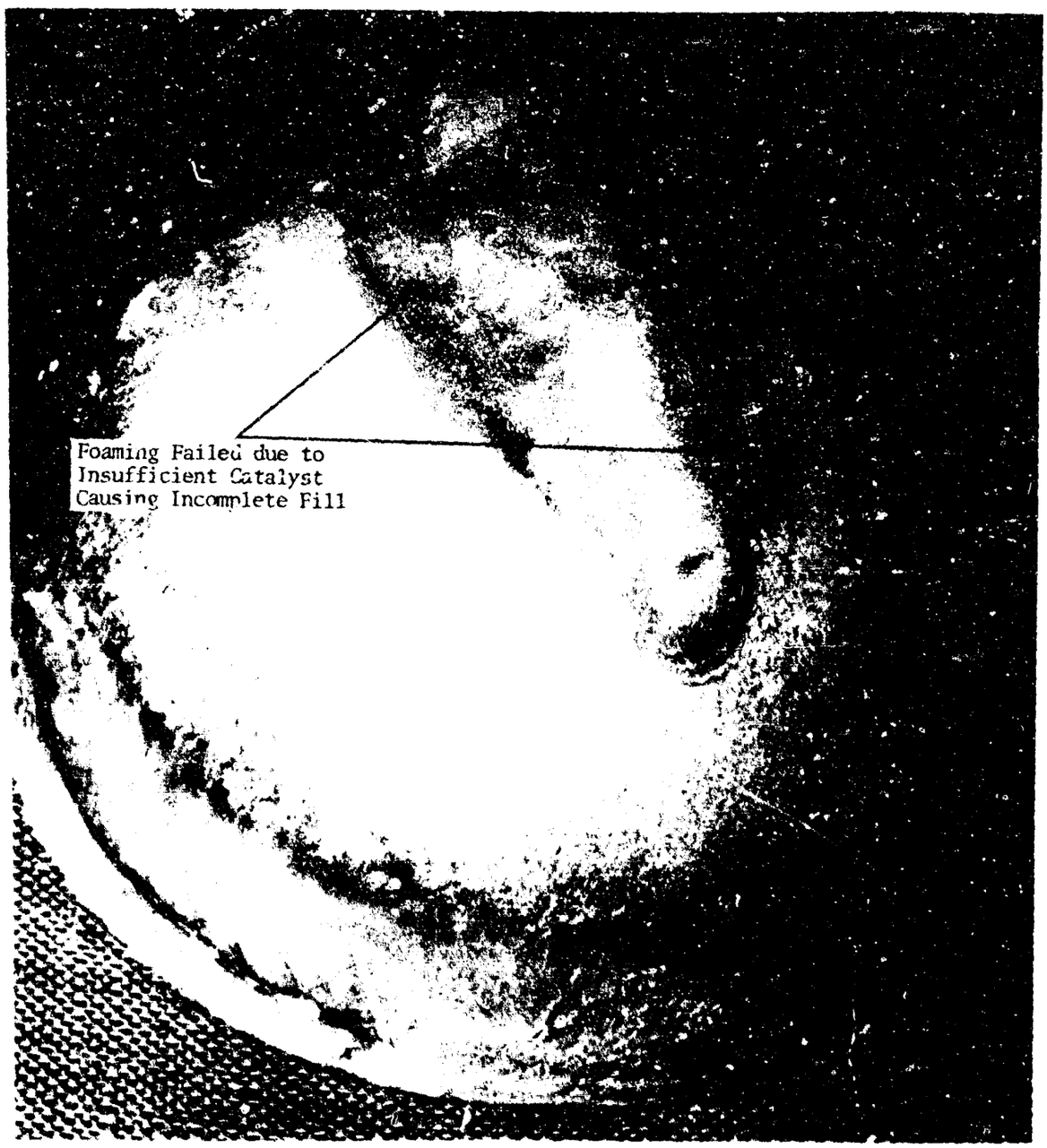


Figure 15. Example of Foaming Failure.

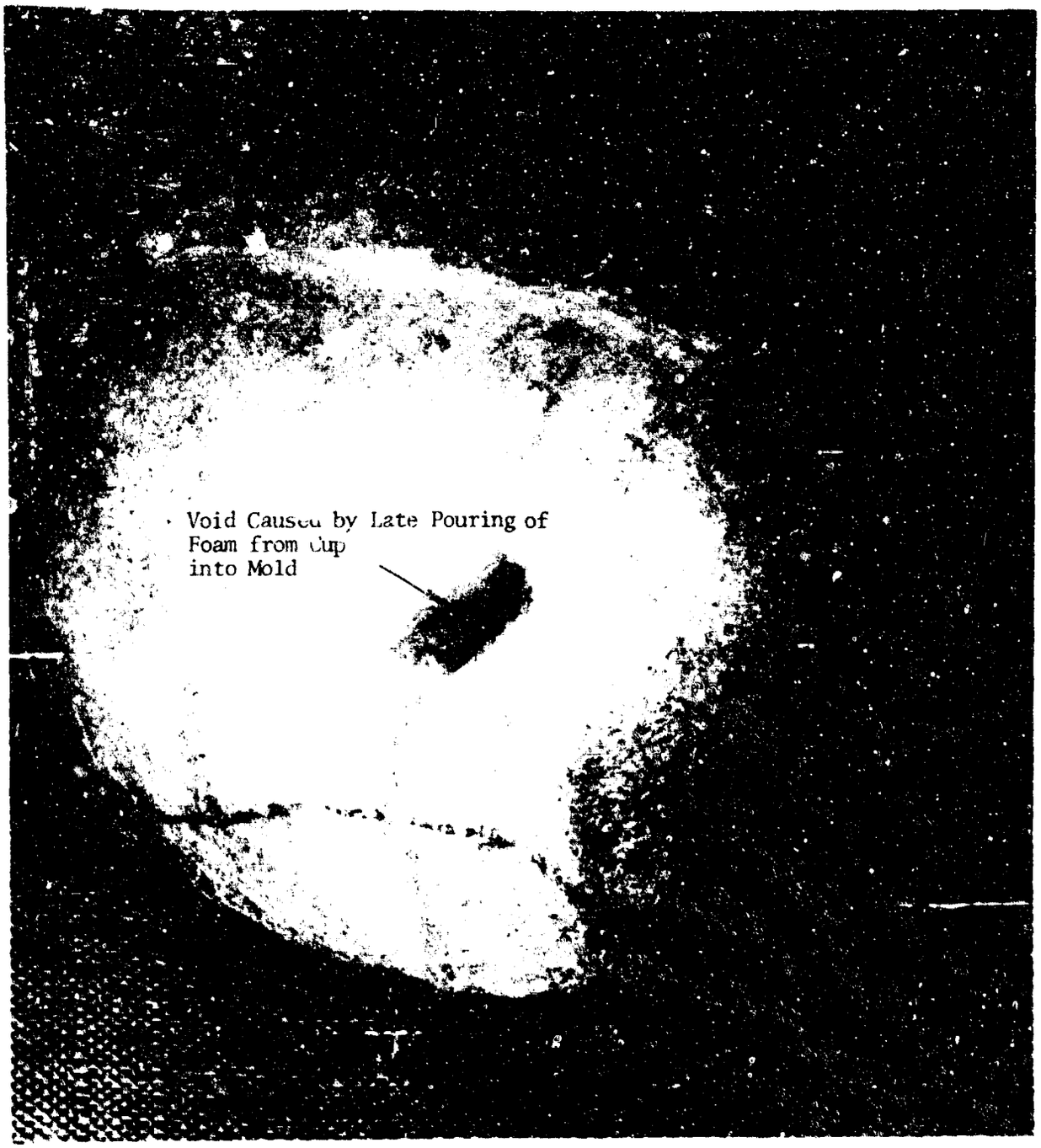


Figure 16. Example of Foaming Failure.

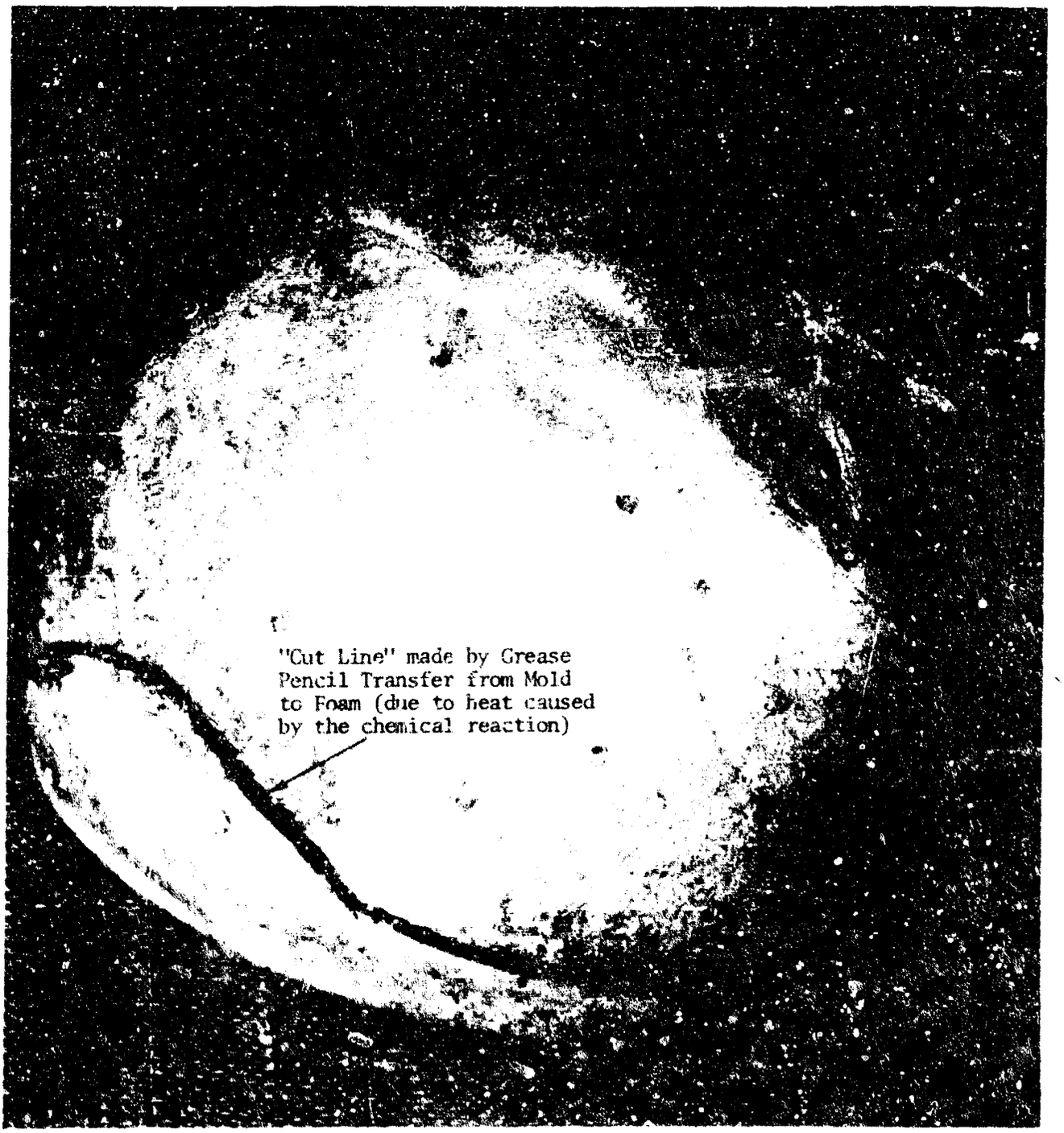


Figure 17. Example of Good Liner.

Figure 18. Liner Cut to Size.

Figure 19. Liner Cut in Two (to facilitate glueing of foam and leather and helmet insertion).

UNCLASSIFIED
Security Classification

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
HQ TAC/DR
Langley AFB VA 23365

13. ABSTRACT

The HGU-2A/P helmet was unsatisfactory because of discomfort, lack of retention during ejections, and restricted upward visibility. The Foamed-In-Place helmet process evaluated in this OT&E was an attempt to correct the deficiencies that existed in the former helmet. Life support technicians are capable, with practice, of local fabrication of acceptable Foamed-In-Place helmets. Most of the material and equipment provided were satisfactory; however, some were unacceptable and considerable supplies were required that were not provided. Instructions for the helmet liner foaming process, issued by Aeronautical Systems Division, were found to be adequate. The instructions should be refined and photographs and illustrations should be added. Instructions for the helmet fabrication were inadequate. Participating aircrews rated the test helmet superior to the previously used helmets in the areas of comfort (82 percent) and stability (80 percent). No significant difference was noted in restrictions to visibility. Noise attenuation was rated acceptable.

It is recommended that immediate action be taken to adopt the Foamed-In-Place helmet process for Air Force use and that ASD/SAAMA take expeditious action to accomplish the following:

a. Develop, procure, and provide comfortable acoustical earcups for retrofit on all Foamed-In-Place helmets.

b. Develop, procure, and provide comfortable, adhesive-backed, leather covered edge rolls for retrofit on all Foamed-In-Place helmets.

DD FORM 1 NOV 65 1473

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| 14 KEY WORDS | LINK A ROLE | LINK A WT | LINK B ROLE | LINK B WT | LINK C ROLE | LINK C WT |
|---|---|---|---|---|---|---|
| Helment Fabrication | | | | | | |
| Helmet Liner Fabrication | | | | | | |
| HGU-2A/P Helmet | | | | | | |
| Form Fitting Helmet | | | | | | |
| Foamed-In-Place Helmet | | | | | | |

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13. ABSTRACT--Continued.

c. All leather and sponge rubber be precut and furnished in a press-on/self-adhesive backing.

d. Talon adhesive (FSN 8040 754 2685) be used in lieu of the Bostik adhesive furnished with the test units.

e. The chemicals should be packaged and controlled to insure exact portions (measures) are available and shelf life is guaranteed.

f. Evaluate the effects of humidity and temperature on the quantity of catalyst required during foaming process.

g. Prepare appropriate technical orders with the assistance of test project officers and technicians.