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SPH-4 Helmet Retention Assembly Reinforcement

By

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The purpose of a helmet's retention assembly is to keep the helmet firmly and securely in place on the wearer's head, thus preventing the exposure of the cranium to direct impact. The standard SPH-4 retention assembly is prone to excessive elongation under stress, and allows excessive helmet displacement and cranium exposure. A modified SPH-4 retention assembly, reinforced with 0.75-inch tubular nylon webbing, was manufactured in this laboratory and tested quasi-statically on a testing machine which exerted a force at a constant speed. A standard SPH-4 retention assembly was also tested as a control. The reinforced retention assembly withstood a 450-lb load without failure. Elongation of the reinforced retention assembly, measured at 300-lb load, was almost 50 percent less than that of the standard retention assembly measured at the same load.

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Introduction

The importance of a helmet's retention system is equal to the importance of its protective covering in providing protection to its wearer. A helmet that is exposed to the impact forces that occur in an accident can be displaced by these forces or, possibly, come off the head entirely, thereby exposing the cranium to direct impact. A helmet with adequate impact protection structure that displaces or does not remain on the head will not provide the protection against the initial or secondary impacts that occur in many rotary-wing accidents.

The SPH-4 flight helmet, with the stronger double-snap chinstrap, does not come off the head easily as is revealed by our Aviation Life Support Equipment Retrieval Program (ALSERP), but the excessive elongation of the retention harness (chinstrap and nape-ear cloth assembly) permits excessive cranium exposure. A new experimental helmet retention test, using a humanoid head and neck attached to a pendulum, also has revealed excessive rotation of the SPH-4 helmet so that the forward brow of the helmet rests on the chin in some simulated "crashes" (Gruver and Haley, 1987). Also, it previously has been reported that retention assembly failure is a significant factor in those cases in which helmet loss occurs (Reading, et al., 1984).

This report will show how the existing SPH-4 retention harness can be reinforced to reduce by 50 percent the stretch of the harness. It is obvious that stiffening the chinstrap and adjacent harness will reduce upward displacement of the helmet when the head is pitched violently forward in an accident. By reducing upward displacement, the degree to which the helmet will displace on the head (forward and backward) also will be reduced, thereby maintaining the protective covering of the head.

Methods

A reinforced retention assembly (Figure 1) was made by removing the retention tabs from a standard SPH-4 retention assembly and stitching 0.75-in. tubular nylon webbing along both sides of each earcup. The thread used was Nymo UVR, size EE, nylon monocord,* which has a strength of 15.5 lbs. Fourteen

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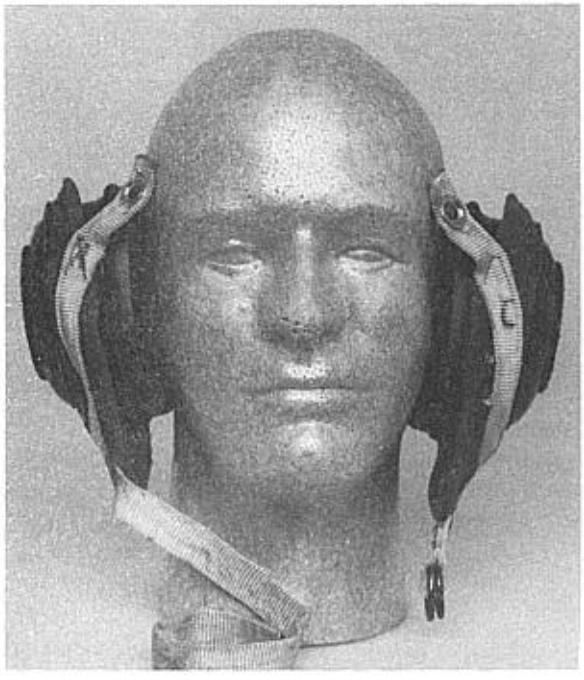
* See Appendix

stitches per inch were sewn. The upper ends of the webbing extended beyond the upper edge of the retention assembly by 1.75 inches. These extensions were grommeted and they provided the points of attachment to the helmet shell, taking the place of the original retention tabs. The webbing on the left rearward side extended 1.5 inches beyond the lower edge of the retention assembly and had two D-rings sewn into its end. The webbing on the right rearward side extended 13 inches beyond the lower edge and formed the chinstrap. No snaps were used. The chinstrap anchor points were located 1 inch to the rear of the original anchor points, as seen in Figures 1a and 1b. However, an impromptu fit test indicated the standard SPH-4 geometry should have been used in regard to the location of the chinstrap anchor points. The reinforced retention assembly weighed 0.22 lb as opposed to the standard retention assembly (including chinstrap) which weighed 0.24 lb.

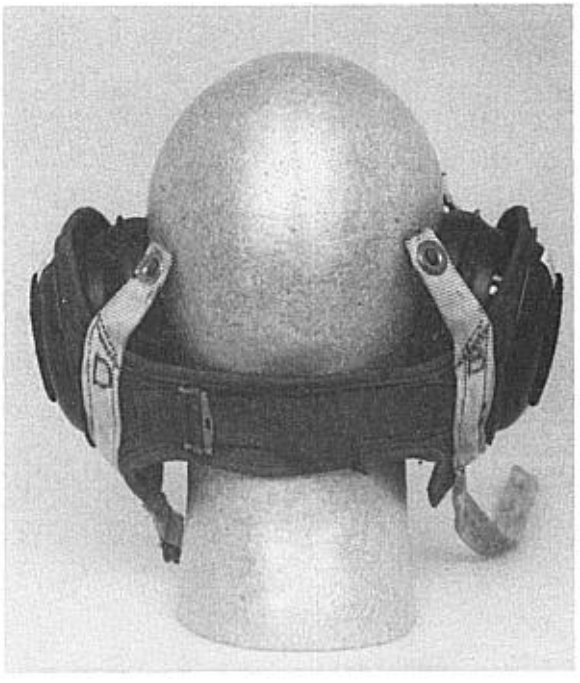
Two standard, extra-large size SPH-4 helmets were used in the test. One helmet (Figure 2) contained the webbing-reinforced retention assembly and the other (Figure 3) contained the standard SPH-4 retention assembly. The retention assemblies were tested quasistatically on a testing machine which exerted a downward force at a constant speed.

1a. Left side view

1b. Right side view



1c. Front view



1d. Rear view

Figure 1. Reinforced retention assembly.

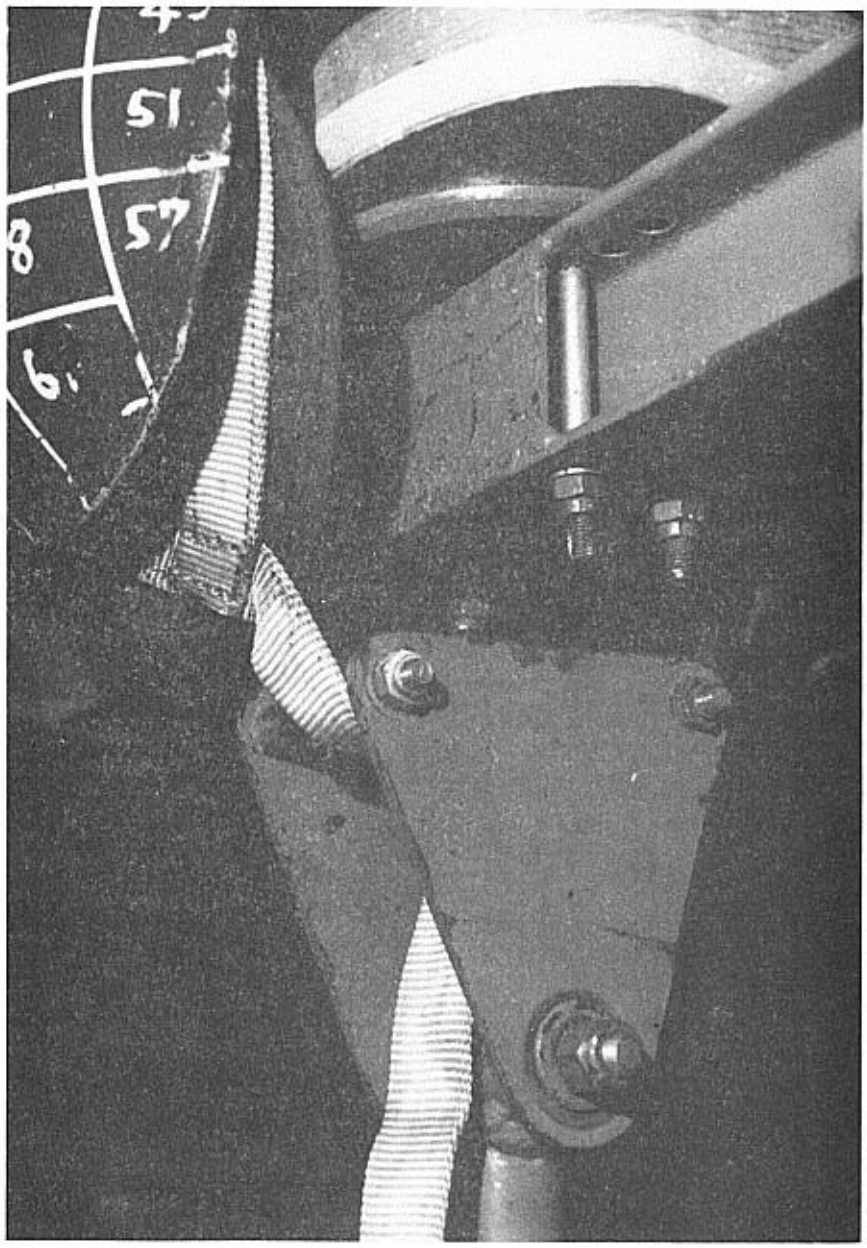


Figure 2. Reinforced retention assembly as installed in an SPH-4 helmet with ANSI Z-90.1 simulated "chin" loading device.

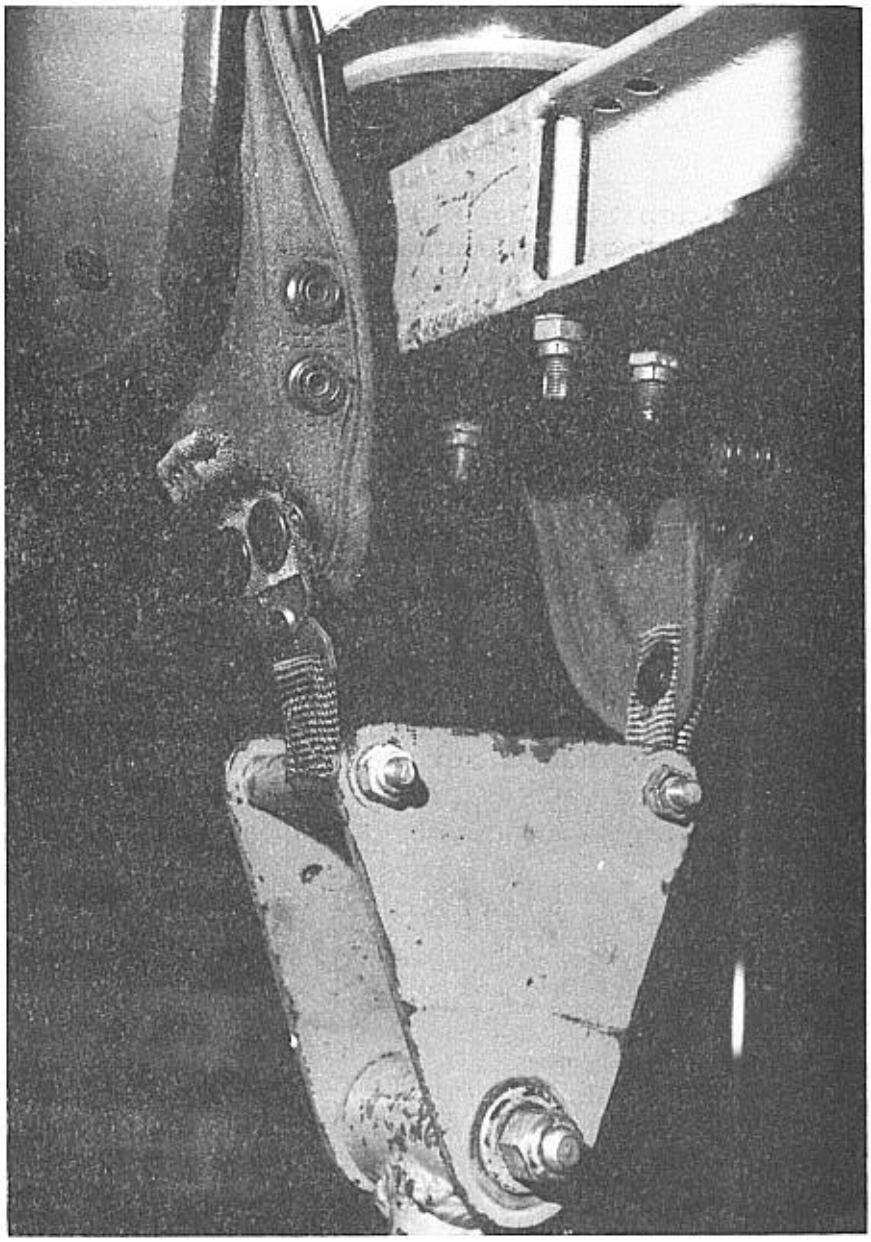


Figure 3. Standard retention assembly as installed in an SPH-4 helmet sustaining the load from a simulated "chin."

Materials

The testing machine used in this experiment was the Tinius-Olsen Locap* testing machine. A 600-pound Revere load cell* was used. The rate of loading was 1.5 inches per minute.

Results

The results are depicted in Figure 4. The reinforced retention assembly did not fail under a load of 450 lb. Deflection was 2.1 in. The reinforced retention assembly was not stressed to failure; however, slight fraying around the grommet of the left, forward retention tab (extension) was seen. Initially, the standard retention assembly failed at 250 lb. However, after the test it was noted that the left, forward retention tab had not been stitched in accordance with MIL-H-43925 because the stitching extended approximately half way across the width of the retention tab. Another retention assembly was tested and loaded to 400 lb with a deflection of 3.2 inches when failure occurred in the left, forward retention tab, as shown in Figure 5.

Deflections of the reinforced and standard retention assemblies, measured at 300 lb loads, were compared and the reinforced retention assembly was shown to have stretched 45 percent less than the standard retention assembly.

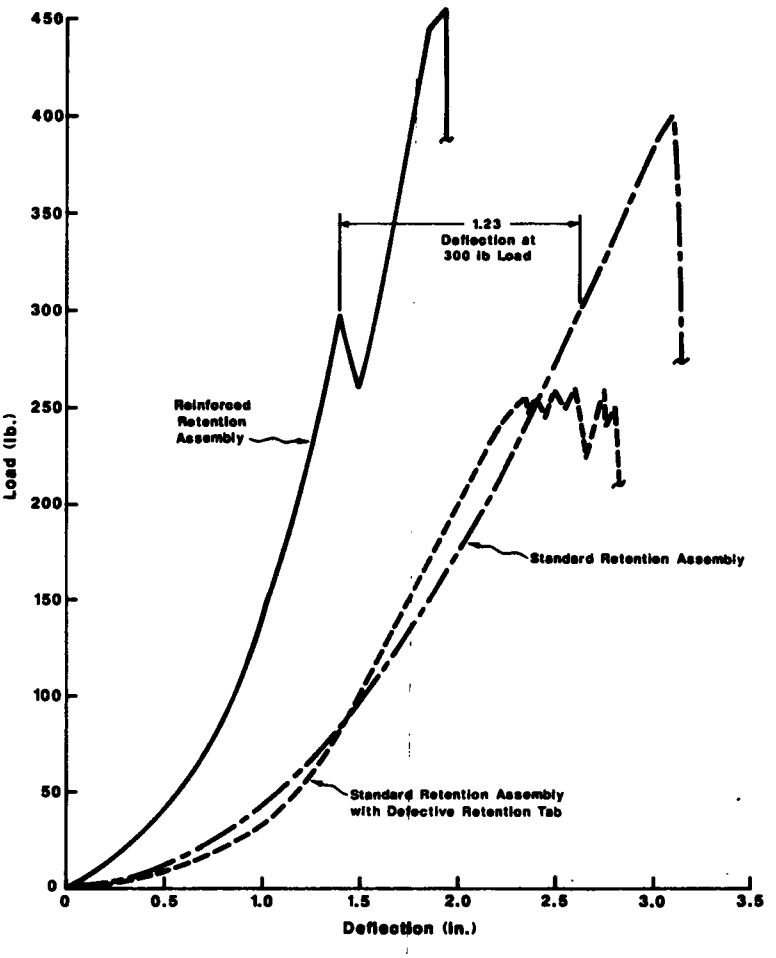


Figure 4. Comparison of the SPH-4 helmet displacement from the head when restrained by a standard and a reinforced retention system.

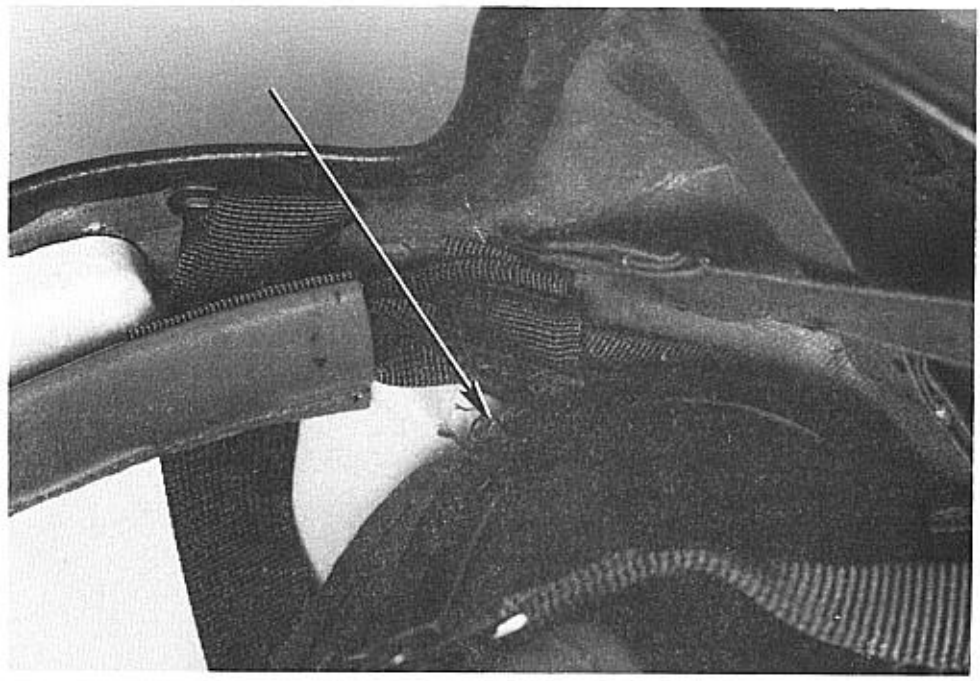


Figure 5. Failure of the left, forward retention tab stitching in the standard retention assembly.

Discussion

All retention assemblies tested either failed or showed slight fraying at the left, forward retention tab, an indication that the test method produced an uneven load distribution among the four retention tabs. Current military specifications for the SPH-4 require that the retention assembly be able to withstand a load of 300 lb which is equivalent to 75 lb per retention tab. The results of this study indicate retention tab failure will occur if the standard SPH-4 retention assembly is subjected to an unequally distributed load, not an unusual event in accidents. Both of the failures observed in this test were due to failure of the retention tab stitching.

The reinforced retention assembly stretched much less than the standard retention assembly. This performance was due to three factors. First, by stitching the tubular nylon webbing longitudinally along the entire length of the retention assembly, the load is distributed directly to the retention material surrounding the earcups and to the chin of the user. This is in contrast to the standard retention assembly in which load is concentrated at four points. Second, each webbing strap was secured to the retention assembly by two parallel

rows of stitching which made the assembly resistant to stitching failure. Third, because the nylon tubular webbing is less elastic than the cloth which surrounds the earcups, the reinforced retention assembly stretches far less than the standard retention assembly which results in reduced deflection under stress.

The effect of excessive chinstrap deflection cannot be overemphasized. Prior helmet retention testing on the U.S Army Aeomedical Research Laboratory pendulum (dynamic) tester revealed the excessive movement of the standard SPH-3 and SPH-4 helmets by comparison to the HGU-33 and HGU-54 helmets (Gruver and Haley, 1987).

Conclusions

1. The standard SPH-4 retention assembly easily can be modified so that it can withstand loads up to 450 lb.

2. Such a modification eliminates retention tab stitching failure and distributes the load over a greater, continuous area.

3. Modification of the standard retention assembly in this way causes the assembly to stretch less when under load and, thus, facilitates helmet retention.

4. Modification of the standard retention assembly in this way will prevent premature retention assembly failure during uneven loading.

Recommendation

Recommend further development and field evaluation of the reinforced retention system to determine its suitability for use in the SPH-4 helmet.

References

Gruver, D. M. and Haley, J. L. 1987. Development of a test method for evaluating the effectiveness of Helmet Retention Systems. U.S. Army Aeromedical Research Laboratory. USAARL Letter Report. In press.

Reading, T. E., Haley, J. L., Jr., Sippo, A. C., Licina, J. R., and Schopper, A. W. 1984. SPH-4 U.S. Army flight helmet performance 1972-1983. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL 85-1.

Appendix

List of equipment manufacturers

Belding Corticelli Thread Company
1430 - T Broadway
New York, NY 10018

Tinius Olsen Testing Machine Company, Inc.
Easton Road, Box 429
Willow Grove, PA 19090