Report for the

National Transportation Safety Board

(NTSB)

Investigation of Gentex Helmets

From Investigation # LAX98GA127

Compiled by

GENTEX

CORPORATION

17 January, 2000

Report for the National Transportation Safety Board (NTSB)

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The following is a two part report that details the analysis of helmets worn by the occupants of a Los Angeles rescue team helicopter crash, designated by the NTBS as LAX98GA127. Additionally, the second part of the report will depict Gentex' position on the current rotary wing helmet designs, and a brief history as to how the performance characteristics have evolved, and improved.

PART I Helmet Analysis

Mr. John Sosnoski, the Product Assurance Manager from the Gentex Corporation, visually examined the helmets from the referenced accident. The helmets were examined in the offices of the NTSB in Gardenia California on Wednesday, 15 December 1999 from 10:00 a.m. until 8:00 p.m. The purpose of the evaluation was to determine if the helmets were in accordance with the configuration (drawing) requirements, were modified from the factory delivered device, detail the specification requirements, and present objective evidence of conformance to the specification requirements.

The helmets were individually boxed and identified by the NTSB accident investigator-in-charge. The helmets were previously examined, and in some cases were disassembled and marked/scratched by the previous analysis. The helmets analyzed were as follows:

- One SPH-5 helmet, single visor, identified by the user name, Silgen
- One SPH-5 helmet, single visor, identified by the user name, McComb
- One HGU-55/P helmet, single visor, identified by the user name, Robinson.

Helmet review - Silgen

The first helmet reviewed was from Silgen. Based on input from the NTSB Investigator, Mr. Silgen was a helitac who was sitting near the rear of the aircraft. Mr. Silgen was wearing an SPH-5 helmet, supplied by Flight Suits Limited.

As stated earlier, the helmet was an SPH-5 helmet sold to Flight Suits Limited as a Gentex Part Number 01045019. The helmet was mostly fabricated by Gentex Corporation. The helmet was sold to Flight Suits without communications, and was processed as a Flight Suits order # 12050 (see Appendix, Page A). This was processed as a Gentex Sales Order Number 57401-000A (see Appendix, Page B). This information was traced from the label on the helmet which indicated the order number 12050.

The helmet had communications installed, probably by Flight Suits, using a David Clark Model M-1/DCC microphone and boom, and earphones from Carter Engineering Model CE 992. The communication cord was labeled, "Flight Suits".

The helmet was compared to the Gentex "Model Parts" sheet 01045019 rev B (reference Appendix, Page C), which depicts the parts, materials, and sub assemblies of the end item device.

One item that was noticed when the helmet was examined was that the earcups were disassembled from the retention, and the retention was folded under the outer surface of the liner between it and the shell. This created an indent in the liner that matched the profile of the retention; and in fact the retention was slightly imbedded into the liner.

Since this phenomenon would be nearly impossible in a crash, it was assumed that this occurred during the disassembly/reassembly of the helmet after the first evaluation of the helmets.

There appeared to be no physical damage to the crown or the headband portions of the helmet, other than a few minor paint scrapes. There did not appear to be a blow to the head, since there was not evidence of indentations from the TPL bubbles on the energy absorbing liner.

The retention system was a Gentex "Coast Guard style" with the part number of D8018. The retention system appeared to be intact, with no evidence of frayed or failed stitching, or loose hardware. Additionally, there did not appear to be any physical damage to the earcups from any impact or blow to the side of the helmet.

There was one impact site located on the left front of the helmet (as worn), near the front trim line. The visor housing was slightly cracked and the lower screw area was cracked. A small portion of the visor track was dislodged. The liner was compressed from 5/8" to 3/8" at the very edge. This extended into the liner for about 1/2". This impact occurred outside the ANSI Z90.1 defined area of protection of the helmet.

The helmet appeared to have all of the parts and materials defined by the part number 01045019 rev B. From what could be determined from the helmet as witnessed, the helmet appeared to be assembled and manufactured in accordance to the drawing requirements. The helmet appeared to function as it was designed.

Through the identification order number found on the helmet, Gentex was able to trace back to performance testing representing the manufacturing lot of helmets delivered under the purchase order to Flight Suits Ltd. A review of the Quality Assurance Process indicated that the order (sales order 57401) was subjected to lot test provisions.

The specification that represents the performance characteristics of these particular helmets is a Gentex developed specification PS-0025. The correct revision of the specification at the time of producing the helmets was revision B dated July 1990.

TPL is a registered trademark of Gentex Corporation.

(Reference Appendix, Page D for the cover page of the specification). Section 3.4. (Page 7) of the specification describes the performance characteristics of the helmets, including the impact requirements in paragraph 3.4.1 (reference Appendix, Page E).

The test protocol is a manufacturing lot test performed to allow release of product, and not an endurance type test. It is performed to insure the manufacturing processes are followed, materials are assembled correctly, and that end item performance of the device is in accordance with the specification requirements. The test protocol requires random sample(s) be taken from the assembled manufacturing lot, consisting of parts made under essentially the same conditions and manufacturing controls.

A Gentex Quality document, QA requirements list CP7/17-1, for this order was created to indicate that this order was subjected to an end item lot test (reference Appendix, Page F). This document outlines the samples to be taken, the specification reference, and the requirements. This sampling protocol is in accordance with PS-0025 requirements.

It was decided by the Quality Assurance personnel that since the dual and single visors were fabricated to order and utilized the same liner and shell materials processed at the same time, that the dual visor version of the helmet would be selected for the impact testing (part number 01045017). It is normal protocol for orders with small quantities to group like assemblies together, when fabricated at the same time. Additionally, the sound attenuation testing and the side impact testing were not performed, since the helmets were ordered without communications, and these particular tests could not be performed without the communication components installed.

The test results for the end item testing are included in the Gentex test report #SPH 5TST1. (Reference Appendix, Page G-I). The test results indicate that the helmet met the requirements for impact of less than 250 G's transmitted in all test locations. Additionally, the test report indicates acceptable results for beading adhesion and chinstrap retention.

The Gentex SPH-5 helmet that was identified and assigned to Mr. Silgen, functioned and performed as it should have in the crash scenario, and performed in accordance with the design specification requirements.

Helmet review – McComb

The second helmet reviewed was from McComb. Based on input from the NTSB Investigator, Mr. McComb was also a helitac who was sitting near the rear of the aircraft. Mr. McComb was wearing an SPH-5 X-large helmet, which was from the identical order from Gentex to Flight Suits Limited as the helmet described above from Silgen. The reference on the label on the helmet was also 12050.

All helmet information from Silgen's helmet regarding part number, configuration, sales order history, lot testing and manufacturing of the helmet apply to the helmet worn by McComb. Even the communications configuration, as supplied by Flight Suits Limited, was the same as Silgen's helmet.

The crown of the helmet had a 1-inch long dent in the shell. The shell was scraped for approximately two inches emanating from the gouge toward the right rear of the helmet. There was a corresponding dent in the crown on the energy absorbing liner that corresponded to the dent mark on the shell.

The front of the helmet had evidence of an impact to the front of the visor housing, right at the edge of the trim line. This continues as a scrape extending a distance of 1½ inches from the brow line toward the crown of the helmet. There is a corresponding compression on the liner at the impact area. The liner is compressed to approximately ¼" at the liner edge, indicating that the impact was severe.

There were numerous paint scrapes and bruises on the helmet, indicating that the individual was tossed around the aircraft during the accident. There appeared to be a minute crack in the center-line of the helmet of approximately two inches long from the edge of the shell at the rear. It could not be determined if the crack was only a superficial paint crack (probable), or a delamination of the helmet shell.

The retention system of the helmet appeared to function correctly and there was no evidence of failed hardware, stitching, or tears in the retention system. There was no evidence of internal delaminations or structural failures on the inside of the helmet shell surface or to the inside surface of the energy absorbing liner.

The right rear portion of the liner was cracked, but this did not appear to be a result of the accident. Rather, it was the result of someone attempting to remove the liner from the shell and breaking the section in its removal.

The screws seemed to make a significant indentation into the liner; much more severe than those witnessed in Silgen's helmet. This could indicate that McComb experienced a much more severe shock to either the head or to the neck during the accident.

It was noticed that the custom fitting liner (TPL®), had only three layers. This is not according to the drawing requirements. There was evidence that the outer layer(s) were removed, since there was a remnant of the outermost TPL® layer still left on the liner. This indicates that the liner did not leave the factory missing the two layers, and that they were removed sometime after the units were shipped.

The Operator and Maintenance Manual for the SPH-5 helmet, section 3-7 (see Appendix, Page J) has a warning which states that while layers may be removed, no outer layers shall be removed, or else helmet stability may be compromised. The fact that the outer layers were removed also explains why there were no indentations in the energy absorbing liner from the impact. The outer layers of the TPL® have the

"bubbles" pointing toward the inner surface of the liner. These convex bubbles will "grab" on to the liner, indenting into the liner during impact and may absorb some of the energy. By removing the outside layers, the TPL® surface to the liner is now concave, and will not afford the additional energy absorption, nor will it provide the friction to help hold the TPL® to liner interface.

Aside from the TPL® liner being fitted and worn incorrectly, the SPH-5 helmet worn by McComb, appeared to be in accordance with the drawing and specification requirements, and performed as would be expected in an accident of this type.

Helmet Review – Robinson

The third helmet reviewed was from Robinson. Based on input from the NTSB Investigator, Mr. Robinson was the pilot of the aircraft. Mr. Robinson was wearing an HGU 55/P style helmet, the detailed configuration of which will be discussed later. The HGU 55/P helmet worn by Robinson was not totally fabricated by Gentex Corporation, but consisted of parts and subassemblies from Gentex, combined with other parts and assembled by Flight Suits Limited. It was not the military issue HGU 55/P helmet.

The components supplied by the Gentex Corporation were the helmet shell, the energy absorbing liner, and the custom fit TPL® liner. Flight Suits components included the edgepad, napepad, chinstrap, earpads, and communications assembly. The visor could have been a Gentex HGU 55/P style visor, though the normal Gentex labeling and markings were not evident on the lens.

Since the helmet was not entirely supplied by Gentex, there would be no end item performance testing associated with the helmets supplied under this order. The acceptance criteria for the components supplied to Flight Suits would be the associated component part drawings. The shell and liner system, if constructed and built in accordance with the drawing requirements, would meet the impact performance requirements of the applicable HGU 55/P Military Specification MIL-H-87174- 1982.

The Gentex label that was supplied with the helmet shell was obliterated by the application of the Flight Suits edgeroll leather, and the traceability information could not be retrieved. Therefore, there was no way to know which order these shells were supplied under, and consequently Gentex could not produce a conformance/inspection report for these helmets or helmet shells.

Regarding the components that were Gentex supplied components, the TPL® layer assembly was only two layers, not the five layers required in the drawing package. There was no attempt to custom fit the TPL® to the pilot's head, as there was no evidence of crushing to the bubble layers. It looked as if the custom fitting was done by removing the layers, and not following the correct fitting procedure.

There did not appear to be a large degree of physical damage to the helmet shell or the liner. There were some scrapes and paint scratches, but nothing to indicate that the

It should be noted that the HGU 55/P helmet is not the recommended helmet for use in a rotary wing (helicopter) environment. Throughout the course of the past several years, both Flight Suits and Gentex have recommended and advised their commercial aviation customers which helmets were most suitable for their particular aircraft. In 1997, Flight Suits issued cautionary statements to their customers; the Los Angeles Police Department was among them.

It goes without saying that the use of almost any helmet is preferable to the use of no helmet, or merely a headset. However, because we have always felt that our customer's safety was our primary concern, it has been our policy to take pains to recommend the helmet which we feel provides the most protection for the desired results. However, it is ultimately the customer's decision whether to choose the most protective helmet available, or for reasons of cost or aesthetics, another less protective model.

PART II Performance History

Gentex's rotary wing helmets have been developed and designed to meet the requirements of U.S. military specifications. The military, through the US Army Aeromedical Research Laboratories (USAARL), have studied numerous crash scenarios and the biodynamics involved in rotary wing accidents and have determined the best combination of mission effectiveness, impact protection, user comfort, and weight in developing helmet specifications.

Gentex is aware of no commercial equivalent specifications to these military specifications. This is in contrast to the ANSI Z90.1 specification for motor vehicular use, or the Snell standards for race car helmets. No known agencies exist that have accumulated the body of biodynamics and physiological data that USAARL used in developing of the current military specifications. Therefore, Gentex has developed its helicopter helmet designs around these military requirements. If there are others in the commercial environment who feel that the military requirements are inadequate commercial applications, Gentex would be interested in seeing the data that backs up this position. In addition, if it is deemed necessary, Gentex would be supportive of any attempt in the commercial industry to develop a commercial specification for rotary wing helmets.

The Gentex rotary wing helmet history is one of constant improvement over the course of the past three decades. For example, the SPH-5 helmet, described in the above accident, has the same basic shape as the SPH-4 helmet developed in the 1970's. However, it has undergone an evolution to decrease weight and increase impact protection. The following table illustrates the evolution of the SPH series of helmets.

However, it has undergone an evolution to decrease weight and increase impact protection. The following table illustrates the evolution of the SPH series of helmets.

Helmet Designation	Approximate Year Of Origin	Impact Velocity (Ft/Sec)	Design Impact Protection (Peak G's)
SPH-4	1974	17.6	400
SPH-4 (new rev)	1982	17.6	400
SPH-4 (new rev)	1988	17.6	300
SPH-4B/SPH-5	1990	19.7	250

It should also be noted that the SPH 4B/SPH-5 had introduced an earcup impact requirement not previously required in the older specifications. The USAARL recommended peak G value for the earcup impacts is based on the risk of basilor skull fracture concomitant with an impact in that area, and the high frequency of occurrence in Army helicopter crashes. It has since been a mainstay on all Gentex rotary wing helmets.

To further demonstrate Gentex' continual improvement of the rotary wing helmet, a new helmet shape was developed by Gentex under a development contract with the US Army. The newest rotary wing helmet, designated the HGU-56/P, offers even more features for the current military missions, lighter weight, and improved impact protection. The protective characteristics of the HGU 56/P are as follows:

Impact Site	Approximate Year Of Origin	Impact Velocity (Ft/Sec)	Design Impact Protection (Peak G's)
Headband	1993	19.7	175
Crown	1993	16.0	150
Earcup	1993	19.7	150

As is shown, the current rotary wing specification requires different impact requirements in different zones of the helmet. Again the 150 G limit for both crown and earcup area impacts is based on the risk of basilor skull fracture concomitant with impacts in those areas.

During the course of the evolution of the helmet shells, materials have changed also. The original SPH-4 helmets utilized a Fiberglass laminate construction. While it was a very strong laminate, it had a weight penalty. The later SPH series helmets utilized a Kevlar® construction. Further improvements were made to the shell laminate to make it stronger and lighter. The current SPH series shells use a Graphalon® hybrid construction. The current HGU 56/P uses a graphite/Spectra laminate. In short, the

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® Graphalon is a registered trademark of Gentex Corporation.

shell construction has continually improved with the advent of newer, lighter and stronger materials.

Throughout this evolution of the shell, the material for the energy absorbing liner continues to be expanded polystyrene foam. Throughout the development of the HGU 56/P many different materials were researched and tried. The polystyrene was found to be the most effective for weight, and impact performance. It is still the material of choice in most motorcycle and bicycle helmets, in different densities and thicknesses.

Additional improvements have been made on the SPH helmet's stability and retention systems, as well as acoustic performance. These improvements have carried forward to the HGU-56/P helmets. The later version of the SPH series and the HGU 56/P utilize a custom fit Thermoplastic Liner (TPL's) for increased pilot comfort, a helmet retention system which reduces helmet rotation, and a stronger chinstrap to insure helmet retention during a crash event.

It should be noted that the SPH series are still the helmets of choice in various other Government agencies other than the military. Specialized versions of the SPH-5 are currently in use and being delivered to the US Coast Guard, and the Bureau of Land Management for use in their rotary wing environments.

In conclusion, Gentex believes that its current generation of rotary wing helmets uniquely addresses the varied demands placed upon helmets in this environment. This assertion is supported by the fact that Gentex and USAARL have many documented instances where pilots have had their lives saved by the SPH series helmets; some in situations that clearly indicate the absence of the helmet would certainly have caused a fatality, or very serious head injury. The SPH has a very good track record, a track record that the HGU 56/P should duplicate or exceed.

Turning to the 55/P, it is noted that most of the helmets designated for fixed wing aircraft (such as HGU 55/P) have impact performance characteristics significantly different that those of rotary wing helmets. The specification requirement for the HGU 55/P, for example, is an impact velocity of 14.1 ft/sec and a peak G limit of 400 G's. (Note, when referring to the Design Impact Protection (Peak G's) table shown on page 7 in this report, greater numeric G values indicate reduced head protection.) The reason for the high G limit is because most fixed wing crashes are not survivable (as opposed to the rotary wing environment where there are a percentage of crashes that are survivable). In a fixed wing environment, the protection is more for windblast and ejection, rather than crash impact to the head. The more important criteria for a fixed wing pilot are light weight and stability for high G maneuvers and visibility. This is one of the reasons why Gentex cautions the user about the use of fixed wing helmets in a rotary wing environment.

Testing of the helmet impact protection has been performed in accordance with ANSI Z90.1 – 1971/1979 with two exceptions. Aircrew helmets are not drop-tested using the hemispherical impact surface, and only one drop test is made per impact location.

These distinctions were incorporated for practical reasons. Flat surfaces are the major impact surfaces found in helicopter cockpits. In order to pass the hemispherical surface impact test it is necessary for the aircrew helmet to possess a relatively thick and rigid shell as well as a relatively high density foam liner. Both of these characteristics are undesirable in an aircrew helmet as they increase the weight of the helmet and reduce its energy-absorbing capability for flat surfaces. Data obtained from US Army helicopter accidents have shown that in most survivable crashes an aircrew helmet usually sustains only one severe impact. Therefore, performing one drop test per impact location appears to be a good representation of what occurs in most survivable crashes. By not requiring aircrew helmets to pass these two tests, a thinner, lighter weight shell and lower density foam liner can be incorporated to reduce weight and provide greater impact protection against the frequently encountered impact surfaces.

The rationale for the impact requirements described above was extracted from the following sources:

- United States Army Aeromedical Research Laboratory Report # 91-11, SPH-4 Aircrew Helmet Impact Protection Improvements 1970-1990. Ronald W. Palmer, February 1991.

- Helmet-Mounted Displays: Design Issues for Rotary-Wing Aircraft, editing by Clarence E. Rash USAARL. Chapter #7, Biodynamics, authored by B. Joseph McEntire.

Additional rationale for the current designs and specifications for rotary wing helmets may be found in these sources.

As cited earlier, there are no known commercial specifications regarding helmets for general aviation use. American National Standard ANSI Z90.1 (the current revision level is 1992) does exist but does not address protective headgear for commercial aviation applications. It should be noted that the "Scope" under paragraph 1.1 of this specification states that "These specifications and test methods apply to protective headgear for wear by drivers and passengers of surface motor vehicles and specifically exclude eye and accessory protective devices".

A helmet in rotary aviation use not only addresses the impact protective capabilities, but also the eye and facial protection necessary to protect the pilot and/or passengers. Additionally, a rotary wing aircraft is noisy. The protective helmets also afford acoustic protection via sound attenuating earcups installed in the helmet. In fact the acronym S-P-H stands for Sound Protective Helmet. Finally, the current rotary wing helmets provide a ear area impact protective capability that ANSI Z90.1 does not address.

Further, ANSI Z90.1 states in the Purpose in paragraph 1.2 the following:

"This standard addresses the problem of protecting the head from transfer of impact energy to the skull and brain. The effects of such an impact are independent of the source; the inadequately protected head is similarly affected regardless of whether it strikes a rock, the highway surface, a tree, a railing, or is struck by an object dropped from some height."

Palmer writes in his USAARL report that while a helmeted head may be subject to being struck by an overhead structure during a rollover crash, or a collapsing cockpit structure, or by intruding limbs, this is rare. 'Since the area immediately in front of the flailing helmeted head usually is clear of obstructions, it may not be logical to use the flailing head velocity as a design value for impact protection."

If an individual in a rotary wing aircraft is involved in an accident and is properly restrained, the probability of coming into contact with surfaces other than those flat surfaces described in the USAARL reports is not as high as an individual who is in a motorcycle type accident. In the motorcycle accident, the individual is unrestrained and potentially subject to contact with many other surfaces, including multiple impacts.

In summary and mission, Gentex feels that the current military specifications define an adequate protective capability for pilots and passengers of rotary wing aircraft. The specifications take into account the entire gamut of protection including the following:

- Impact protection
- Eye and face protection
- Hearing Protection
- Weight and center of mass effect on neck strain
- Helmet retention
- Ability to carry out the functions in the aircraft (mission effectiveness)
- Penetrative resistance

While helmets can be built and designed with increased impact protection, there would be other tradeoffs that may have to be considered. The most likely would be a weight increase. A heavier helmet would increase neck fatigue and could actually be detrimental in a crash by increasing neck loading (the whiplash effect).

The current specifications take into account many aspects of crash and protective dynamics that are derived from numerous accident investigations, physiological, and cadaver tests by USAARL. Gentex knows of no other commercial or Government database that contains the body of biodynamic information that USAARL has collected on rotary wing accidents. The specifications represent the best balance of ALL of the protective requirements needed for the occupant of a rotary wing aircraft.

This is not to say that as technology and materials advance, the existing specifications will not be enhanced. As has been outlined above, numerous improvements have already been made to the specifications and our helmet designs throughout the years.

Improvements will continue to be made in the future as new materials are developed. However, Gentex believes that its current helmets represent the state of the art in aircrew helmet design. They are the result of countless hours of work by Gentex and its military customers; customers that demand the very best equipment available. Although Gentex will continue to push the envelope of aircrew helmet design, we believe that our currently available helmets offer pilots, passengers, and aircrew the very best equipment available in the world today.

Appendix

Flight Suits

1675 Pioneer Way
El Cajon, CA 92020-1642

Tel: 619-440-6977
Fax: 619-440-4618

PURCHASE ORDER

NUMBER 12060
TYPE GEN1
DATE 02/11/97

TO:

GENTEX CORPORATION
PO BOX 315
CARBONDALE, PA 18407-0315

SHIP TO:

FLIGHT SUITS LTD
1675 PIONEER WAY
EL CAJON, CA 92020-1642
USA

TERMS	PHONE	F.O.B.	PER US
Net 30	717-282-3550	VENDOR	UPS GROUND
VENDOR CONTACT	FAX	RESALE NUMBER	FREIGHT
SKIP / LEO	717-282-8555	SY FH 25-685865	PREPAY/BILL

QUANTITY	UNIT	ITEM NUMBER	DESCRIPTION	DUE HERE	TAX	PRICE	EXTENDED
72	EACH	8191-XL	SPH-5 HELMET DUAL X-LARGE Your No: 01045017	09/01/97	No		
60	EACH	8192-XL	SPH-5 HELMET SINGLE X-LARGE Your No: 01045019	09/01/97	No		

MERCHANDISE	FREIGHT	SALES TAX	TOTAL

Authorized Signature

GENTEX CORPORATION
PO BOX 315
CARBONDALE PA 18407-0315
TEL (717) 282-3550

ACKNOWLEDGMENT
THIS IS NOT
AN INVOICE

FAX (717) 282-8555
PAGE 1
2/18/9

FABRICATED PRODUCTS GROUP

SHIPMENT NUMBER	STATUS	CUSTOMER ORDER NUMBER	CUSTOMER CODE NUMBER	SALES ORDER RELEASE NUMBER	DATE	WORK ORDER NUMBER
		12050	34011-0000	57401-000A	2/18/97	

SOLD TO
FLIGHT SUITS LTD.
1675 PIONEER WAY
EL CAJON CA 92020-1642

SHIP TO
SAME AS SOLD TO

SI SM	SHIPPED FROM	TERMS (FROM DATE OF INVOICE)	CONTRACT NUMBER	SO REV
900	CARBONDALE, PA	NET THIRTY (30) DAYS		

SHIPPING WGT - LBS GROSS	NET	CARTONS	PALLETS	DATE SHIPPED	SHIPPED VIA	FREIGHT TERMS
					UPS/Buck	PREPAY & CHARGE

LINE NO.	ITEM NUMBER	QUANTITY ORDERED	U/M	DESCRIPTION	UNIT PRICE	TOTAL AMOUNT
1	0001045017	72	EA	SPH-5 HELMET,X L,WHT,NO COMMS		
2	0001045019	60	EA	SPH-5 HELMET,X-L,WHT,NO COMMS		

NOTE:
1) DEL'Y: 97SEP01

Del: 8/15/97

THIS TRANSACTION IS SUBJECT TO THE TERMS AND CONDITIONS ON REVERSE SIDE. NO OTHER TERMS AND CONDITIONS APPLY.

TOTAL

1/94 CUSTOMER COPY

REV.	DATE	
A	3-4-91	CHANGED QTY. OF P/N 69A2142 FROM 2 TO 1 DELETED 85C7136 E.A.EARCUP KIT-ADDED INDIVIDUAL P/N'S
B	7-09-91	CORRECTED PART NUMBERS AND QUANTITIES

QTY.	PART NUMBER	DESCRIPTION
1	91D8050-1	HLMT SHL, GRAPHITE, X-L, WHT (CG)
1	85D7211-2	E.A. LINER, X L, 4.5 LB.
1	85D7087-5	TPL ASSY, X-L
1	90D8018-2	WIDE YOKE RETENTION, BLK
2	85A7256-20	PILE FSTNR, BLK, PSA
4	67B1732-1	CROSSTRAP, EARCUP TENSION, BLK
4	69A2118	ADAPTER
2	67A1777	EARCUP CHAFING PAD
1	85C7135-4	E.A.EARCUP,LH
1	85C7135-5	E.A.EARCUP,RH
2	81B6572-5	FILLER PAD
2	83C6573	CUSHION,EARCUP INSERT
2	88C7589	EARPAD SEAL
AR	71949-1	ELECTRICAL TAPE
1	71B2302	SPACER PAD KIT
10	76A3443	ARC WASHER, BLK
4	75A3093-5	SCR,8-32 x 3/16, BLK
6	75A3093-9	SCR, 8-32 x 1/4, BLK
4	69A2104-1	POST, 1/16
1	69A2104-2	POST, 1/8
5	69A2104-3	POST, 3/16
AR	70972	ADH MIXTURE (CHAFING PAD ATTACH)
AR	63A1088	EDGE BEADING, BLK
AR	70031	WHITE GLUE (USED FOR THREAD LOCK)
AR	70048	PRIMER, TACC PC-612
AR	70023	ADH, TACC MA-212
AR	70030	ADH ACTIVATOR, #9
1	78A4131-1	GENTEX NAMEPLATE
1	71650-1	GENTEX DECAL, BLACK
1	70788	LABEL BLANK,WHITE
1	86A7390	LABEL,NON-EPA NRR
1	76A3257-1	VISOR ASSY,WHT,NEUTRAL LENS ONLY
1	78A4047	SWIVEL ASSY
1	69A2142	WASHER (SWIVEL ASSY)

CUSTOMER: FLIGHT SUITS
SALES ORDER:
CUSTOMER ORDER:

FOR ASSEMBLY PURPOSES SEE DRAWING NUMBER:	DWN BY R. ARMONDI DATE 1-7-91 CKD.	GENTEX CORPORATION CARBONDALE, PA. 18407
GENTEX CORPORATION CLAIMS PROPRIETARY RIGHTS IN THE INFORMATION DISCLOSED HEREON. THIS DRAWING IS FURNISHED IN CONFIDENCE ON THE EXPRESS UNDERSTANDING THAT NEITHER IT NOR ANY REPRODUCTION THEREOF WILL BE DISCLOSED TO OTHERS OR USED FOR THE PURPOSE OF MANUFACTURE OR PROCUREMENT OF ARTICLE OR PART SHOWN HEREON, WITHOUT EXPRESS WRITTEN AUTHORIZATION.		HLMT ASSY, SPH-5, X-LARGE, WHITE
	SIZE A / CAGE/FSCM 97427 / SCALE	MODEL NO(s) 01045019

PS-0025

UNCONTROLLED
DISTRIBUTION

PRODUCT SPECIFICATION
PS-0025

HELMET, FLYERS, PROTECTIVE
GENTEX MODEL SPH-5

GENTEX CORPORATION
CARBONDALE, PA 18407

PS-0025 Revision B July 1990	PS0025	Prepared: [redacted] 8/1 R.J. Long Reviewed: [redacted] C.F. Acker 23 Aug 90 Reviewed: [redacted] 8/24/90 R. Dion Approved: [redacted] 8/24/90 C.A. Westgate Approved: [redacted] J. Sosnoski 30 Aug 90	GENTEX CORPORATION PRODUCT SPECIFICATION HELMET, FLYERS, PROTECTIVE GENTEX MODEL SPH-5

PS-0025

3.4 Performance.

3.4.1 Shell impact.

3.4.1.1 Impact resistance. When tested as specified in 4.5.2, the complete helmet assembly shall not exceed the fail criteria specified in paragraph 9.2 modified to not exceed 250 G's of American National Standard Z90.1b-1979 when subjected to impacts with terminal velocities of 19.6 + .3 -0 feet per second. Helmets shall be impacted at ambient temperature per 4.5.1.

3.4.1.2 Lateral impact. A lateral impact for the light weight shell per 3.3.11.1 only at a requirement of 19.6 + .3 -0 feet per second not to exceed 175 G's (average of (2) impacts (1) on each side of a helmet with no single impact in excess of 190 G's at ambient temperature shall be accomplished in the earcup area.

3.4.2 Ballistic resistance of shell. On orders requesting ballistic shells, the V_{50} ballistic limit for each shell shall be a 10 shot V_{50} limit of 1200 feet per second with a spread not to exceed 125 FPS when tested as specified in 4.5.3.

3.4.3 Adhesion of the shell edge beading before aging. The beading shall remain firmly bonded to the shell when tested in accordance with 4.5.4. Unbonded areas up to a total of two inches in length are acceptable providing no individual unbonded area is more than 1/2 inch in length and 1/8 inch in width. There shall be a minimum distance of 1/2 inch between any two unbonded areas.

3.4.4 Adhesion of the shell edge beading after aging. When tested in accordance with 4.5.5, the beading shall not peel back more than 1/4 inch from the helmet shell.

3.4.5 Communication equipment operation. The communications equipment (headset-microphone assembly) installed in the helmet, shall function satisfactorily when tested as specified in 4.5.6.

3.4.6 Sound attenuation. The nominal sound attenuating capability of the helmet shall be in accordance with the following values, when tested as specified in 4.5.7 with not more than 2 dB below the values stated. Total values must equal minimum of 261 dB.

Sound Attenuation - S12.6-1984

Hertz units	125	250	500	1000	2000	3150	4000	6300	8000 / Total
Decibels	17	14	20	21	26	38	37	46	42 / 261

3.4.7 Chinstrap/retention system assembly retention strength. When the chinstrap/retention system assembly is tested as specified in 4.5.8 there shall be no separation of components at 300 lbs. of applied force. Chinstrap elongation shall be no greater than 1-1/8" as measured in the vertical distance of the chinstrap from the helmet crown as measured between the preload and 300 lbs.

QA REQUIREMENTS

(FABRICATED COMPONENTS, SUBASSEMBLIES, AND ASSEMBLIES)

SALES ORDER # 57401-412 CONTRACT/ORDER #

☐ GOVERNMENT INSPECTION REQUIRED	☐ FIRST ARTICLE REQUIRED ☐ AT GENTEX ☐ AT OUTSIDE FACILITY

SUBMIT UNITS TO TEST LABORATORY FOR THE FOLLOWING:

P/N	DRAWING REV	GOV'T DRAWING	REQUIREMENT	QUANTITY
01045017	B		Impact Resistance	4
01045017	B		Shell edge beading adhesion before aging	1
01045017	B		Shell edge beading adhesion after aging	1
01045017	B		Chinstrap/Retention system retention strength	4

ADDITIONAL QA PROVISIONS:

Helmets subjected to impact testing shall be tested for chinstrap/retention sys assy retention strength and shell edge beading.The above QA reqt.s encompass S.O.'s 57401 thru 57412.These reqt's also cover p/n 01045019.Tests to be performrd IAW PS-0025.Contact C.Pisa if any questions.

DISTRIBUTION:

MANUFACTURING (REC. BY)

1. J.Connor
2. _____
3. _____
4. _____

QUALITY CONTROL (REC. BY)

1. D.Young
2. H.Tomasofsky
3. _____
4. _____

GENTEX CORPORATION
INSPECTION TEST REPORT
IMPACT RESISTANCE TEST

PART NUMBER: 01045017
DESCRIPTION: SPH-5 X-LARGE
TECHNICIAN : PETER C. MILLS
VENDOR : GENTEX
REPORT # : D-13-32
QUANTITY : 4 FOR IMPACTING
SALES ORDER: 57401-412

INSP.TEST DATE: 08/14/97
CONTRACT # : N/A
DOCUMENT # : SPH5TST1

FIRST PIECE APPROVAL ____
FIRST ARTICLE END ITEM ____
PRODUCT ACCEPTANCE __X__

HELMET # : XL01

	G's	Vel.	Offset
FRONT -	214.75	19.65	1 11/16"
REAR -	183.50	19.61	1 3/8"
L.SIDE -	178.50	19.69	1 1/2"
R.SIDE -	238.00	19.69	1 7/16"
CROWN -	202.50	19.61	1 3/8"

HELMET # : XL02

	G's	Vel.	Offset
FRONT -	247.50	19.61	1 11/16"
REAR -	240.50	19.61	1 3/8"
L.SIDE -	226.75	19.63	1 1/2"
R.SIDE -	245.75	19.65	1 7/16"
CROWN -	207.00	19.61	1 3/8"

HELMET # : XL03

	G's	Vel.	Offset
FRONT -	196.00	19.61	1 11/16"
REAR -	247.00	19.61	1 3/8"
L.SIDE -	226.75	19.65	1 1/2"
R.SIDE -	222.50	19.65	1 7/16"
CROWN -	209.50	19.61	1 3/8"

HELMET # : XL04

	G's	Vel.	Offset
FRONT -	157.50	19.61	1 11/16"
REAR -	247.00	19.61	1 3/8"
L.SIDE -	226.00	19.69	1 1/2"
R.SIDE -	244.25	19.61	1 7/16"
CROWN -	227.25	19.63	1 3/8"

1st Programmer: G's -	250.50	249.25	244.25
2nd Programmer: G's -	253.50	254.75	246.25

DISTRIBUTION: D.YOUNG
J.CONNOR
File

COMMENTS BY TEST LAB: Helmets were tested I.A.W. PS-0025
Velocity Requirement: 19.6 +.3 / -0
Maximum G's: 250 G's

Helmets are ACCEPTABLE for impact testing per PS-0025 PARA. 3.4.1.1

Performed by: [redacted] Date: 08/14/97
PETER C. MILLS 08/14/97

GENTEX CORPORATION
INSPECTION TEST REPORT
SHELL BEADING ADHESION

PART NUMBER	: 01045017	TEST REPORT NO.	: D13-32
DESCRIPTION	: SPH-5 X-LARGE	SALES ORDER NO.	: 57401-412
VENDOR	: GENTEX	DOCUMENT #	: SPH5TST3
CONTRACT NO.	: N/A	TECHNICIAN	: P.C.MILLS
QUANTITY	: 4 FOR TESTING	PRODUCT SPEC.	: PS-0025
LOT NUMBER	: N/A	INSP./TEST DATE	: 8/14/97

ADHESION OF THE SHELL EDGE BEADING BEFORE AGING

REQUIREMENTS: Maximum unbonded areas 2". Maximum one area 1/2" length. Para. 3.4.3 1/8" width, Minimum 1/2" apart.

RESULTS : **4 Helmets PASS**

Helmets were placed in an air circulating oven at 160 F (+/- 5 F) for 4 hours.

ADHESION OF THE SHELL EDGE BEADING AFTER AGING

REQUIREMENTS: Maximum peelback 1/4". Para. 3.4.4

RESULTS : **4 Helmets PASS**

DISTRIBUTION: D.Young
J.Connor
FILE

COMMENTS BY TEST PERSONNEL:

- Helmets are **ACCEPTABLE** for beading adhesion per PS-0025 Paragraphs 3.4.3, and 3.4.4.

PERFORMED BY: [redacted] DATE: 08/14/97
Peter C. Mills 08/14/97

GENTEX CORPORATION
INSPECTION TEST REPORT
CHINSTRAP RETENTION SYSTEM TEST

PART NUMBER:	01045017	TEST REPORT NO.:	D13-32
DESCRIPTION:	SPH-5 X-LARGE	SALES ORDER NO.:	57401-412
INSPECTOR :	PETER C. MILLS	CONTRACT # :	N/A
VENDOR :	GENTEX	TEST DATE :	08/14/97
QUANTITY :	4 FOR TESTING		
DOCUMENT :	SPH5TST2	PRODUCT ACCEPTANCE	__X__

CHINSTRAP RETENTION SYSTEM TEST

REQUIREMENTS: There shall be no separation of components at 300 lbs. of applied force. Chinstrap elongation shall be no greater than 1 1/8" as measured in the vertical distance of the chinstrap from the helmet crown as measured between the preload and 300 lbs.

RESULTS: X-LARGE SPH-5

XL01: ACCEPTABLE (Elongation 0.912").
XL02: ACCEPTABLE (Elongation 0.877").
XL03: ACCEPTABLE (Elongation 0.972").
XL04: ACCEPTABLE (Elongation 0.880").

DISTRIBUTION: D.Young
J.Connor
P/N File

COMMENTS BY TEST LAB:

- Helmets were tested IAW PS-0025.
- Helmets are acceptable for chinstrap retention system testing.

PERFORMED BY: [redacted] DATE: 08/14/97
Peter C. Mills 08/14/97

Custom-Fitting Procedure (continued)

Step	Results/Remarks
10. Have crewmember pull helmet down until ears are centered in earcups.	- Hold for three to five minutes. - Chinstrap may be fastened to hold helmet in position.
11. Check eyebrow-to-shell offset.	- Shell should be approximately 3/4" above eyebrow for maximum field of view. - Lower visors to check centering and nose clearance.
12. Release pressure on top of helmet at end of three to five minutes.	- Raise visors. - Adjust rear-closure hook-and-pile fasteners of retention assembly; adjust earcups; tighten nape strap and chinstrap as required.
13. Check fit.	- Check for hot spots or pressure points. - TPL can be reheated and fitting procedures repeated. Remove masking tape from rear hook fasteners before reheating. - TPL cover can be laundered or dry-cleaned. Replace two-sided tape after laundering. **WARNING** If removing layers, at least two layers must be retained or helmet stability will not be maintained. *Do not remove outer layers; remove inner layers only. TPL will not fit into the EA liner properly if outer layers are removed.* - In some cases, it will be necessary to remove one or more *inner* plastic layers from TPL to achieve an optimum fit. - A special Small/Regular TPL is available for head sizes less than 21.5 inches. - A special XX-Large energy-absorbing liner is available for head circumferences exceeding 24.0 inches.