



Royal Netherlands Air Force

User evaluation of custom moulded earplug with communications in rotary wing aircraft of the Royal Netherlands Air Force



Center for Man in Aviation
Yuval Steinman

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Introduction

Communications Ear Plug (f-CEP)

- Introduced in 2003
- Use of the original model (CEP199-C01)
- 3 sizes of foam tips used
 - Standard
 - Slim
 - Short

Advantages of CEP

- Improved noise attenuation
- Improved speech intelligibility





Introduction I

Problems with the f-CEP (survey results)

- 26% rate f-CEP comfort as poor
 - Irritation
 - Pressure in ear canal – pain
 - Further decrease in comfort after 2 hours use
- Falls out
- Rigid cables
- Foam tips don't fit (one size doesn't fit all)
- Proper insertion takes too long
- Hygiene

Negative influence on aircrew performance



Introduction II

Custom moulded earplugs

- Tailor made to match the contour of the ear
- Soft
- Flexible
- Comfortable
- Easy to insert



Are custom moulded earplugs the solution for our CEP problems???



Phase I method

- Introduction of custom moulded earplugs for the CEP (c-CEP)
 - Standard CEP (CEP199-C01)
- Importance of instructions to the user
 - Two groups
 - Instructions vs. no instructions
- Attenuation test
 - f-CEP vs. c-CEP
 - Real Ear At Threshold (REAT) method





Phase I method I

20 aircrew

- Minimal one year of experience with f-CEP

Questionnaire (Likert scale, open questions)

- Fit
- Comfort
- Ease of use
- Insertion ease
- Speech intelligibility
- Subjective attenuation
- Pressure build up
- Comparison with foam tips

ja nee

.....
Indien ja, op welke manier? In welke mate?

12. Belemmert het systeem het uitvoeren van u werkzaamheden?
 ja nee

.....
Indien ja, op welke manier? Ik krijg pijn aan mijn oren tijdens het vliegen wat niet helpt bij de concentratie en uitvoering van de vlucht.

Opmerkingen over passing en draagcomfort Het indragen van de CEP gaat goed, maar na een half uur gaan mijn oren pijn doen. Zelfs na regelmatig gebruik verbetert dit niet.

Toepasbaarheid

13. Hoe beoordeelt u het gebruikersgemak van dit systeem?
 zeer slecht slecht matig goed zeer goed

14. In combinatie met welke helm heeft u het systeem gebruikt?
 HGU-55P JHMCS

15. Bemoedigt het systeem het opzetten van de helm?
 ja, heel erg ja, een beetje nee

16. Indien ja, in combinatie met welke helm?
 HGU-55P JHMCS

17. Hoe beoordeelt u de flexibiliteit van de kabels?
 zeer slecht slecht matig goed zeer goed

18. Hoe beoordeelt u de afslchting van het systeem?
 zeer slecht slecht matig goed zeer goed

19. Hoe ervaart u de geluidsdemping van dit systeem?
 zeer slecht slecht matig goed zeer goed

20. Is de geluidsdemping van dit systeem in combinatie met beide helmen hetzelfde?
 ja nee n.v.t.

21. Indien nee, wat is het verschil... Ik ervaar bij gebruik dat ik aan een kant meer demping heb dan aan de andere kant. Met de HGU-55P helm is dit meer duidelijk dan met de JHMCS. Dit probleem is onderzocht, maar uiteindelijk niet verholpen. Waarschijnlijke oorzaak lag in het gebruik van niet organieke bekabeling in de helm voor de CEP.

22. Heeft u last van overdemping tijdens het gebruik van het systeem, in combinatie met uw helm?
 ja nee

23. Indien ja, in combinatie met, welke helm
 HGU-55P JHMCS

24. Heeft de overdemping invloed gehad op uw prestaties?
 ja nee geen last



Phase I results

Questionnaire

- 15 received
 - 8 instruction group
 - 7 non instruction group

Attenuation test

- 10 subjects



Phase I results I

General results c-CEP

Aspect	Unsatisfactory	Poor	Satisfactory	Good	Excellent
Fit			2	9	4
Comfort		2	3	9	1
Ease of use			3	10	2
Insertion ease		1	2	10	2
Speech intelligibility				8	7
Subjective attenuation			1	7	7



Phase I results II

Comparison with foam tips

Aspect	Much worse	Worse	No difference	Better	Much better
Fit			1	13	
Comfort		5		6	4
Ease of use		3	2	10	
Speech intelligibility			4	11	
Subjective attenuation			4	11	

c-CEP sticks further out the ear than f-CEP



Phase I results III

Comparison with foam tips – instructions group only

Aspect	Much worse	Worse	No difference	Better	Much better
Fit			1	7	
Comfort		2		3	3
Ease of use			1	7	
Speech intelligibility			1	7	
Subjective attenuation			2	6	



Phase I results IV

Pressure build up in ear

- 7 temporary pressure in ear
- 8 constant pressure in ear
 - 5 reported influence on performance
- 3 reported choosing the f-CEP over the c-CEP till pressure build up issue is resolved



Phase I results V

Assumed protection values (APV) Gentex HGU-56/P

Condition	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
HGU-56/P	16	13	18	27	34	41	48
HGU-56/P + f-CEP	28	25	33	29	42	53	54
HGU-56/P + c-CEP	27	24	32	29	41	54	53

Significant difference in attenuation variance

- In frequencies between 125 – 500 Hz



Phase I summery

Positive results

- Fit
- Comfort
- Attenuation
- Speech intelligibility

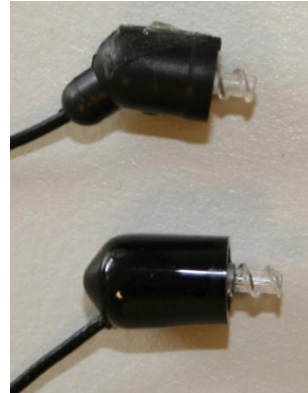
Issues to solve

- Pressure build up
- CEP sticks to far out of ear
- Instructions for the user



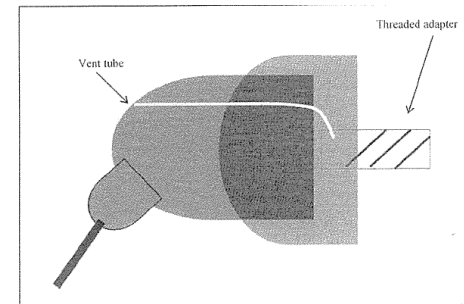
Phase II method

- Introduction of new CEP
 - Vented CEP (c-vCEP)

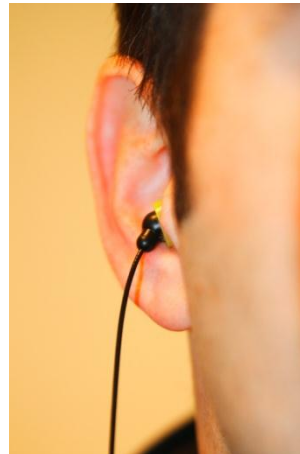


CEP505-C11V

CEP199-C01



- Introduction of new earplug
 - CEP deeper in plug
 - Lower silicone softness (40 to 60 Shore)





Phase II method II

- 20 aircrew
 - 10 participated in phase I
 - 10 new subjects with minimal one year of experience with f-CEP
- Attenuation test
 - c-CEP vs. c-vCEP
 - Real Ear At Threshold (REAT) method
- Fast ascent and descent tests hypobaric chamber
 - 1000 - 3000 feet per minute
- Instructions to all participants



Phase II method III

Comparison questionnaire of c-vCEP with f-CEP and c-CEP

- Fit
- Comfort
- Ease of use
- Insertion ease
- Speech intelligibility
- Subjective attenuation
- Pressure build up



Phase II results I

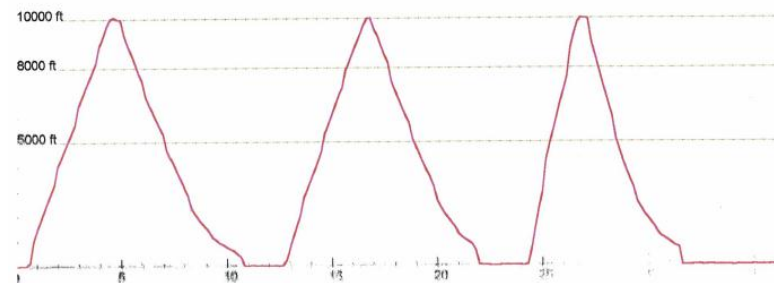
20 questionnaires received

• Performance of the c-vCEP same as c-CEP and better than f-CEP in the following aspects:

- Insertion ease
- Ease of use
- Subjective attenuation
- Speech intelligibility

c-vCEP no longer sticks out to far out of ear

- No pressure build up in ear canal
- During operational flights
- During hypobaric chamber tests





Phase II results II

Performance of the c-vCEP less than the c-CEP and f-CEP in the aspects:

- Fit
- Comfort
- Earplug too hard

Cause: Decrease in silicone softness (40 to 60 shore)



Phase II results III

Assumed protection values (APV) Gentex HGU-56/P

Condition	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
HGU-56/P	16	13	18	27	34	41	48
HGU-56/P + c-CEP	27	24	32	29	41	54	53
HGU-56/P + c-vCEP	22	24	31	29	42	55	53

No significant difference in attenuation variance



Summery phase II

Problems solved

- Pressure build up
- Sticks to far out of ear

New problem

- Earplug too rigid



Phase III method

- Introduction of new earplug
 - Softer silicone (60 to 40 Shore)
 - Slight change in design





Phase III method I

18 aircrew

- 8 participated in phase II
- 10 new subjects with minimal one year of experience with f-CEP (no phase 1 or 2)

Comparison questionnaire c-vCEP version 1 and f-CEP

- Fit
- Comfort
- Ease of use
- Insertion ease
- Speech intelligibility
- Subjective attenuation
- Pressure build up



Phase III results I

New participants (no participation in phase 1 or 2)

- Improvement in comparison with f-CEP
 - Fit
 - Comfort
 - Ease of use
 - Insertion ease
 - Dunning the helmet (some)

Participants phase 2

- Improvement in comparison with c-vCEP (phase 2)
 - Fit
 - Comfort



Summery

Custom moulded vs. foam

Aspect	Custom moulded	Foam
Fit	+	-
Comfort	+	-
Ease of use	+	-
Insertion ease	+	-
Speech intelligibility	+	+
Attenuation	+	+
Pressure build up	+	+



Recommendations

Provide all helicopter aircrew of the Royal Netherlands Air Force with custom moulded earplugs for CEP.

Implementation: 2012-2013



Remarks

- Importance of proper instructions en demonstration for the user
- Refitting the helmet when introducing a new system
- Adaptation period
- Custom moulded earplugs are hand made
- Constantly working with manufacturer to further improve product

