NL Calculation of needed head restaint height

This document is meant as a more detailed explanation of a former
document of The Netherlands with no. HR-2

Explanation

Height of head restaint, how measured:
It shoud be understood that when we discus the height of head restraints it is meant measured
as described in par. 6.5 of UN-ECE-Reg.17, that is to say this height is measured in a plane
with a rearward inclination as close as possible to 25° from the vertical of the torso reference
line of the manikin, described in Annex 3 of UN-ECE-Reg.17, unless otherwise specified by
the manufacturer.
Recent stature of the population of The Netherlands:
In the years 1998-2001 The Netherlands has worked together with o.a. USA to measure the
3D body dimensions of a representative part of the Dutch and American population. This
coöperation of scientists resulted in the up-to-date anthropometry database CAESAR
(Civilian American and European Surface Anthropometry Resource); see www.nedscan.nl.
In earlier doc.HR-2-14 in table 2 data is provided on the stature and sitting height of the 5th,
50th, and 95th percentile male and female from the USA and The Netherlands.
In this document the following data con   cerning the population of The Netherlands is
presented:
- sitting height, in a more detailed distribution, originating from CEASAR and given
  for the year 2004 and 2015 having used the secular trend of the Dutch population;
- face length and head circumference, originating from CEASAR too;
- a calculation of the distance from H-point to head centre of gravity (cog) of the
  Dutch 2004 human, based on the shown distribution of head circumference in
  combination with the known H-point and the known head cog of a designated
  reference human being the UMTRI 1983 human with a sitting height of 911 mm[1]
  (Formula A).
- a calculation of the distance from H-point to head centre of gravity (cog) of the
  Dutch 2004 human, based on the shown distribution of face length in combination
  with the known H-point and the known head cog of a designated reference human
  being the UMTRI 1983 human with a sitting height of 911 mm (Formula B).
- a calculation of the needed height of head restaints for the Dutch 2004 human that
  takes also on board matters like ramping up as reported a.o. by A. van den
  Kroonenberg[2] (Formula C).

In the latter calculation the distribution of face length has been used because it is thougth to be
a better approach for the calculation of the head cog.
The used formule for the needed head restraint height HR is:
HR x% human = (sitting height x % human)- 93* (face length x % human / face length of
designated reference human) –67*(H-point x % human / H-point of designated reference
human length) + 15 mm.

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[1] Source: UMTR-83-53-1, December 1983
- erect sitting height average male = 911 mm
- distance crown to cog head =93 mm
- distance H-point to lowest part buttocks (excluding flesh) is 67 mm
[2] Kroonenberg, A. van den, Philippens, M., Cappon, H., Wismans, J., Hell, W., Langwieder, K.: Human Head-
Neck Response During Low-Speed Rear End Impact (1998). SAE paper 983158

Nederland, age: 20 - 60 years   alle maten in mm / all measures in mm

N = 635

Percentiel	zitvlak-kruinhoogte / sitting height		gezichtslengte / face length		head circumference	Formule A: H-point cog head	Formule B: H-point cog head	Formule C: minimum height HR
	2004	2015	2004	2015	2000	2000	2004	2004
1	804	809	98	99	516	659	666	681
5	827	832	102	103	523	679	684	699
10	840	845	104	105	530	690	695	710
20	856	861	107	108	538	703	707	722
25	864	869	108	109	540	710	714	729
30	872	877	109	110	542	717	720	735
40	883	888	111	112	547	727	729	744
50	890	895	112	113	550	733	735	750
60	899	904	114	115	554	740	741	756
70	908	913	116	117	559	748	748	763
75	915	920	117	118	561	754	754	769
80	920	925	119	120	563	758	757	772
90	936	941	121	122	570	772	770	785
95	947	952	123	124	575	781	779	794
99	986	991	130	131	586	816	809	824

N = 495

Percentiel	zitvlak-kruinhoogte / sitting height		gezichtslengte / face length		head circumference	Formule A: H-point cog head	Formule B: H-point cog head	Formule C: minimum height HR
	2004	2015	2004	2015	2000	2000	2004	2004
1	860	870	104	105	534	708	714	729
5	882	892	111	112	546	727	729	744
10	896	906	114	115	553	739	740	755
20	912	922	117	119	562	752	752	767
25	916	926	118	120	565	755	755	770
30	924	933	119	121	567	762	762	777
40	940	949	121	123	572	776	775	790
50	949	959	123	125	576	784	782	797
60	960	969	125	127	580	793	790	805
70	971	981	127	129	584	803	799	814
75	976	986	128	130	587	807	803	818
80	982	991	129	131	589	812	807	822
90	1001	1011	133	135	597	829	822	837
95	1016	1026	135	137	605	841	834	849
99	1052	1061	141	143	616	873	863	878

Percentiel		zitvlak-kruinhoogte / sitting height			gezichtslengte / face length			head circumference	Formule A: H-point cog head	Formule B: H-point cog head	Formule C: minimum height HR
N = 1130		2004	2015		2004	2015		2000	2000	2004	2004
1		808	813		99	100		518	663	670	685
5		838	843		103	104		529	689	695	710
10		852	858		106	107		535	701	705	720
20		875	881		110	111		543	721	723	738
25		883	889		111	112		547	727	730	745
30		889	895		112	113		550	733	735	750
40		901	907		114	115		556	743	744	759
50		912	919		117	118		561	752	752	767
60		924	930		119	121		567	762	762	777
70		940	948		121	123		572	776	775	790
75		948	957		123	125		575	783	781	796
80		956	965		125	126		579	790	786	801
90		981	990		129	131		588	811	806	821
95		998	1008		133	134		596	826	819	834
99		1039	1049		137	139		610	862	854	869

Formule A: result calculation H-point - head cog, (having used: the shown distribution of head circumference in combination with known H-point and known head cog of the UMTRI 1983 human with sitting height of 911mm).

Formule B: result calculation H-point - head cog (having used: the shown distribution of face length in combination with known H-point and known head cog of the UMTRI 1983 human with sitting height of 911mm).
Formule C: takes on board the result of Formule B ánd adds 15 mm extra for matters like ramping up (because having taken "sitting height" the effect of spine straightening is nót taken on board).

Conclusion
Based on the data above our conclusion is still that a head restraint height of 800 mm is not enough to cover a decent percentage of the population of The Netherlands. Making use of the **conservative** calculations above only up to the 50th % Dutch 2004 male is covered!
Therefore, hereby it is stated again that a head restraint height of 850 mm is more appropriate!