



©2016 VestGuard UK All rights reserved. <i>Confidential</i>	Doc. n°: VC-001
Project: ACH AR/PD 10-02A	Croydon: 30/11/2016
Test Report: D3O® TRUST Helmet Pads System	Page 1 of 6

1. Executive Summary

The D3O® TRUST Helmet Pad System was designed using patented D3O® impact protection technology to exceed the performance and verification requirements for the Advanced Combat Helmet (ACH) defined in the Purchase Description for the acquisition of an ACH (AR/PD 10-02 Rev A Change 3, dated 22 February 2012). As specified in section 3.7, the suspension system consists of seven (7) pads ($\frac{3}{4}$ inch) of three (3) different shapes: 1 circular pad (crown), 2 trapezoidal pads (front and back) and 4 oblong pads (sides and napes). The system is shown in the Figure 1.



Figure 1 – D3O® TRUST Helmet Pad System: (a) suspension system assembled in an ACH helmet and (b) set of 7 pads

The D3O® TRUST Helmet Pad System complies with the requirements specified for the pad suspension system of the ACH as laid out in AR/PD 10-02A:

- Pad suspension system (3.7)
- Pad construction (3.7.1)
- Pad compression durability (3.7.2)
- Hook/loop adhesion (3.8.3)
- Blunt impact protection (3.11)
- High temperature storage and use (3.12.5)
- Cold temperature storage and use (3.12.6)
- Temperature shock (3.12.7)
- Altitude (3.12.8)
- Vibration (3.12.9)
- Integration/compatibility (3.13)
- Marking of pad suspension system components (3.14.2)
- Washability (Launderability)/colorfastness (3.14.4)
- Shelf life (3.14.5)
- Health/safety (3.15)

The main goal of the suspension system as part of the Advanced Combat Helmet is to reduce the acceleration of the wearer's head during low velocity blunt impact events. Therefore, in the following section the impact performance in the blunt impact protection testing is presented in more detail.



©2016 VestGuard UK All rights reserved. <i>Confidential</i>	Doc. n°: VC-001
Project: ACH AR/PD 10-02A	Croydon: 30/11/2016
Test Report: D3O® TRUST Helmet Pads System	Page 2 of 6

2. Blunt Impact Protection

Advanced Combat Helmets incorporating the D3O® TRUST Helmet Pad System were tested at Chesapeake Testing in accordance with the blunt impact testing procedure of the AR/PD 10-02 Rev A Change 3, dated 22 February 2012 (ACH Helmet Blunt Impact Test Performance Specification). ACH large (L) and extra-large (XL) helmets were tested at the impact speed of 10 ft/s after exposure to each of the three environment conditions: ambient (68±10 °F and relative humidity of 50±20%), cold (14 °F) and hot (130 °F). A representation of the testing setup is shown in Figure 2.



Figure 2 – Blunt impact protection testing setup

It must be taken into account that the data was obtained from limited testing:

- Only large and extra-large helmets were tested
- Only one helmet per environmental condition
- Only Gentex ACH shells were tested (aramid fiber-reinforced thermoset resin)

Furthermore, several aspects were not considered as part of the experimental study from which the data came, which can affect the testing results. Some of these factors are as follows:

- Gage R&R between test houses
- Pad installation
- Different shell types and/or manufacturers

The independent testing results from Chesapeake Testing for the large and extra-large size helmets are presented in the Figure 3 and Figure 4, respectively. The D3O® TRUST Helmet Pad System proved to provide a great impact protection level achieving an average across both tested sizes and all temperatures of **92 G** (vs maximum acceleration of 150 G per section 3.11 of AR/PD 10-02 Rev A), as shown in Figure 5. Another important feature of the D3O® TRUST Helmet Pad System is the ability to keep similar performance in multiple impacts, even for short recovery times. The system performance in the first and second impacts is very similar indeed (**2G** delta on average), as shown in Figure 6.

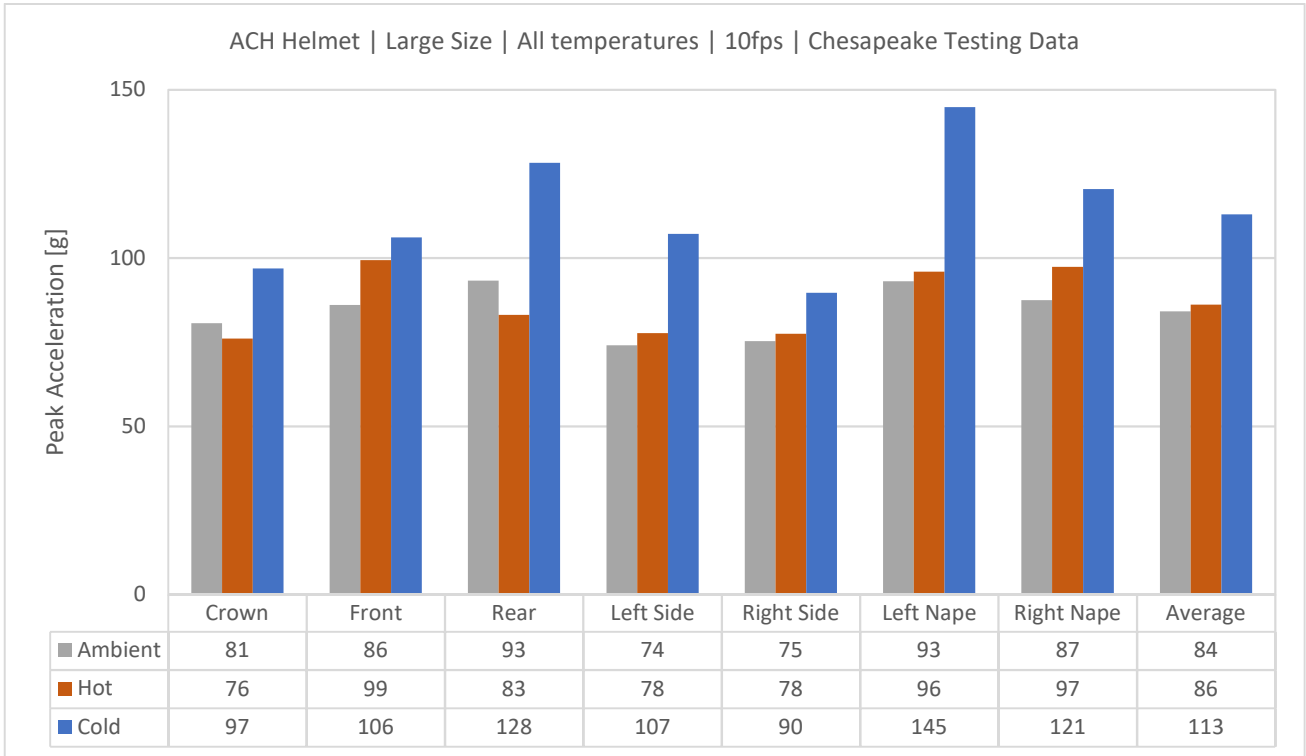


Figure 3 – Blunt impact protection testing data: large (L) size helmets tested at Chesapeake Testing.

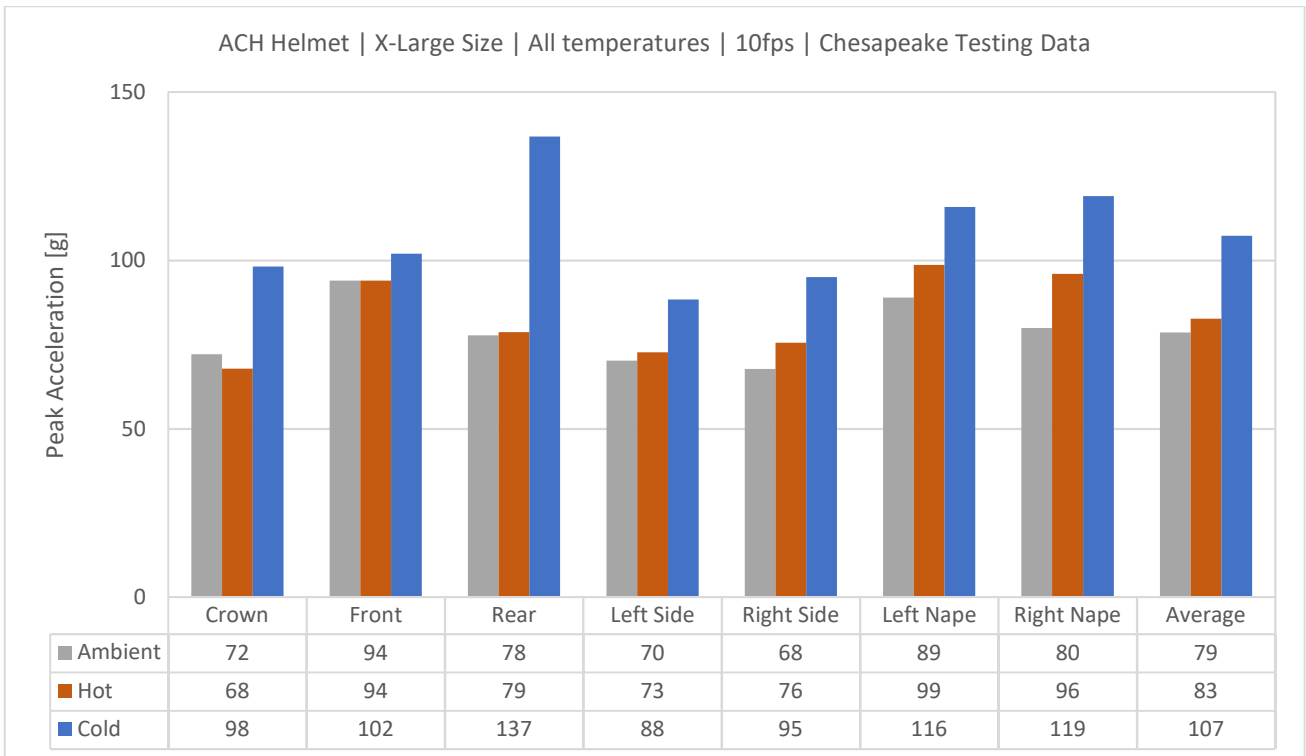


Figure 4 – Blunt impact protection testing data: extra-large (XL) helmets tested at Chesapeake Testing.

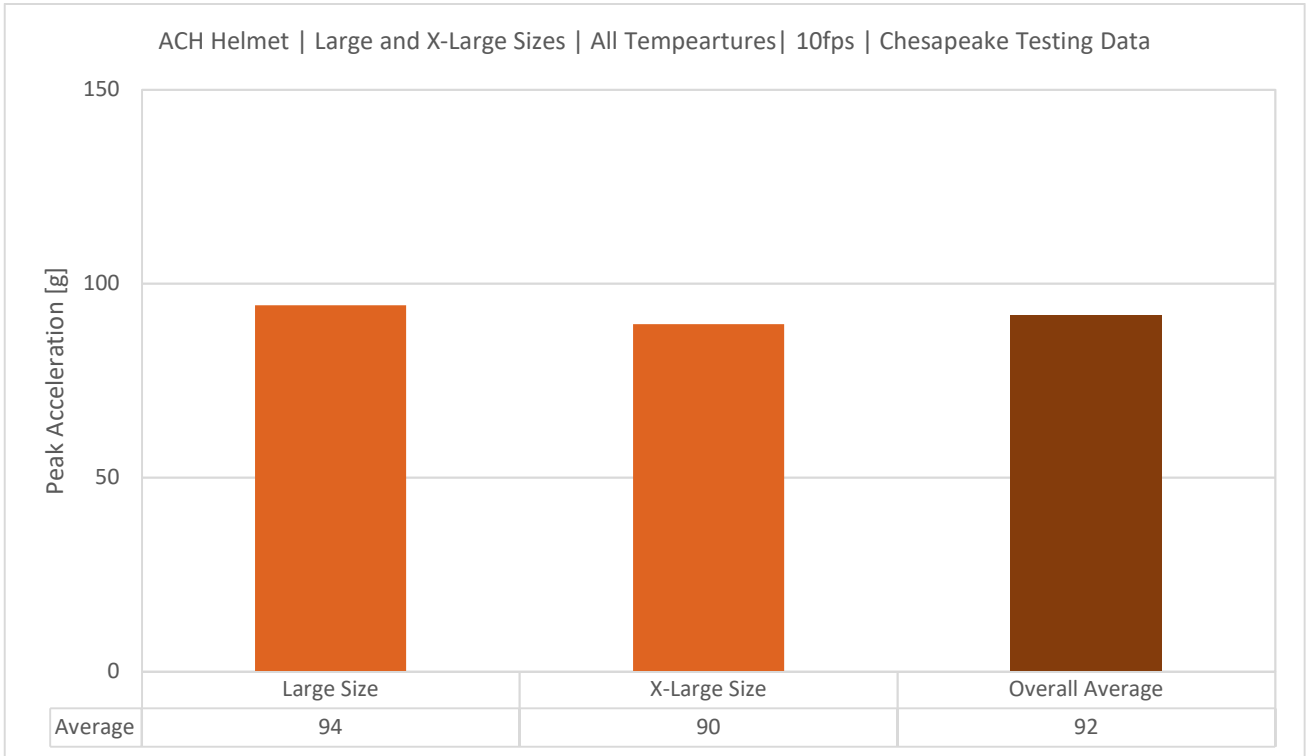


Figure 5 – Blunt impact protection testing data: overall average for helmets tested at Chesapeake Testing.

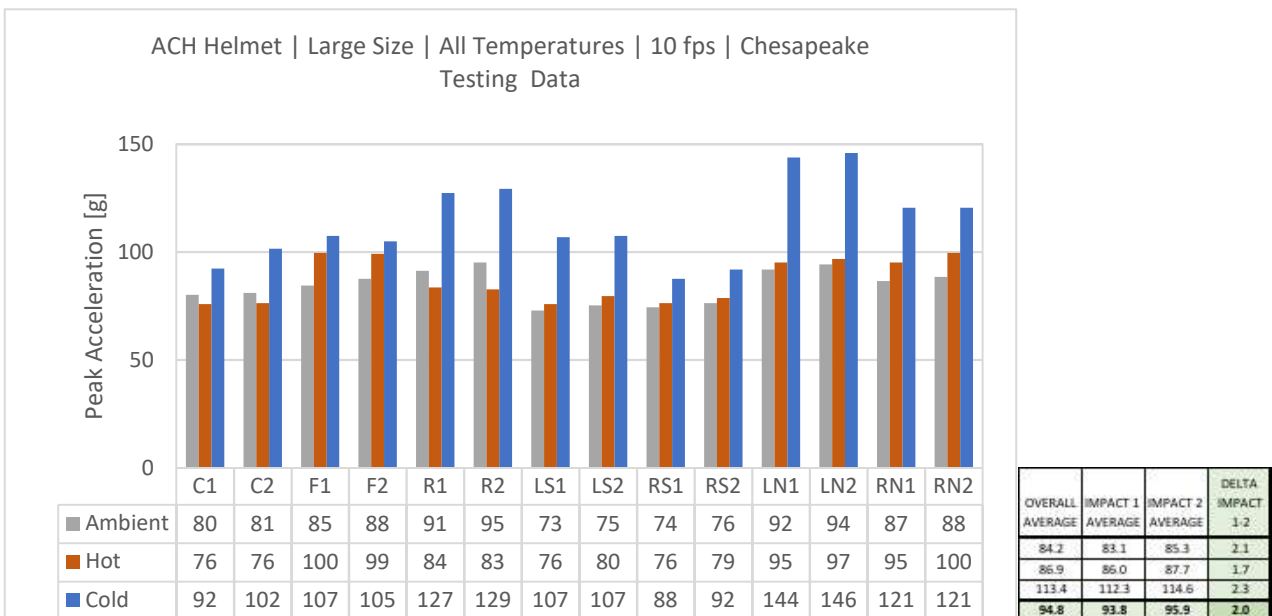


Figure 6 – Blunt impact protection testing data for both first and second impact in each location: large (L) size helmets tested at Chesapeake Testing.



©2016 VestGuard UK All rights reserved. <i>Confidential</i>	Doc. n°: VC-001
Project: ACH AR/PD 10-02A	Croydon: 30/11/2016
Test Report: D3O® TRUST Helmet Pads System	Page 5 of 6

As seen in Figure 7, the D3O® 10 fps TRUST helmet pad system demonstrates several advantages over the Team Wendy ZAP system when tested at 14fps (*note that the test was performed vs the 150G threshold established in AR/PD 10-02A; individual test point failures are shaded in pink*). Not only does the D3O system show an average **6G advantage** over Team Wendy ZAP, but more importantly, the performance difference between Impact 1 and Impact 2 is significantly lower for D3O at **4.9G** vs Team Wendy at 25.2G. While only two replicates were tested for Team Wendy, we saw significantly higher variability in the ZAP data set vs D3O.

Figure 7 – D3O® 10fps TRUST Helmet Pads vs Team Wendy ZAP at 14fps ambient, ACH, multiple impacts

Team Wendy ZAP at 14fps, 2 impacts per location	Front 1	Front 2	Rear1	Rear2	Left1	Left2	Right1	Right2	LNape1	LNape2	RNape1	RNape2	Crown1	Crown2	Average Deceleration, G	Sigma
Replicate 1	167.5	187.4	103.8	135.8	103.7	154.5	98.9	120.2	267.6	260.1	163.7	185.7	108.2	119.4	155.5	55.04
Replicate 2	152.7	185.4	92.0	99.8	102.4	125.6	96.8	120.6	133.7	210.5	162.1	184.7	101.1	117.9	134.7	38.34
Avg	160.1	186.4	97.9	117.8	103.0	140.0	97.8	120.4	200.7	235.3	162.9	185.2	104.6	118.7	145.1	47.73
Sigma	10.44	1.41	8.32	25.48	0.95	20.47	1.50	0.31	94.65	35.08	1.07	0.74	5.01	1.07		
															Impact 1 avg	132.4
															Impact 2 avg	157.7
															Delta Impact 1-2	25.2

D3O TRUST 10fps pads at 14 fps, 2 impacts per location	Front 1	Front 2	Rear1	Rear2	Left1	Left2	Right1	Right2	LNape1	LNape2	RNape1	RNape2	Crown1	Crown2	Average Deceleration, G	Sigma
Replicate 1	143.8	140.5	102.3	120.9	121.2	125.6	121.3	136.6	143.9	146.0	142.2	169.7	126.9	119.9	132.9	16.49
Replicate 2	158.8	171.5	135.8	129.4	116.7	124.2	113.3	125.4	163.4	157.9	166.6	166.1	115.4	117.6	140.1	22.47
Replicate 3	150.4	166.1	121.6	109.7	114.9	125.9	119.7	123.4	169.4	172.4	168.4	170.7	126.0	124.7	140.2	24.27
Avg	151.0	159.4	119.9	120.0	117.6	125.2	118.1	128.4	158.9	158.8	159.1	168.8	122.8	120.7	137.8	21.10
Sigma	7.51	16.59	16.83	9.91	3.23	0.88	4.24	7.10	13.31	13.19	14.63	2.44	6.36	3.60		
															Impact 1 avg	135.3
															Impact 2 avg	140.2
															Delta Impact 1-2	4.9

Figure 8 demonstrates D3O® TRUST Helmet Pad compliance to the Resistance to Penetration Test, with backface deformation values within the specified limits at each of the shooting positions, and system weight within prescribed limits.

Figure 8 – Resistance to Penetration Test vs AR/PD 10-02A 3.9.2





©2016 VestGuard UK All rights reserved. <i>Confidential</i>	Doc. n°: VC-001
Project: ACH AR/PD 10-02A	Croydon: 30/11/2016
Test Report: D30® TRUST Helmet Pads System	Page 6 of 6

Large ACH with D30 Comfort Pads									
Size		Helmet Weight (g)	9mm BFD (mm)						UTL Confidence
				Crown	Right	Left	Front	Back	
	Req't:	1501		16.0	16.0	16.0	25.4	25.4	90%
Large	Average	1439	Average (12)	8.7	8.1	9.2	12.4	12.5	99.7%
			Std Dev	1.8	1.8	1.5	1.1	1.2	
	St. Dev:	6	90/90 UTL	15.8	14.6		16.6	17.3	

12 Helmets Total
 3 at Ambient
 3 at Hot 160 F
 3 at cold -40F
 3 after Seawater Immersion

CONCLUSION

The D30® TRUST Helmet Pad system demonstrates several important performance advantages for the ACH application:

- Average peak impact acceleration of 92G vs 150G max limit
- Repeat impact consistency – 2G average delta across all positions and environmental conditions
- Improved performance vs Team Wendy ZAP at 14fps
 - o 6G average advantage
 - o Performance drop from Impact 1 to Impact 2 limited to 4.9G, vs a 25.2G drop for Team Wendy

