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U.S. Department of Transportation
National Highway Traffic Safety Administration

Memorandum

NHTSA - 98-4283-1

Subject: Reports on the Effectiveness of Neck Wrap and Head Skin Modifications for the Hybrid III Small Female Dummy

Date: **AUG - 5 1998**

From: Stan Backhaus
Principal Engineer, NPS-10

Reply to Attn. of:

To: Docket

Thru: James R. Hackney, Director
Office of Crashworthiness Standards

DEPARTMENT OF TRANSPORTATION
98 AUG - 6 PM 3: 11
DOCKET SECTION

Frank Seales, Jr.
Chief Counsel

Attached for placement into the docket are two reports dealing with the effectiveness of neck wrap and head skin modifications for the Hybrid III small female dummy. Report No. 1 was generated by NHTSA/VRTC under the title, "Evaluation of Neck Wrap and Skin Modifications for the Hybrid III Small Female Dummy," and report No. 2 was published by the Insurance Institute for Highway Safety at the 1998 ESV Conference under the title, "Measuring Air-bag Injury Risk to Out-of-Position Occupants." The data in these reports relate to the impact response measurements by the crash sensors contained within the Hybrid III small female dummy.

2 Attachments (2 copies each)

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NHTSA-98-4283-1

**An Evaluation of Neck Wrap and Head Skin Modifications
for the Hybrid III Small Female Dummy**

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DEPARTMENT OF TRANSPORTATION
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An Evaluation of Neck Wrap and Head Skin Modifications for the Hybrid III Small Female Dummy

Background

Historically, industry testing of the small female dummy in out-of-position (OOP) scenarios has generated questions about the biofidelity of the neck and chin. Specifically, there were concerns raised in the SAE Hybrid III Family Task Group that the airbag material was expanding in the chin cavity and around the neck during OOP testing and this phenomena was believed to result in unrealistic neck responses. Over the years, several different modifications have been examined by the SAE.

Objective

The purpose of this research is to evaluate the latest SAE-proposed neck wrap and head skin modifications for the Hybrid III small female dummy. The neck skin consists of a rectangular wet-suit-like material with a Velcro closure which allows the material to be wrapped around the neck. This wrap covers the metal disks in the neck and prevents airbags from catching on the disks. The head skin, referred to as the TMJ skin, contains vinyl which closes out the chin cavity and which also provides a more realistic jaw line. Figure 1 shows a side profile of the TMJ head skin and Figure 2 demonstrates the chin cavity cover feature.

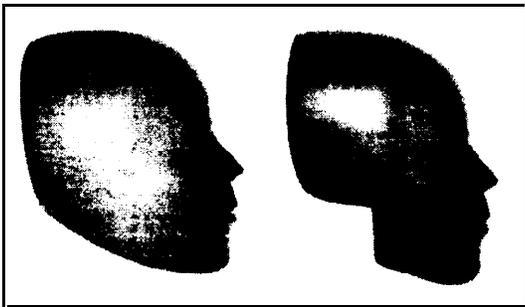


Fig. 1. TMJ Head Skin (left) and Standard Skin (right)

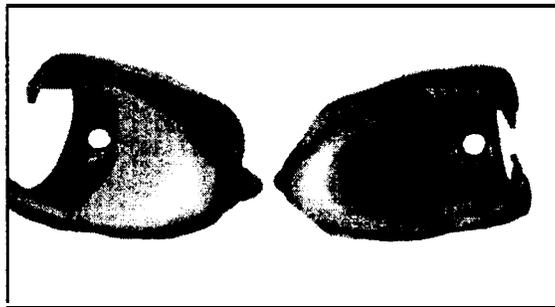


Fig. 2. TMJ Head Skin (left) and Standard Skin (right)

Static Out-of-Position (OOP) Testing

As an initial evaluation of the TMJ skin and neck wrap, VRTC conducted six-driver OOP tests in the ISO 1 position using the '98 Ford Explorer airbag system (see Fig.3). Three tests were conducted with the standard head skin and no neck wrap; and three tests were conducted with the TMJ head skin and the neck wrap. The results of significance appear in the Table 1 and Table 2 below.

Table 1. OOP Test Results for Standard Head Skin without Neck Wrap

test # 043400--		48	50	52	AVG	STDEV	%CV
Neck Fx	N	-741.6	-599.9	-733.0	-691.5	79.4	11.5
Neck Fz	N	995.3	1008.7	956.6	986.9	27.1	2.7
Neck Moc	Nm	-40.6	-28.2	-34.1	-34.3	6.2	18.1
Head Res	g	18.7	22.0	21.4	20.7	1.8	8.5
Chest Res	g	20.1	25.5	24.6	23.4	2.9	12.4

Table 2. OOP Test Results for TMJ Head Skin with Neck Wrap

test # 043400--		49	51	53	AVG	STDEV	%CV
Neck Fx	N	-629.9	-810.6	-829.4	-777.6	74.0	9.5
Neck Fz	N	946.8	1079.2	1061.4	1029.1	71.9	7.0
Neck Moc	Nm	-40.3	-43.9	-45.1	-43.1	2.5	5.8
Head Res	g	17.3	17.4	26.7	20.5	5.4	26.4
Chest Res	g	16.6	18.7	32.9	22.7	8.9	39.0



Figure 3. Static OOP Test Setup (TMJ head skin and SAE-proposed Neck Wrap)

Table 3 compares the computed averages for each set of three tests. The column on the right computes the percent difference in average response between the two configurations.

Table 3. Average Responses and Percent Difference in Response

		standard head skin, no neck wrap	TMJ head skin, neck wrap	difference between standard and TMJ
		AVG	AVG	%
Neck Fx	N	-691.5	-777.6	12.5
Neck Fz	N	986.9	1029.1	4.3
Neck Moc	Nm	-34.3	-43.1	25.7
Head Res	g	20.7	20.5	-1.0
Chest Res	g	23.4	22.7	-3.0

For purposes of comparison to the results presented in Table 3, Table 4 contains average responses presented by GM at the 4/17/98 SAE Hybrid III Family meeting. GM conducted passenger OOP tests which also compared the standard head skin with the TMJ skin and neck wrap. Comparing Table 3 with Table 4, it is observed that the same trends were present in both the VRTC and GM data. That is, the neck responses for the TMJ head skin with the neck wrap were larger in magnitude than the standard configuration.

Table 4. GM Passenger OOP Results

		standard head skin, no neck wrap	TMJ head skin, neck wrap	difference between standard and TMJ
		AVG	AVG	%
Neck Fx	N	-1350	-1580	17.0
Neck Fz	N	1660	1790	7.8
Neck Moc	Nm	-50.8	-67.2	32.3
Head Res	g	36.6	40.7	11.2
Chest Res	g	27.3	26.7	-2.2

Review of the high speed films of the OOP events and post-test observations of the air bag cushion indicate that, in the case of the standard configuration head skin, the cushion is inflating into the chin cavity area. Furthermore, the cushion snags slightly behind the jaw as the dummy begins to move rearward in the vehicle. With the TMJ head skin and the neck wrap, the cushion does not penetrate the chin cavity region. Also, the TMJ feature of the head skin, with its improved jaw-line, prevents the cushion from snagging behind the jaw as it did in the standard head skin configuration. Thus,

even though the TMJ-neck wrap configuration had an effect on the responses, it contained some desirable features.

As a result of these findings, it was determined that additional testing would be required to better understand the effects of the TMJ-neck wrap system. VRTC conducted six additional driver OOP tests using the '98 Ford Explorer driver system in the ISO 1 position. Of the six tests, three utilized the TMJ skin without a neck wrap, two utilized the TMJ skin with an alternative neck wrap (SB wrap), and one test was conducted using the standard head skin and no neck wrap. The purpose of repeating the standard configuration was to evaluate the variability of the airbag performance by comparing the results to the original standard configuration results which had been conducted several weeks prior and with a different manufacturing lot of airbags.. Table 5 below contains the results for the repeat standard configuration test (test #58). Comparing the responses in Table 5 with the results in Table 1 shows that the responses were relatively consistent between the two lots of airbags.

Table 5. OOP Test Results for Test #58, Standard Head Skin and No Neck Wrap

test # 043400--		58
Neck Fx	N	-731.0
Neck Fz	N	1137.3
Neck Moc	Nm	-31.9
Head Res	g	27.7
Chest Res	g	23.6

Table 6 contains the responses for the three tests which utilized the TMJ skin and no neck wrap, while Table 7 summarizes the results of the two tests which utilized the TMJ skin with the SB neck wrap. The alternative material in the SB neck wrap was a noticeably softer and lighter open-celled foam which was wrapped around the neck. A single 4 inch strip of duct tape was used to hold the material around the neck.

Table 6. OOP Test Results for TMJ Skin and No Neck Wrap

test # 043400--		54	55	56	AVG	STDEV	%CV
Neck Fx	N	-611.8	-557.0	-641.2	-603.3	42.7	7.1
Neck Fz	N	1159.0	1017.0	950.9	1042.3	106.3	10.2
Neck Moc	Nm	-26.4	-25.6	-29.6	-27.2	2.1	7.8
Head Res	g	27.9	28.4	25.5	27.3	1.6	5.7
Chest Res	g	22.8	39.1	36.6	32.8	8.8	26.7

Table 7. OOP Test Results for TMJ Skin and SB Neck Wrap

test # 043400--		57	59	AVG	STDEV	%CV
Neck Fx	N	-675.0	-706.0	-690.5	21.9	3.2
Neck Fz	N	1075.0	937.6	1006.3	97.2	9.7
Neck Moc	Nm	-32.2	-37.1	-34.7	3.5	10.0
Head Res	g	24.4	25.6	25.0	0.8	3.4
Chest Res	g	25.6	25.2	25.4	0.3	1.1

Table 8 compares the average results of the three configurations which utilized the TMJ head skin to the average results of all the standard configuration tests. Table 8 contains the percent difference of the average response for each TMJ configuration relative to the standard configuration.

Table 8. Percent Difference of Average Neck Responses Relative to Standard Configuration

	SAE Neck Wrap	No Neck Wrap	SB Neck Wrap
Neck Fx	10.9	-14.0	-1.6
Neck Fz	0.5	1.7	-1.8
Neck Moc	27.9	-19.3	2.8

As Table 8 indicates, the neck shear and moment responses increase when the SAE-proposed neck wrap is used and decrease when no neck wrap is used (when both conditions are used with the TMJ head skin). When the SB neck wrap is used, there is only 2-3% difference in neck responses as compared to the standard configuration.

Figures 4 and 5 are bar charts of the neck responses for each test. Figure 4 shows the neck shear loads and Figure 5 contains the neck moment about the occipital condyle.

Calibration Testing

In Fall '97, VRTC conducted standard neck calibration tests with two configurations: (1) the standard configuration head and neck and (2) the standard head skin with a soft foam chin insert and the SAE-proposed neck wrap. This neck wrap was the same as the one used in the OOP testing in conjunction with the TMJ skin. Three tests were conducted for each condition - flexion with neck skin, flexion without neck skin, extension with neck skin, and extension without neck skin - for a total of 12 tests.

Tables 9 and 10 summarize the results of the tests.

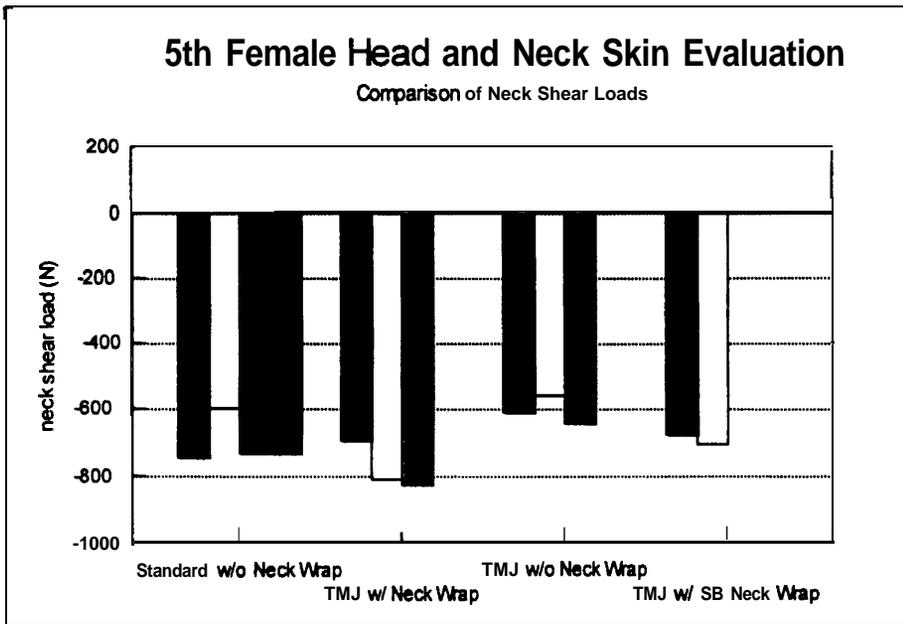


Fig. 4. 5th Female Head and Neck Skin Evaluation

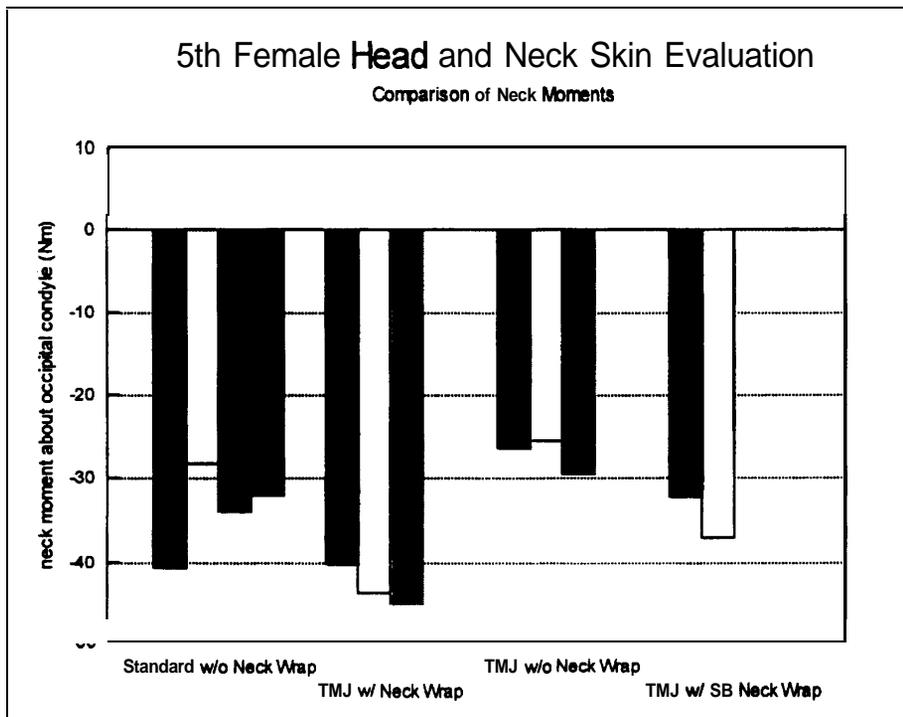


Fig. 5. 5th Female Head and Neck Skin Evaluation

Table 9.a. Neck Extension Tests With Neck Skin

performance criteria	ext #1	ext #2	ext #3	avg	std.dev.	% cv
peak D-plane rotation	102.7	103.0	101.6	102.4	0.74	0.72
rotation angle at - 10 Nm	80.8	80.6	78.9	80.1	1.04	1.30
peak moment about condyle	-59.1	-60.8	-62.2	-60.7	1.55	2.56
moment decay time from peak to -10 Nm	34.6	34.0	35.0	34.5	0.5	1.46
time to peak rotation after peak moment	7.6	7.9	5.1	6.9	1.54	22.39

Table 9.b. Neck Extension Tests Without Neck Skin

performance criteria	ext #4	ext #5	ext #6	avg	std.dev.	% cv
peak D-plane rotation	102.2	103.4	104.0	103.2	0.92	0.89
rotation angle at - 10 Nm	83.1	82.1	80.4	81.9	1.37	1.67
peak moment about condyle	-54.8	-62.2	-65.4	-60.8	5.44	8.94
moment decay time from peak to -10 Nm	33.9	33.6	35.6	33.9	1.62	4.77
time to peak rotation after peak moment	9.5	9.8	6.3	8.5	1.94	22.73

Table 10.a. Neck Flexion Test With Neck Skin

performance criteria	flx #1	flx #2	flx #3	avg.	std.dev.	% cv
peak D-plane rotation	82.5	84.8	86.8	84.7	2.15	2.54
rotation angle decay time from peak to 0	60.7	60.7	63.7	61.7	1.73	2.81
peak moment about condyle	72.5	74.7	73.8	73.7	1.11	1.50
moment decay time from peak to 0 Nm	41.8	42.5	39.6	41.3	1.51	3.66
time to peak rotation after peak moment	4.1	3.2	2.6	3.3	0.75	22.88

Table 10.b. Neck Flexion Test Without Neck Skin

performance criteria	flx #4	flx #5	flx #6	avg.	std.dev.	% cv
peak D-plane rotation	86.3	86.9	86.9	86.7	0.35	0.40
rotation angle decay time from peak to 0	63.3	62.1	62.2	62.5	0.67	1.06
peak moment about condyle	73.7	75.2	75.7	74.9	1.04	1.39
moment decay time from peak to 0 Nm	40.2	39.8	40.1	40.0	0.21	0.52
time to peak rotation after peak moment	2.8	3.4	3.6	3.3	0.42	12.74

Figures 6 and 7 are graphical representations of the extension and flexion responses. Review of Tables 9 and 10 and Figures 6 and 7 indicate that there was no significant difference between the response with and without the neck skin when used with the standard head skin.

Conclusions and Comments

The results of the calibration testing indicate that the SAE-proposed neck wrap has no significant effect on the neck responses. However, the static OOP testing presents results which are contradictory to this conclusion. The OOP test results demonstrate that the SAE-proposed neck wrap does indeed have a significant effect on the neck responses. On the other hand, the visual observations from the OOP tests illustrate the improvements of the TMJ head skin in preventing the cushion from getting into the chin cavity and snagging on the rearward edge of the jaw-line. In this regard, the TMJ head skin appears to be an improvement. In OOP tests with the TMJ head skin only (no neck wrap) the responses were, on average, lower than those seen in tests in which the standard head skin and neck were used. This may be attributed to the observation that the TMJ head skin prevents the cushion from expanding into the chin cavity which may in turn generate unrealistic loading in the standard configuration.

As a result of these findings, VRTC recommends incorporating the TMJ head skin into the Hybrid III small female. However, VRTC has not determined the need for the neck wrap and further testing may be required to better understand its role and its effect on neck responses.

Neck Extension Response

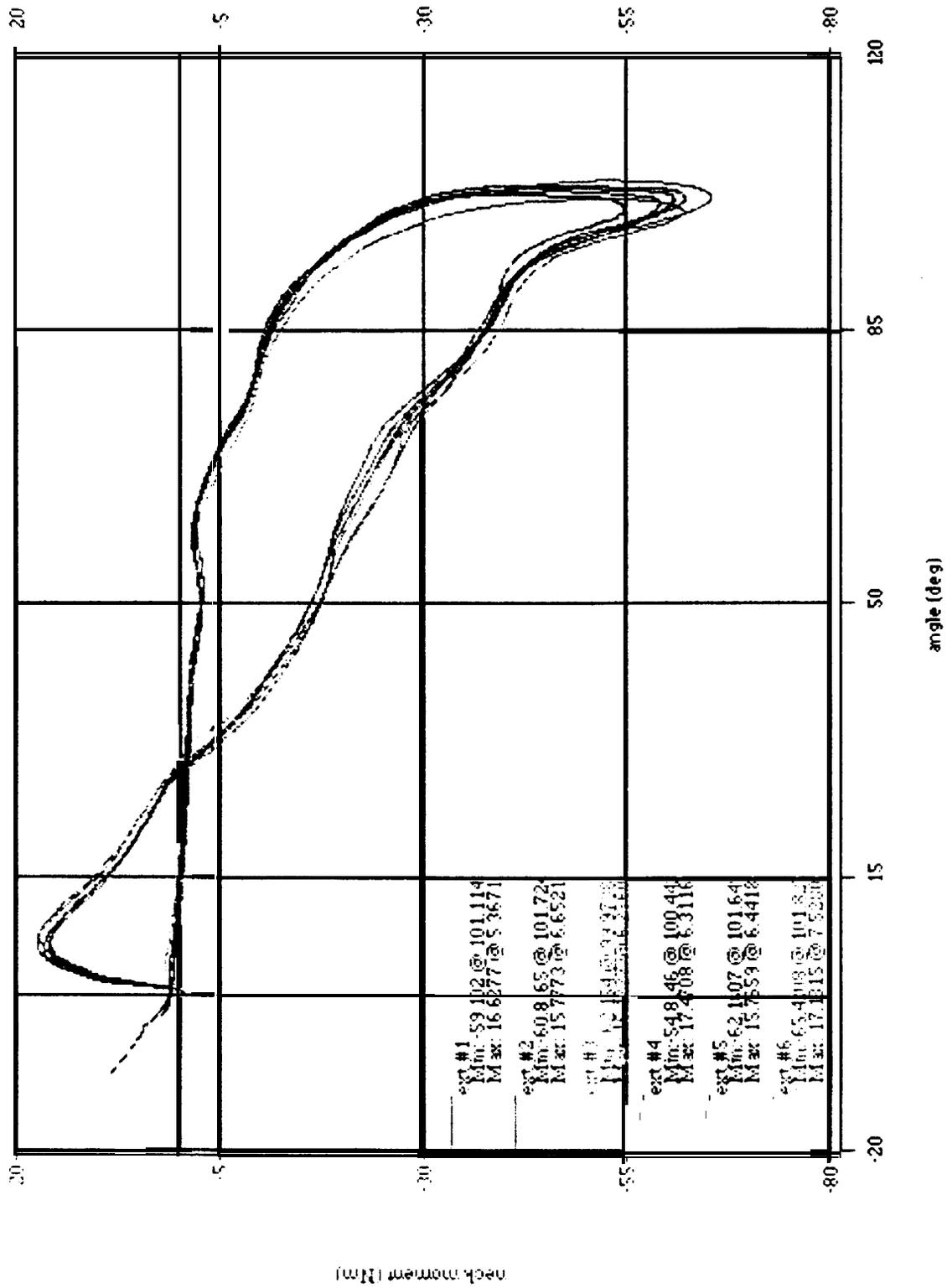


Fig. 6. Neck Extension Response

Neck Flexion Response

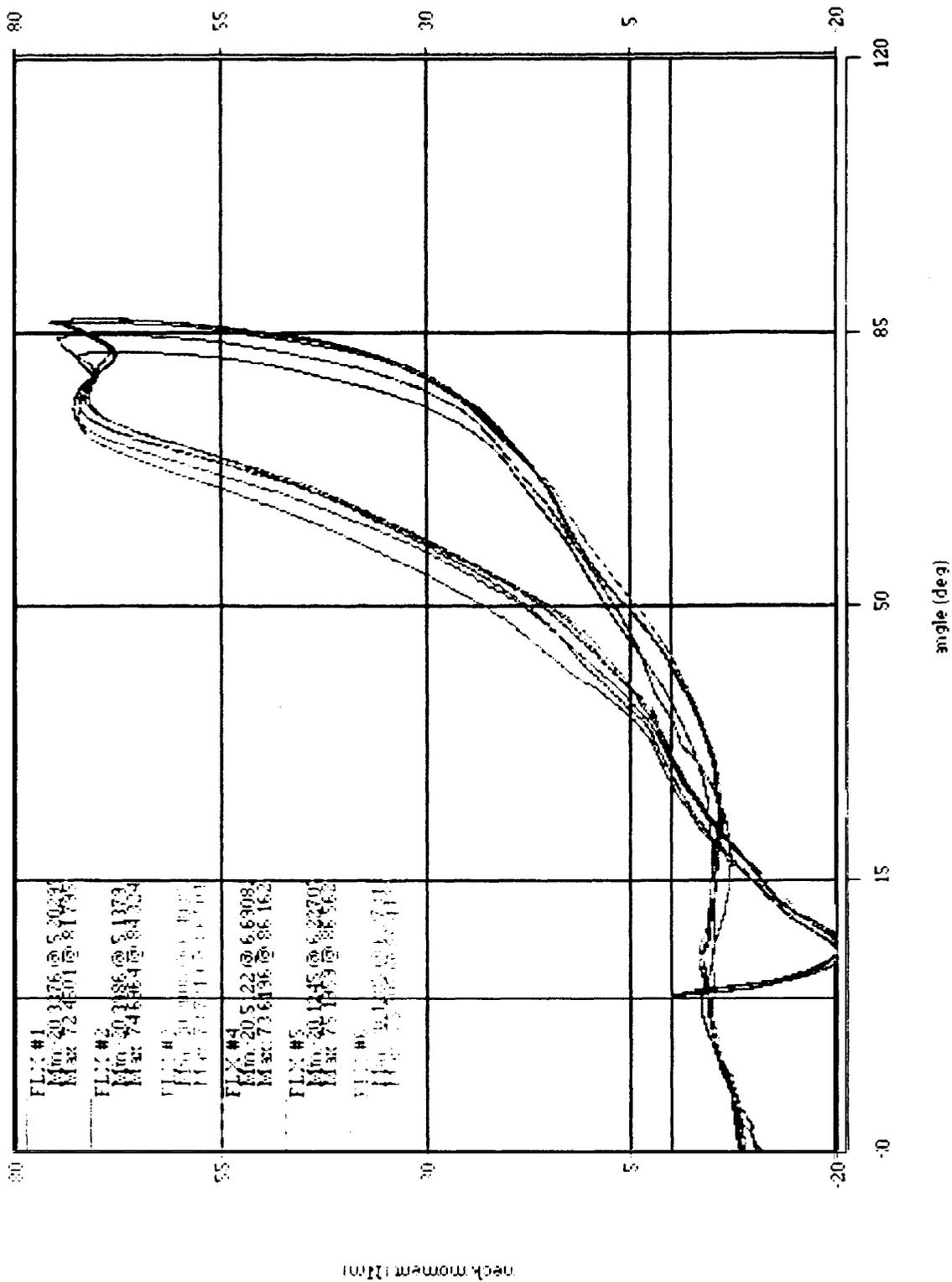


Fig. 7. Neck Flexion Response