VRTC Biofidelity Evaluation of WorldSID-05F with mod kit and SID-IIs BLD

Presentation to WorldSID-05F TEG
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Biofidelity History

ISO 9790 Ranking System and Tests

Dummy	WS 5th				SID-IIs
Dummy Version	Prototype	Rev 1		Mod Kit	BLD
Reference	Been et al.	Eggers et al.	Eggers et al., corrected	WS5th Biofidelity Improvement TG meeting^	OSRP SID-IIs Upgrade Task Group minutes
Date/Year	2007	2009	2021	10/18/2016	5/25/2006
Biofidelity Corridors Used	Irwin 2002	Irwin 2002	Irwin 2002	Irwin 2002	Irwin 2002
Head	10*	10	Same	10***	7.5
Neck	4.9*	6.5**	Same	5.3	5.1
Shoulder	5.0*	7.4	Same	5.4	5.8
Thorax	5.6*	~~6.9~~	5.3 or 6.0	5.7	6.6
Abdomen	8.5*	8.5	Same	6.1	7.7
Pelvis	5.6*	6.5	Same	4.6	4.3
Overall	**6.7***	**7.6**	**7.2 or 7.4**	**6.2**	**6.2**

*dummy data was normalized

**prototype data from Been et al. evaluated using different scaled response corridors

***head score was taken from Eggers et al., 2009

^Scores came from meeting attachment "ISO WS 5th Biofidelity Testing OSRP Update Plots and Scores 2NOV2016.pdf"

Biofidelity Score	ISO Biofidelity Rating
8.6 ≤ B ≤ 10	Excellent
6.5 ≤ B < 8.6	Good
4.4 ≤ B < 6.5	Fair
2.6 ≤ B < 4.4	Marginal
0.0 ≤ B < 2.6	Unacceptable

Biofidelity History

Equivalent ISO 9790 Tests

Dummy	WS 5th						WS 5th	SID-IIs
Dummy Version	Rev 1			Mod Kit			Mod Kit	BLD
Reference	Crawford et al., 2017	Crawford corrected	With additional tests	Crawford et al., 2017	Crawford corrected	With additional tests	WS5th Biofidelity Improvement TG meeting 10/18/2016	OSRP SID-IIs Upgrade TG Draft Meeting Minutes 5/25/2006, recalculated for equivalent tests
Head	10	same	n/a	Not tested	same	n/a	10[a]*	7.5[a]
Neck	Not tested	same	n/a	5.3	same	n/a	5.3[b]	5.1[b]
Shoulder	7.1[a]	same	6.7[e]	~~7.1[a]~~	~~same~~	5.0[e]	5.4[c]	6.2[c]
Thorax	5.5[b]	same	4.3[f]	~~6.0[b]~~	~~same~~	5.3[f]	5.7[d]	7.0[d]
Abdomen	5.0[c]	same	5.0[c]	5.0[c]	same	5.0[c]	6.1[e]	6.8[e]
Pelvis	~~8.1[d]~~	8.6[d]	5.9[g]	~~7.9[d]~~	~~4.2[d]~~	4.3[g]	4.6[f]	4.5[f]
Overall w\out head & neck	**6.3**	**6.5**	**5.3**	**6.4**	**5.5**	**4.9**		
Overall							**6.2**	**6.2**

[a] Results from Shoulder Test 1
[b] Results from Thorax Test 5
[c] Results from Abdomen Test 3
[d] Results from Pelvis Tests 1 & 10
[e] Results from Shoulder Tests 1 & 2
[f] Results from Thorax Tests 1, 2, & 5
[g] Results from Pelvis Tests 1, 7, & 10

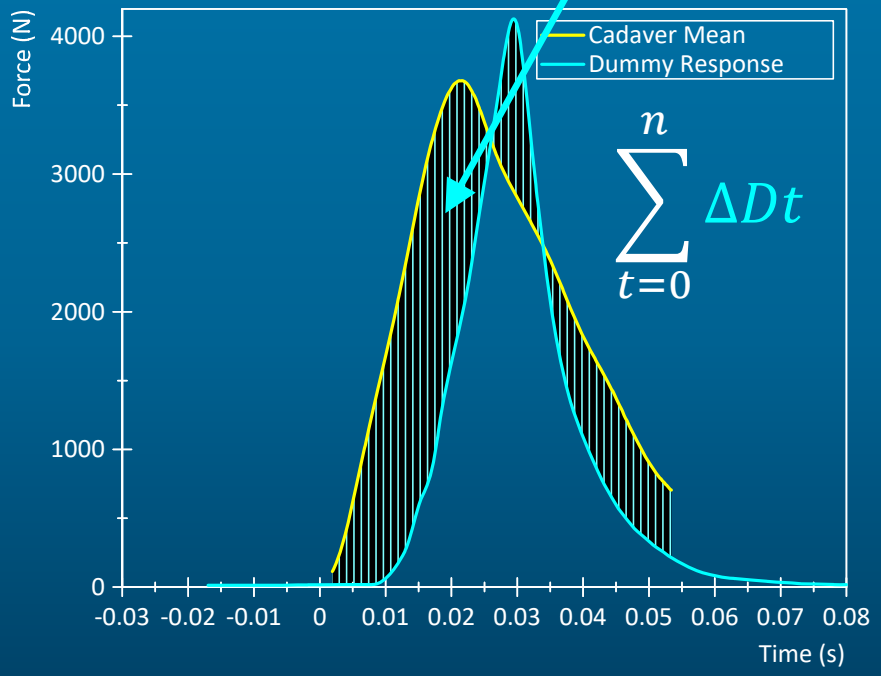
*head score taken from Eggers et al., 2009
[a] Results from Head Test 1
[b] Results from Neck Tests 1-3
[c] Results from Shoulder Tests 1-3
[d] Results from Thorax Tests 1-3, 5
[e] Results from Abdomen Tests 1, 3
[f] Results from Pelvis Tests 1, 3, 4, 7, 10

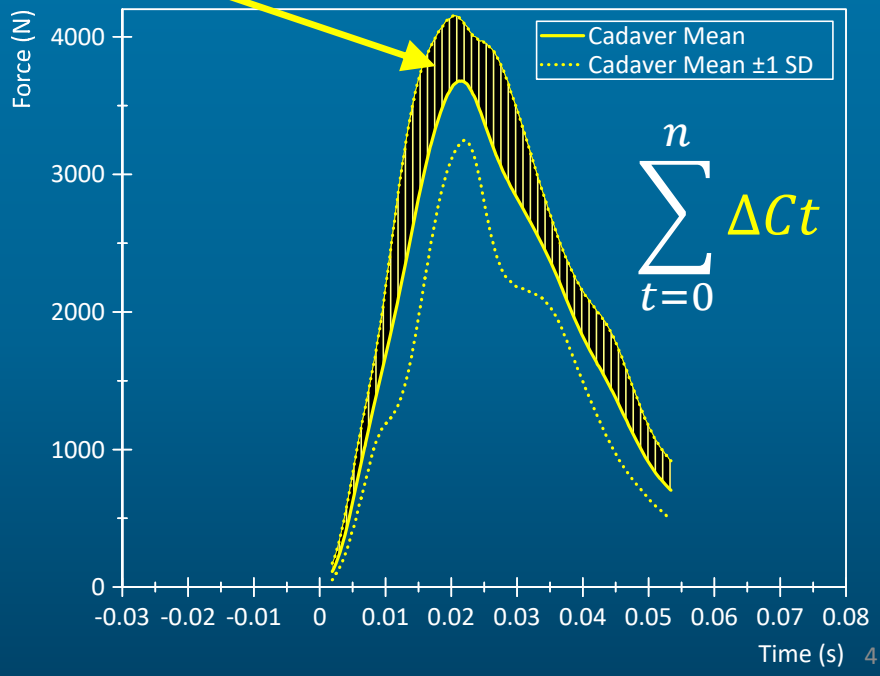
WS-05F Mod kit dummy needs biofidelity improvement

NHTSA Biofidelity Evaluation

Shape and Magnitude

$$SM = \frac{DCAD}{CCSD} = \frac{Dummy\ Cumulative\ Absolute\ Difference}{Cadaver\ Cumulative\ Standard\ Deviation}$$





NHTSA Biofidelity Evaluation

Shape and Magnitude → $SM = \frac{DCAD}{CCSD} = \frac{Dummy\ Cumulative\ Absolute\ Difference}{Cadaver\ Cumulative\ Standard\ Deviation}$

- SM calculated between t_0 and the time of the cadaver mean peak
- Dummy curve was repetitively shifted with respect to the cadaver mean curve to find the minimum SM
- If dummy curve peak was not included in calculation period, calculation period was increased in increments until the dummy curve peak was included
- As supplemental information, the dummy phase shift required to minimize SM was also reported

Peak Only

- Comparison of the dummy response peak to the cadaver mean peak
- No phase shift of dummy curve
- As supplemental information, the difference of time of peak between cadaver and dummy are also reported

$$\frac{Abs(Dummy\ Response\ Peak\ -\ Cadaver\ Mean\ Peak)}{Cadaver\ Std.\ Dev._{Avg.\ upper\ 80\%\ of\ Cadaver\ Mean}}$$

NHTSA Biofidelity Evaluation

3 tests each
- WS-05F MK
- SID-IIs BLD

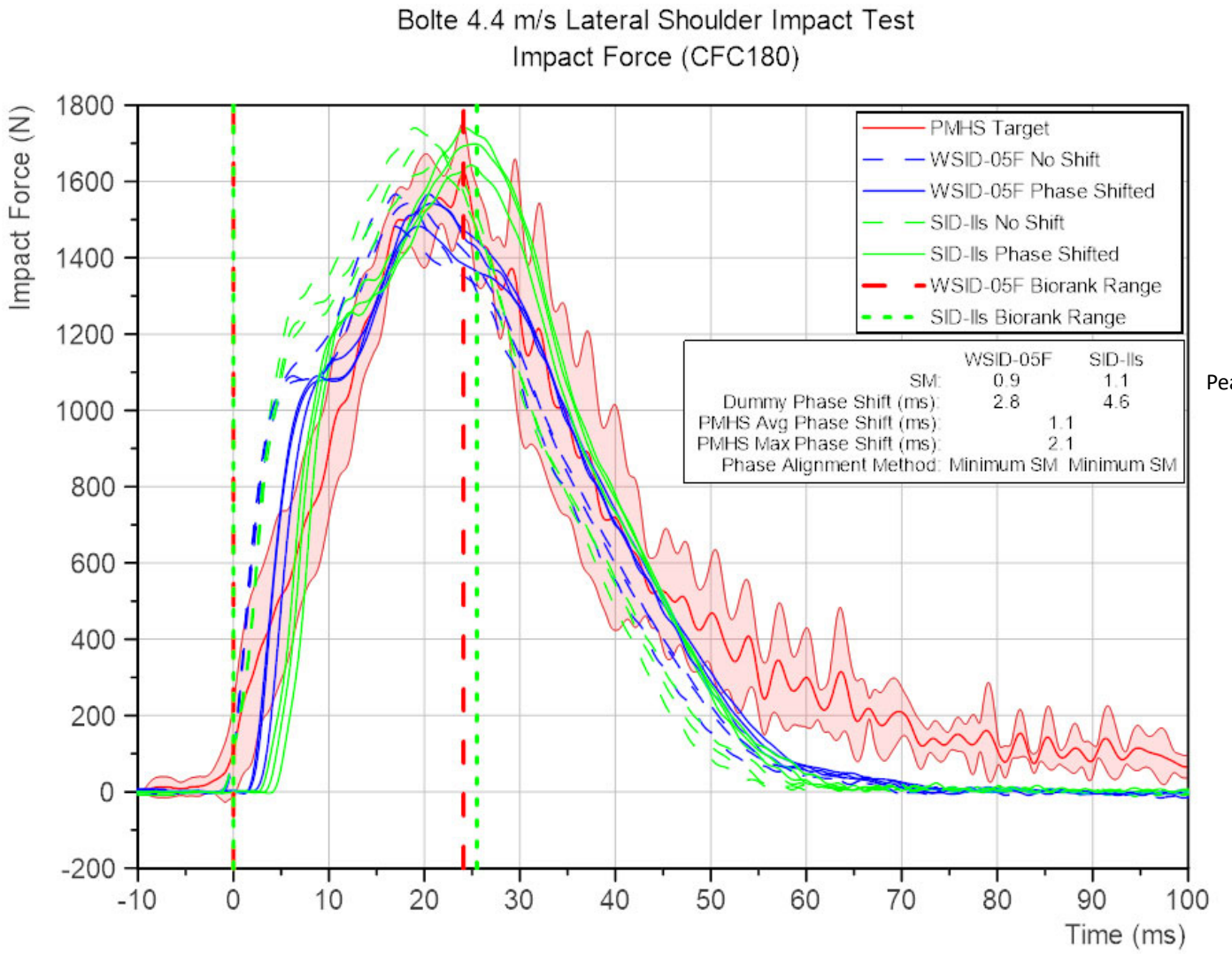
Body Region	Test Condition
Shoulder	4.4 m/s Bolte Lateral Impact
Thorax	2.5 m/s Shaw Lateral Impact
	2.5 m/s Shaw Oblique Impact
	4.5 m/s Rhule Lateral Impact
	4.5 m/s Rhule Oblique Impact
	6.7 m/s MCW Rigid-Wall Sled Test
	6.7 m/s MCW Padded-Wall Sled Test
	8.9 m/s MCW Padded-Wall Sled Test
Abdomen	6.7 m/s MCW Rigid-Wall Sled
	6.7 m/s MCW Padded-Wall Sled
	8.9 m/s MCW Padded-Wall Sled
	6.7 m/s MCW Abdomen-Offset Sled
Pelvis	6.7 m/s MCW Rigid-Wall Sled
	6.7 m/s MCW Padded-Wall Sled
	8.9 m/s MCW Padded-Wall Sled
	6.7 m/s MCW Pelvis-Offset Sled

Results of NHTSA Biofidelity Evaluation

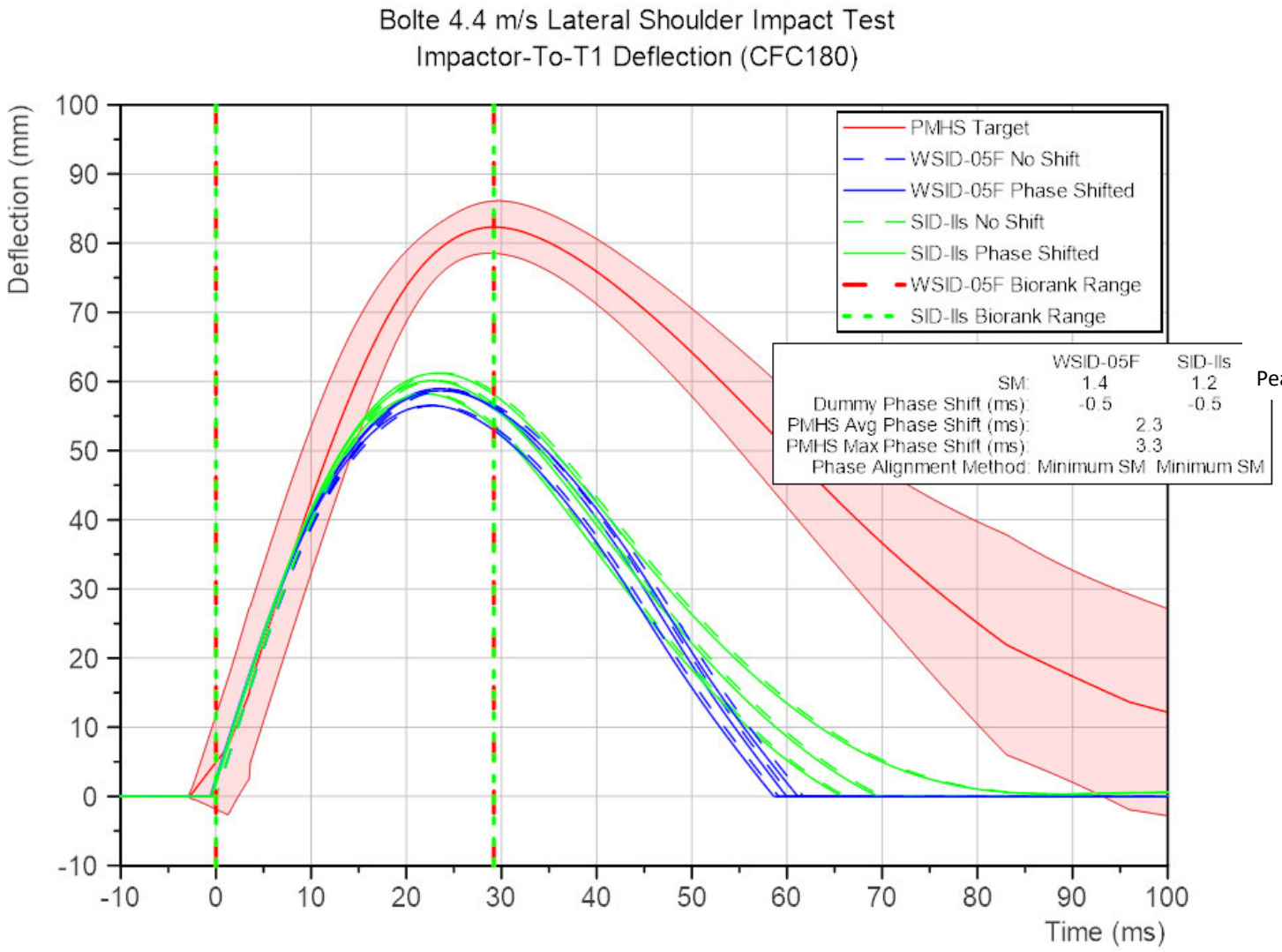
Biofidelity Results

Method	SM	SM	Peak Only	Peak Only	ISO 9790	ISO 9790
Dummy	WS 5th	SID-IIs	WS 5th	SID-IIs	WS 5th	SID-IIs
Dummy Version	Mod Kit	BLD	Mod Kit	BLD	Mod Kit	BLD
Head	n/a	n/a	n/a	n/a	10	7.5
Neck	n/a	n/a	n/a	n/a	5.3	5.1
Shoulder	1.1	1.2	3.0	2.7	5.4	6.2
Thorax	3.0	2.0	6.8	4.2	5.7	7.0
Abdomen	1.3	1.3	2.9	3.4	6.1	6.8
Pelvis	1.3	1.8	2.5	3.6	4.6	4.5
Overall	**1.7**	**1.5**	**3.8**	**3.5**	**6.2**	**6.2**
	Lower is better biofidelity				Higher is better biofidelity	

WorldSID thorax definitely needs improved biofidelity



	WS-05F	SID-IIs
Peak only	0.8	0.6



	WS-05F	SID-IIs
Peak only	5.3	4.9

SM

Body Region	Test Condition	Measurement	PMHS Avg Phase Shift (ms)	PMHS Max Phase Shift (ms)	WorldSID-05F SM	WorldSID-05F Phase Shift (ms)	SID-IIs SM	SID-IIs Phase Shift (ms)
Shoulder	4.4 m/s Bolte Lateral Impact	Impactor Force	1.1	2.1	0.9	2.8	1.1	4.6
		Impactor-To-T1 Deflection	2.3	3.3	1.4	-0.5	1.2	-0.5
		Test Condition Avg.			1.1		1.2	
	Shoulder Avg.				1.1		1.2	

Peak Only

Body Region	Test Condition	Measurement	Target Mean Peak	Target Std. Dev.	Target Mean Peak Time	WorldSID-05F Dummy Peak	WorldSID-05F Dummy Peak Time	WorldSID-05F Peak DAD/CSD	WorldSID-05F Dummy Peak Time Diff.	SID-IIs Dummy Peak	SID-IIs Dummy Peak Time	SID-IIs Peak DAD/CSD	SID-IIs Dummy Peak Time Diff.
Shoulder	4.4 m/s Bolte Lateral Impact	Impactor Force	1623	116	24.1	1530	17.4	0.8	-6.7	1694	20.2	0.6	-3.9
		Impactor-To-T1 Deflection	82	5	29.2	58	23.7	5.3	-5.5	60	23.1	4.9	-6.1
		Test Condition Average						3.0				2.7	
	Shoulder Avg.							3.0				2.7	

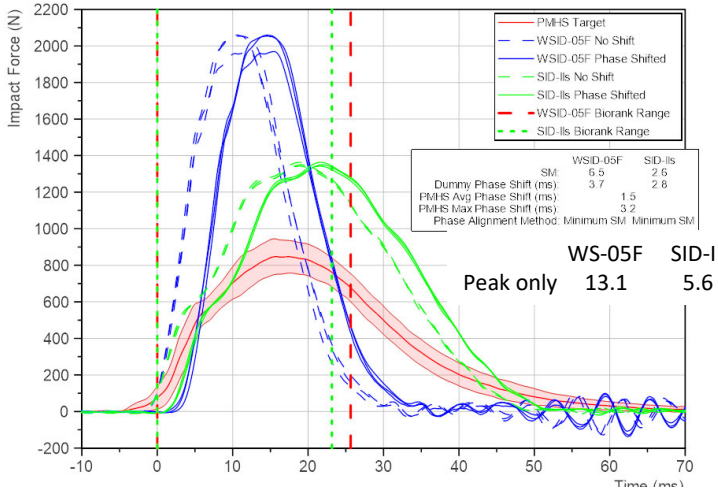
SM

Body Region	Test Condition	Measurement	PMHS Avg Phase Shift (ms)	PMHS Max Phase Shift (ms)	WorldSID-05F SM	WorldSID-05F Phase Shift (ms)	SID-IIs SM	SID-IIs Phase Shift (ms)
Thorax	2.5 m/s Shaw Lateral Impact	Impactor Force	1.5	3.2	6.5	3.7	2.6	2.8
		Chest Band Deflection	2.4	4.9	1.3	8.2	5.1	7.7
		Test Condition Avg.			3.9		3.9	
	2.5 m/s Shaw Oblique Impact	Impactor Force	3.5	7.0	5.8	13.7	2.0	5.8
		Chest Band Deflection	3.4	6.7	3.0	4.5	1.7	4.3
		Test Condition Avg.			4.4		1.8	
	4.5 m/s Rhule Lateral Impact	Impactor Force	1.9	3.1	5.8	8.3	3.4	5.7
		Chest Band Deflection	1.7	2.1	0.7	8.4	0.7	9.1
		Test Condition Avg.			3.3		2.1	
	4.5 m/s Rhule Oblique Impact	Impactor Force	1.7	3.3	5.7	3.6	3.0	2.5
		Chest Band Deflection	1.9	3.8	4.2	5.0	1.3	5.4
		Test Condition Avg.			4.9		2.1	
	6.7 m/s Rigid-Wall Sled Test	Thorax Plate Force	3.1	6.3	3.3	14.2	3.1	5.1
		Upper Thorax Deflection	2.2	4.3	3.0	4.0	1.2	7.9
		Lower Thorax Deflection	2.3	4.3	0.7	11.1	0.3	9.4
		T1 Y-axis Acceleration	2.8	5.9	1.2	11.8	1.9	4.1
		T12 Y-axis Acceleration	1.9	2.3	1.6	7.3	1.4	1.0
		Test Condition Avg.			2.0		1.6	
	6.7 m/s Padded-Wall Sled Test	Thorax Plate Force	4.7	9.2	1.2	13.8	0.9	10.7
		Upper Thorax Deflection	4.6	6.9	2.6	4.1	2.0	15.8
		Lower Thorax Deflection	5.4	10.6	1.2	14.6	1.4	12.5
		T1 Y-axis Acceleration	6.4	9.7	0.9	4.0	0.9	8.5
		T12 Y-axis Acceleration	4.3	8.3	0.9	9.1	1.2	2.7
		Test Condition Avg.			1.4		1.3	
	8.9 m/s Padded-Wall Sled Test	Thorax Plate Force	3.1	6.0	1.7	12.8	0.5	4.1
		Upper Thorax Deflection	5.9	7.7	2.9	-0.9	1.9	4.7
		Lower Thorax Deflection	4.1	8.3	0.7	10.7	2.0	10.5
		T1 Y-axis Acceleration	3.6	7.5	0.3	6.4	0.4	3.2
		T12 Y-axis Acceleration	2.0	3.5	1.0	9.6	0.7	2.1
		Test Condition Avg.			1.3		1.1	
	Thorax Avg.				3.0		2.0	

Peak Only

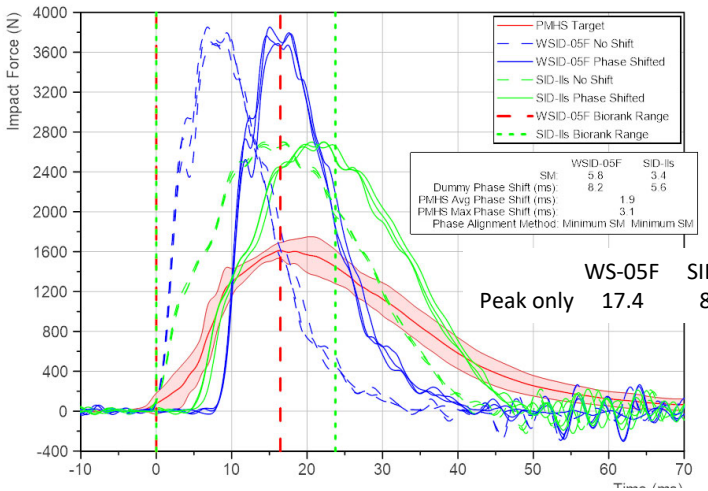
Body Region	Test Condition	Measurement	Target Mean Peak	Target Std. Dev.	Target Mean Peak Time	WorldSID-05F				SID-IIs			
						Dummy Peak	Dummy Peak Time	Peak DAD/CSD	Dummy Peak Time Diff.	Dummy Peak	Dummy Peak Time	Peak DAD/CSD	Dummy Peak Time Diff.
Thorax	2.5 m/s Shaw Lateral Impact	Impactor Force	847	90	15.7	2027	11.2	13.1	-4.5	1351	18.9	5.6	3.2
		Chest Band Deflection	26	1	24.9	28	12.3	1.8	-12.7	40	21.0	13.7	-3.9
		Test Condition Average						7.5				9.7	
	2.5 m/s Shaw Oblique Impact	Impactor Force	710	86	21.0	1941	12.3	14.3	-8.7	1084	22.0	4.4	1.0
		Chest Band Deflection	34	2	30.4	22	14.9	6.7	-15.5	30	26.2	2.5	-4.2
		Test Condition Average						10.5				3.4	
	4.5 m/s Rhule Lateral Impact	Impactor Force	1611	124	16.5	3778	8.0	17.4	-8.4	2699	16.0	8.7	-0.4
		Chest Band Deflection	44	3	25.1	37	10.9	2.8	-14.1	48	18.6	1.6	-6.4
		Test Condition Average						10.1				5.2	
	4.5 m/s Rhule Oblique Impact	Impactor Force	1740	128	16.0	3562	9.9	14.3	-6.1	2963	20.9	9.6	4.9
		Chest Band Deflection	43	1	24.8	30	10.6	9.3	-14.2	43	23.0	0.6	-1.8
		Test Condition Average						11.8				5.1	
	6.7 m/s Rigid-Wall Sled Test	Thorax Plate Force	3633	466	28.2	8193	14.2	9.8	-14.1	8565	23.2	10.6	-5.1
		Upper Thorax Deflection	71	8	38.8	28	22.2	5.5	-16.6	58	26.3	1.6	-12.5
		Lower Thorax Deflection	60	7	38.4	56	20.2	1.0	-18.2	61	24.2	0.1	-14.2
		T1 Y-axis Acceleration	56	12	23.7	46	8.7	0.9	-15.0	58	19.6	0.3	-4.1
		T12 Y-axis Acceleration	55	15	24.6	62	17.2	0.5	-7.3	58	23.6	0.2	-1.0
		Test Condition Avg.						3.5				2.6	
	6.7 m/s Padded-Wall Sled Test	Thorax Plate Force	2974	326	42.1	4360	26.9	4.3	-15.2	3851	28.0	2.7	-14.1
		Upper Thorax Deflection	57	11	51.7	18	35.0	3.4	-16.7	29	38.7	2.5	-12.9
		Lower Thorax Deflection	66	8	51.9	48	33.4	2.2	-18.6	45	34.1	2.6	-17.8
		T1 Y-axis Acceleration	40	21	37.9	28	33.9	0.5	-4.0	26	29.5	0.7	-8.5
		T12 Y-axis Acceleration	50	22	33.7	41	24.5	0.4	-9.1	37	31.0	0.6	-2.7
		Test Condition Avg.						2.2				1.8	
	8.9 m/s Padded-Wall Sled Test	Thorax Plate Force	5196	836	34.9	8392	22.6	3.8	-12.2	4939	26.0	0.3	-8.9
		Upper Thorax Deflection	73	10	50.9	25	29.3	4.7	-21.6	36	31.7	3.7	-19.2
		Lower Thorax Deflection	66	11	45.4	52	30.1	1.3	-15.4	28	20.4	3.4	-25.0
		T1 Y-axis Acceleration	45	19	30.7	49	24.0	0.2	-6.8	41	26.6	0.2	-4.1
		T12 Y-axis Acceleration	71	25	29.0	68	23.3	0.1	-5.7	54	25.6	0.7	-3.4
		Test Condition Avg.						2.0				1.7	
	Thorax Avg.							6.8				4.2	

2.5 m/s Shaw Lateral Impact Test
Impact Force (CFC180)



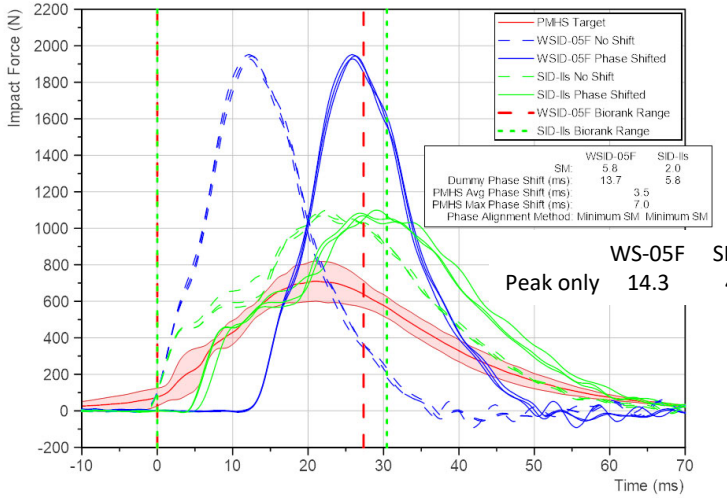
	WS-05F	SID-IIs
Peak only	13.1	5.6

4.5 m/s Rhule Lateral Impact Test
Impact Force (CFC180)



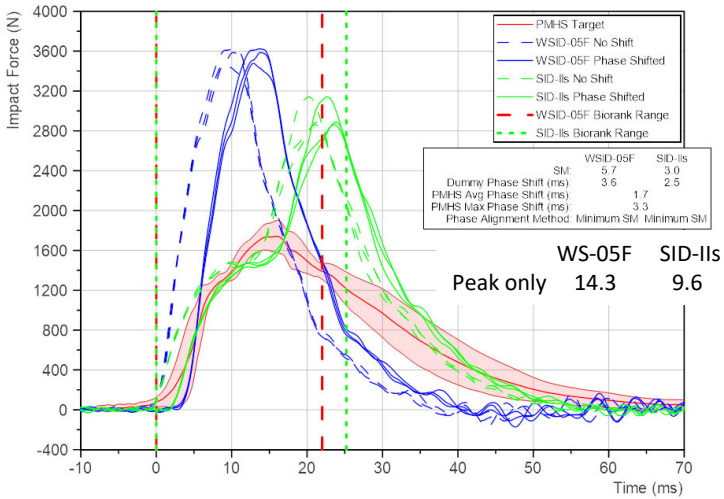
	WS-05F	SID-IIs
Peak only	17.4	8.7

2.5 m/s Shaw Oblique Impact Test
Impact Force (CFC180)

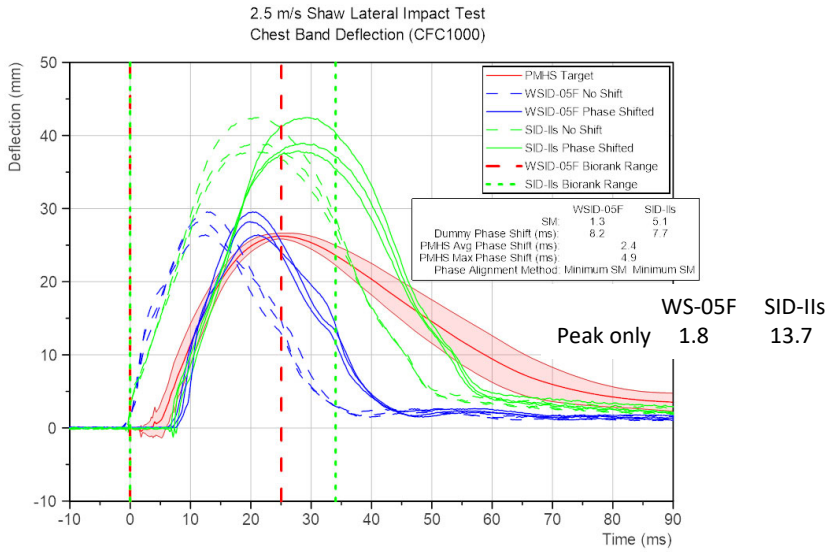


	WS-05F	SID-IIs
Peak only	14.3	4.4

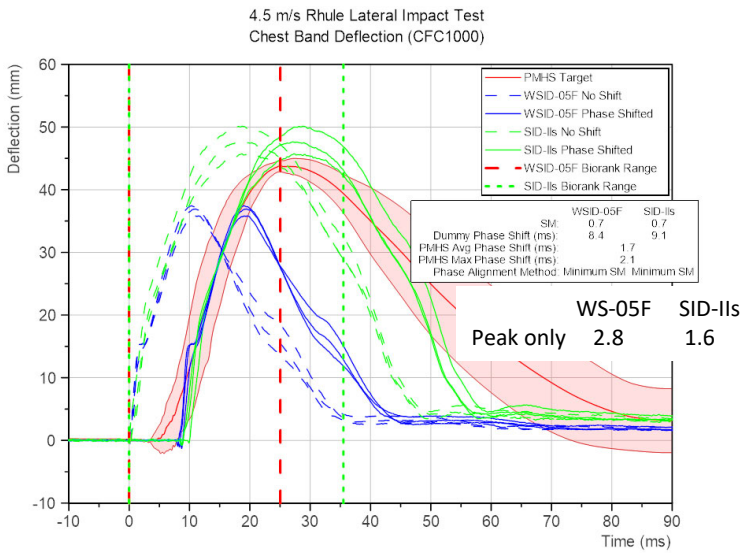
4.5 m/s Rhule Oblique Impact Test
Impact Force (CFC180)



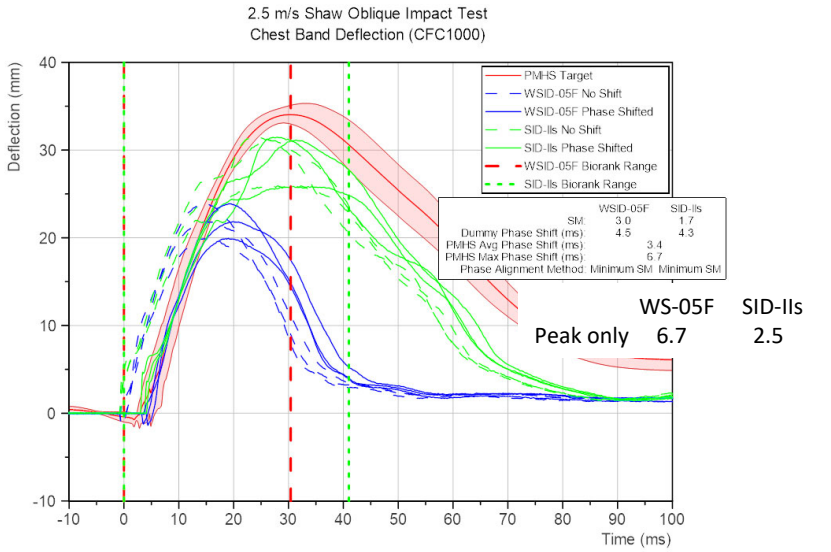
	WS-05F	SID-IIs
Peak only	14.3	9.6



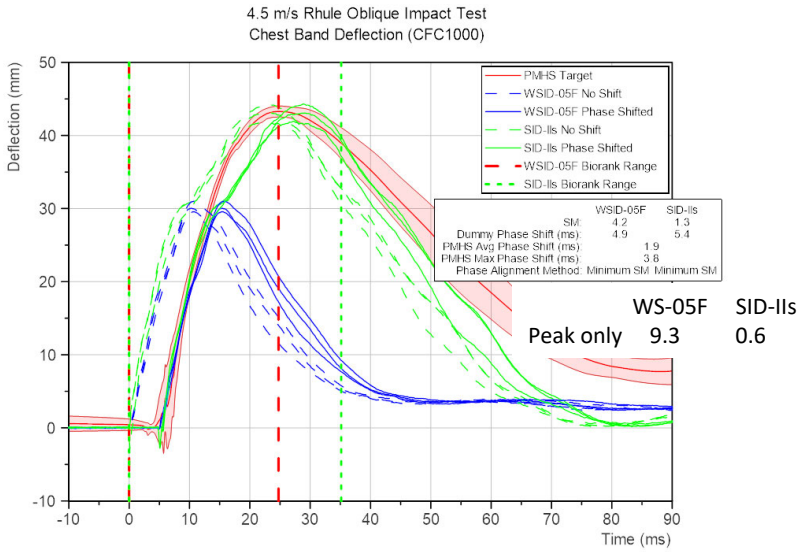
	WS-05F	SID-IIs
Peak only	1.8	13.7



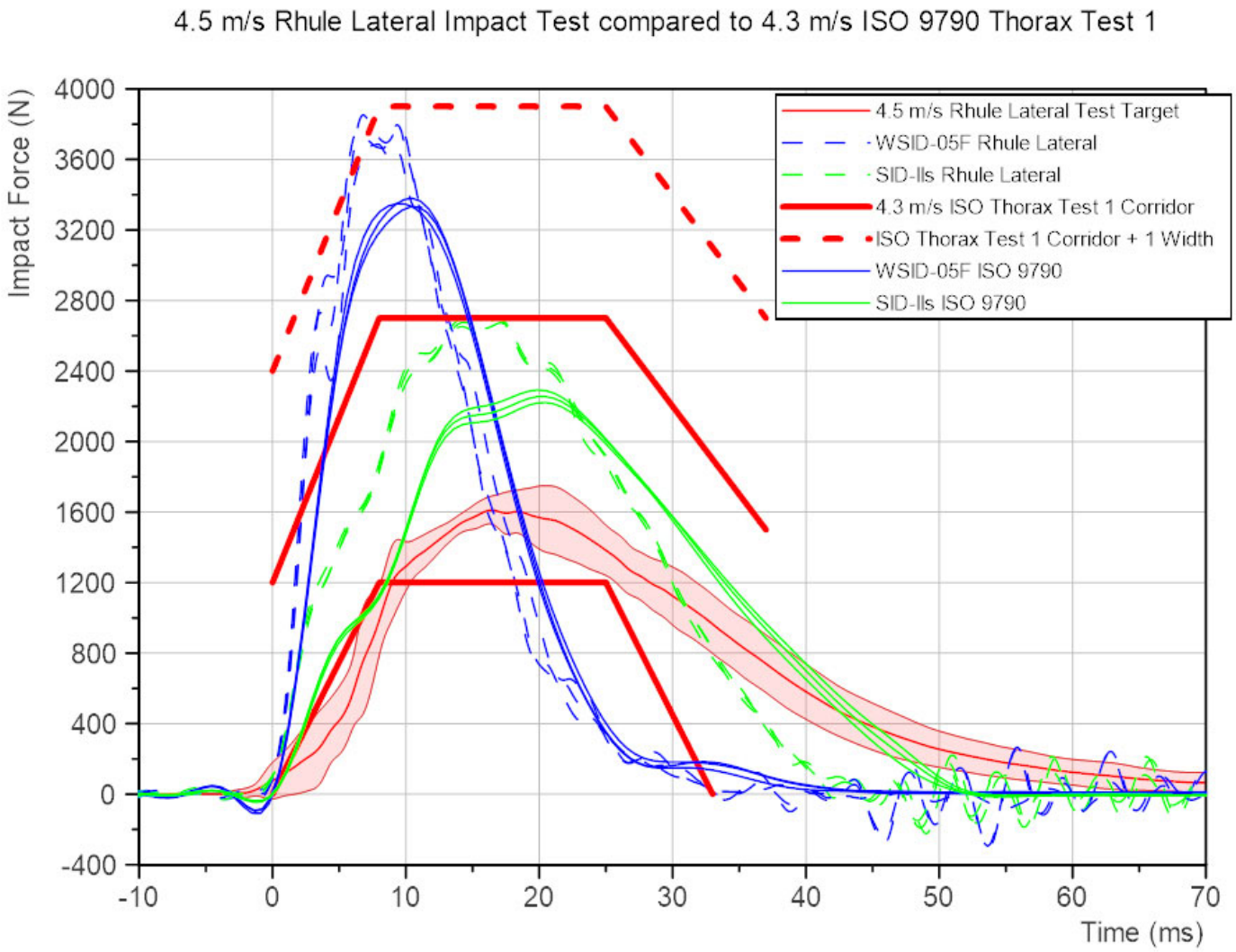
	WS-05F	SID-IIs
Peak only	2.8	1.6



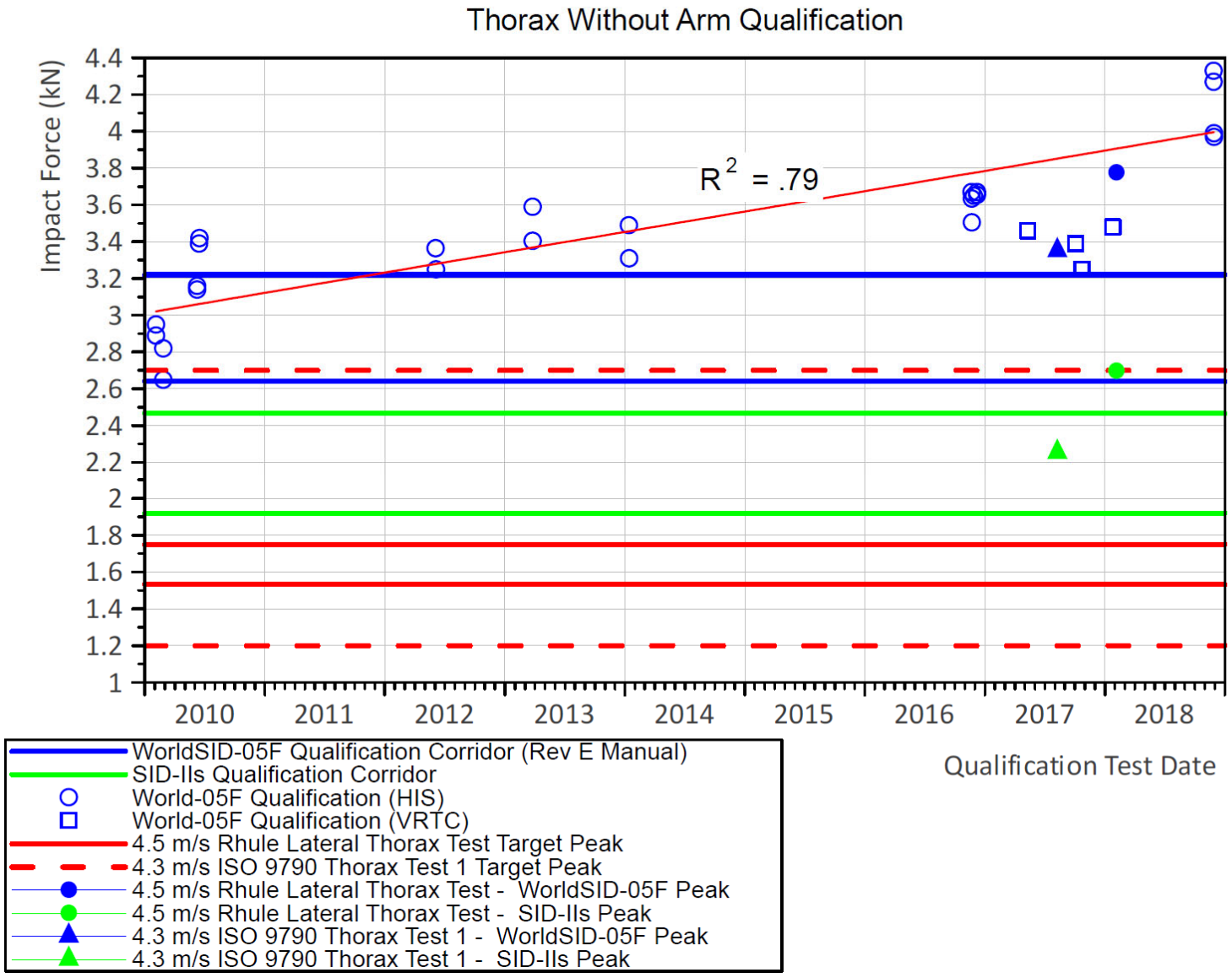
	WS-05F	SID-IIs
Peak only	6.7	2.5

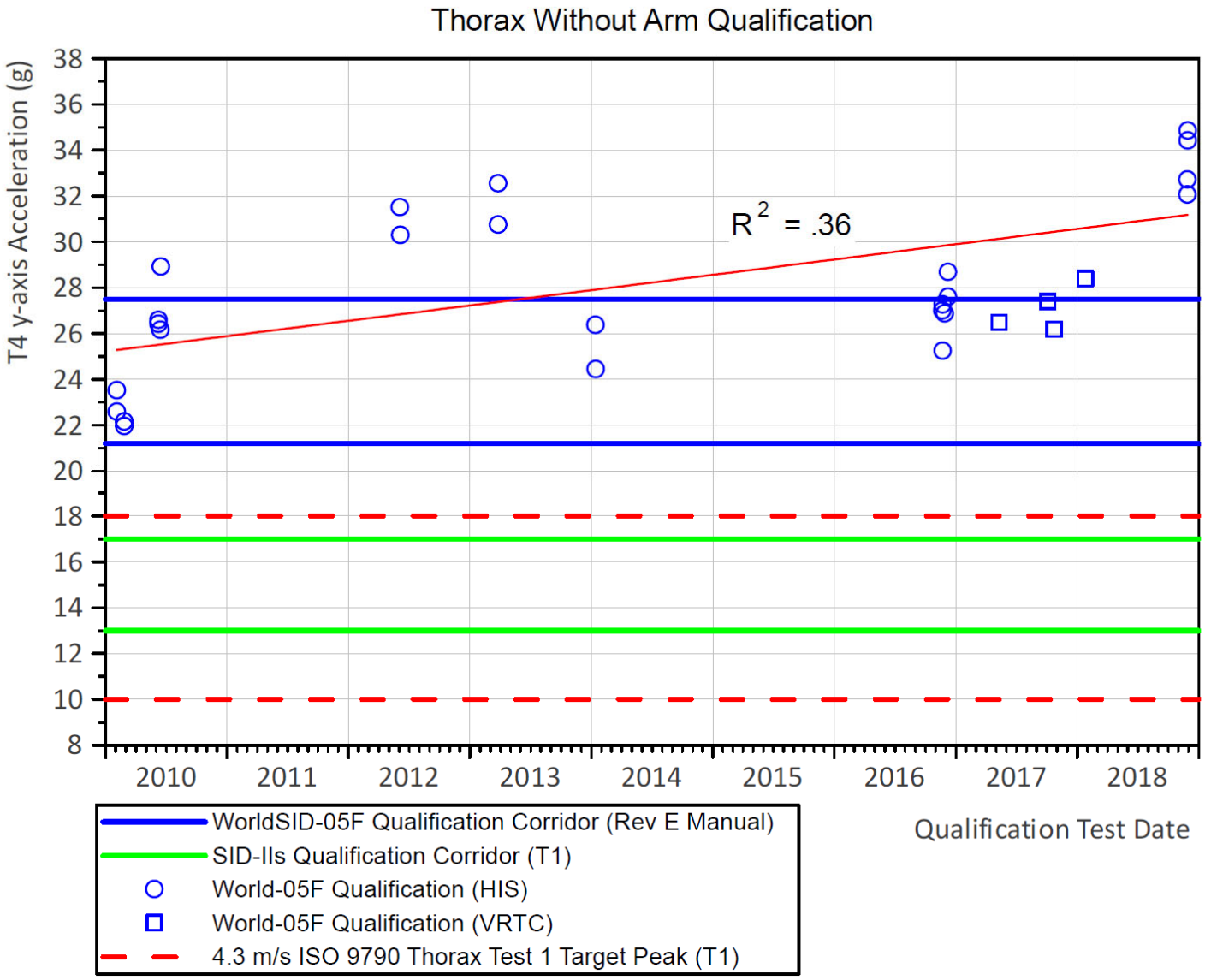


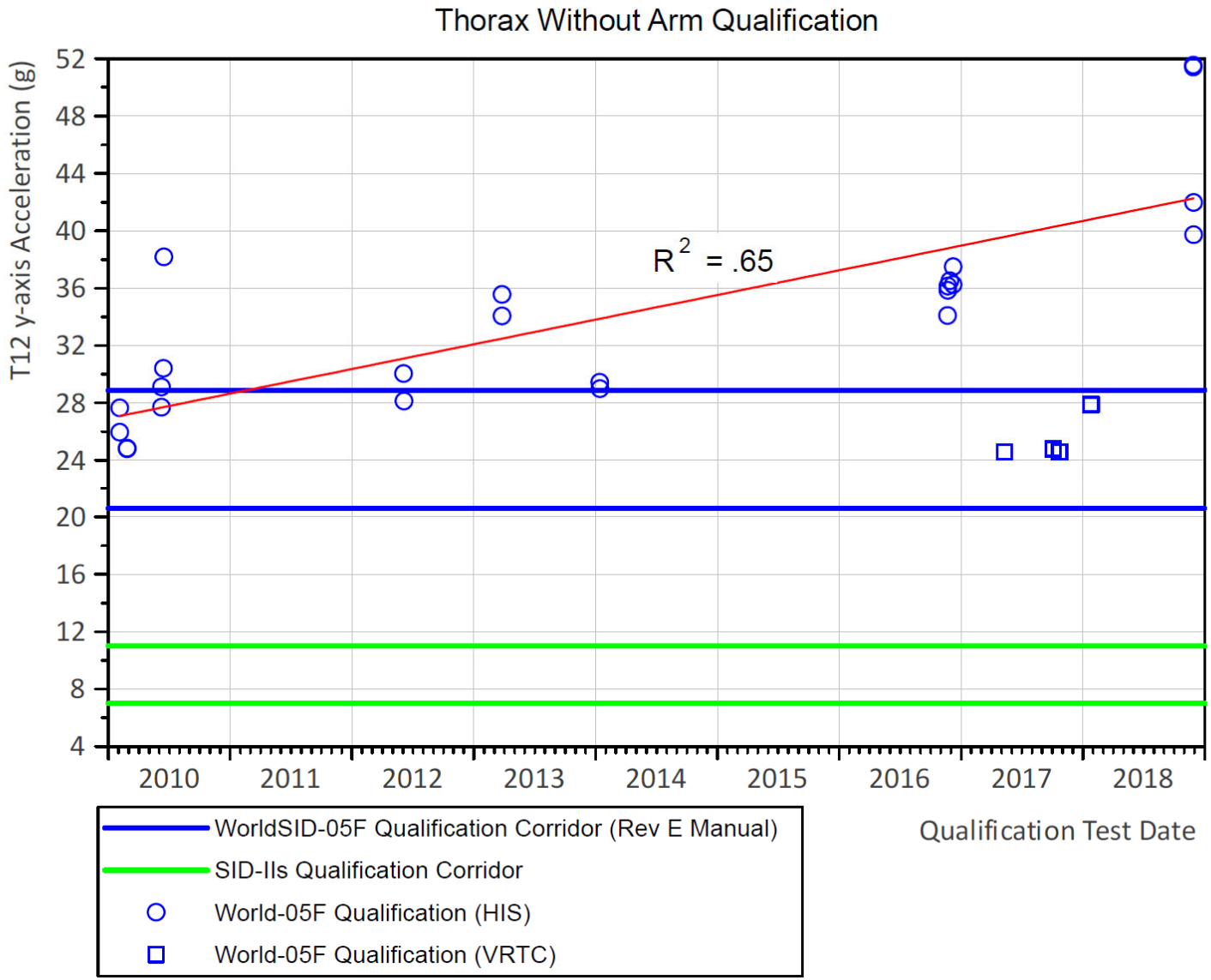
	WS-05F	SID-IIs
Peak only	9.3	0.6

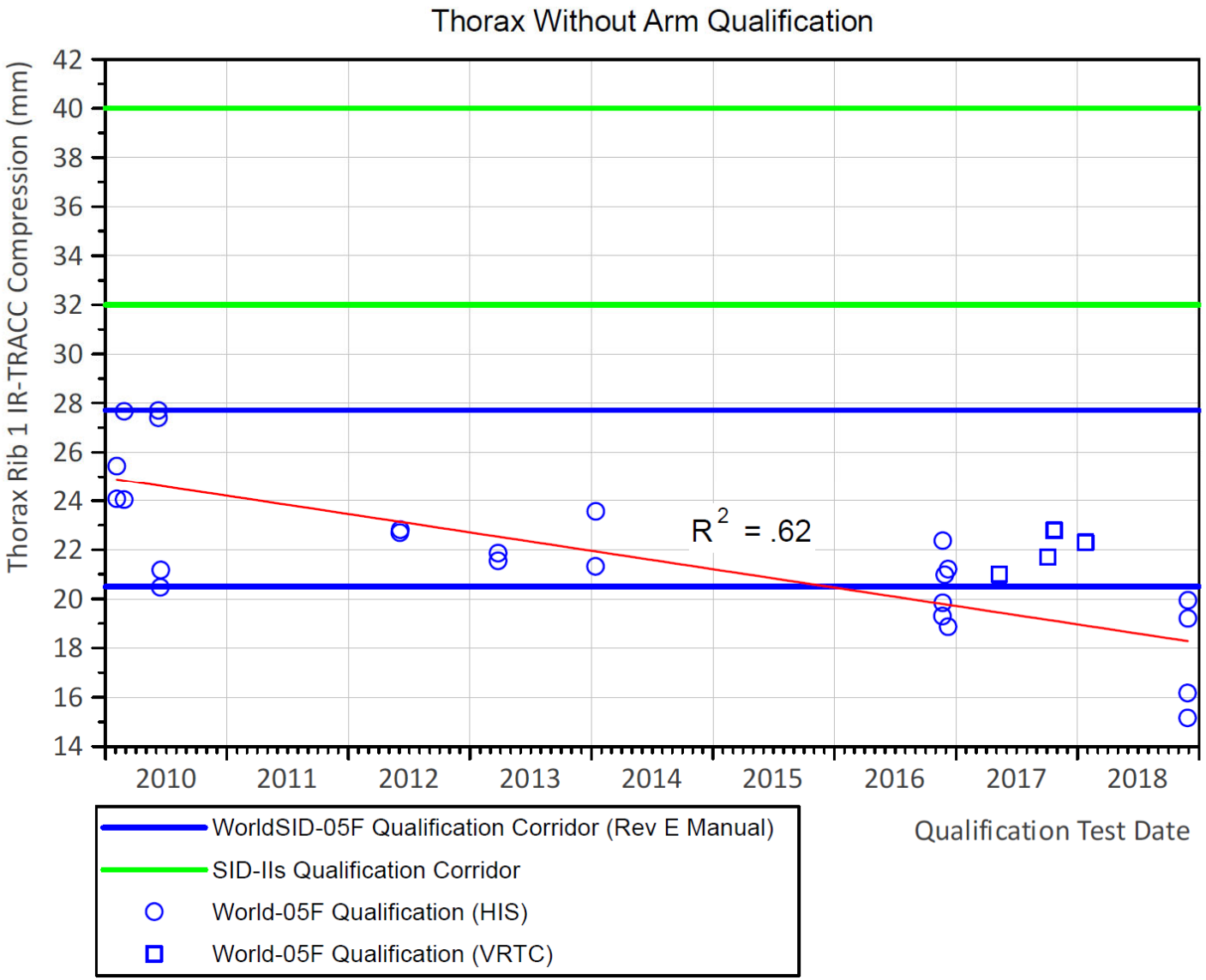

4.5 m/s Rhule Lateral Impact Test compared to 4.3 m/s ISO 9790 Thorax Test 1
Impact Force (N)
4000
3600
3200
2800
2400
2000
1600
1200
800
400
0
-400
-10
0
10
20
30
40
50
60
70
Time (ms)
4.5 m/s Rhule Lateral Test Target
WSID-05F Rhule Lateral
SID-IIs Rhule Lateral
4.3 m/s ISO Thorax Test 1 Corridor
ISO Thorax Test 1 Corridor + 1 Width
WSID-05F ISO 9790
SID-IIs ISO 9790

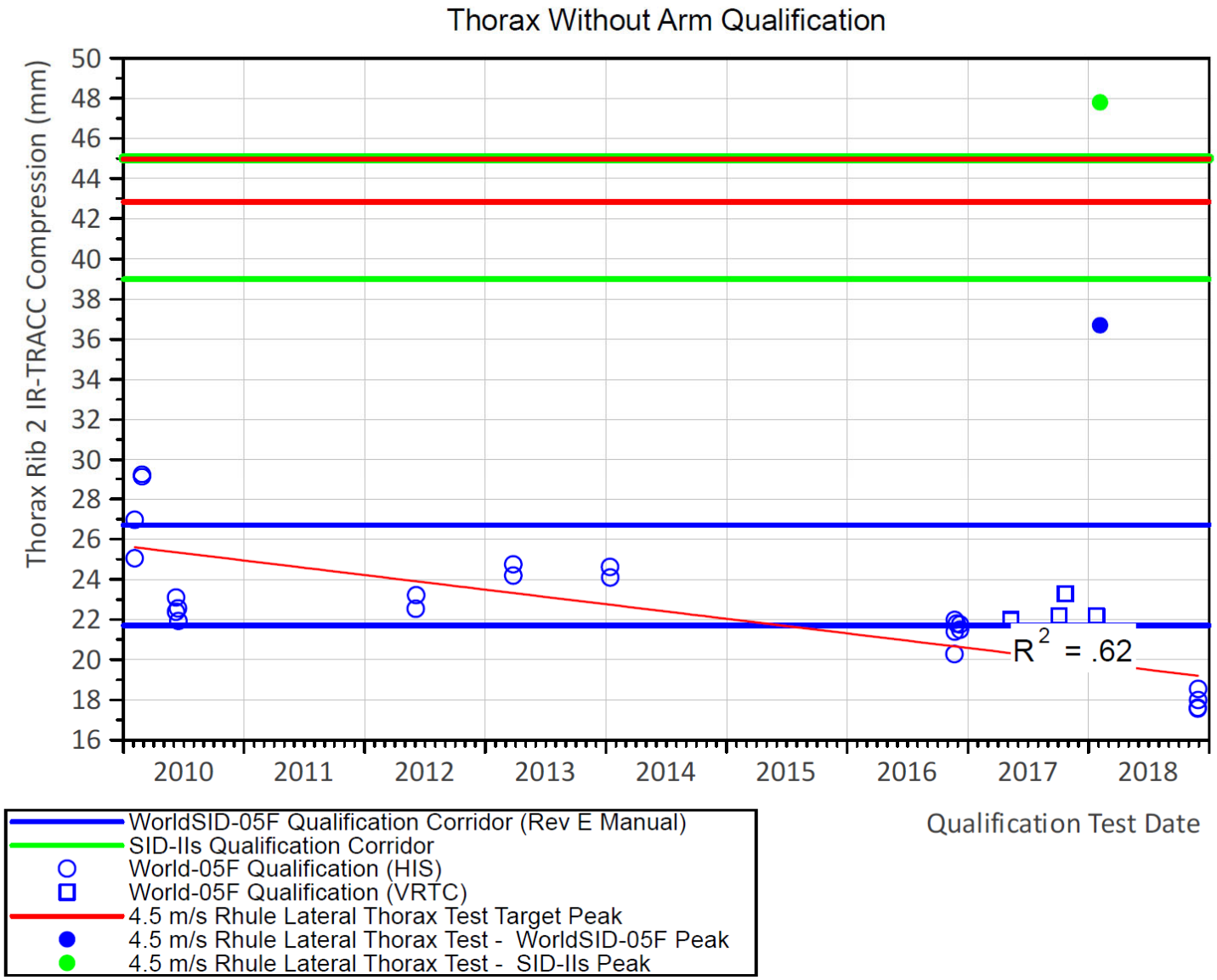
Thorax Qualification Response Over Time and Corridor Comparison

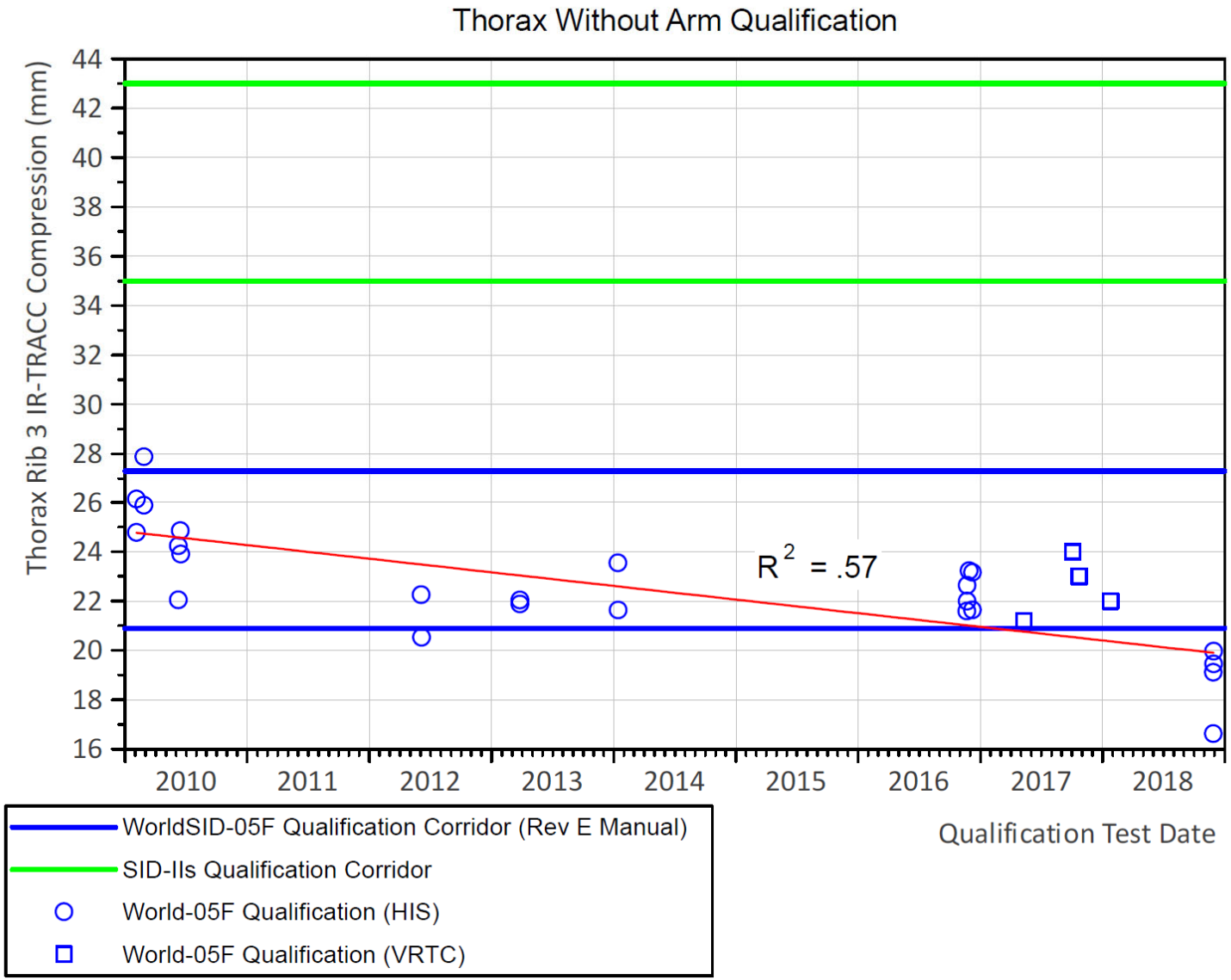

Thorax Without Arm Qualification
Impact Force (kN)
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
R 2 = .79
2010
2011
2012
2013
2014
2015
2016
2017
2018
Qualification Test Date
WorldSID-05F Qualification Corridor (Rev E Manual)
SID-IIs Qualification Corridor
World-05F Qualification (HIS)
World-05F Qualification (VRTC)
4.5 m/s Rhule Lateral Thorax Test Target Peak
4.3 m/s ISO 9790 Thorax Test 1 Target Peak
4.5 m/s Rhule Lateral Thorax Test - WorldSID-05F Peak
4.5 m/s Rhule Lateral Thorax Test - SID-IIs Peak
4.3 m/s ISO 9790 Thorax Test 1 - WorldSID-05F Peak
4.3 m/s ISO 9790 Thorax Test 1 - SID-IIs Peak


Thorax Without Arm Qualification
T4 y-axis Acceleration (g)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
R 2 = .36
2010
2011
2012
2013
2014
2015
2016
2017
2018
Qualification Test Date
WorldSID-05F Qualification Corridor (Rev E Manual)
SID-IIs Qualification Corridor (T1)
World-05F Qualification (HIS)
World-05F Qualification (VRTC)
4.3 m/s ISO 9790 Thorax Test 1 Target Peak (T1)


Thorax Without Arm Qualification
T12 y-axis Acceleration (g)
52
48
44
40
36
32
28
24
20
16
12
8
4
R^2 = .65
2010
2011
2012
2013
2014
2015
2016
2017
2018
Qualification Test Date
WorldSID-05F Qualification Corridor (Rev E Manual)
SID-IIs Qualification Corridor
World-05F Qualification (HIS)
World-05F Qualification (VRTC)


Thorax Without Arm Qualification
Thorax Rib 1 IR-TRACC Compression (mm)
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
2010
2011
2012
2013
2014
2015
2016
2017
2018
R 2 = .62
Qualification Test Date
WorldSID-05F Qualification Corridor (Rev E Manual)
SID-IIs Qualification Corridor
World-05F Qualification (HIS)
World-05F Qualification (VRTC)


Thorax Without Arm Qualification
Thorax Rib 2 IR-TRACC Compression (mm)
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
2010
2011
2012
2013
2014
2015
2016
2017
2018
R 2 = .62
Qualification Test Date
WorldSID-05F Qualification Corridor (Rev E Manual)
SID-IIs Qualification Corridor
World-05F Qualification (HIS)
World-05F Qualification (VRTC)
4.5 m/s Rhule Lateral Thorax Test Target Peak
4.5 m/s Rhule Lateral Thorax Test - WorldSID-05F Peak
4.5 m/s Rhule Lateral Thorax Test - SID-IIs Peak


Thorax Without Arm Qualification
Thorax Rib 3 IR-TRACC Compression (mm)
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
2010
2011
2012
2013
2014
2015
2016
2017
2018
R 2 = .57
Qualification Test Date
WorldSID-05F Qualification Corridor (Rev E Manual)
SID-IIs Qualification Corridor
World-05F Qualification (HIS)
World-05F Qualification (VRTC)

Conclusions/Questions

- WorldSID-05F thorax is too stiff, needs improved biofidelity
- Why is Mod Kit dummy biofidelity worse than Rev 1?
- Why has thorax become stiffer over time?
- Next steps?

Additional slides provided after presentation on 11/17/21

Biofidelity History

Eggers et al., 2009

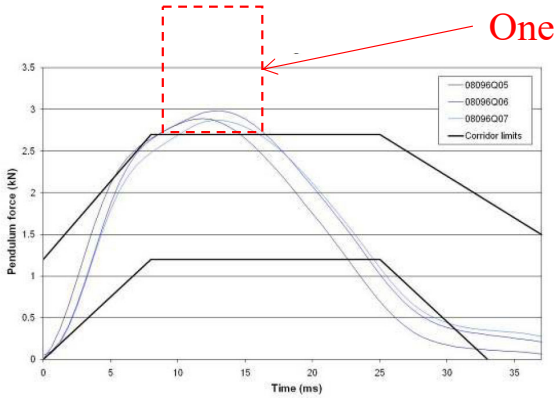


Figure 6. 4.3 m/s, 14 kg, pendulum force responses using lateral WSU setup, ISO corridor

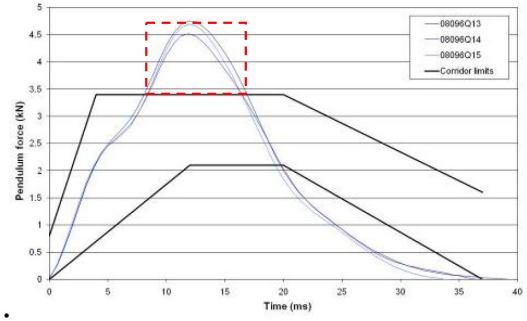


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Figure 7. 6.0 m/s, 14 kg, pendulum force response, ISO corridor

Table 8.
Thorax biofidelity rating for Revision1 prototype

Body region	Ui	Impact condition	Vij	Measurement	Wijk	Boundary Lower	Boundary Upper	Boundary Unit	Ratings test 1	Ratings test 2	Ratings test 3	Ratings Average	Biofidelity Impact	Biofidelity Test	Test condi	Body region
Thorax	10	4.3 m/s	9	Pendulum force	9	force time corridor				5	8.3	6.7	59.9			
test 1		HSRI				1.2	2.7	kN								
		pendulum		Peak T4 Y acc.	7	acc. time corridor				5	5	5.0	35			
					16	**10**	**18**	**G**					94.9	**5.9**	53.4	
test 2		6.0 m/s	9	Pendulum force	9	force time corridor				5	10	7.5	67.5			
		WSU/GML				2.1	3.4	kN								
		pendulum			9								67.5	**7.5**	67.5	
test 5		6.8 m/s	7	Thorax plate force	8	force time corridor			10	10	5	8	66.7			
		Heidelberg				3.7	12.4	kN								
		rigid sled		peak T1 Y acc.	7	100	149	G	5	0	5	3.3	23.3			
				peak T12 Y acc.	7	87	131	G	5	5	5	5.0	35			
				peak rib acc.	6	78	122	G	5	5	5	5.0	30			
					28								155	**5.5**	38.8	
test 6		8.9 m/s	7	shoulder + thoracic plate force	9	force time corridor			10	10	5	8	75			
		WSU				4.4	6.9	kN					0			
		sled		Peak lateral displacement of T12	5	65.0	88.0		10	10	10	10	50			
		23 PSI padded			14								125	**8.9**	62.5	
			32												222	**6.9**

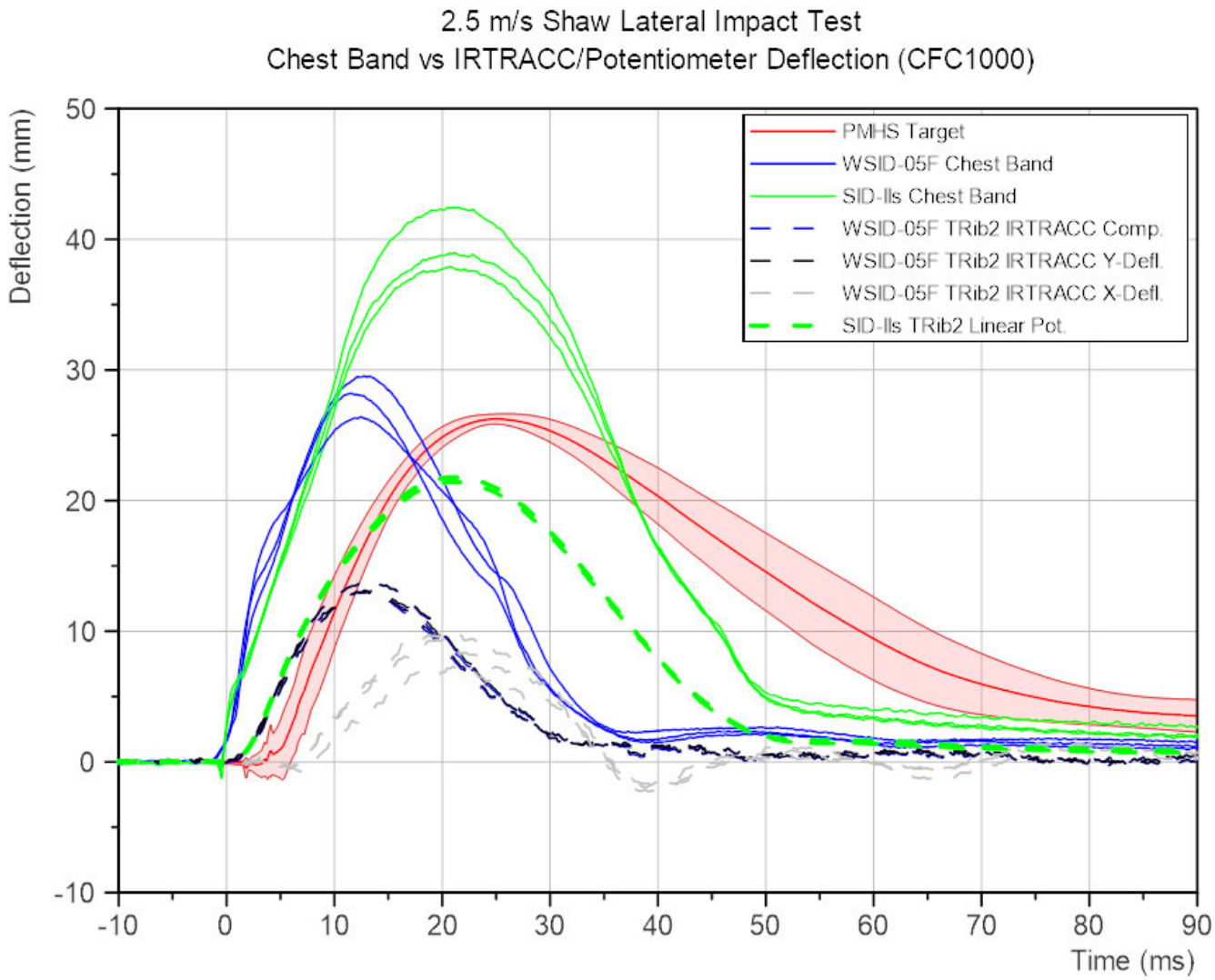
5 5 45 5.0

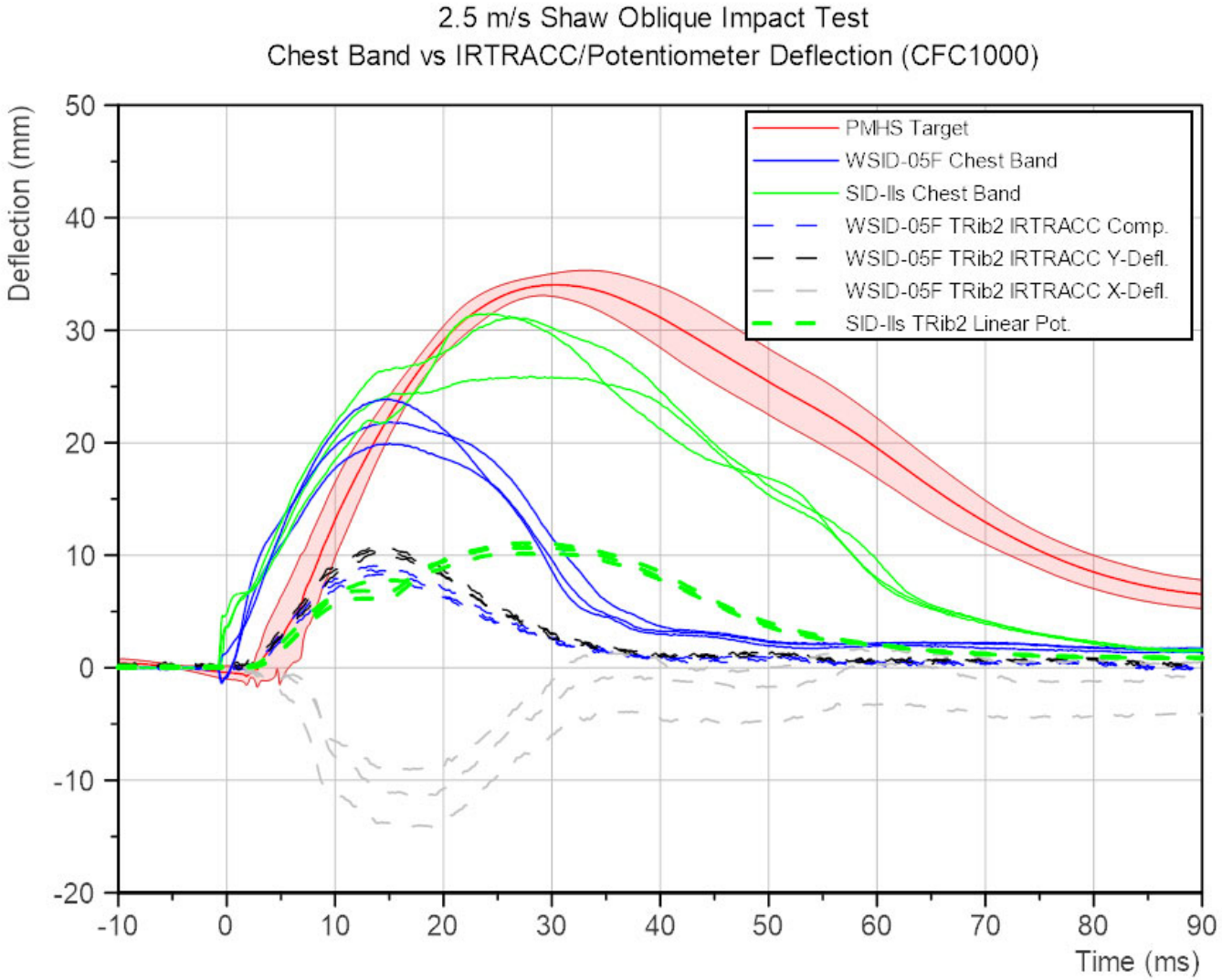
0 or 5 2.5 or 5 22.5 or 45

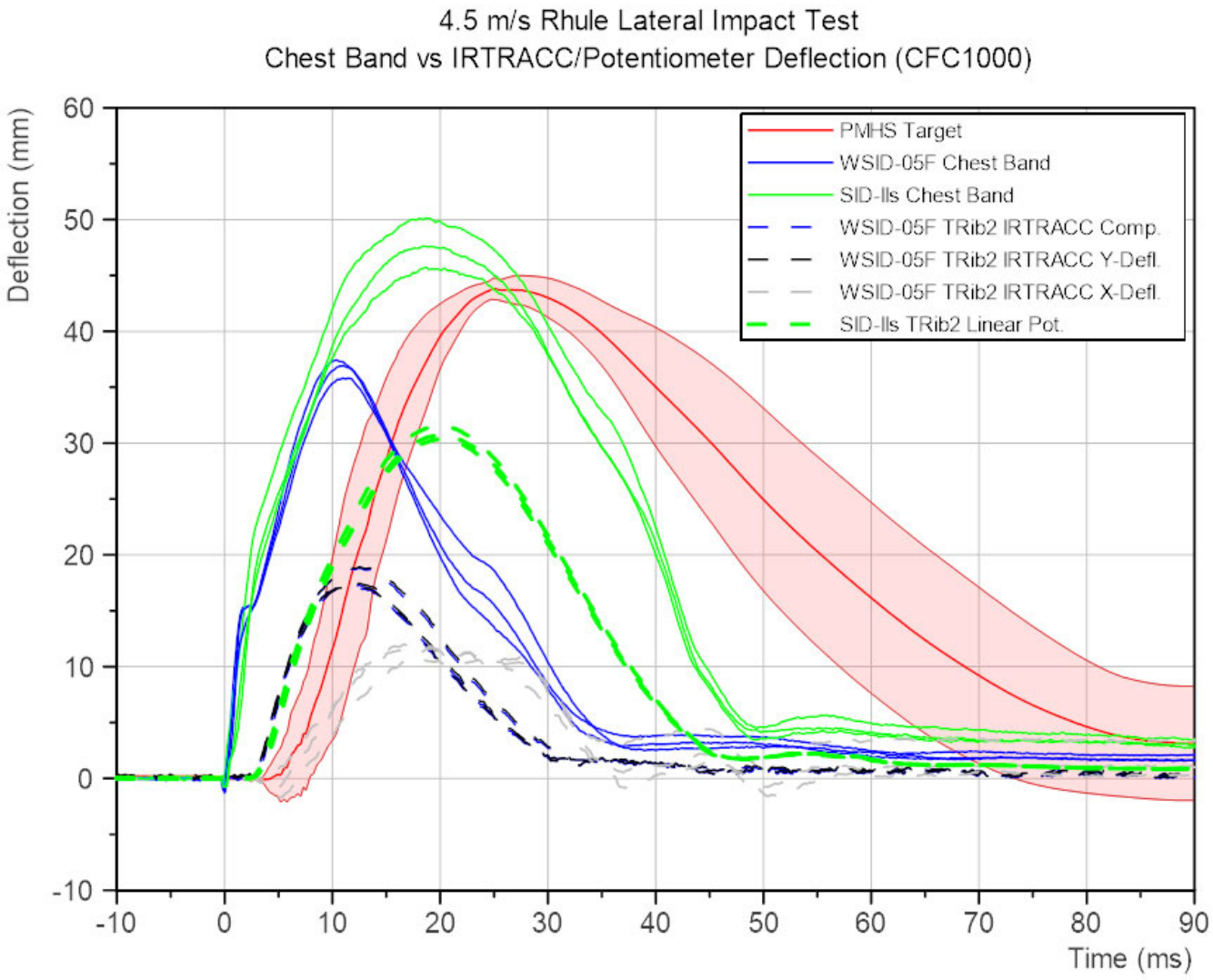
2.5 or 5

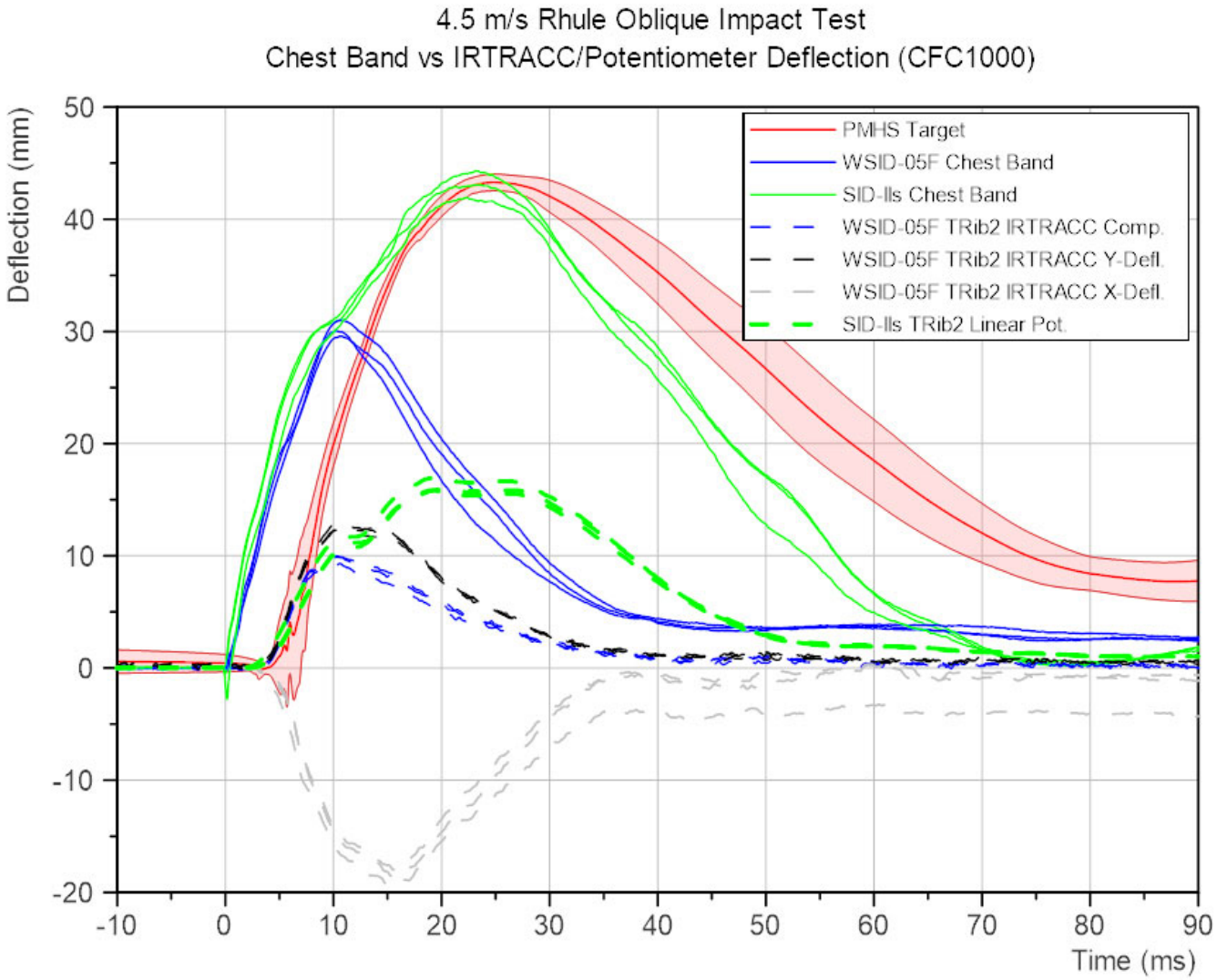
5.3 or 6.0

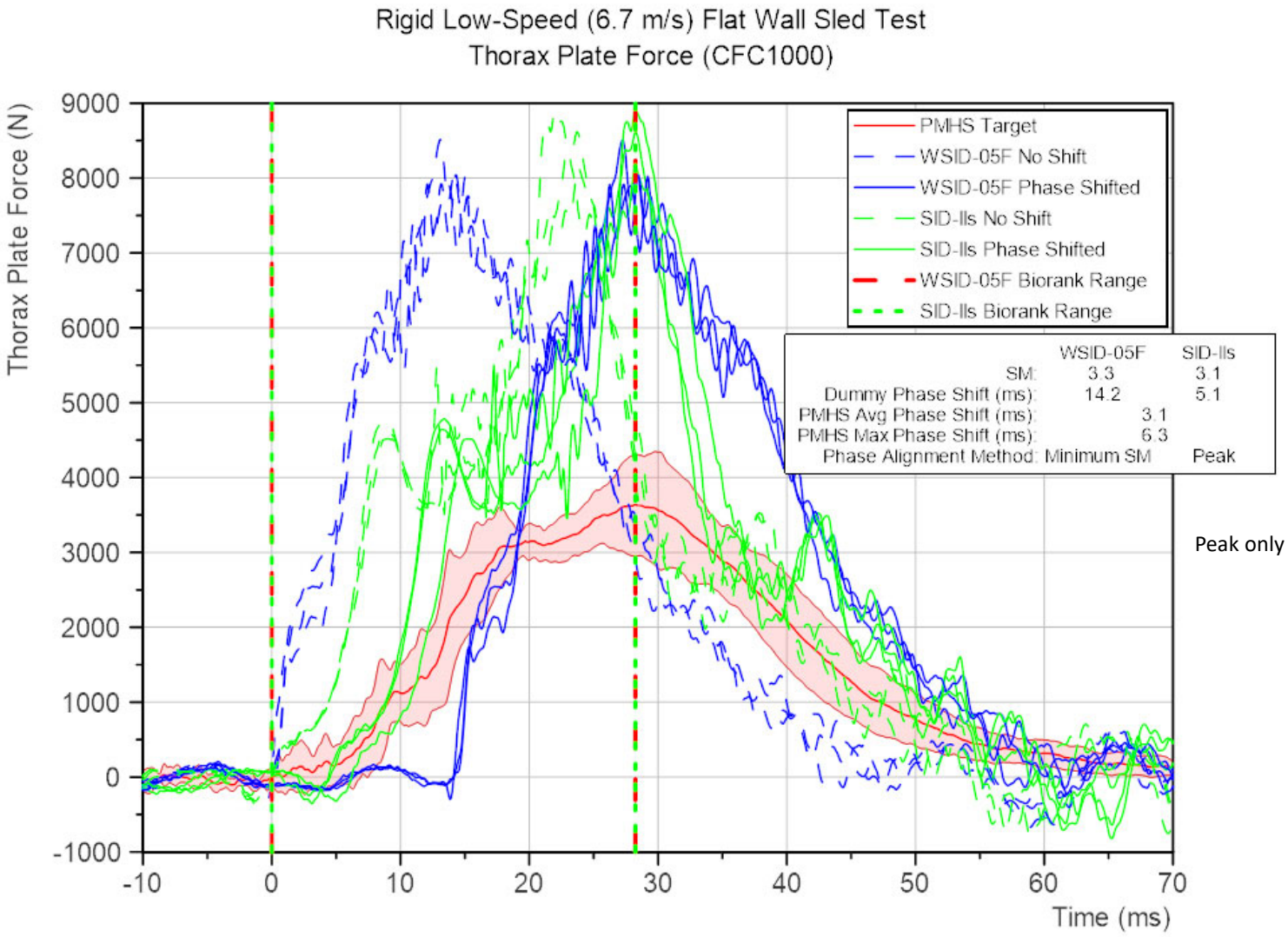
Overall: 7.6 7.2 or 7.4


2.5 m/s Shaw Lateral Impact Test
Chest Band vs IRTRACC/Potentiometer Deflection (CFC1000)
Deflection (mm)
Time (ms)
PMHS Target
WSID-05F Chest Band
SID-IIs Chest Band
WSID-05F TRib2 IRTRACC Comp.
WSID-05F TRib2 IRTRACC Y-Defl.
WSID-05F TRib2 IRTRACC X-Defl.
SID-IIs TRib2 Linear Pot.
50
40
30
20
10
0
-10
-10
0
10
20
30
40
50
60
70
80
90

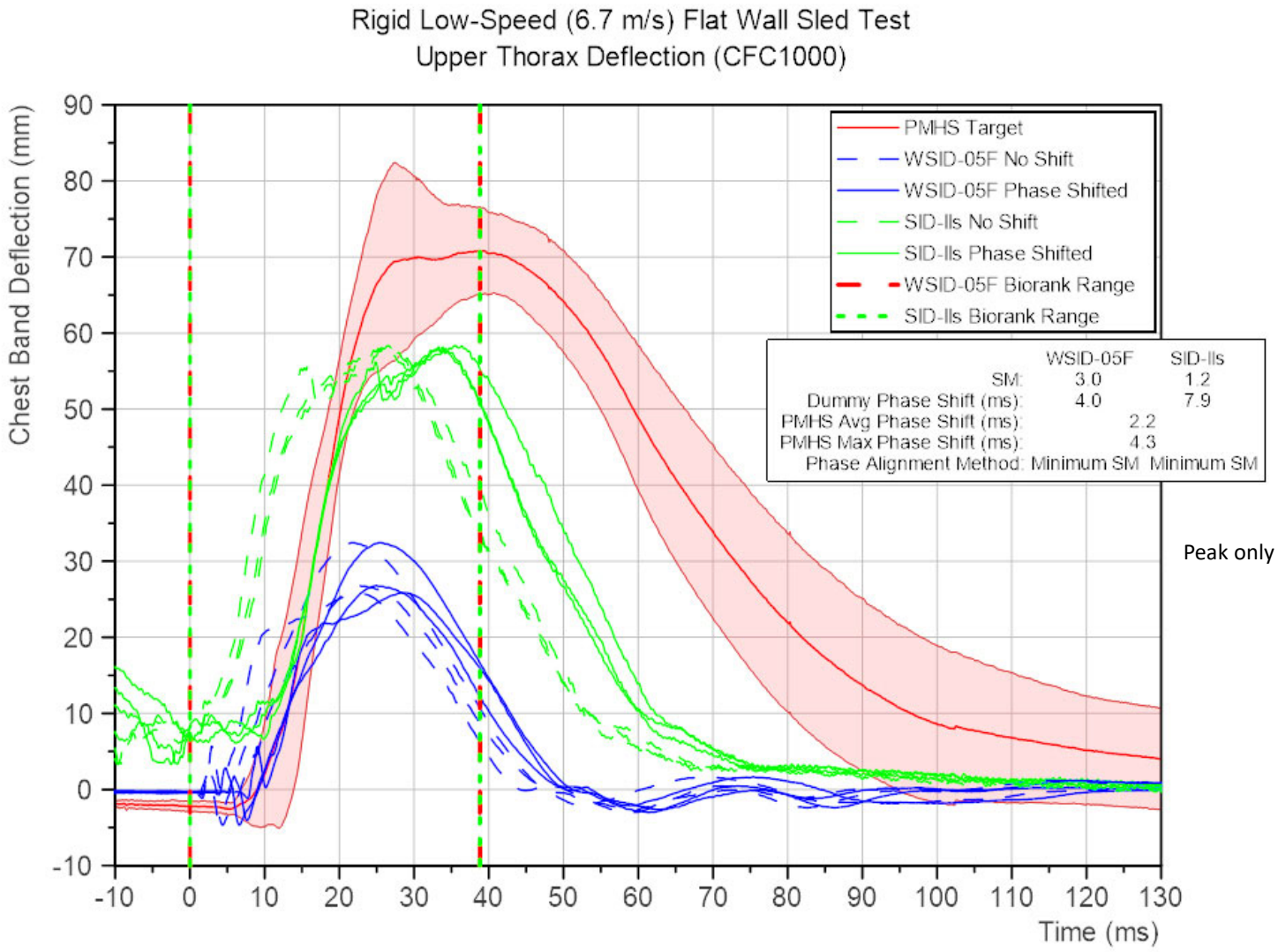

2.5 m/s Shaw Oblique Impact Test
Chest Band vs IRTRACC/Potentiometer Deflection (CFC1000)
Deflection (mm)
Time (ms)
PMHS Target
WSID-05F Chest Band
SID-IIs Chest Band
WSID-05F TRib2 IRTRACC Comp.
WSID-05F TRib2 IRTRACC Y-Defl.
WSID-05F TRib2 IRTRACC X-Defl.
SID-IIs TRib2 Linear Pot.
50
40
30
20
10
0
-10
-20
-10
0
10
20
30
40
50
60
70
80
90


4.5 m/s Rhule Lateral Impact Test
Chest Band vs IRTRACC/Potentiometer Deflection (CFC1000)
Deflection (mm)
Time (ms)
PMHS Target
WSID-05F Chest Band
SID-IIs Chest Band
WSID-05F TRib2 IRTRACC Comp.
WSID-05F TRib2 IRTRACC Y-Defl.
WSID-05F TRib2 IRTRACC X-Defl.
SID-IIs TRib2 Linear Pot.
60
50
40
30
20
10
0
-10
-10
0
10
20
30
40
50
60
70
80
90

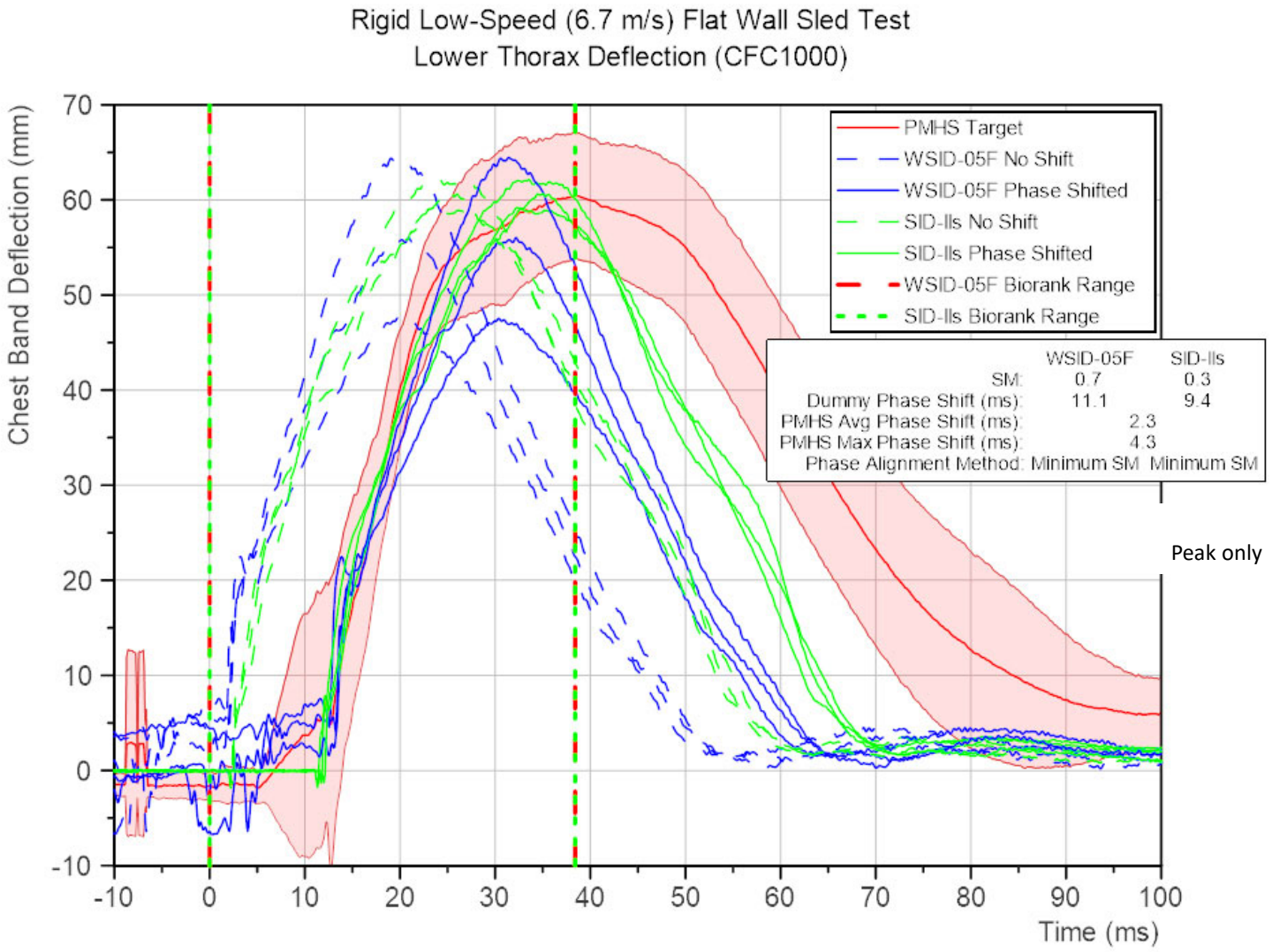

4.5 m/s Rhule Oblique Impact Test
Chest Band vs IRTRACC/Potentiometer Deflection (CFC1000)
Deflection (mm)
Time (ms)
PMHS Target
WSID-05F Chest Band
SID-IIs Chest Band
WSID-05F TRib2 IRTRACC Comp.
WSID-05F TRib2 IRTRACC Y-Defl.
WSID-05F TRib2 IRTRACC X-Defl.
SID-IIs TRib2 Linear Pot.
50
40
30
20
10
0
-10
-20
-10
0
10
20
30
40
50
60
70
80
90



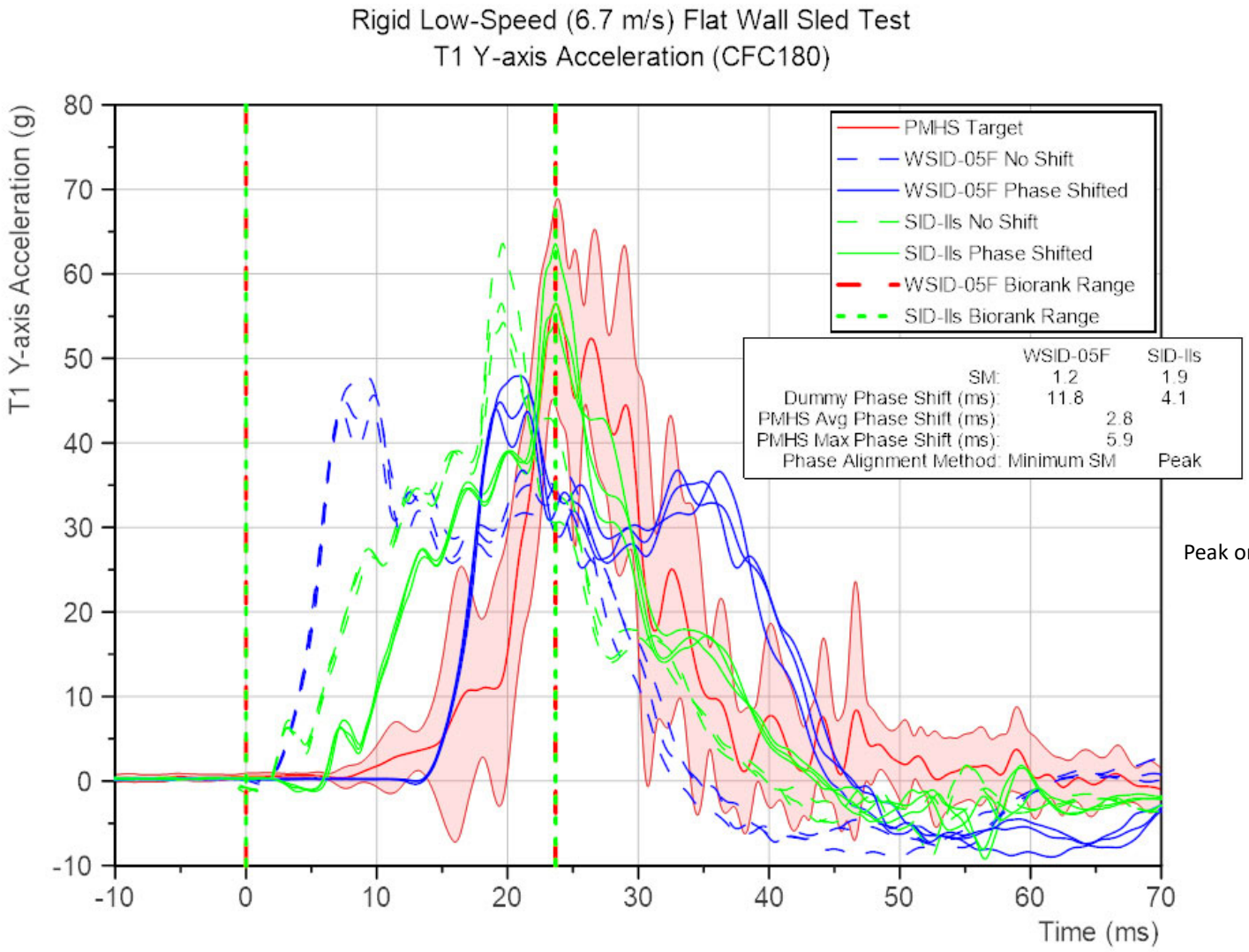
	WS-05F	SID-IIs
Peak only	9.8	10.6



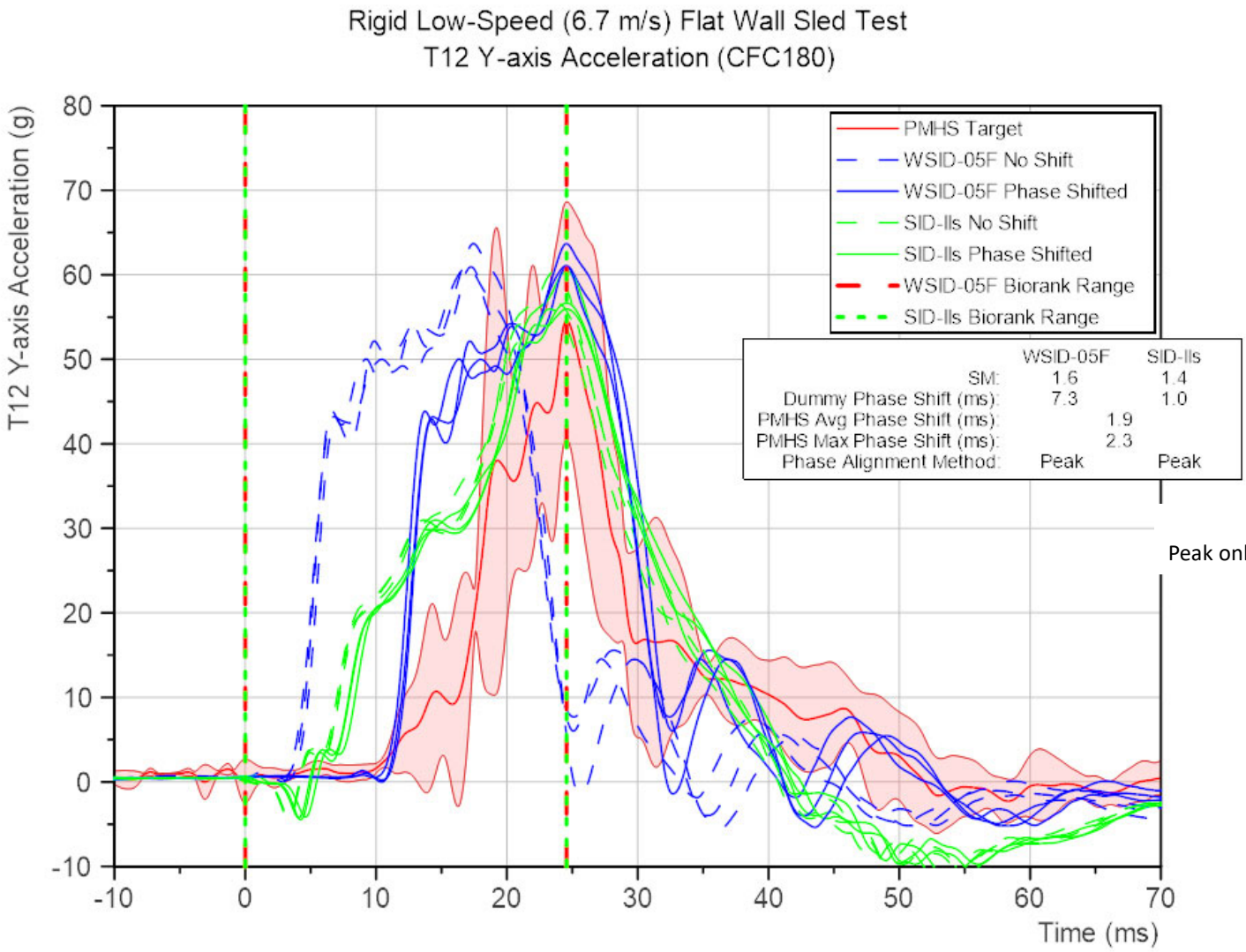
	WS-05F	SID-IIs
Peak only	5.5	1.6



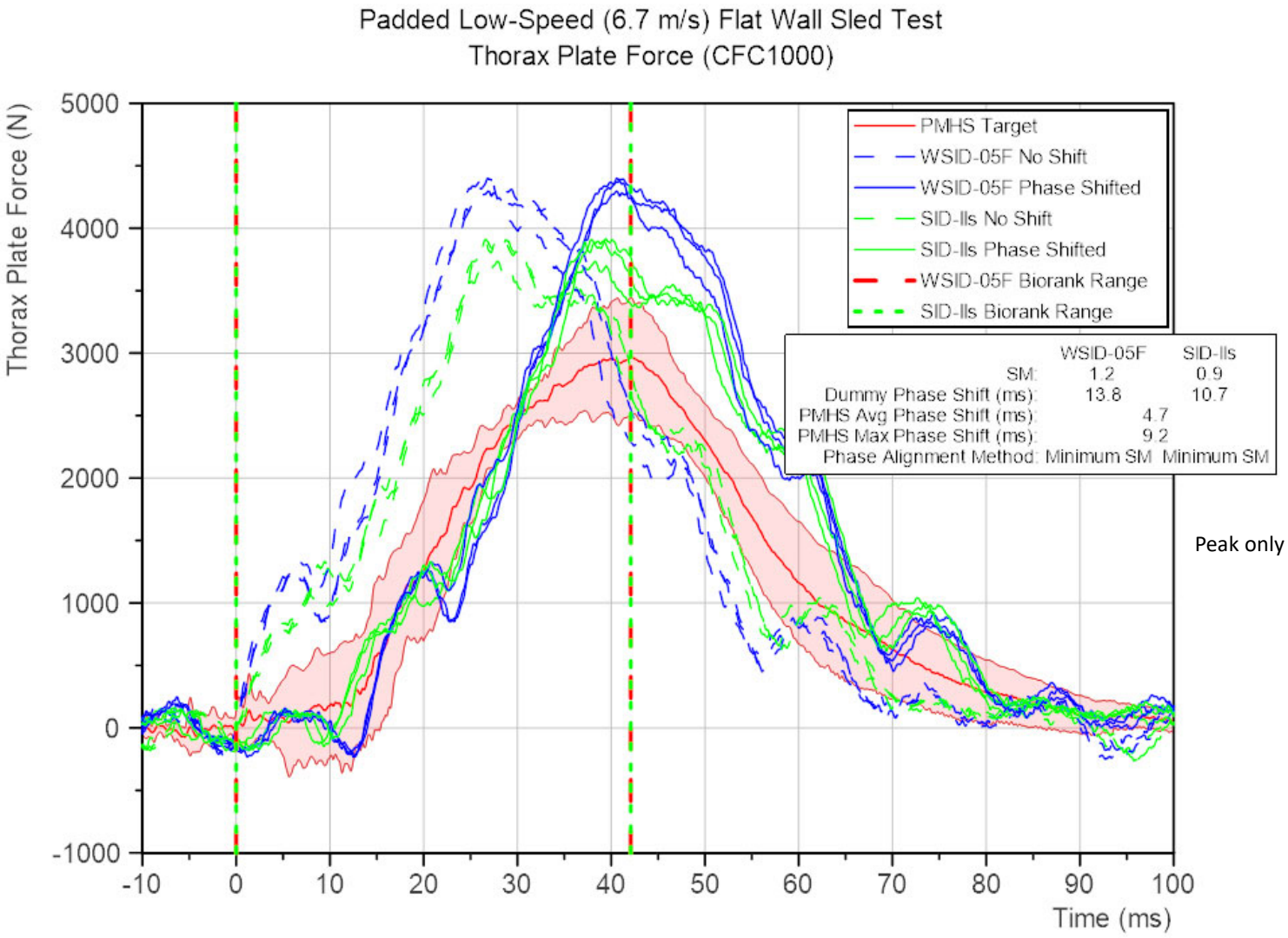
	WS-05F	SID-IIs
Peak only	1.0	0.1



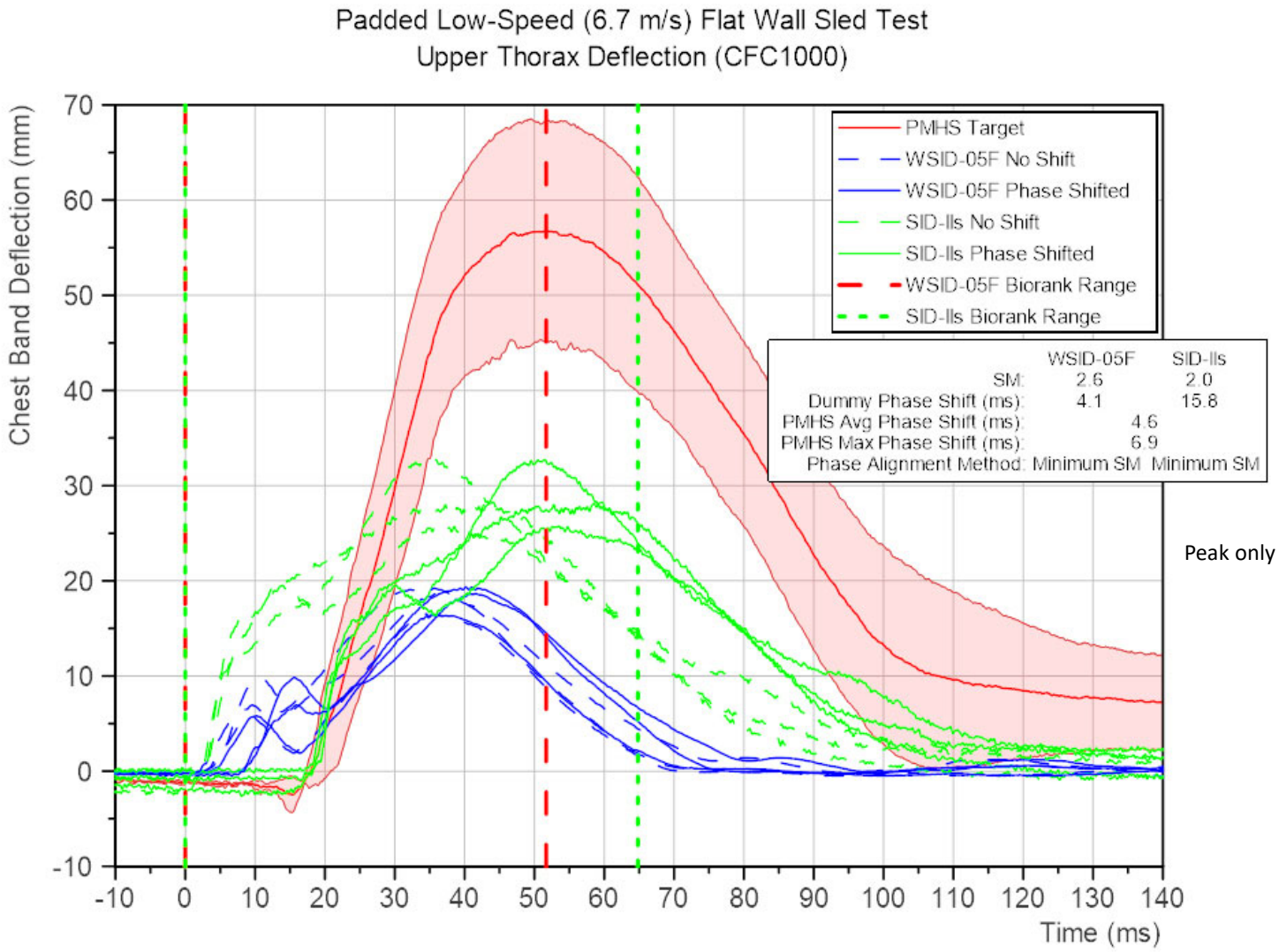
	WS-05F	SID-IIs
Peak only	0.9	0.3



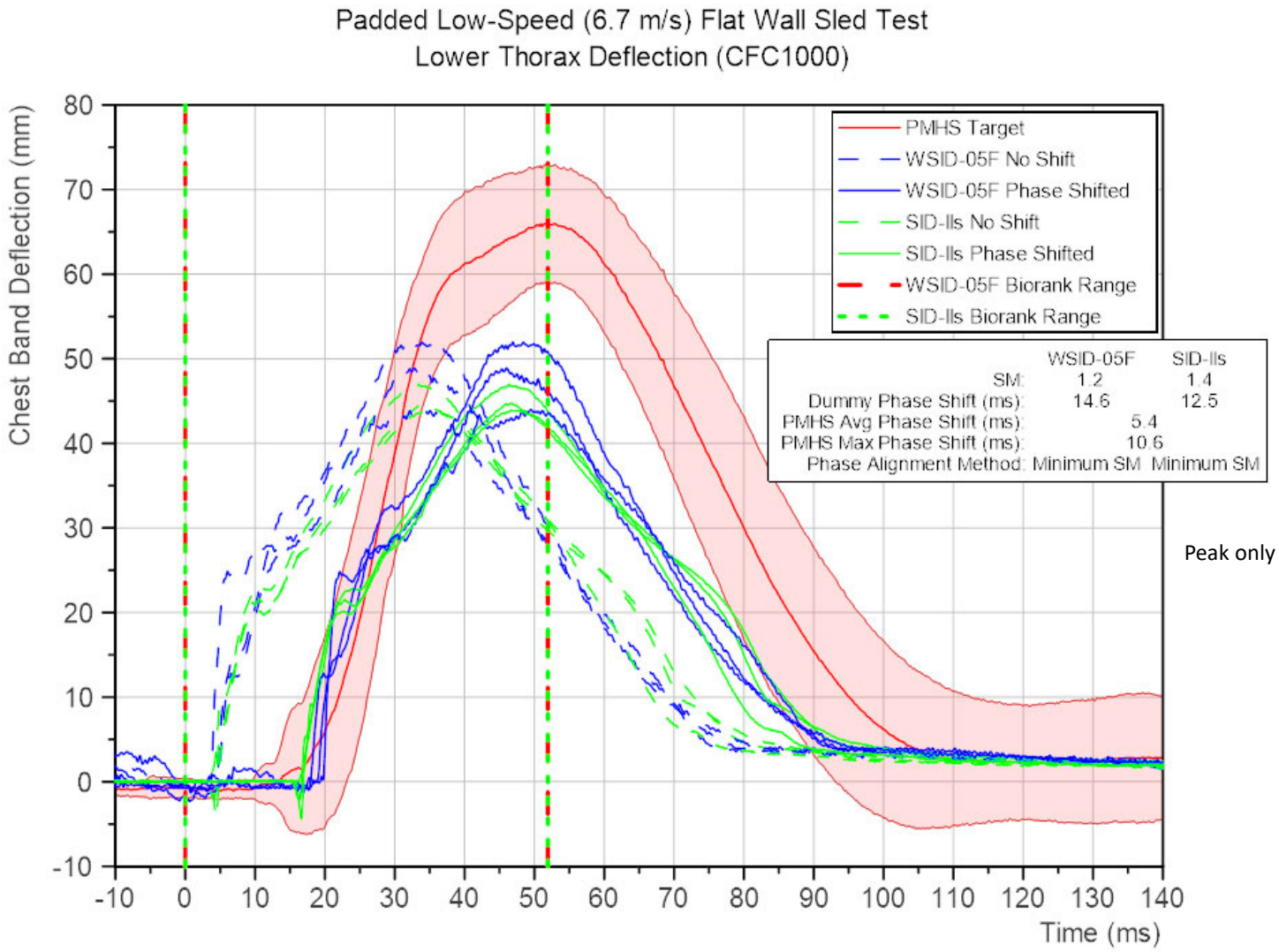
	WS-05F	SID-IIs
Peak only	0.5	0.2



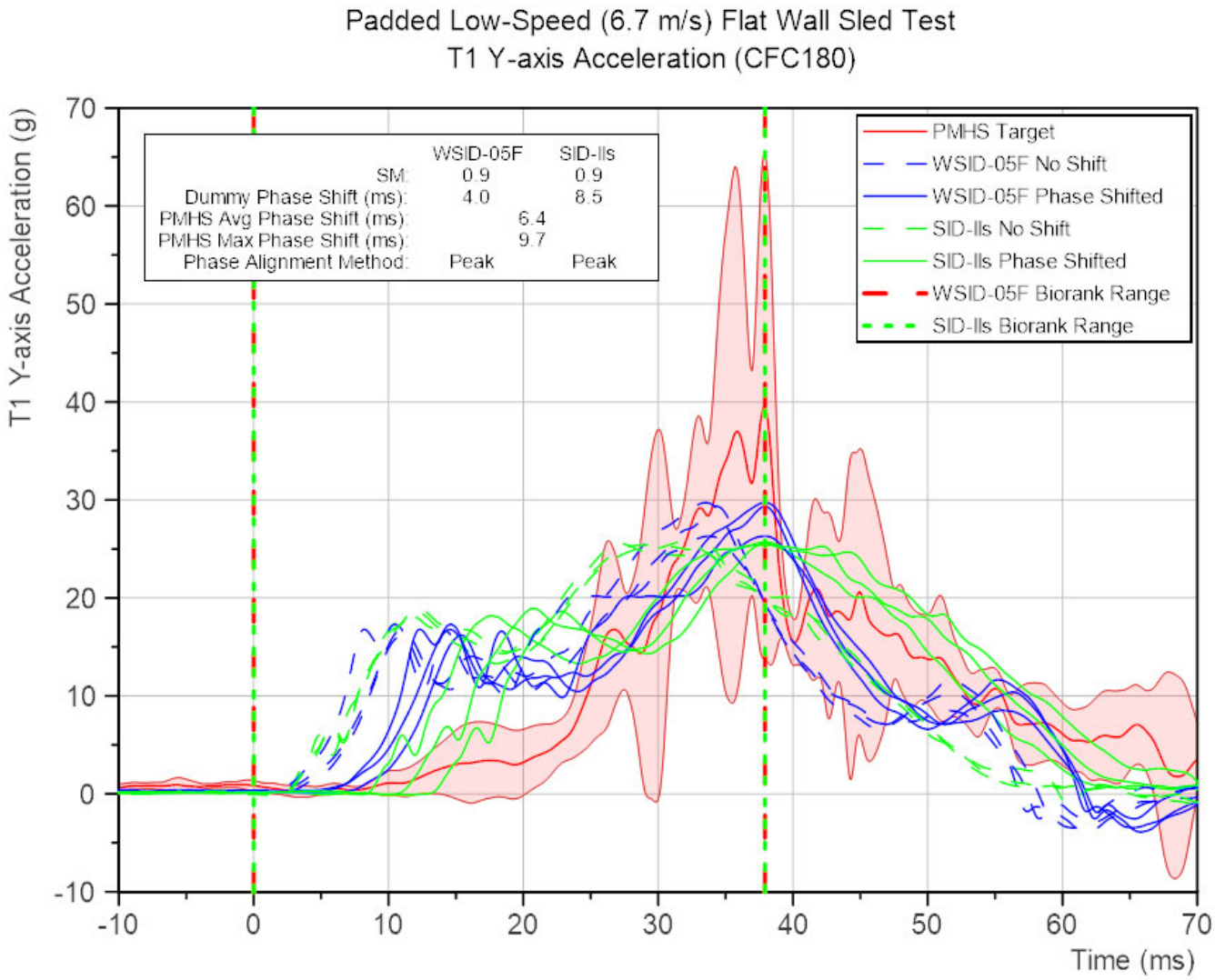
	WS-05F	SID-IIs
Peak only	4.3	2.7



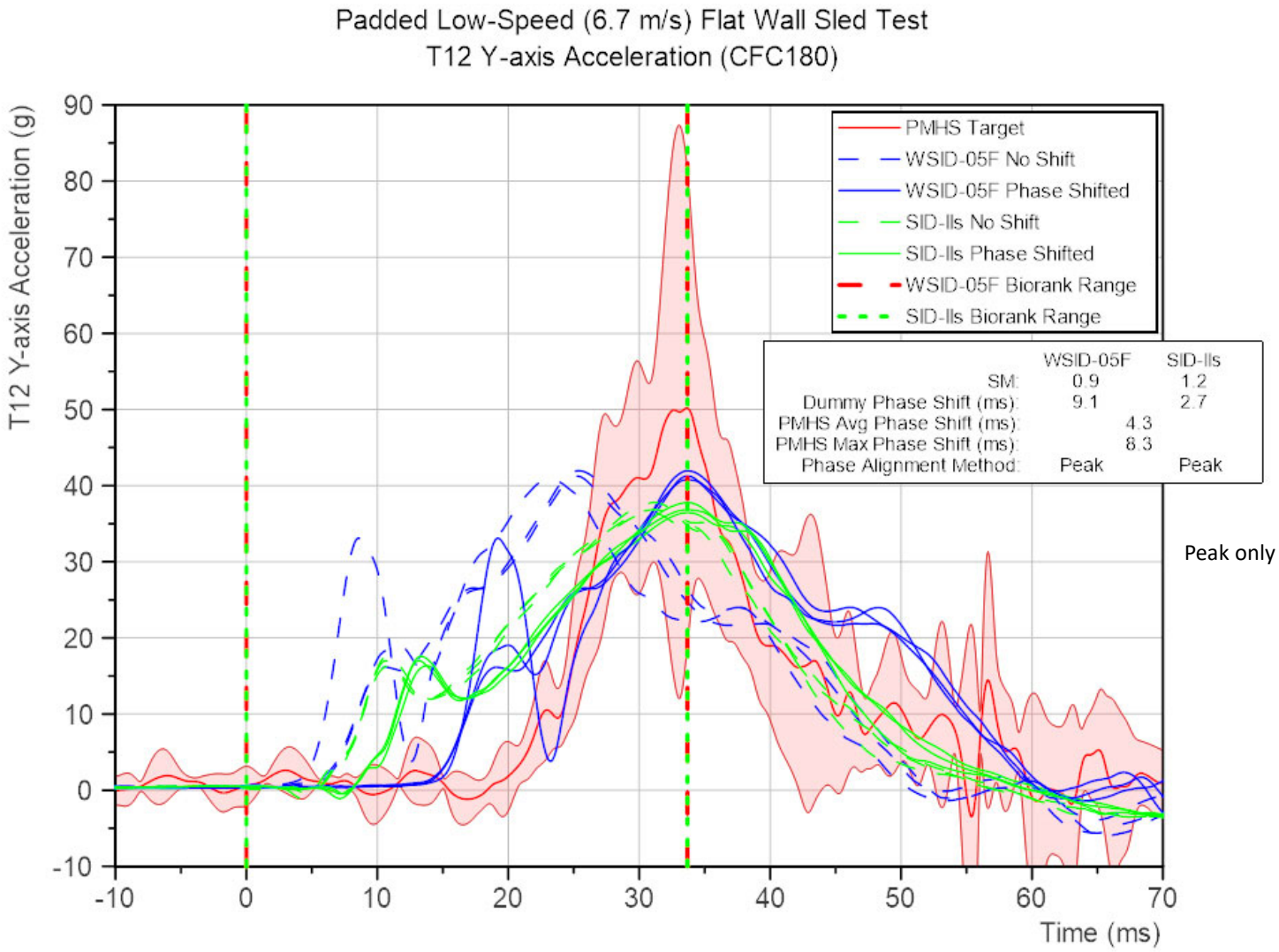
	WS-05F	SID-IIs
Peak only	3.4	2.5



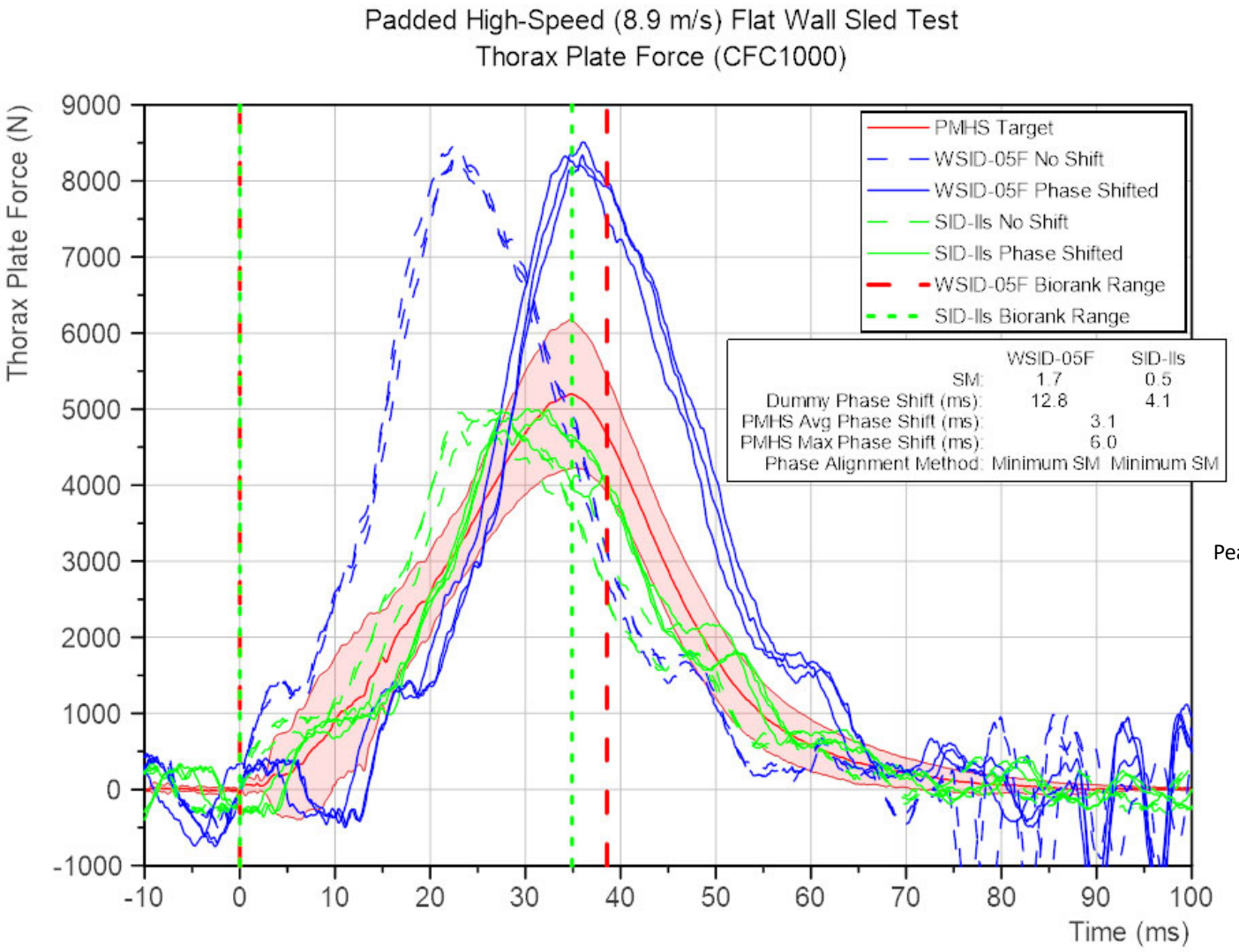
	WS-05F	SID-IIs
Peak only	2.2	2.6



	WS-05F	SID-IIs
Peak only	0.5	0.7



	WS-05F	SID-IIs
Peak only	0.4	0.6



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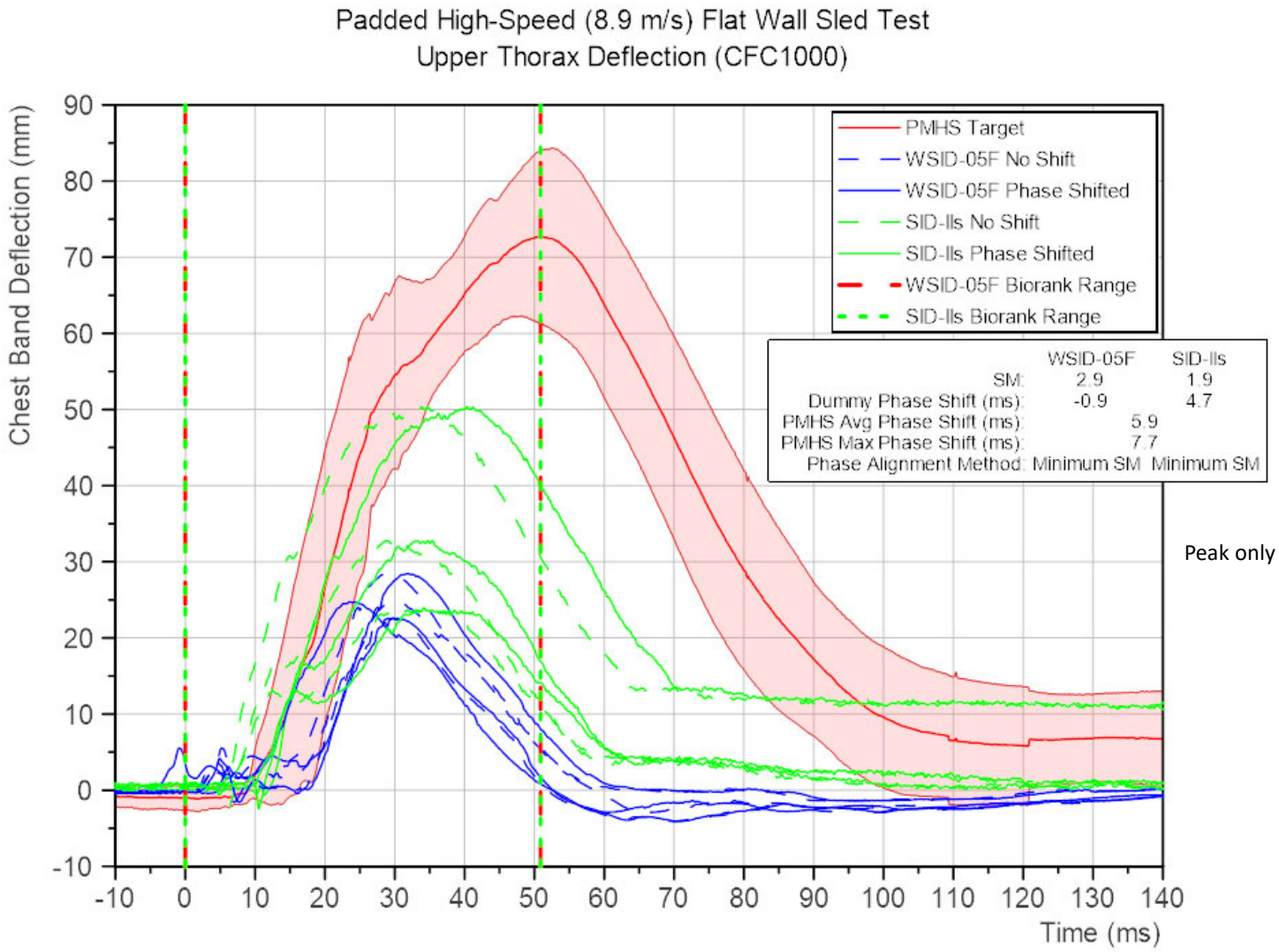
Peak only	3.8	0.3



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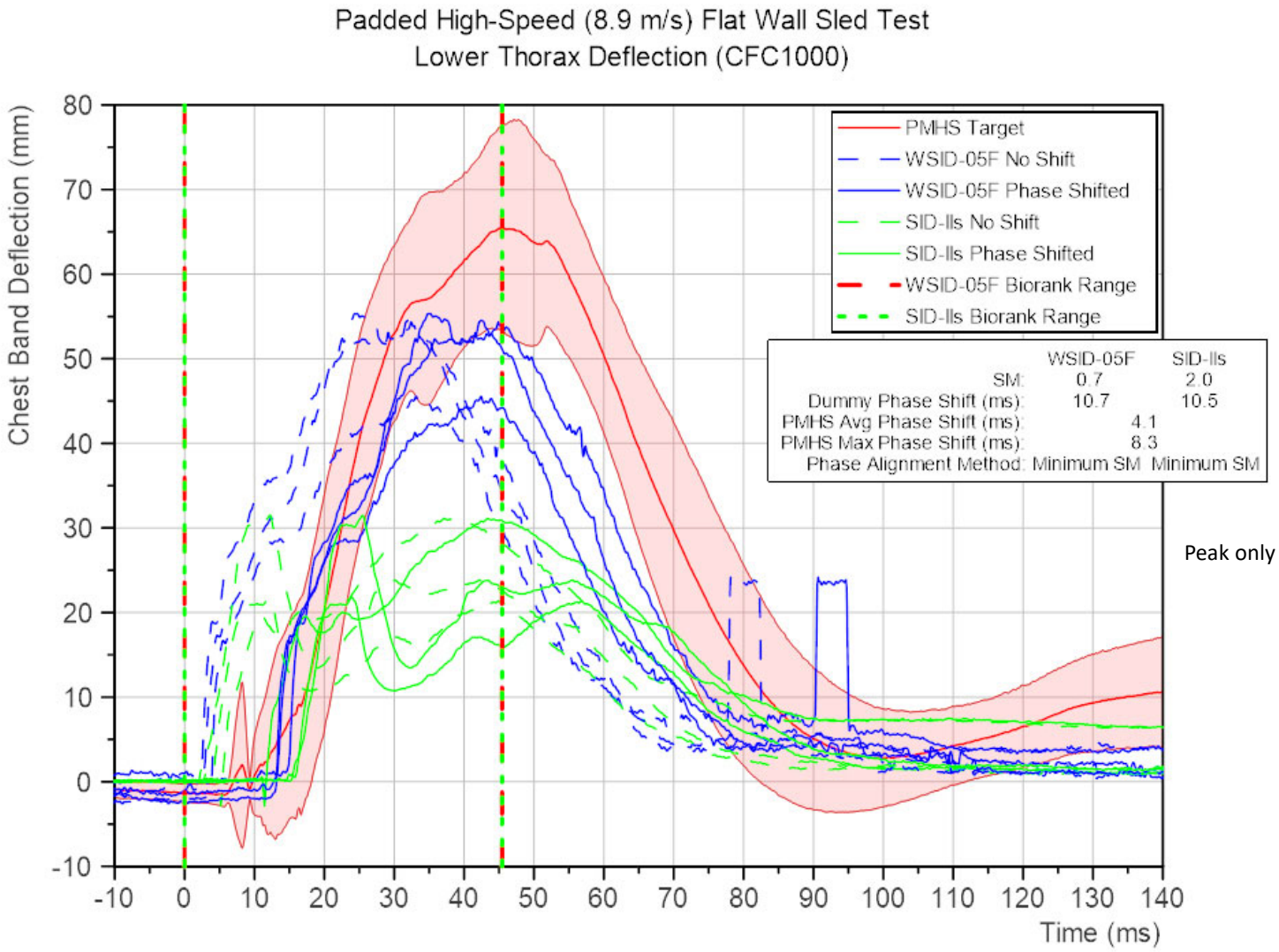
Peak only	4.7	3.7



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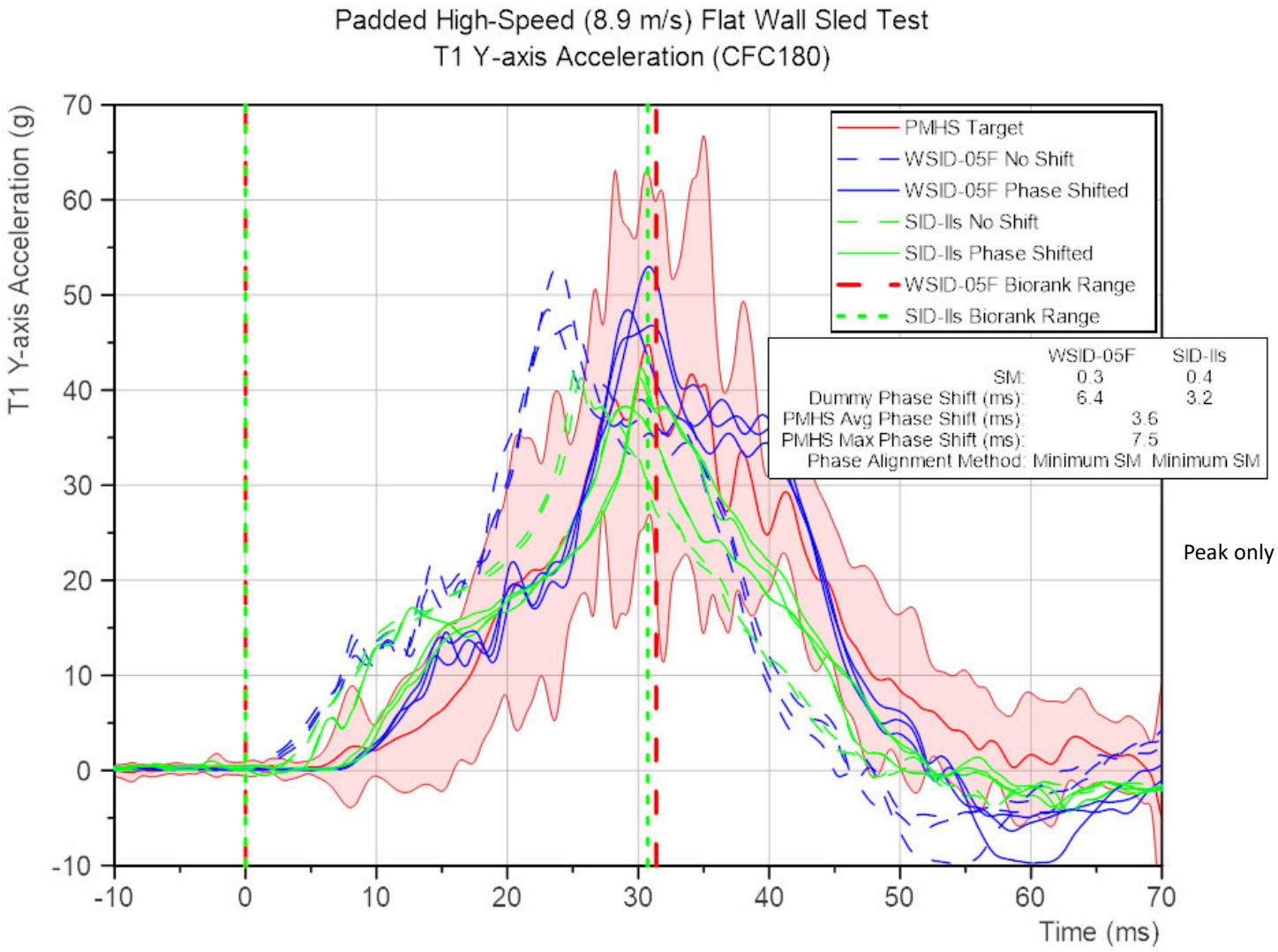
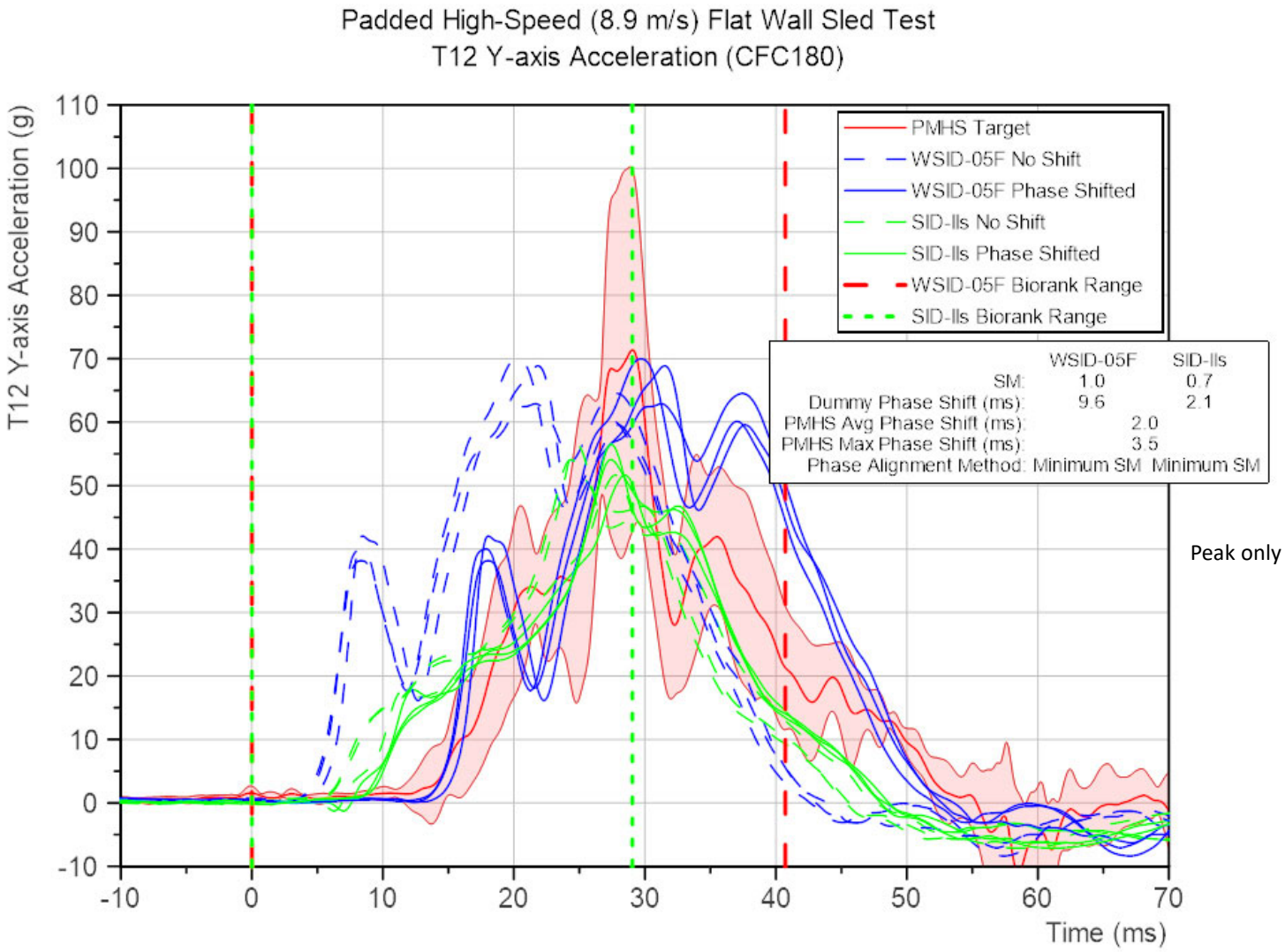
Peak only	1.3	3.4



	WS-05F	SID-IIs
Peak only	0.2	0.2



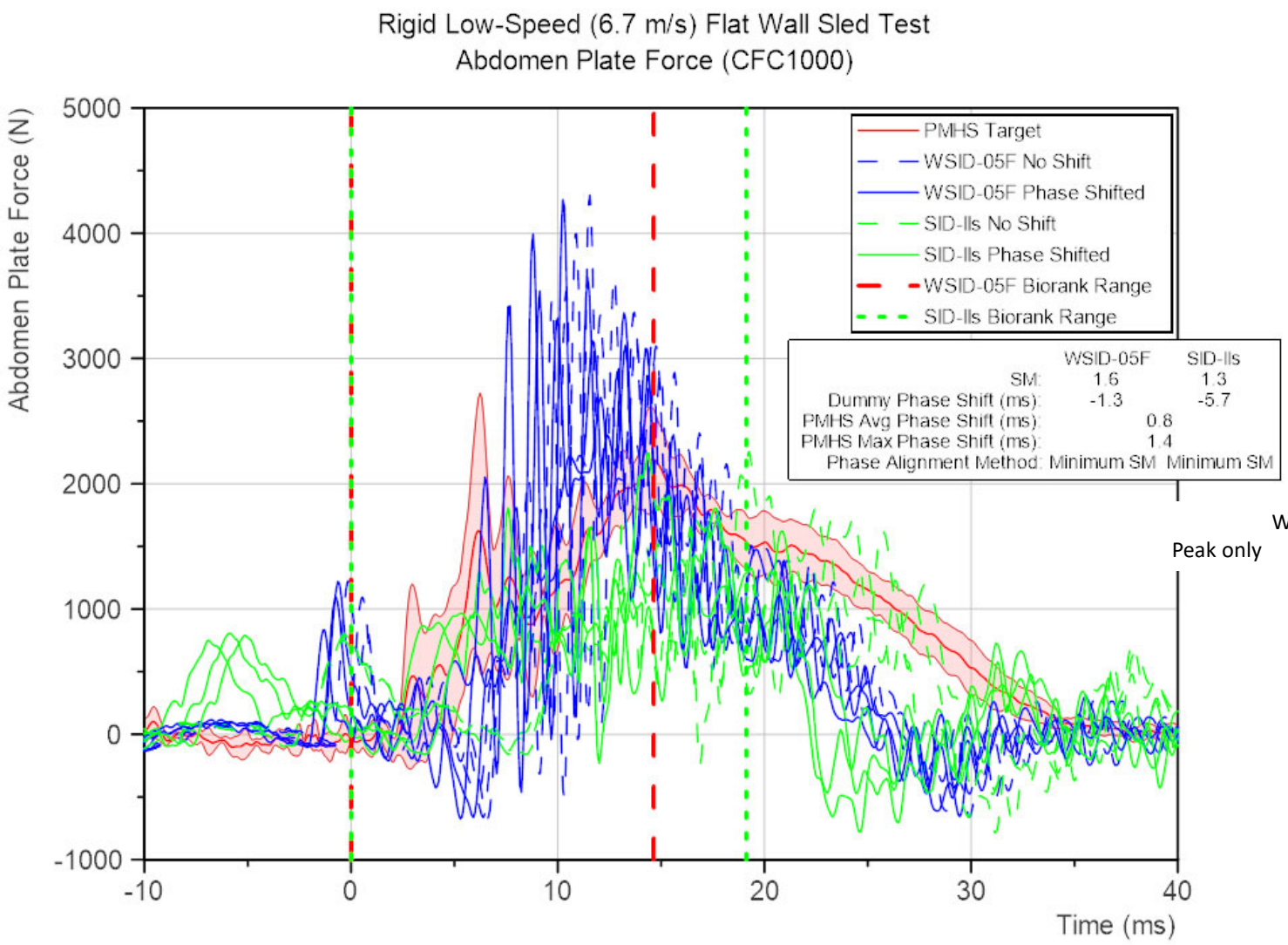
	WS-05F	SID-IIs
Peak only	0.1	0.7

SM

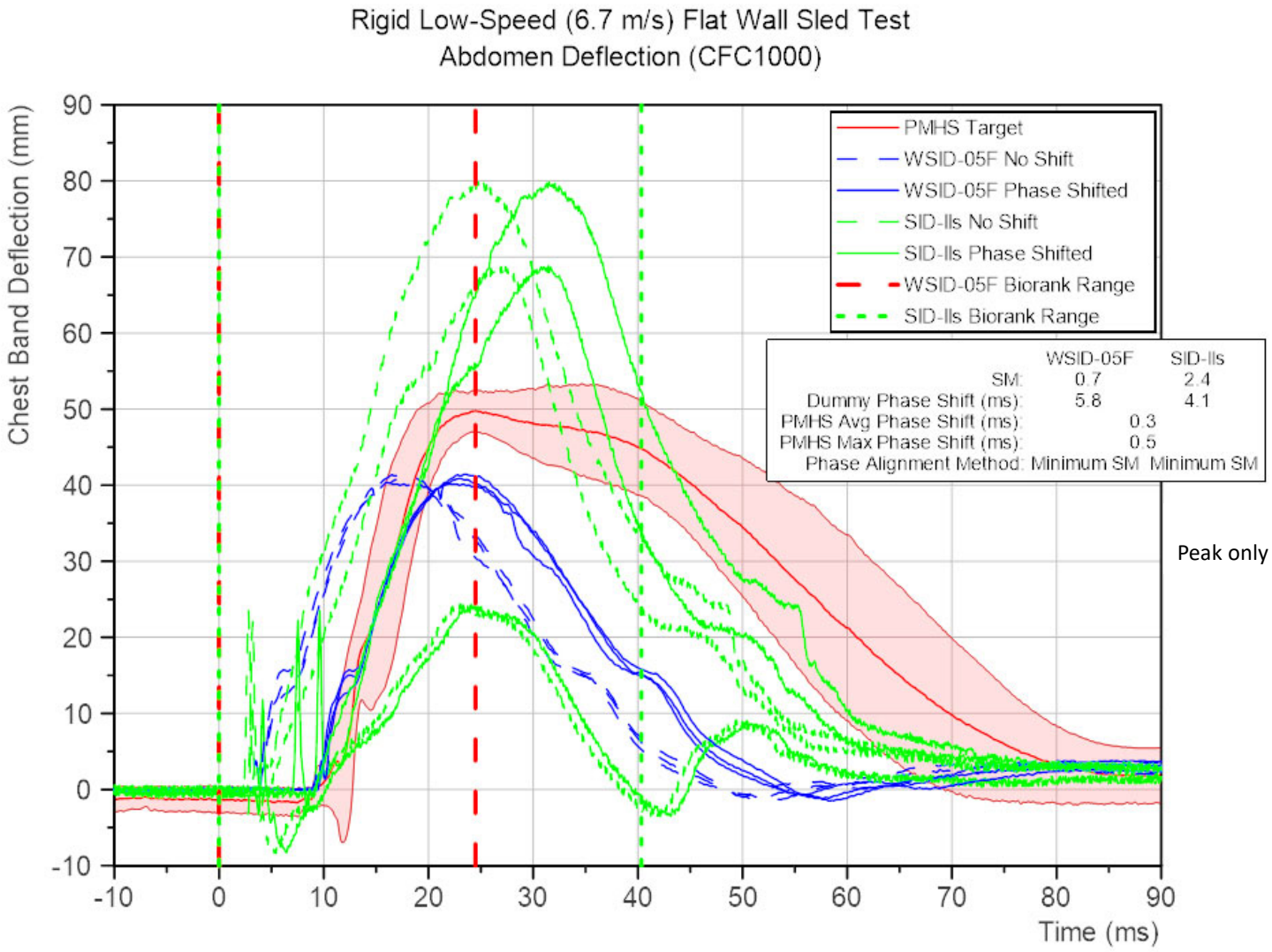
Body Region	Test Condition	Measurement	PMHS Avg Phase Shift (ms)	PMHS Max Phase Shift (ms)	WorldSID-05F		SID-IIs	
					SM	Phase Shift (ms)	SM	Phase Shift (ms)
Abdomen	6.7 m/s Rigid-Wall Sled	Abdomen Plate Force	0.8	1.4	1.6	-1.3	1.3	-5.7
		Abdomen Deflection	0.3	0.5	0.7	5.8	2.4	4.1
		Test Condition Avg.			1.1		1.9	
	6.7 m/s Padded-Wall Sled	Abdomen Plate Force	3.6	6.3	0.5	8.7	0.5	8.7
		Abdomen Deflection	4.6	6.9	2.6	4.1	2.0	15.8
		Test Condition Avg.			1.5		1.3	
	8.9 m/s Padded-Wall Sled	Abdomen Plate Force	4.3	12.4	0.7	8.3	0.4	2.9
		Abdomen Deflection	5.7	14.2	1.8	12.1	0.6	13.6
		Test Condition Avg.			1.2		0.5	
	6.7 m/s Abdomen-Offset Sled	Abdomen Plate Force	2.8	2.8	1.0	4.0	1.5	0.2
		Abdomen Deflection	2.8	2.8	1.6	2.5	1.3	0.7
		Test Condition Avg.			1.3		1.4	
	Abdomen Avg.				1.3		1.3	

Peak Only

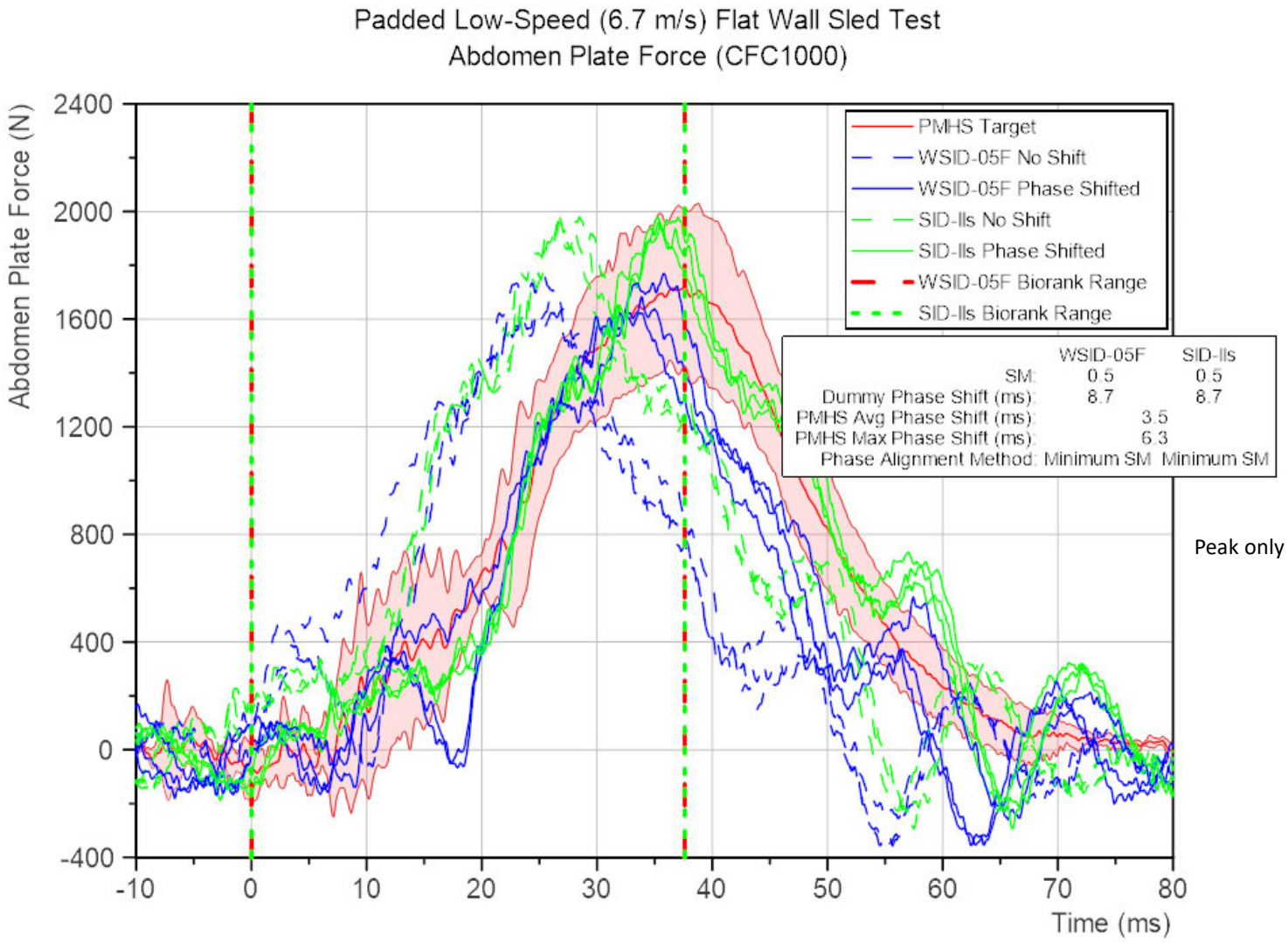
Body Region	Test Condition	Measurement	Target Mean Peak	Target Std. Dev.	Target Mean Peak Time	WorldSID-05F				SID-IIs			
						Dummy Peak	Dummy Peak Time	Peak DAD/CSD	Dummy Peak Time Diff.	Dummy Peak	Dummy Peak Time	Peak DAD/CSD	Dummy Peak Time Diff.
Abdomen	6.7 m/s Rigid-Wall Sled	Abdomen Plate Force	2194	241	14.6	3888	12.1	7.0	-2.6	1931	18.9	1.3	4.3
		Abdomen Deflection	50	5	24.5	41	17.0	1.7	-7.5	58	24.8	4.8	0.3
		Test Condition Average						4.4				3.0	
	6.7 m/s Padded-Wall Sled	Abdomen Plate Force	1719	283	37.6	1693	25.8	0.2	-11.8	1967	26.7	0.9	-10.9
		Abdomen Deflection	74	12	54.8	21	29.5	4.2	-25.3	54	37.8	1.6	-17.0
		Test Condition Average						2.2				1.2	
	8.9 m/s Padded-Wall Sled	Abdomen Plate Force	2461	367	33.8	3124	22.4	1.8	-11.4	2279	26.5	0.5	-7.3
		Abdomen Deflection	62	8	51.8	39	24.4	2.9	-27.4	63	25.8	1.2	-26.0
		Test Condition Average						2.4				0.8	
	6.7 m/s Abdomen-Offset	Abdomen Plate Force	5537	457	21.4	6540	18.3	2.2	-3.2	12617	19.7	15.5	-1.7
		Abdomen Deflection	69	5	21.0	73	22.5	2.7	1.5	61	19.2	1.7	-1.7
		Test Condition Average						2.5				8.6	
	Abdomen Avg.							2.9				3.4	



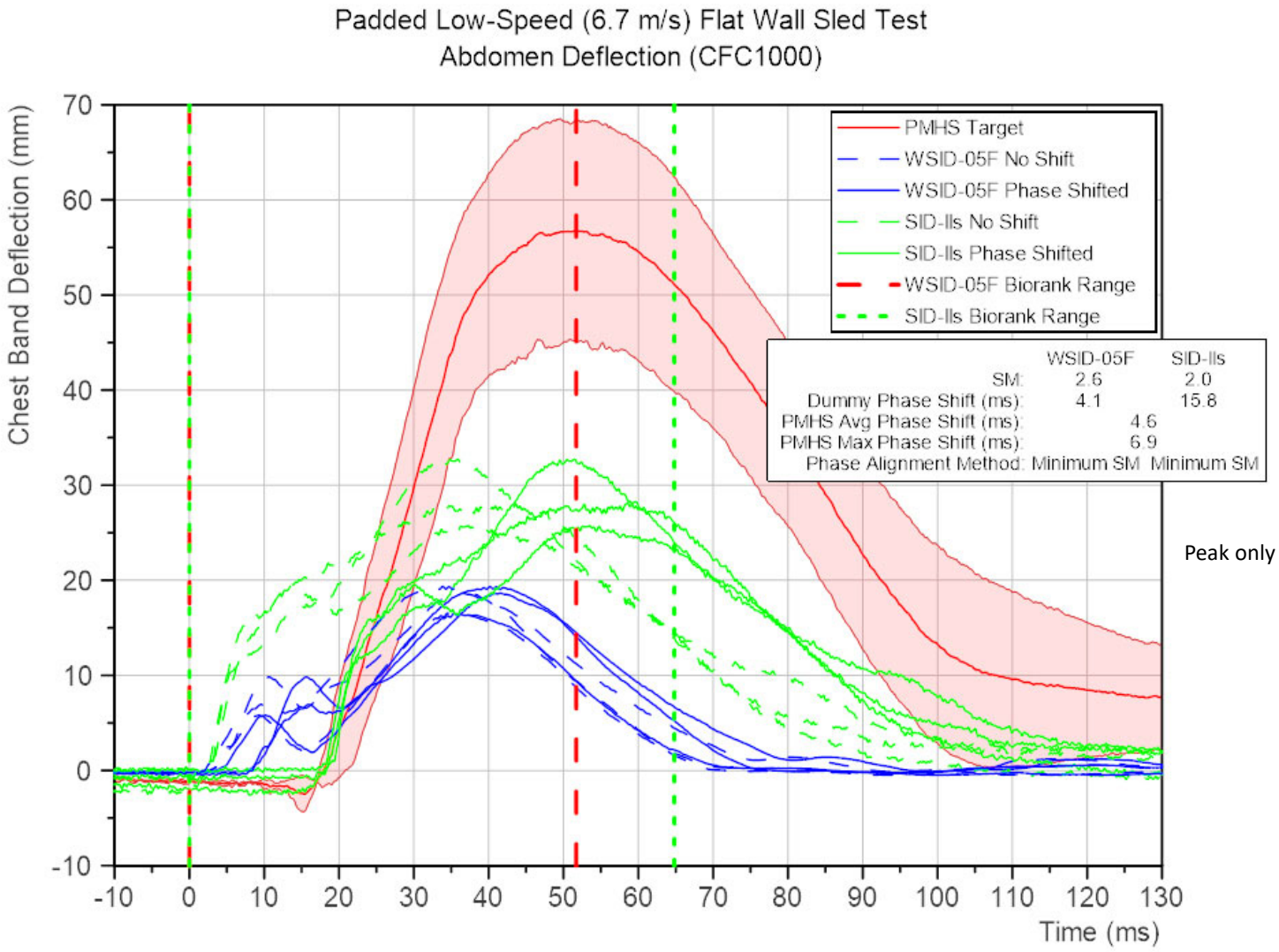
	WS-05F	SID-IIs
Peak only	7.0	1.3



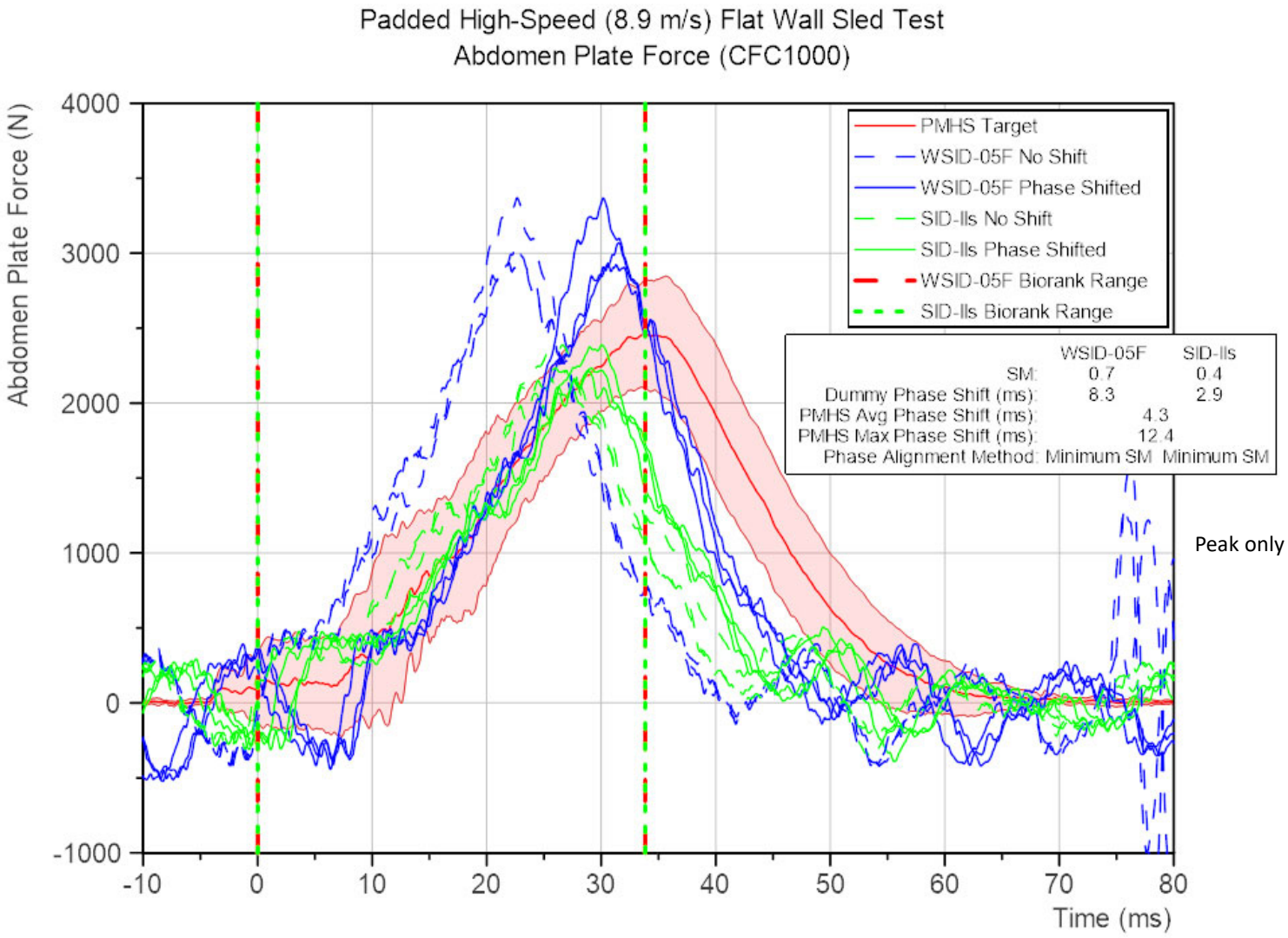
	WS-05F	SID-IIs
Peak only	1.7	4.8



	WS-05F	SID-IIs
Peak only	0.2	0.9



	WS-05F	SID-IIs
Peak only	4.2	1.6



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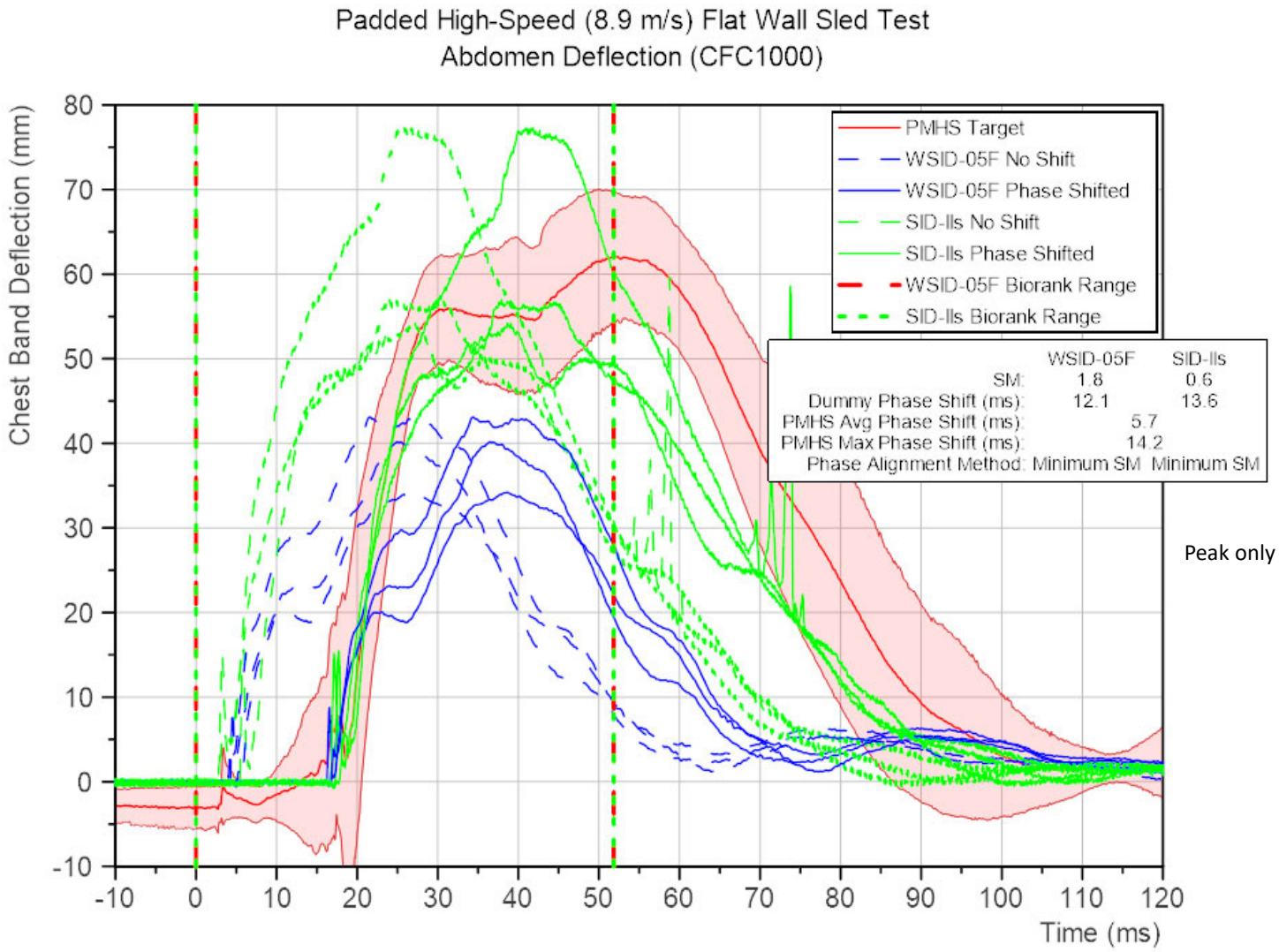
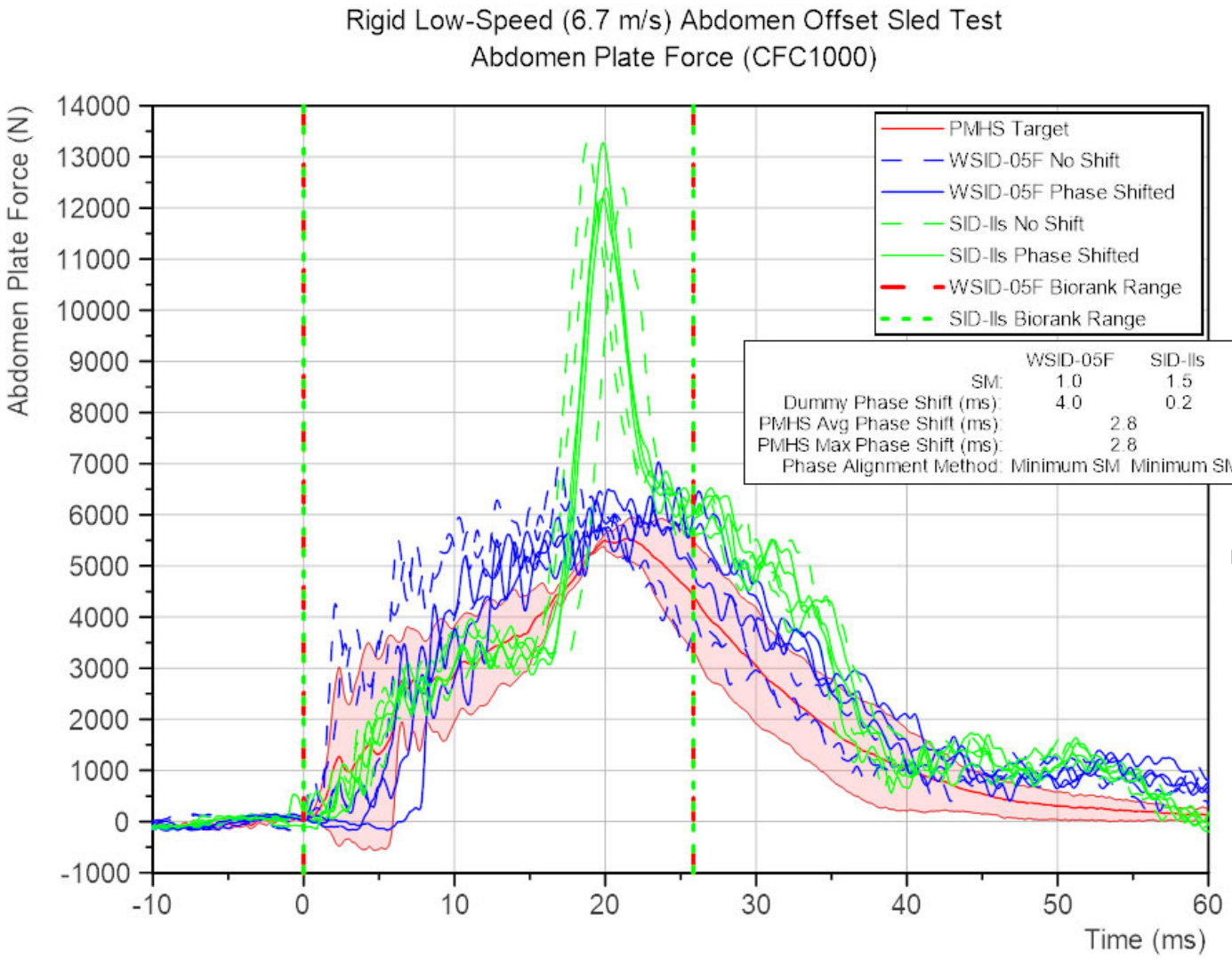
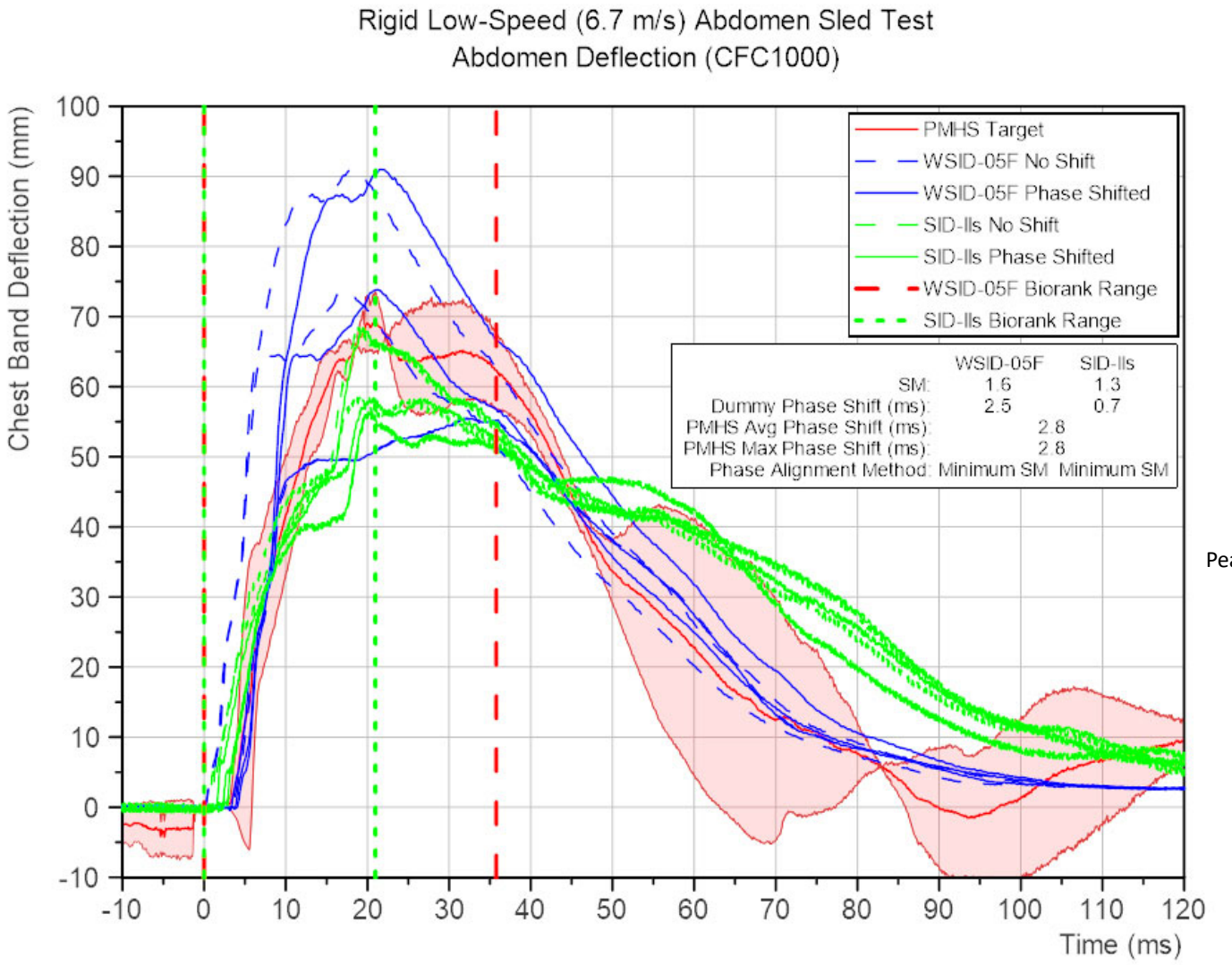


	WS-05F	SID-IIs
Peak only	2.9	1.2



	WS-05F	SID-IIs
Peak only	2.2	15.5



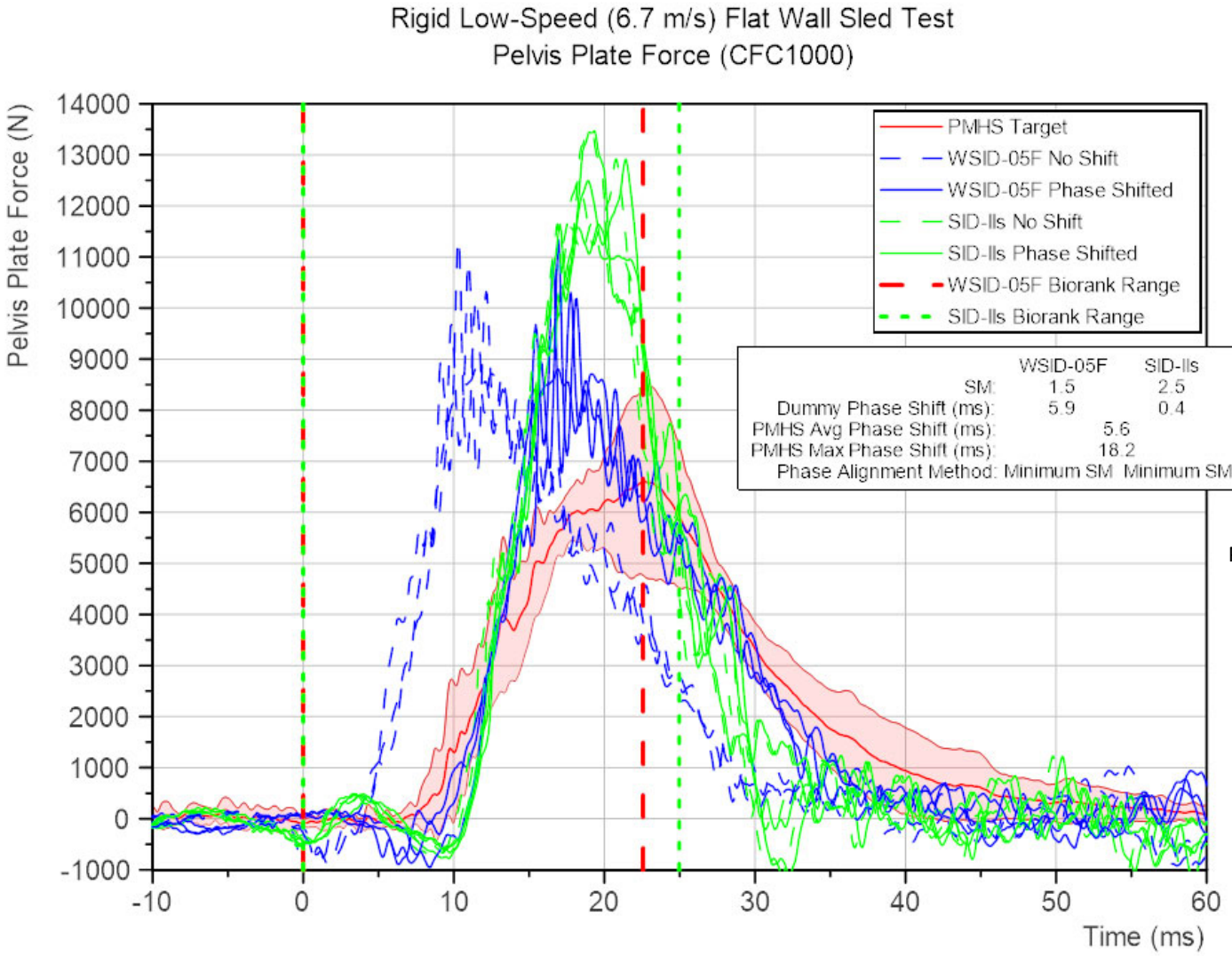
	WS-05F	SID-IIs
Peak only	2.7	1.7

SM

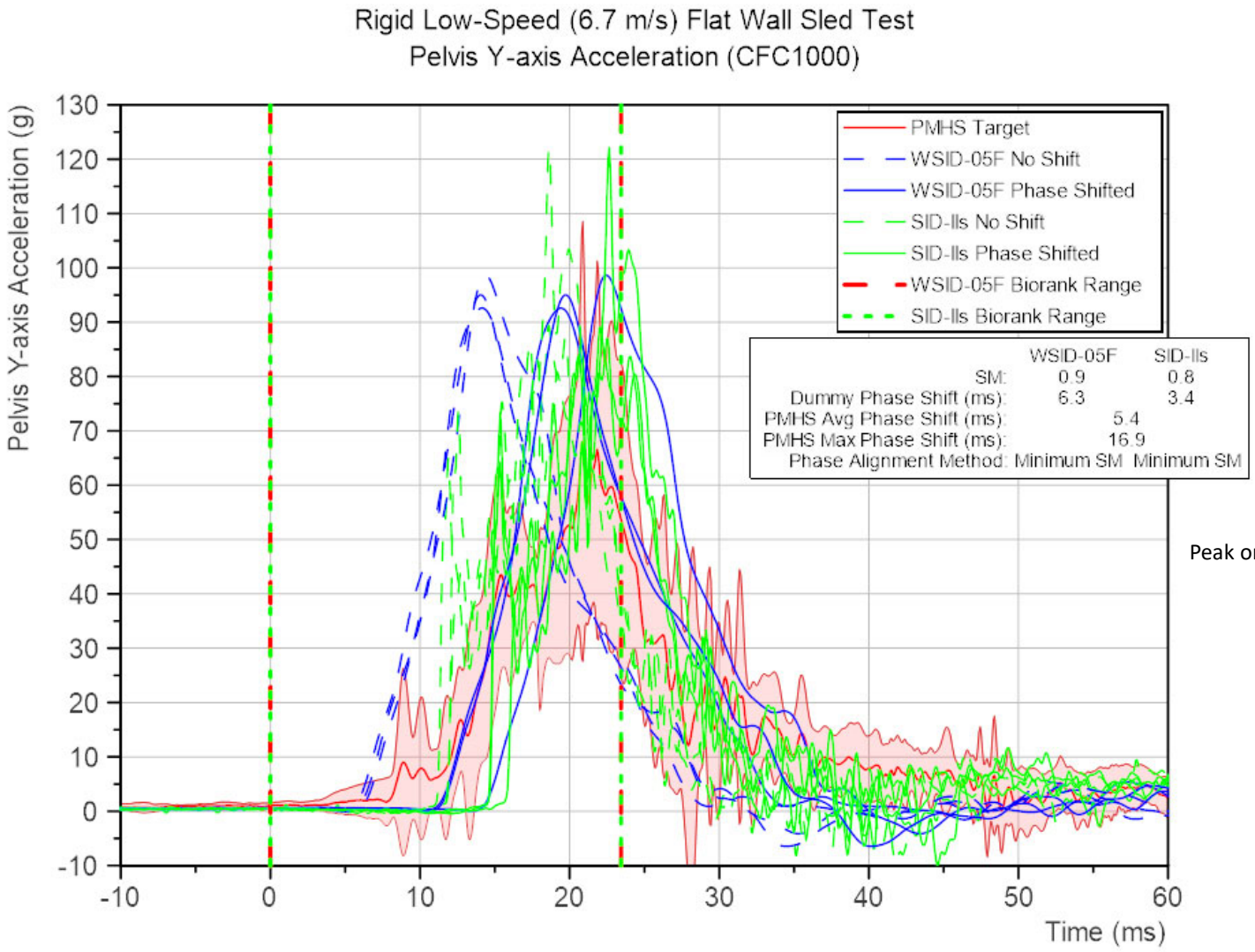
Body Region	Test Condition	Measurement	PMHS Avg Phase Shift (ms)	PMHS Max Phase Shift (ms)	WorldSID-05F SM	WorldSID-05F Phase Shift (ms)	SID-IIs SM	SID-IIs Phase Shift (ms)
Pelvis	6.7 m/s Rigid-Wall Sled	Pelvis Plate Force	5.6	18.2	1.5	5.9	2.5	0.4
		Pelvis Y-axis Acceleration	5.4	16.9	0.9	6.3	0.8	3.4
		Test Condition Avg.			1.2		1.6	
	6.7 m/s Padded-Wall Sled	Pelvis Plate Force	5.1	15.3	1.2	13.8	1.5	8.3
		Pelvis Y-axis Acceleration	5.9	17.6	0.9	13.7	0.7	8.7
		Test Condition Avg.			1.1		1.1	
	8.9 m/s Padded-Wall Sled	Pelvis Plate Force	2.9	7.8	2.6	12.5	1.5	5.8
		Pelvis Y-axis Acceleration	2.7	5.5	1.0	11.4	0.5	6.4
		Test Condition Avg.			1.8		1.0	
	6.7 m/s Pelvis-Offset Sled	Pelvis Plate Force	1.8	4.2	1.5	7.8	3.8	9.2
		Pelvis Y-axis Acceleration	1.8	3.3	1.1	6.4	3.0	7.9
		Test Condition Avg.			1.3		3.4	
	Pelvis Avg.				1.3		1.8	

Peak Only

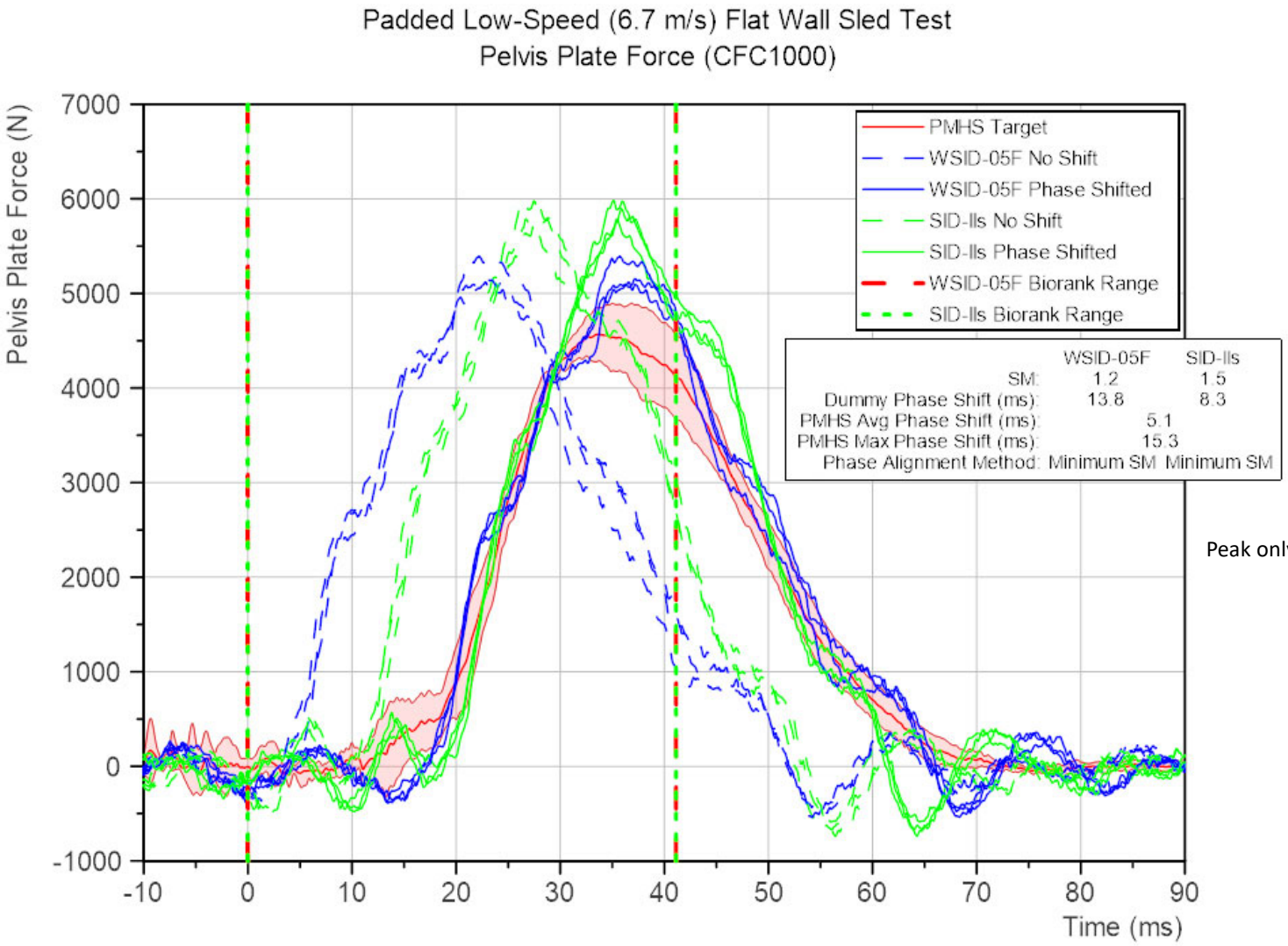
Body Region	Test Condition	Measurement	Target Mean Peak	Target Std. Dev.	Target Mean Peak Time	WorldSID-05F Dummy Peak	WorldSID-05F Dummy Peak Time	WorldSID-05F Peak DAD/CSD	WorldSID-05F Dummy Peak Time Diff.	SID-IIs Dummy Peak	SID-IIs Dummy Peak Time	SID-IIs Peak DAD/CSD	SID-IIs Dummy Peak Time Diff.
Pelvis	6.7 m/s Rigid-Wall Sled	Pelvis Plate Force	6605	1176	22.6	10378	10.9	3.2	-11.6	12675	19.7	5.2	-2.9
		Pelvis Y-axis Acceleration	68	28	20.9	95	14.2	1.0	-6.7	100	19.0	1.1	-1.9
		Test Condition Avg.						2.1				3.1	
	6.7 m/s Padded-Wall Sled	Pelvis Plate Force	4568	318	33.7	5223	22.7	2.1	-11.0	5890	27.1	4.2	-6.5
		Pelvis Y-axis Acceleration	47	32	32.2	44	18.9	0.1	-13.3	47	31.0	0.0	-1.2
		Test Condition Avg.						1.1				2.1	
	8.9 m/s Padded-Wall Sled	Pelvis Plate Force	5875	323	32.1	8773	21.7	9.0	-10.4	7929	25.3	6.4	-6.7
		Pelvis Y-axis Acceleration	58	11	30.5	79	22.3	1.9	-8.2	68	26.3	0.9	-4.2
		Test Condition Avg.						5.4				3.6	
	6.7 m/s Pelvis-Offset Sled	Pelvis Plate Force	8070	1187	15.0	9967	9.6	1.6	-5.5	18033	8.6	8.4	-6.4
		Pelvis Y-axis Acceleration	48	26	15.8	85	9.4	1.4	-6.4	112	6.5	2.4	-9.3
		Test Condition Avg.						1.5				5.4	
	Pelvis Avg.							2.5				3.6	



	WS-05F	SID-IIs
Peak only	3.2	5.2



	WS-05F	SID-IIs
Peak only	1.0	1.1



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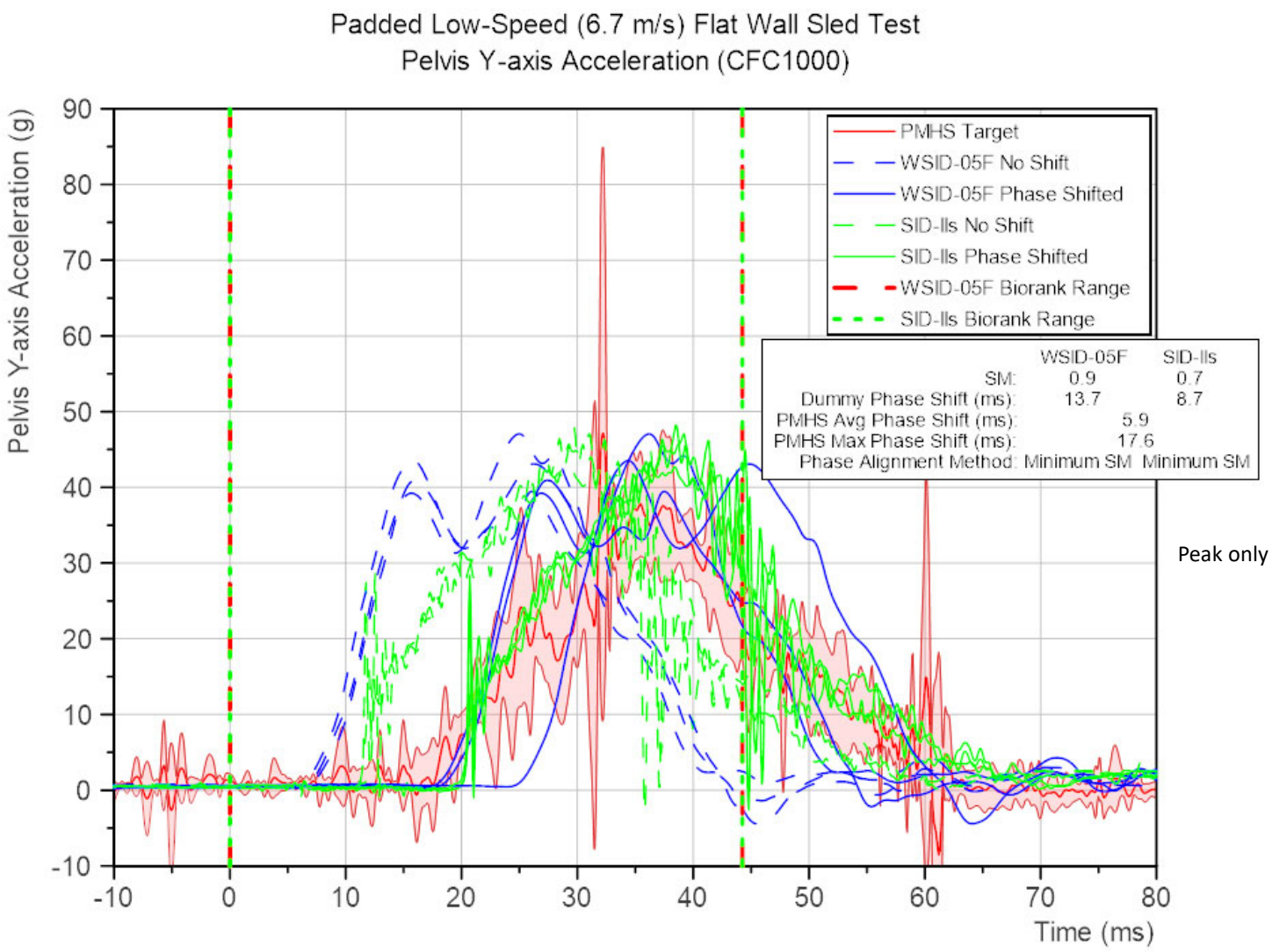
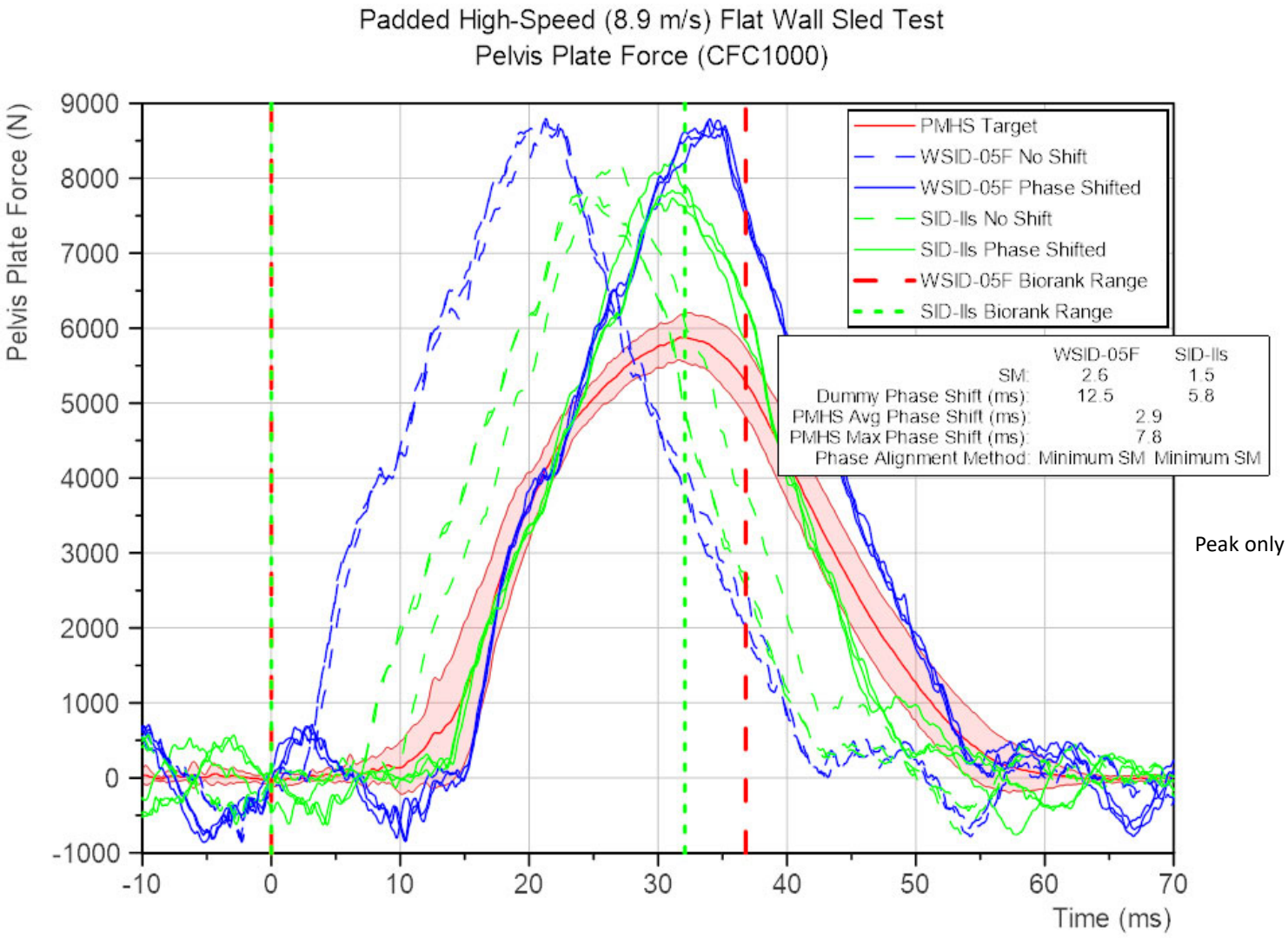
Peak only	2.1	4.2



	WS-05F	SID-IIs
Peak only	0.1	0.0



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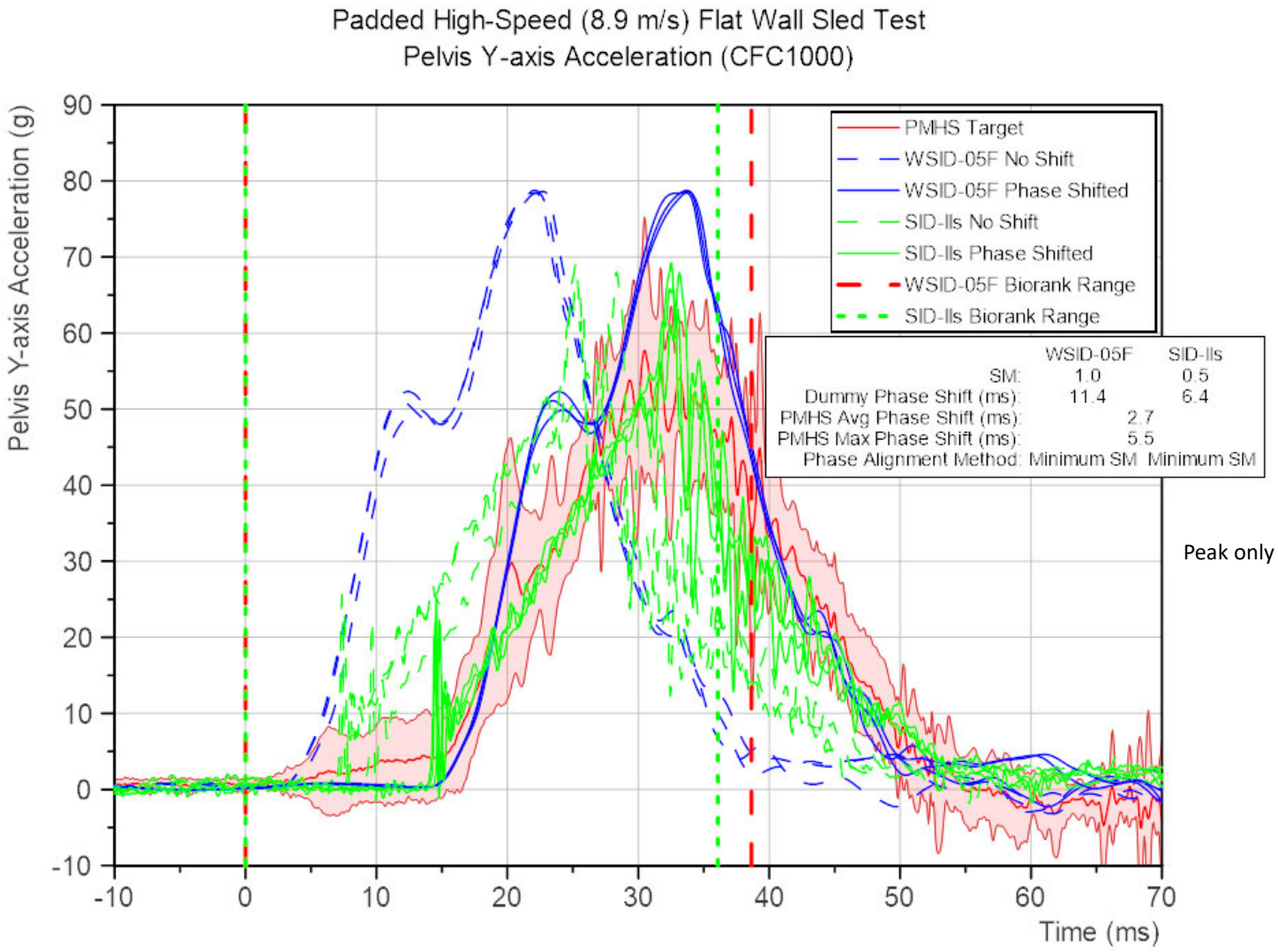
Peak only	9.0	6.4



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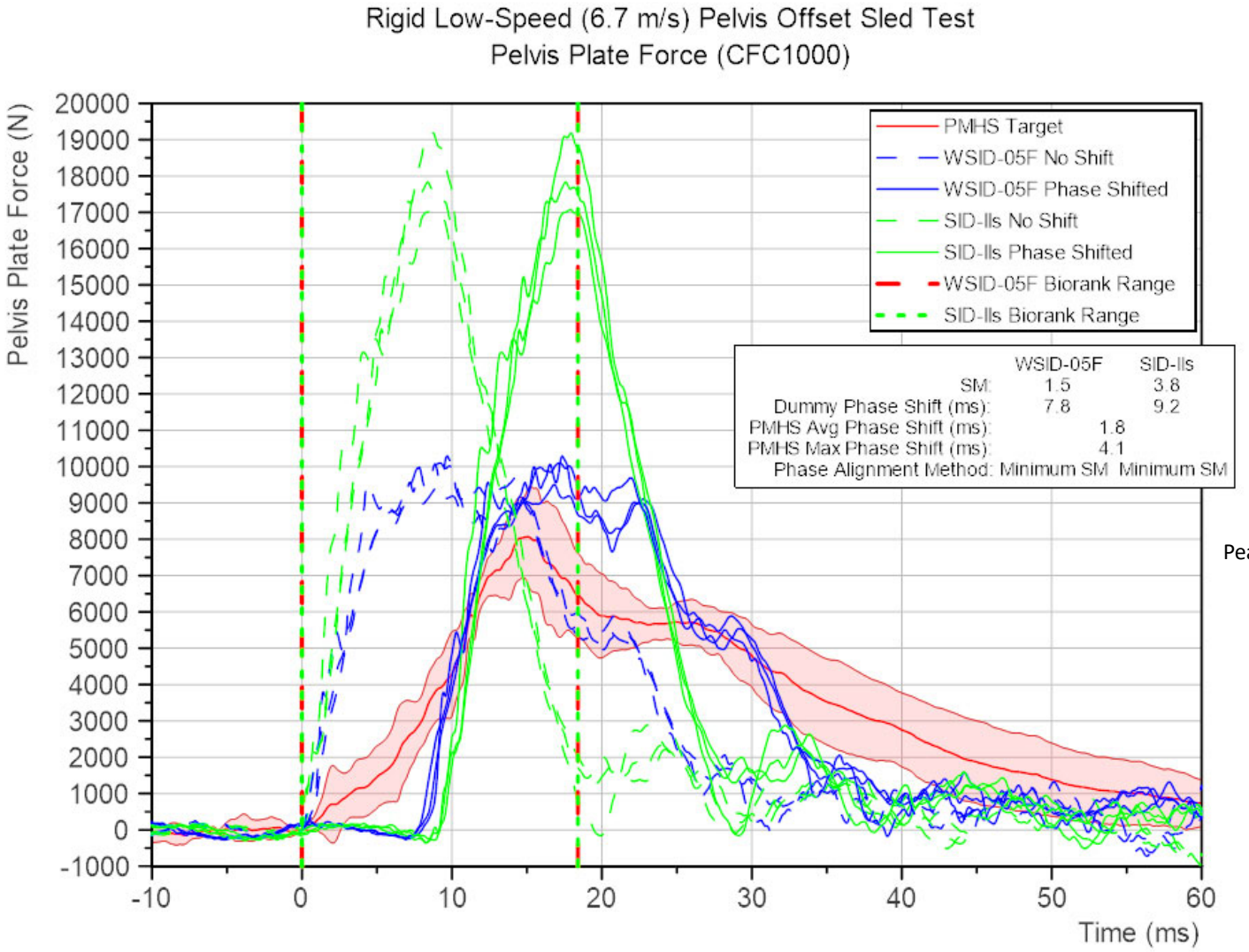
Peak only	1.9	0.9



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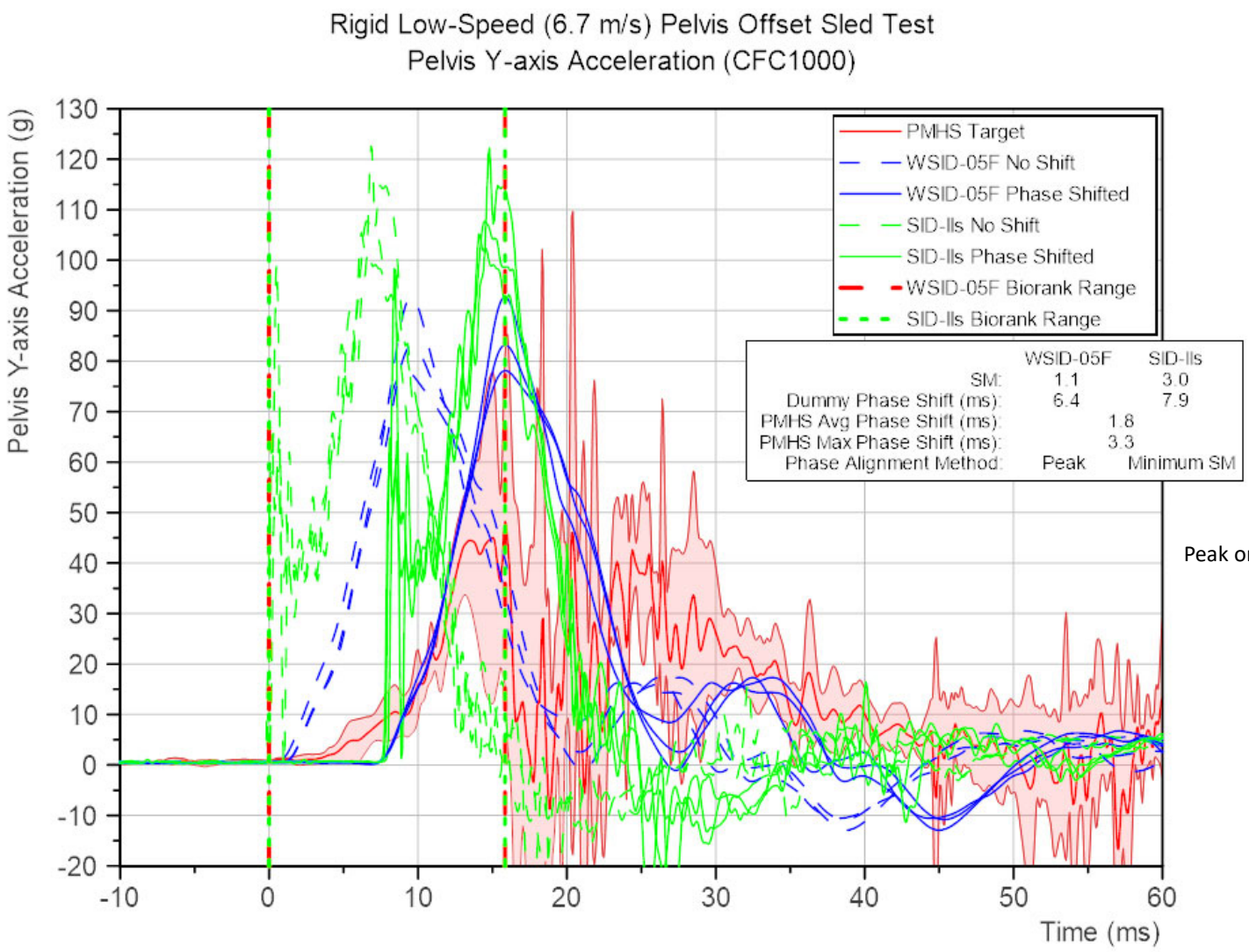
Peak only	1.6	8.4



	WS-05F	SID-IIs
Peak only	1.4	2.4