U.S. CONSUMER PRODUCT SAFETY COMMISSION
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August XX, 2013

Ms. Vesta Garcia
Subcommittee Chairman for ASTM F2907 Sling Carriers
100 Barr Harbor Dr.
West Conshohocken, PA 19428-2959

Dear Ms. Garcia:

This letter[1] is a follow-up to the ASTM F2907 task group meeting held by conference call on April 17, 2013, regarding the sling carrier voluntary standard. In that meeting, some members of the task group expressed concerns regarding the test methods in the ASTM F2907-12 voluntary standard for sling carriers. Specifically, the group expressed concerns about the following:

1) whether the occupant retention test is reasonable;
2) whether there is a possible redundancy between the dynamic test (6.1.2) and the occupant retention test (6.3); and
3) whether the component-level fastener test, recently added to the soft infant and toddler carrier standard (SITC), F2236-13, would be an appropriate test for the sling carrier standard.

Because there were no test laboratories participating in that task group meeting, the task group asked U.S. Consumer Product Safety Commission (CPSC) technical staff to review the test methods, explore "combining" the two tests, and consider the possibility of including the component-level fastener test recently added for F2236-13 in the F2907 voluntary standard. In addition, the task group asked CPSC Human Factors staff for research on human gait to determine if the occupant retention test, which specifies a 4.75-inch displacement at 2 cycles/second, is similar to human walking.

Task Group Concern #1

The occupant retention test requires the sling to be attached to a specified test torso, which roughly mimics a human torso, with a weighted bag placed in the sling to simulate the loading of a child. The whole system (torso, sling, and weighted bag) is then moved up and down 4.75 ± 0.25 inches at a frequency of 2 Hz (±10 %). Several members of the task group were concerned that this was not an accurate representation of a human walking. CPSC Human Factors staff

[1] Unless otherwise indicated, the views expressed in this letter are those of CPSC technical staff and have not been reviewed or approved by, and may not reflect the views of, the Commission.

found two published articles of interest related to this issue. One study[2] measured vertical displacement of the center of mass when walking and found that normal human walking varied between 0.6[3] and 1.3[4] inches, while “bouncy walking” was up to 4.5 inches.[5] A second study[6] reported an average human walking speed between 101 and 122 steps per minute, which converts to 1.7 to 2 steps per second, or about 2 Hz. The two articles suggest that 2 Hz is a reasonable cyclic test to simulate human walking, and that 4.75 inches of displacement, while it is considerably more than the vertical displacement of normal walking, is not necessarily unreasonable. This is especially true when one considers that cyclic testing generally is intended to generate an accelerated lifecyle rather than to mimic normal loading conditions.

Task Group Concern #2

CPSC Laboratory Sciences staff reviewed the dynamic and occupant retention test methods and agrees that the test methods are similar in that both methods involve cyclic testing and use a weighted test mass to exercise the sling. There are, however, differences between the methods. A comparison of the major differences between the two test methods is shown in Table 1.

Table 1. Cyclic test comparison

	Dynamic Test	Occupant Retention Test
Cycle rate	0.25 cycles/second	2 cycles/second
Time to complete 1000 cycles	~67 minutes	~8 minutes
Test mass	35 pounds	20 or 35 pounds*
Drop distance	1 inch	4.75 inches
Drop object	test mass only	carrier system (Torso + test mass+ sling)

*depending on manufacturer’s recommended weight

CPSC technical staff has done considerable testing and analysis of the test methods in the F2907-11 voluntary standard that were developed through the ASTM consensus process, which includes manufacturers, test labs, consumer groups, and others. Staff would like to share these results with the subcommittee for consideration should the subcommittee wish to continue exploring this issue. A description of these results follows.

CPSC staff purchased 14 sample slings from major retailers. The slings were subjected to static, dynamic, and occupant retention tests. All 14 samples passed the static test. Four samples[7] failed both the dynamic test and the occupant retention test, and three additional samples failed

[2] Massaad, F., Lejeune, T. M., & Detrembleur, C. (2007). The up and down bobbing of human walking: a compromise between muscle work and efficiency. *Journal of Physiology*, 789-793. Is there a website link?

[3] Reported as 0.015 ± 0.003 m (mean ± s.d).

[4] Reported as 0.034 ± 0.004 m (mean ± s.d.).

[5] Reported at 0.095 ± 0.02 m (mean ± s.d.). 4.5 inches represents one standard deviation over the mean (*i.e.*, 0.115 m).

[6] Winter, D.A.: The Biomechanics and Motor Control of Human Gait: Waterloo, Ontario, Canada, University of Waterloo Press, 1887, in Rogers, M.M. 1988 in Rodgers, M. M. (1988). Dynamic Biomechanics of the Normal Foot and Ankle During Walking and Running. Physical Therapy Journal of the American Physical Therapy Association, 68(12), 1823–1824.

[7] New samples were used for each test.

the occupant retention test only. Two of the three additional failures were related to the test mass ejecting from the sling, and the third failure involved a ring sling that slipped more than 1 inch. A summary table of the test results is enclosed with this letter.

Test cycle calculation

Upon initial review of the F2907-12 standard, CPSC staff recommended adding specificity to ensure that the test cycles were divided evenly among all carrying positions. Staff's original suggestion was discussed with the technical requirements task group, and the task group agreed on language that was balloted in January 2013. The ballot item did not pass and the subcommittee decided to withdraw the ballot to discuss the issues raised and further refine the test methods. Since the January ballot, CPSC staff has completed testing of available sling carriers. This testing suggests that for some slings with multiple carrying positions, many of these carrying positions were substantially the same for testing purposes. For example, a sling may list two distinct carrying positions, but the only difference is the direction the child faces. Another example is a wrap that is tied in the same manner for a front or hip carry. Because the test mass is symmetrical and does not vary based on the direction it faces, and the loading patterns do not differ for the same wrap pattern, engineering staff judged these carrying positions as substantially similar and tested only substantially different carrying positions.

Occupant Retention Test Concerns

At the April subcommittee meeting, CPSC staff raised concerns about the pass/fail criteria in the occupant retention test. At that meeting, staff mentioned that some slings stretched significantly, resulting in the test mass ejecting from the sling during the test. In other cases, specifically some ring slings, staff noted that the attachment system (*i.e.*, the rings) passed the initial test (less than 1-inch slippage in the first 90 cycles); however, staff observed that the attachment system continued to slip in the remaining cycles and, although not completely releasing, the system slipped enough so that the test mass ejected before the end of the test.

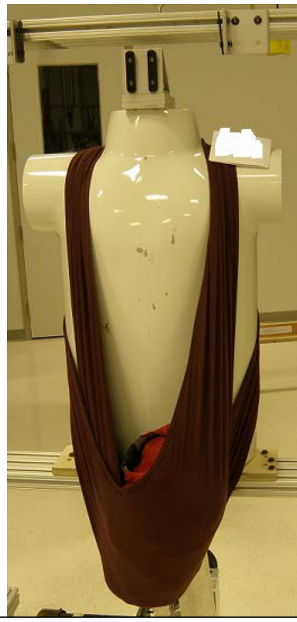

Figure 1: Test mass is not supported in a proper position at the beginning of the test. Test mass ejected.

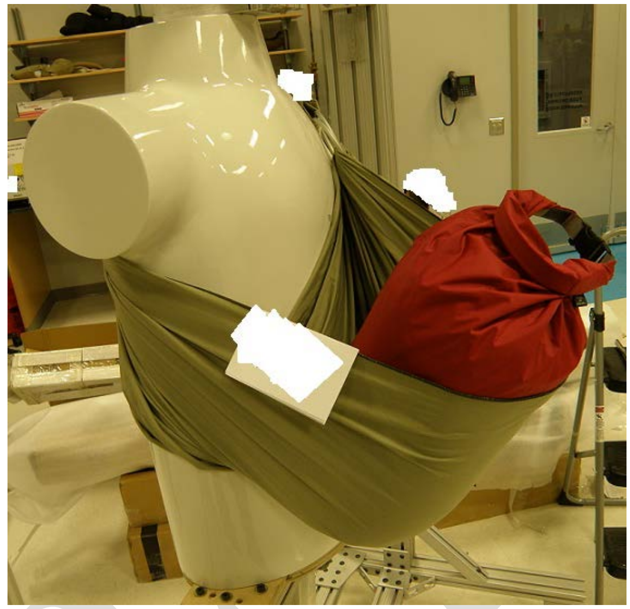

Figure 2: Ring slippages allowed test mass to eject.

Because positioning is so vital in sling safety, staff is particularly concerned with slings that cannot properly support the test mass. Figure 1 demonstrates a sample that was loaded with the proper test mass, based on the manufacturer’s recommended maximum weight, but this sling was unable to support that weight in the proper position prior to beginning the test. Not surprisingly, the test mass was ejected during the test. Figure 2 shows a different situation, where the rings slipped enough to free the test mass; however, the rings did not completely fail. Staff remains concerned about both of these cases because the occupant retention test does not contain pass/fail criteria regarding retention of the test mass.

<u>Task Group Concern #3</u>

The task group expressed interest in the fastener test that was developed and added to the SITC standard (§ 6.3 in F2236-13). CPSC staff replicated this test on the ring slings available for testing by placing a clamp on either side of the ring and applying an 80-pound force between the clamps. All the rings passed the test, *i.e.*, there were neither breaks, nor 1-inch separations; however, staff noted that the fabric tore around the clamps for one product. In addition to the ring slings currently on the market and purchased for this project, CPSC staff examined several case files and samples of ring slings that were the subject of recalls between 2001 and 2008. For the recalled ring slings where test results were available, the recalled rings did not fail until loads were more than 80 lbs.

In addition to testing the ring slings, staff applied the F2236-13 fastener test to the four other samples that used fasteners as part of the attachment. Typically, these were buckles or hook-and-loop fasteners that allowed the sling to be adjusted to fit the wearer. Three of the four samples failed this test. In one case, the buckle broke; in another case, the buckle could not be loaded to the full 80 lbs. because the strap slipped (failure by slipping more than 1 inch); and in the third case, the stitching for the hook-and-loop ruptured. Two of these three failures were also identified by the dynamic and occupant retention tests. The third failure, where the hook-and-loop's stitching failed, is not an incident pattern that has been seen in the data.

Summary of staff recommendations

1) Staff has provided the included test results for the subcommittee to consider when evaluating the test methods.

2) Staff did not find the fastener test, as written in F2236-13, to be acceptable for identifying known ring failures and believes that the current test methods, particularly occupant retention, exercises the fasteners in a manner that would identify problem fasteners. Staff presents the enclosed test results for the subcommittee to consider should they wish to continue to explore the fastener test.

3) Staff continues to recommend clarifying the test methods. The original recommended clarification was balloted in January 2013. After completing the tests, as specified in the standard, and considering the negative votes received on the initial ballot, staff presents the following recommendation to the subcommittee for consideration. If the standard continues to include both the dynamic and occupant retention test, staff considers the additions specified below to be necessary:

6.1 Structural Integrity—At ~~test~~ the conclusion of each test, there shall be no seam separation, fabric deterioration, breakage or disengagement of attachment systems, or a hazardous condition as defined in Section 5.2, 5.3, 5.4, 5.5, 5.8, or 5.9. Adjustable attachment systems of the sling carrier shall not slip more than 1 in. (25.44 mm) per element.
6.1.1 Static Load—The sling carrier shall support a static load in accordance with the failure criteria in 6.1 when tested in accordance with 7.1.
6.1.2 Dynamic Load—The sling carrier shall support a dynamic load in accordance with the failure criteria in 6.1 when tested in accordance with 7.2.

6.3.1 When tested in accordance with 7.5, after ~~90~~ 100 cycles the maximum slippage of the attachment system and the restraint system (if applicable) shall be 1 in and no part of the test mass shall pass below the bottom of the test torso.
6.3.2 When tested in accordance with 7.5, after the completion of ~~1000 cycles~~each phase of the test, the attachment system and the restraint system (if applicable) shall not be released, there shall be no fabric failures, and no part of the test mass shall pass below the bottom of the test torso.

7.2.3 Calculate the variable X by dividing 1000 test cycles by the total number of substantially different manufacturer's recommended carrying positions and rounding up to the nearest multiple of 50. If the manufacturer has more than 3 substantially different carrying positions, X shall be 350. Drop the weight onto the support area an additional ~~1000~~ X times with a cycle time of 4 +/- 1s/cycle. ~~If the sling, according to manufacturer's instructions, has more than one usage position, the 1000 cycles will be divided among the different usage positions~~ Repeat the test for each different manufacturer's recommended carrying position.

7.5.2 Place the sling on the test torso in accordance with the manufacturer's instructions. Calculate the variable X by dividing 1000 test cycles by the total number of substantially different manufacturer's recommended carrying positions and rounding up to the nearest multiple of 50. If the manufacturer has more than 3 substantially different recommended carrying positions, X shall be 350. Select either test mass A or test mass B. Place the appropriate test mass into the sling carrier and firmly secure any restraint system (if applicable). Carry out the test for 10 cycles. Mark all straps to enable measurement of slippage of straps in buckles or other devices. Carry out the test for ~~90~~ 100 additional cycles and measure any slippage. Carry out the test for a further ~~900~~ X-100 cycles. If the sling, according to manufacturer's instructions, has more than one substantially different carrying position, ~~divide those 900 cycles equally among the different use positions.~~repeat the test for each substantially different manufacturer's recommended carrying position.

I hope this information will be useful to the task group and subcommittee.

Sincerely,

Hope E. J. Nesteruk
Project Manager, Sling Carrier Section 104 Project
Engineering Psychologist, Division of Human Factors

Enclosure
Summary Table of CPSC Staff Testing Results

cc:

Colin Church, CPSC Voluntary Standards Coordinator
Len Morrissey, ASTM F15 Manager

Summary Table of CPSC Staff Testing Results

	Orientation	Restraint (6.2)	Dynamic (6.1.2)	Occupant Retention (6.3)	Static (6.1.1)	Fastener (F2236-13)
Wrap 1	1	n/a	Pass	Pass	Pass	n/a
	2	n/a	Pass	Pass	Pass	n/a
	3	n/a	Pass	Pass	Pass	n/a
	4	n/a	Pass	Pass	Pass	n/a
	5	n/a	Pass	Pass	Pass	n/a
Wrap 2	1	n/a	Pass	Pass	Pass	n/a
	2	n/a	Pass	Pass	Pass	n/a
	3	n/a	Pass	Pass	Pass	n/a
Wrap 3	1	n/a	Pass	Pass	Pass	n/a
	2	n/a	Pass	Pass	Pass	n/a
Wrap 4	1	n/a	Pass	Fail	Pass	n/a
	2	n/a	Pass	Fail	Pass	n/a
Ring 1		n/a	Fail	Fail	Pass	Pass
Ring 2		n/a	Pass	Fail	Pass	Pass
Ring 3		n/a	Pass	Pass	Pass	Pass
Ring 4		n/a	Fail	Fail	Pass	Pass
Bag 1		Fail	Pass	Pass	Pass	Pass
Bag 2		Pass	Fail	Fail	Pass	Fail
Adjustable Pouch 1		n/a	Fail	Fail	Pass	Fail
Adjustable Pouch 2		n/a	Pass	Pass	Pass	Fail
Pouch		n/a	Pass	Pass	Pass	n/a
Other		n/a	Pass	Fail	Pass	n/a