ISSN 1041-9489

SAFETY BRIEF

July, 2002 — Volume 21, No. 1

Triodyne Inc.

Consulting Engineers & Scientists – Safety Philosophy & Technology

5950 West Touhy Avenue Niles, IL 60714-4610

(847) 677-4730 FAX: (847) 647-2047

e-mail: infoserv@triodyne.com *www.triodyne.com*

Standard Infant Crib Testing Enhanced with Live Children Shaking

By Dennis B. Brickman, P.E.*

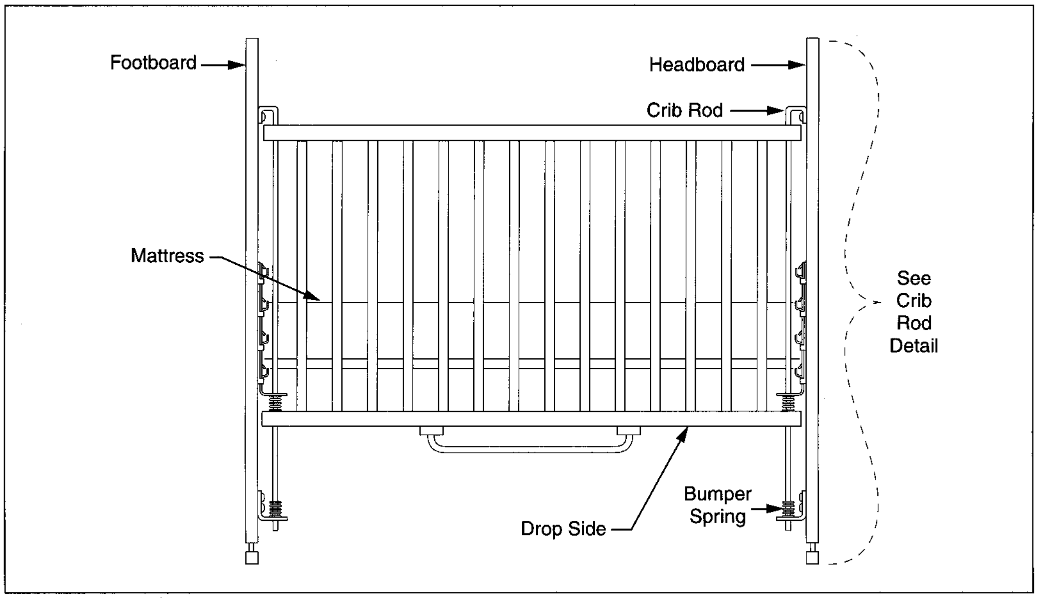

Figure 1a - Subject Full Size Crib

ABSTRACT

An infant asphyxiated when a machine screw detached from a crib, the headboard separated from the crib rod, and the infant's head stuck in the opening. The evaluation of infant cribs by inanimate standard test protocols is enhanced by live child crib shake testing. This live testing provides data for quantifying the horizontal push and pull forces that children actually apply to the sides of a crib. Comparisons are made between the live child shake test results and the inanimate test requirements contained in crib safety standards. Although the inanimate standard test protocols are inconsistent, the machine screw did not fail from normal use because the inanimate test requirements far exceed the maximum live results.

INTRODUCTION

An infant crib was alleged to cause a 10 month old child's death when a machine screw became detached from the crib rod attached to the headboard creating a gap between the end of the drop side rail and the headboard. Figures 1a and 1b illustrate

This paper will be published in the Proceedings of the American Society of Mechanical Engineers' International Mechanical Engineering Congress and Exposition in November of 2002.

*Senior Mechanical Engineer, Triodyne Inc., Niles, IL.

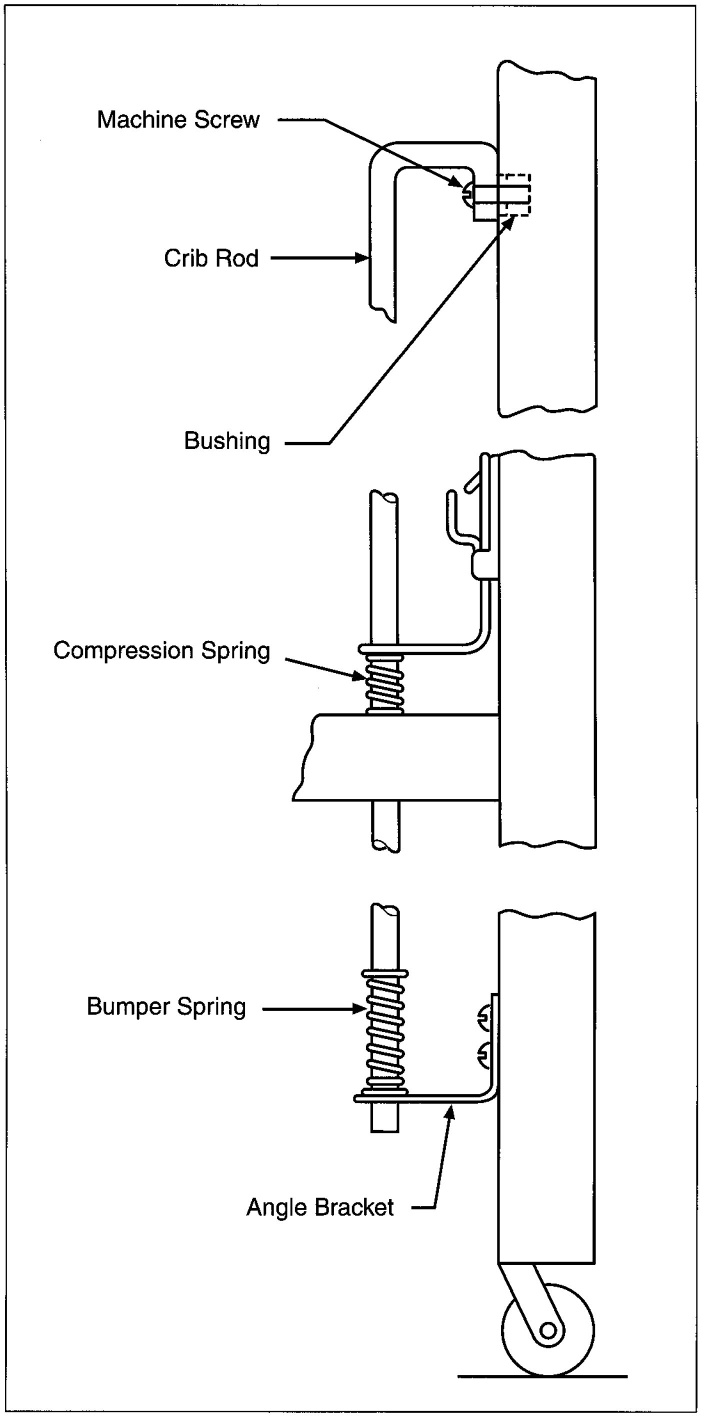

Figure 1b - Crib Rod Detail

the subject full size crib and its associated components. According to the U.S. Consumer Product Safety Commission epidemiologic investigation report, the child's neck was found in between the end/vertical edge of the side rail and the headboard. The cause of death was recorded as asphyxia due to neck compression with the manner of death accidental. The police officers who were called in to investigate the scene of the accident conducted an extensive search of the child's bedroom and discovered that the machine screw was missing along with a bumper spring which should have been located at the bottom of the detached crib rod. In addition, the machine screws for the crib rods at the remaining three corners of the crib were loose and the police officers were able to unscrew these screws with their bare hands. Furthermore, the police officers found the bottom of the crib rod was not secured in the angle bracket at the base of the headboard and wear marks were present on the interior of the headboard near the top of the crib rod which is consistent with the machine screw being missing for some period of time. Physical evidence was corroborated by statements made by the child's parents which indicated that the missing machine screw had been disconnected for at least a year before the subject accident.

It was proposed that the connection between the machine screw and a threaded metal bushing located inside the wooden headboard was inadequately designed because it lacked a locking device and redundancy. The idea was the racking environment of the crib would loosen the unrestrained fasteners and allow them to dislodge. Previous studies have utilized random vibration testing with a mechanical shake table to analyze the structural integrity of infant crib fastener systems [1, 2]. The purpose of this paper is to test whether children placed in a crib can produce a live shaking environment aggressive enough to cause the machine screws to disconnect from the crib.

INANIMATE CRIB SAFETY STANDARDS

This section of the paper compares inanimate crib safety standards from the American Society for Testing and Materials (ASTM), Europe, Canada, and Underwriters Laboratories (UL).

American Society for Testing and Materials ASTM F1169-88 (Reapproved 1993)

Previous research has focused on the American Society for Testing and Materials ASTM F1169-88 testing requirements for full size baby cribs [2]. The scope of ASTM F1169-88 (Reapproved 1993) Standard Specification for Full Size Baby Crib states that this consumer safety specification establishes testing requirements for structural integrity of cribs [3]. ASTM F1169-88 (Reapproved 1993) contains test methods which include vertical impact testing and crib side testing to assist in evaluating the structural integrity of the crib assembly. The protocol for the vertical impact testing calls for a 343 mm (13.5 in.) diameter 20.4 kg (45 lb) weight to free fall 152 mm (6 in.) onto the upper surface of a foam pad at a rate of 4 plus or minus 1 seconds per cycle. Five hundred cycles are to be applied within 6.4 mm (0.25 in.) of the geometric center of the mattress area and 100 cycles are to be applied at each of two diagonally opposite corners centered 230 mm (9 in.) from the crib sides forming the corner. The performance requirements for the vertical impact testing state that components attached by screws shall not have separated by more than 1 mm (0.04 in.) upon completion of testing.

The crib side testing consists of cyclic testing and static testing. The protocol for the drop side cyclic test specifies that the side shall be removed from the crib assembly and mounted in a rigid test fixture so that it will hang vertically as it would when assembled to a crib. An 11.3 kg (25 lb) weight is allowed to free fall 76 mm (3 in.) 50 times at a rate of 4 plus or minus 1 seconds per cycle such that it impacts either directly or indirectly through a mechanical linkage upon the 9 mm (0.375 in.) rubber pad located on the top surface of the bottom rail between two adjacent slats as near the center of the rail as possible. Upon completion of the cyclic test, a static load of 45.4 kg (100 lb) is gradually applied at the point of impact testing over a period of 5 seconds and maintained for an additional 30 seconds. The performance requirements for the crib side testing state that components attached by screws shall not have separated by more than 1 mm (0.04 in.) upon completion of testing. It should be noted that the subject model crib meets the testing requirements set forth in ASTM F1169-88 (Reapproved 1993).

European Standard EN 716-2 (1995)

The scope of European Standard EN 716-2 (1995) states that this part of EN 716 describes test methods that assess the safety of children's cots and folding cots for domestic use [4]. EN 716-2 (1995) contains test methods which include impact testing and fatigue testing. The protocol for the impact testing specifies dropping the 10 kg (22 lb) bottom impactor freely 1,000 times at not more than 30 times per minute through a distance of 160 mm (6.30 in.) above the bed base onto the test mattress at each of the selected positions of impact. After completion of the impact testing, the test requirements call for removing the test mattress and checking if parts of the bed frame are broken or if the bed base has loosened from its fastening.

The protocol for the fatigue test sets forth positioning the test load of 20 kg (44.1 lb) distributed over an area of approximately 150 mm (5.91 in.) x 150 mm (5.91 in.) at the center of the bottom of the cot. Then forces of 100 N (22.5 lb) are applied by means of loading pads and a device that can press the cot in four directions horizontally, with two of the forces in the longitudinal direction and two in the lateral direction (AB/CD) opposite each other as shown in Fig. 2. The forces shall act for 2,000 cycles on each point in turn, in the order A, B, C, D or A-B followed by C-D (which equals one cycle), and each time the force shall increase from 0 to 100 N (22.5 lb) and back to 0 in not less than 1 second. The point for applying the forces (A, B, C, D) shall be located 50 mm (1.97 in.) from the intersection point of the centerlines of the side members at the highest point at that position. The test requirements call for recording any damage, loosening or detachment of fittings or fastening devices.

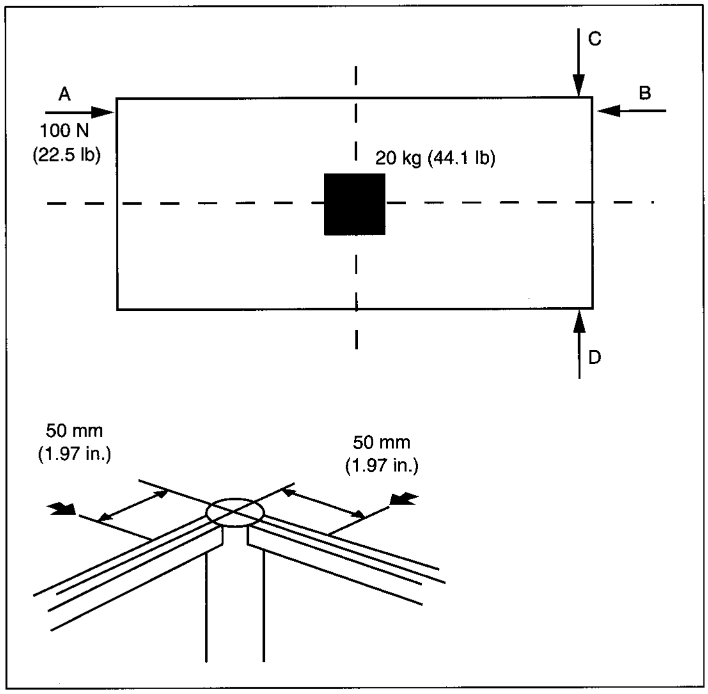

Figure 2 - EN 716-2(1995) Fatigue Test

Canadian SOR/86-962 (1986)

Cribs and cradles regulations set forth in Canadian SOR/86-962 (1986) contain tests for structural integrity of cribs [5]. The protocol for the structural integrity tests calls for allowing a 20 kg (44.1 lb) load, 200 mm (7.87 in.) in diameter, with a 260 mm (10.2 in.) bottom curvature and with cambered edges to fall freely from a height of 150 mm (5.91 in.) 150 times at a rate of one impact per second at the geometric center of the upper surface of the polyurethane foam, at each corner of the mattress support such that the center of the test load is 150 mm (5.91 in.) from the two sides forming the corners, and at the mid-point along the edge of the mattress support on all adjustable sides of the product such that the test load is 150 mm (5.91 in.) from those sides. The performance requirements for this testing specify to note any visible signs of damage to the crib, any disengagement or deformation of any latching or locking mechanism or any loosening of any screw or fastening.

The method prescribed for testing the structural integrity of a standard crib under horizontal force conditions includes applying an alternating force of 120 N (27.0 lb) in the transverse direction on the top of each side, at the midpoint, not more than 50 mm (1.97 in.) from the top of the side being tested at a frequency of no less than 150 cycles per minute for a total of 9,000 cycles. The performance requirements for the horizontal force testing specify to note any visible signs of damage to the crib or disengagement or deformation of any latching or locking mechanism. It should be noted that the subject model crib meets the testing requirements for structural integrity as set forth in Canadian SOR/86-962 (1986).

Underwriters Laboratories UL 2275 (2001)

The scope of UL 2275 (2001) states in part that these requirements cover testing for structural integrity to reduce the risk of injury to an infant within a crib due to poor construction and structural defects [6]. UL 2275 (2001) contains test methods for crib side testing, vertical impact testing, and fatigue testing. The UL protocol for the crib side cyclic testing is similar to that contained in ASTM F1169-88 (Reapproved 1993) except that a 15.9 kg (35 lb) weight is to be used in lieu of the 11.3 kg (25 lb) weight specified in ASTM F1169-88 (Reapproved 1993) and the number of cycles utilized for testing shall be increased from 50 cycles to 250 cycles.

The UL protocol for the vertical impact testing is once again similar to that contained in ASTM F1169-88 (Reapproved 1993) with the notable exception that the total weight is to be 31.7 kg (70 lb) instead of 20.4 kg (45 lb) specified in ASTM F1169-88 (Reapproved 1993). Another exception includes testing for 11,000 cycles in the UL protocol at the geometric center compared to 500 cycles for the ASTM F1169-88 (Reapproved 1993) test method. In addition, the UL vertical impact testing protocol specifies 2,200 cycles at each of two diagonally opposite corners as opposed to 100 cycles in the ASTM F1169-88 (Reapproved 1993) test method. Furthermore, the UL protocol adds an additional 2,200 cycles any place where the bottom appears the weakest.

The UL fatigue test protocol has been developed from the EN 716-2 (1995) test method. However, the UL protocol specifies a force of 200 N (45 lb) shall be applied against the crib for 11,000 cycles compared to the EN 716-2 (1995) test method which calls for a 100 N (22.5 lb) force to be applied for 2,000 cycles. UL increased the number of cycles from 2,000 to 11,000 based on an estimated 6 times per day a child will cause movement inside the crib times a safety factor of five.

LIVE CHILD CRIB SHAKE TESTING

Test Setup

Table 1 shows the characteristics of the 112 child test subjects who participated in the crib shake testing program. The average age, height, and weight of the child test subjects was 36.5 months, 93.5 cm (36.8 in.), and 13.9 kg (30.7 lb) respectively. It should be pointed out that the average child test subject height of 93.5 cm (36.8 in.) exceeds the maximum allowable height of 88.9 cm (35 in.) stated by the crib manufacturer, CPSC Part 1508, and ASTM F1169-88 (Reapproved 1993). Before performing the crib shake testing, each child test subject pushed and pulled with their maximum effort on a wood rail attached to a force gauge as depicted in Fig. 3. The resulting push and pull force data can be found in Table 1. The children were then placed in an exemplar crib and encouraged by their parent or caregiver to shake all four sides of the crib with both of their hands as hard and as long as they could. All crib shake testing was recorded by videotape. Video still frames of two representative child subjects, subject number 12 and subject number 13, who participated in the crib shake testing are displayed in Fig. 4 and Fig. 5 respectively.

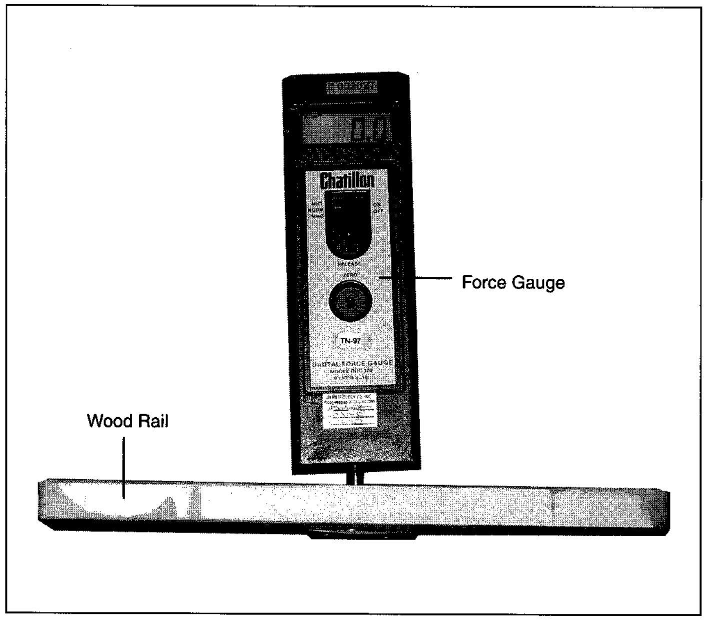

Figure 3 - Wood Railing - Force Gauge Set-up

Test Results

After a cumulative total of over 6 hours of crib shaking by the child test subjects, no machine screws loosened. The crib rods remained attached to the top corner posts of the headboard and footboard of the crib at the conclusion of the testing. It should be noted that the duration of the shake testing approximates the time that the subject child was alone in the crib before being found. Based upon this shake testing program, it seems that the fasteners are tenacious and the subject model crib has a high level of structural integrity.

A review of Table 1 reveals that the maximum push and pull force recorded for a 10 month old (Subject No. 11) is 6.7 N (1.5 lb). A force of 6.7 N (1.5 lb) does not appear to be sufficient for the subject infant to have caused the machine screw to disconnect from the subject crib. The maximum push force and pull force recorded for the child test subjects was 86.3 N (19.4 lb) (58 month old - subject 75) and 98.3 N (22.1 lb) (55 month old - subject 28) respectively. The average push force was 30.7 N (6.9 lb) and the average pull force was 27.1 N (6.1 lb). This data can be useful to organizations who promulgate crib safety standards for quantifying the force application levels specified during horizontal fatigue testing.

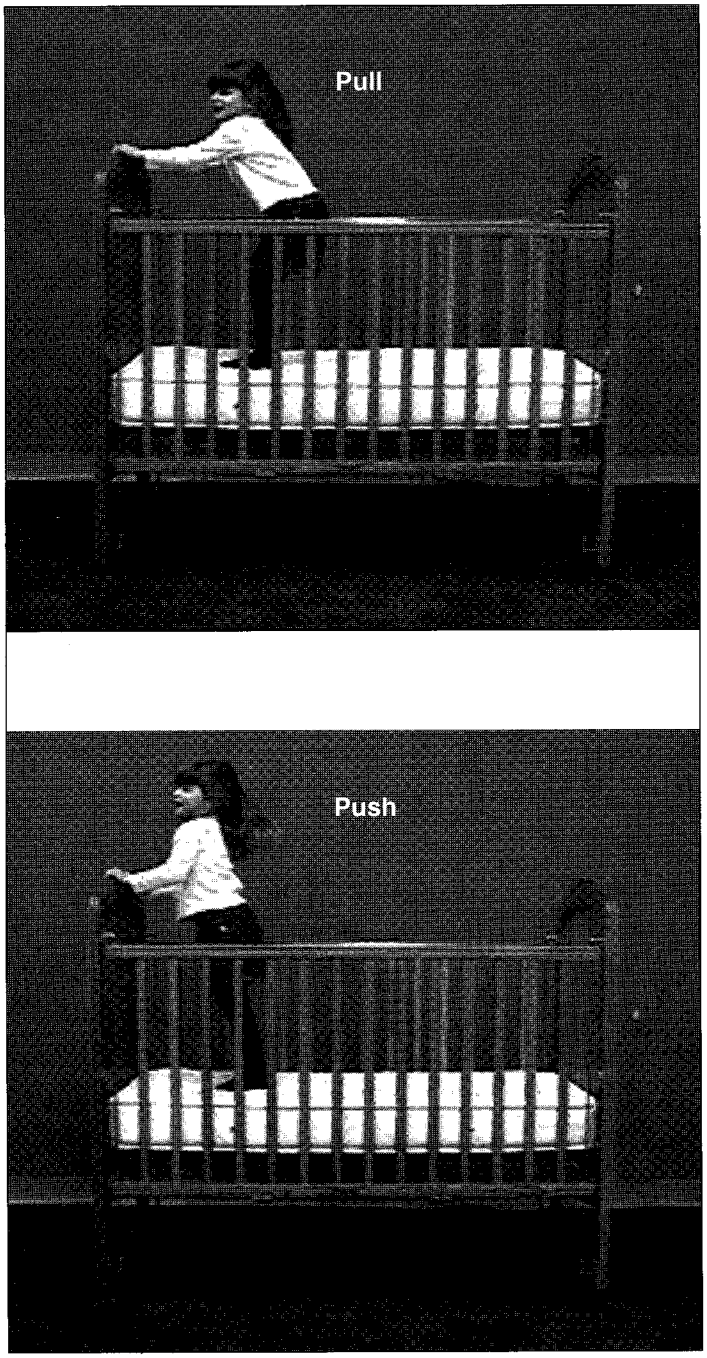

Figure 4 - Test Subject #12

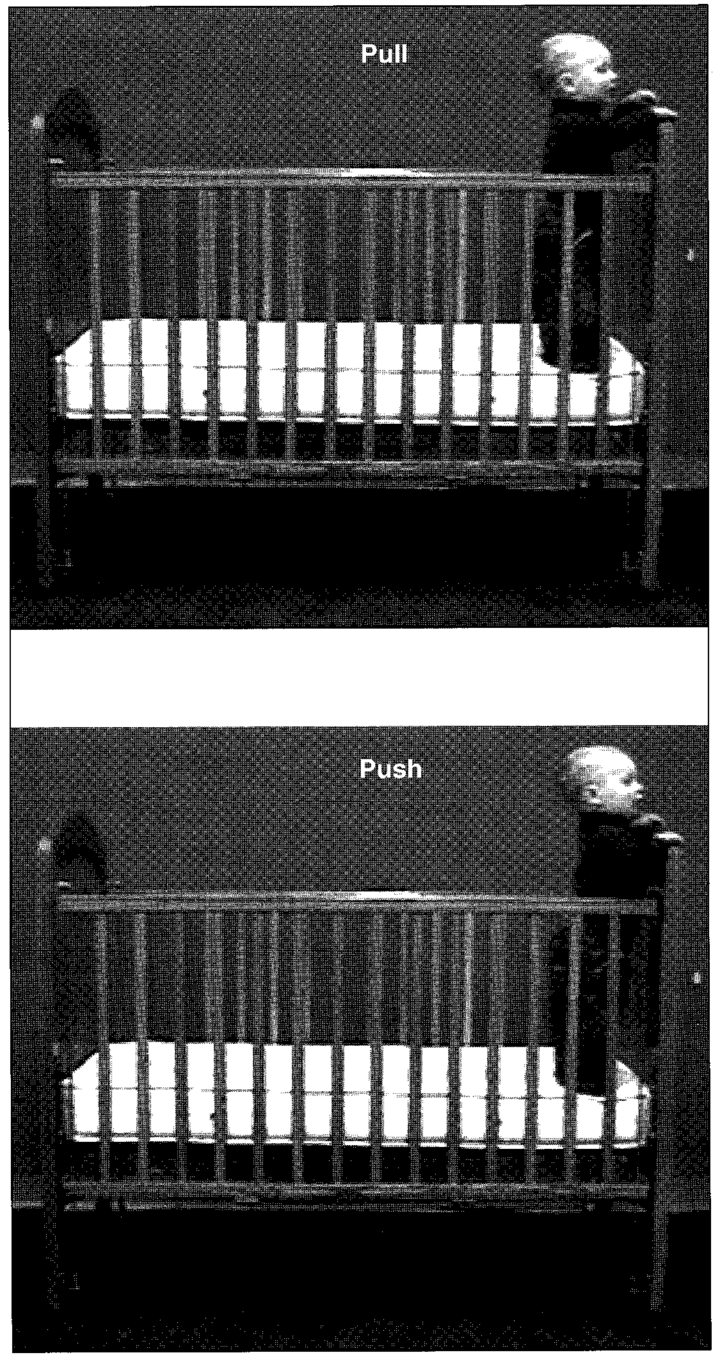

Figure 5 - Test Subject #13

CONCLUSIONS

A survey of the American and international crib safety standards reveals noticeable differences in the classification of test requirements and the quantification of test requirements. For instance, the ASTM F1169-88 (Reapproved 1993) Standard Specification for Full Size Baby Crib does not include a fatigue testing requirement. However, the UL 2775 (2001) has increased the applied force from 100 N (22.5 lb) for 2,000 cycles according to the requirements of EN 716-2 (1995), to 200 N (45 lb) for 11,000 cycles. The 11,000 cycles specified in the UL 2775 (2001) fatigue testing protocol represents 2,190 movements of crib joints in a year multiplied by a safety factor of five. A review of the child crib shake test results presented in Table 1 reveals that the 200 N (45 lb) applied force requirement contained in UL 2775 (2001) exceeds the largest recorded push and pull forces, 86.3 N (19.4 lb) and 98.3 N (22.1 lb) respectively, by over a factor of two and exceeds the average push force of 30.7 N (6.9 lb) and the average pull force of 27.1 N (6.1 lb) by over a factor of six. In comparison, the Canadian method for testing the structural integrity of a standard crib under horizontal force conditions according to SOR/86-962 (1986) includes applying an alternating force of 120 N (27.0 lb) in the transverse direction on top of each side for a total of 9,000 cycles. The child crib test results show that the applied

Table 1 - Child Crib Shake Test Log

Subject No	Gender	Age (mos.)	Height cm (in.)	Weight kg (lb)	Pull N (lb)	Push N (lb)
1	M	21	85.1 (33.5)	11.8 (26)	44.5 (10.0)	30.2 (6.8)
2	F	36	88.9 (35.0)	10.9 (24)	17.3 (3.9)	29.8 (6.7)
3	M	18	81.3 (32.0)	10.9 (24)	-	-
4	F	14	81.3 (32.0)	11.3 (25)	-	-
5	F	35	96.5 (38.0)	15.9 (35)	23.1 (5.2)	27.6 (6.2)
6	M	10	81.3 (32.0)	9.5 (21)	-	-
7	F	43	97.8 (38.5)	14.5 (32)	26.2 (5.9)	34.7 (7.8)
8	M	42	97.8 (38.5)	15.4 (34)	44.0 (9.9)	48.5 (10.9)
9	F	10	73.7 (29.0)	9.1 (20)	-	-
10	M	51	102.9 (40.5)	15.9 (35)	42.3 (9.5)	82.3 (18.5)
11	M	10	73.7 (29.0)	9.5 (21)	6.7 (1.5)	6.7 (1.5)
12	F	49	104.1 (41.0)	15.9 (35)	46.7 (10.5)	41.8 (9.4)
13	M	14	81.3 (32.0)	11.3 (25)	5.8 (1.3)	11.6 (2.6)
14	M	25	87.6 (34.5)	12.2 (27)	8.5 (1.9)	8.9 (2.0)
15	F	20	83.8 (33.0)	10.9 (24)	3.1 (0.7)	3.1 (0.7)
16	F	46	108.0 (42.5)	18.1 (40)	59.2 (13.3)	74.7 (16.8)
17	M	26	87.6 (34.5)	10.9 (24)	4.0 (0.9)	4.0 (0.9)
18	M	26	88.9 (35.0)	12.2 (27)	8.5 (1.9)	8.5 (1.9)
19	F	26	88.9 (35.0)	11.3 (25)	-	-
20	M	43	101.6 (40.0)	16.3 (36)	39.1 (8.8)	52.9 (11.9)
21	M	15	81.3 (32.0)	13.2 (29)	3.1 (0.7)	3.1 (0.7)
22	F	31	92.7 (36.5)	14.1 (31)	30.7 (6.9)	19.6 (4.4)
23	F	45	97.8 (38.5)	13.2 (29)	43.1 (9.7)	28.9 (6.5)
24	M	48	102.9 (40.5)	17.2 (38)	45.8 (10.3)	83.2 (18.7)
25	M	53	99.1 (39.0)	15.9 (35)	46.3 (10.4)	37.4 (8.4)
26	F	30	86.4 (34.0)	12.2 (27)	24.5 (5.5)	19.6 (4.4)
27	M	35	102.9 (40.5)	20.0 (44)	43.6 (9.8)	59.6 (13.4)
28	F	55	114.3 (45.0)	27.2 (60)	98.3 (22.1)	81.8 (18.4)
29	F	53	110.5 (43.5)	23.1 (51)	56.5 (12.7)	60.9 (13.7)
30	F	32	92.7 (36.5)	13.2 (29)	8.5 (1.9)	12.0 (2.7)

Subject No	Gender	Age (mos.)	Height cm (in.)	Weight kg (lb)	Pull N (lb)	Push N (lb)
31	F	57	102.9 (40.5)	15.9 (35)	49.4 (11.1)	81.8 (18.4)
32	F	27	85.1 (33.5)	12.2 (27)	24.0 (5.4)	20.0 (4.5)
33	M	33	91.4 (36.0)	13.6 (30)	24.0 (5.4)	20.5 (4.6)
34	F	35	87.6 (34.5)	11.8 (26)	23.6 (5.3)	23.6 (5.3)
35	M	44	96.5 (38.0)	16.8 (37)	39.1 (8.8)	19.6 (4.4)
36	F	10	53.3 (21.0)	7.7 (17)	-	-
37	F	24	83.8 (33.0)	11.3 (25)	-	-
38	F	24	83.8 (33.0)	11.3 (25)	4.0 (0.9)	4.0 (0.9)
39	F	36	91.4 (36.0)	11.3 (25)	9.8 (2.2)	9.8 (2.2)
40	F	31	90.2 (35.5)	11.8 (26)	19.6 (4.4)	19.1 (4.3)
41	F	44	99.1 (39.0)	15.9 (35)	48.0 (10.8)	40.0 (9.0)
42	M	46	104.1 (41.0)	19.5 (43)	43.6 (9.8)	42.3 (9.5)
43	F	24	83.8 (33.0)	11.3 (25)	-	-
44	M	36	99.1 (39.0)	14.1 (31)	24.5 (5.5)	41.8 (9.4)
45	F	34	94.0 (37.0)	14.1 (31)	4.0 (0.9)	4.0 (0.9)
46	M	14	71.1 (28.0)	9.1 (20)	-	-
47	M	54	104.1 (41.0)	15.4 (34)	52.9 (11.9)	55.2 (12.4)
48	M	36	96.5 (38.0)	14.5 (32)	37.4 (8.4)	60.1 (13.5)
49	F	17	76.2 (30.0)	9.1 (20)	4.0 (0.9)	4.0 (0.9)
50	M	17	78.7 (31.0)	11.3 (25)	4.0 (0.9)	4.0 (0.9)
51	M	50	101.6 (40.0)	14.5 (32)	37.4 (8.4)	46.3 (10.4)
52	M	50	101.6 (40.0)	15.9 (35)	46.3 (10.4)	50.7 (11.4)
53	F	35	95.3 (37.5)	13.6 (30)	14.7 (3.3)	19.6 (4.4)
54	M	43	106.7 (42.0)	20.0 (44)	51.2 (11.5)	77.8 (17.5)
55	F	18	78.7 (31.0)	10.0 (22)	-	-
56	M	49	106.7 (42.0)	20.4 (45)	59.2 (13.3)	48.0 (10.8)
57	F	45	101.6 (40.0)	15.0 (33)	42.7 (9.6)	38.3 (8.6)
58	M	17	83.8 (33.0)	12.2 (27)	4.0 (0.9)	4.0 (0.9)
59	F	46	97.8 (38.5)	13.6 (30)	32.0 (7.2)	30.2 (6.8)
60	M	21	78.7 (31.0)	12.7 (28)	-	-

Table 1 - Child Crib Shake Test Log (continued)

Subject No	Gender	Age (mos.)	Height cm (in.)	Weight kg (lb)	Pull N (lb)	Push N (lb)
61	F	52	106.7 (42.0)	18.6 (41)	55.2 (12.4)	60.1 (13.5)
62	M	30	94.0 (37.0)	13.6 (30)	13.8 (3.1)	16.5 (3.7)
63	M	19	81.3 (32.0)	9.1 (20)	4.0 (0.9)	4.0 (0.9)
64	F	53	101.6 (40.0)	15.4 (34)	37.4 (8.4)	43.1 (9.7)
65	F	17	78.7 (31.0)	10.0 (22)	1.8 (0.4)	1.8 (0.4)
66	M	23	86.4 (34.0)	12.7 (28)	3.6 (0.8)	4.0 (0.9)
67	F	54	105.4 (41.5)	17.2 (38)	55.6 (12.5)	73.0 (16.4)
68	M	31	92.7 (36.5)	14.5 (32)	16.0 (3.6)	73.4 (16.5)
69	F	32	96.5 (38.0)	14.5 (32)	46.3 (10.4)	20.5 (4.6)
70	F	59	104.1 (41.0)	18.1 (40)	70.3 (15.8)	69.4 (15.6)
71	M	52	106.7 (42.0)	17.2 (38)	48.0 (10.8)	72.1 (16.2)
72	M	24	94.0 (37.0)	15.4 (34)	21.4 (4.8)	19.6 (4.4)
73	M	24	88.9 (35.0)	13.2 (29)	-	-
74	F	42	101.6 (40.0)	15.0 (33)	14.7 (3.3)	10.2 (2.3)
75	M	58	102.9 (40.5)	15.9 (35)	64.1 (14.4)	86.3 (19.4)
76	F	45	100.3 (39.5)	14.5 (32)	54.3 (12.2)	29.4 (6.6)
77	F	15	73.7 (29.0)	7.7 (17)	-	-
78	M	58	106.7 (42.0)	17.7 (39)	36.5 (8.2)	64.1 (14.4)
79	F	36	95.3 (37.5)	14.1 (31)	39.6 (8.9)	45.4 (10.2)
80	F	53	104.1 (41.0)	16.3 (36)	51.2 (11.5)	50.7 (11.4)
81	M	57	101.6 (40.0)	16.3 (36)	47.2 (10.6)	55.2 (12.4)
82	F	36	91.4 (36.0)	11.8 (26)	17.3 (3.9)	44.5 (10.0)
83	F	48	97.8 (38.5)	11.8 (26)	24.5 (5.5)	34.3 (7.7)
84	F	48	101.6 (40.0)	16.3 (36)	38.3 (8.6)	46.3 (10.4)
85	F	48	96.5 (38.0)	13.6 (30)	30.2 (6.8)	29.4 (6.6)
86	M	48	106.7 (42.0)	13.6 (30)	28.5 (6.4)	28.9 (6.5)
87	F	48	94.0 (37.0)	12.7 (28)	29.4 (6.6)	46.3 (10.4)
88	F	48	102.9 (40.5)	14.1 (31)	51.6 (11.6)	34.7 (7.8)
89	M	55	104.1 (41.0)	16.3 (36)	68.9 (15.5)	46.7 (10.5)
90	M	55	101.6 (40.0)	15.9 (35)	48.0 (10.8)	83.2 (18.7)
91	M	36	94.0 (37.0)	12.7 (28)	23.1 (5.2)	29.8 (6.7)
92	F	60	104.1 (41.0)	15.9 (35)	44.5 (10.0)	56.9 (12.8)
93	M	14	76.2 (30.0)	9.1 (20)	4.0 (0.9)	10.2 (2.3)
94	M	45	106.7 (42.0)	19.1 (42)	61.4 (13.8)	64.1 (14.4)
95	M	31	91.4 (36.0)	14.5 (32)	10.7 (2.4)	27.6 (6.2)
96	F	14	76.2 (30.0)	9.5 (21)	-	-
97	M	60	105.4 (41.5)	15.9 (35)	45.4 (10.2)	28.5 (6.4)
98	M	60	114.3 (45.0)	25.4 (56)	73.0 (16.4)	59.6 (13.4)
99	F	53	101.6 (40.0)	14.1 (31)	34.3 (7.7)	43.1 (9.7)
100	F	20	78.7 (31.0)	9.5 (21)	4.0 (0.9)	19.6 (4.4)
101	M	15	76.2 (30.0)	9.5 (21)	-	-
102	F	51	104.1 (41.0)	17.2 (38)	32.5 (7.3)	24.5 (5.5)
103	F	33	88.9 (35.0)	11.3 (25)	33.4 (7.5)	28.9 (6.5)
104	M	54	104.1 (41.0)	14.5 (32)	29.8 (6.7)	58.3 (13.1)
105	F	35	92.7 (36.5)	13.6 (30)	8.5 (1.9)	8.5 (1.9)
106	F	12	74.9 (29.5)	8.2 (18)	-	-
107	M	60	101.6 (40.0)	15.9 (35)	48.5 (10.9)	49.4 (11.1)
108	M	60	105.4 (41.5)	17.2 (38)	59.2 (13.3)	39.1 (8.8)
109	F	33	85.1 (33.5)	9.5 (21)	8.5 (1.9)	8.0 (1.8)
110	F	31	87.6 (34.5)	11.3 (25)	12.9 (2.9)	30.2 (6.8)
111	F	36	86.4 (34.0)	10.4 (23)	8.0 (1.8)	8.0 (1.8)
112	M	33	83.8 (33.0)	10.9 (24)	4.0 (0.9)	4.0 (0.9)
Average		36.5	93.5 (36.8)	13.9 (30.7)	27.1 (6.1)	30.7 (6.9)

force fatigue testing requirements contained in EN 716-2 (1995) and the structural integrity horizontal force conditions contained in Canadian SOR/86-962 (1986) appear to be closer to the actual child applied force capabilities than the UL 2775 (2001) fatigue testing applied force requirements.

In conclusion, the live child crib shake test data obtained in this study provide a significant first step in the quantification of the horizontal push and pull forces that children can apply to the sides of a crib. This live data can be utilized by crib safety standard organizations as a foundation to develop inanimate test requirements for fatigue testing and structural integrity testing of cribs. Without such fundamental test data, a survey of the American and international crib safety standards reveals a lack of uniformity in testing methods and requirements. Because the inanimate standard test requirements far exceed the live child shaking results, it is clear that the 10 month old infant did not cause the subject crib machine screw to loosen.

REFERENCES

1. Brickman, D.B. and Barnett, R.L., "Strongest Link Principle," 94-WA/DE-2, American Society of Mechanical Engineers, New York, Nov. 6-11, 1994, pp. 1-6.

2. Brickman, Dennis B. and Barnett, Ralph L., "Infant Crib Failure Analysis Case Study," Proceedings of the 12th Biennial Conference on Reliability, Stress Analysis and Failure Prevention, Society of Machinery Failure Prevention Technology, Haymarket, VA, 1997, pp. 171-180.

3. "Standard Specification for Full Size Baby Crib," ASTM F 1169-88 (Reapproved 1993), American Society for Testing and Materials, Philadelphia, PA, approved Aug. 26, 1988.

4. "Furniture - Children's Cots and Folding Cots for Domestic Use - Part 2: Test Methods," EN 716-2, European Committee for Standardization, 1995.

5. "Canadian Hazardous Products (Cribs and Cradles) Regulations," SOR/86-962, Canada Gazette Part II, Vol. 120, No. 20, Sep. 11, 1986.

6. "Full Size Baby Cribs," UL 2775, First Edition, Underwriters Laboratories, Northbrook, IL, Mar. 6, 2001.

SAFETY BRIEF

July, 2002 – Volume 21, No. 1

Editor: Paula L. Barnett

Illustrated and Produced by

Triodyne Graphic Communication