Health Canada Santé Canada

Testing of Baby Walkers

Test Report

August 21, 2002

Baby Walkers were tested using a procedure based on ASTM 977-00. The principal variables of the current test program were the input energy and angle of approach.

Baby walkers equipped with skid pads were frequently able to stop before falling off the test platform yet some thresholds were reached and some apparent randomness was observed.

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Mechanical and Electrical Hazards Division
Consumer Product Safety
Product Safety Programme
Healthy Environments and Consumer Safety Branch

Canada

BACKGROUND

Baby walkers are not currently regulated in Canada. In 1989, industry had voluntarily agreed to not sell the product in Canada. However, the CJPA[1], which had administered this *de facto* ban, no longer exists. And as a result baby walkers have once again begun to appear for sale in Canada in stores and street corners. Health Canada's Consumer Product Safety Bureau is currently looking at options to address the safety of baby walkers. The test program that led to this report is in support of that effort.

The testing of baby walkers has progressed from a simple static measure of their resistance to tipping, to a dynamic test of the same measure, to the current tests that evaluate the ability of a moving baby walker to come to a complete stop when encountering a step. ASTM International (ASTM), an industry-based standards body, has been largely responsible for the development of these tests.

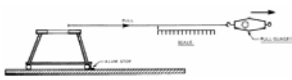

Figure 1: Stability test

The current ASTM standard describes the evaluation of 3 behaviours related to stability:

- *Forward and rearward stability* (an aspect of tip resistance) is tested by placing the wheels against an abutment and, at a specific height, pulling on the walker in an attempt to tip it over (Figure 1[2]).
- The stability of the baby walker when an *occupant is leaning outward over the edge* is tested by applying a moment to the walker (Figure 3, Figure 2).
- The *ability to prevent falling down steps* is tested by seating an infant mannequin[3] in a walker that is directed, at a pre-determined velocity, toward the edge of a platform on which it travels. After the leading wheels of the walker fall off the platform, friction between the walker and the platform is to be sufficient to stop the walker before it falls off the platform (Figure 4).

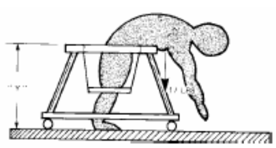

Figure 2: Leaning resistance test

ASTM F 977–00 specifies tests for several other baby walker features including structural integrity of components and the permanency of labels that are not considered in the current test program.

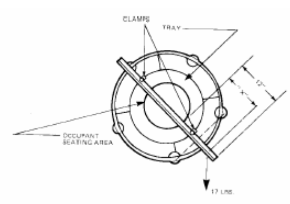

Figure 3: Leaning resistance test

Baby walker designs intended to comply with the ASTM steps test requirement are typically fitted with strips of a high-friction material on the undercarriage. When the front wheels of a moving baby walker fall off a step, these strips contact the floor and act as a brake (Figure 5).

The Consumer Product Safety Bureau's Mechanical and Electrical Hazards Division conducted a first series of tests in October 2001. The tests were not conducted using the ASTM test procedure however they demonstrated that when moving at speeds below that of the ASTM F 977–00 test, baby walkers could not always keep from tipping when reaching the end of the test platform furthermore, in the ranges of speeds examined, both *stopping* and *tipping* behaviours were observed. The range of speeds used in the first test series was not intended to fully characterize the transition between stopping and tipping behaviours of baby walkers.

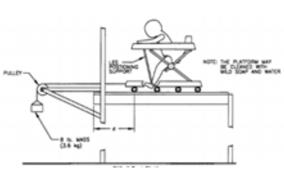

Figure 4: Steps test

[1] Canadian Juvenile Products Association

[2] Figure 1, Figure 3, Figure 2 and Figure 4: Extracted, with permission, from ASTM F 977-00 Standard Consumer Safety Specification for Infant Walkers, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be purchased from ASTM, phone: 610-832-9585, fax: 610-832-9555, e-mail: service@astm.org, website: www.astm.org.

[3] 6-month CAMI infant dummy

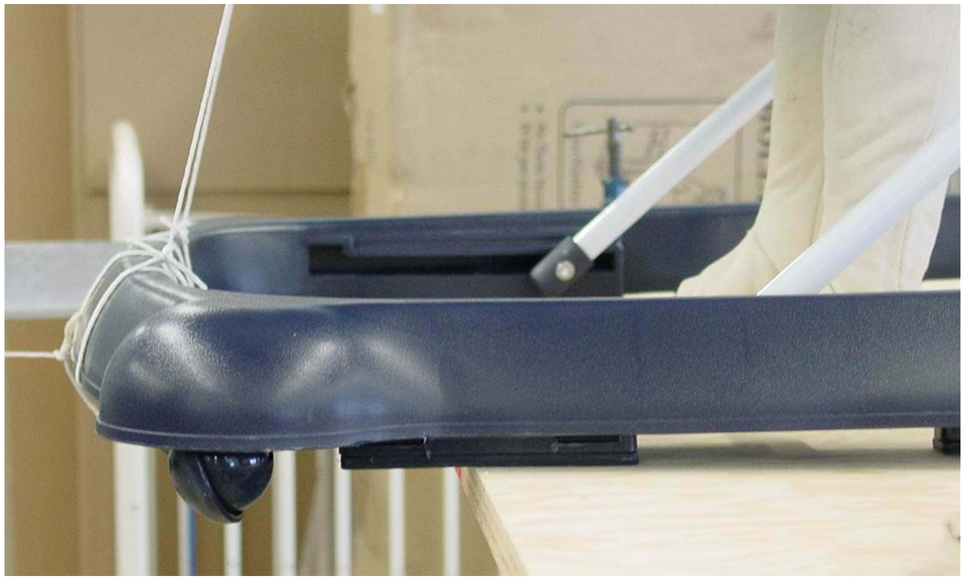
Figure 5: Friction pad against test surface

OBJECTIVES

The current series of tests was conducted in order to assist in analyzing options to address the safety of baby walkers.

There were indications from the preliminary test series discussed above, that baby walkers fitted with friction pads were not always effective at stopping before falling off at speeds lower than that which the ASTM standard targets. A more complete study was necessary.

In addition, a general understanding of the ASTM steps test including the relationship between drop height and test velocity was, in a very practical sense, lacking.

The Mechanical and Electrical Hazards Division had concerns that did not appear to be addressed by the ASTM standard. Studies, out of the UK[4] in particular, indicated that children can travel significantly faster than the speed at which the ASTM step test is conducted hence knowledge of the behaviour of baby walkers at higher speeds was required.

Sunken living rooms and open staircases—popular features of contemporary Canadian homes—present very wide openings and the possibility for a baby walker to approach the opening at a relatively shallow angle. This is a hazard not explicitly contemplated by the ASTM standard.

METHODOLOGY

The equation by which the speed of the baby walker, prior to reaching the edge of the table, can be estimated by:

$$v = \sqrt{2gh \times \left(\frac{m_1 - \mu_k \left(m_2 + m_3 \right)}{m_1 + \left(m_2 + m_3 \right)} \right)} \qquad (1)$$

[4] UK study reference.

where

g is gravitational acceleration (32.2 f/s^2 or 9.81 m/s^2)

h is the drop fall height (m or ft)

m_1 is the mass of the weight (8 lbs or 3.6 kg)

m_2 is the mass of the baby walker (lb or kg)

m_3 is the mass of the CAMI ATD (17 lbs or 7.7 kg)

μ_k is the kinetic friction coefficient

Testing was conducted at the Product Safety Laboratory on Walkley Road in Ottawa in the March 18 – April 12 timeframe in a joint effort by Laboratory staff and Consumer Product Safety staff.

Testing was based on that prescribed in ASTM F 977-00 Standard Consumer Safety Specification for Infant Walkers.

For the steps test, the ASTM standard specifies that a baby walker, initially at rest on the flat, horizontal test surface, be accelerated towards a step by a free falling weight attached to the baby walker. Tension in the string between the weight and the baby walker helps to maintain tracking. Free-falling weights are generally considered a repeatable method of accelerating an object. There are, however, potential drawbacks to this method. The continual acceleration makes the precise determination of pre-event velocity difficult. There is some residual effect of the mass pulling on the baby walker in the event of it partially going off the test surface. This residual effect is intended as it represents the force exerted by a child who is still trying to propel the baby walker. Nonetheless, this test method is widely used and is the one selected for these tests.

The procedures were adapted for testing conducted at different approach angles.

In all, 7 baby walkers were available for testing. Only the three equipped with friction strips (Figure 6, Figure 7 and Figure 8) underwent the entire range of tests. Three old-style (non-braked) baby walkers (Figure 9, Figure 10 and Figure 11) and one ride-on toy (also non-braked) (Figure 12) were also available.

Figure 6: Brand A

Figure 7: Brand B

Figure 8: Brand C

Figure 9: Brand D

Figure 10: Brand E

Figure 11: Brand F

Figure 12: Brand G

Baby walkers were propelled towards the edge of the test platform at speeds ranging essentially from when they stopped all the time to when they tipped all the time.

The angles of approach of the baby walker toward the edge of the platform were: 90° (forward), 15°, 30° and 45°. A very limited number of tests with the baby walker facing backwards were also conducted.

The ASTM standard specifies that tests be conducted with the 17-lb CAMI dummy and again with the addition of an 11 lb vest to the CAMI dummy. For this test series, only the 17-lb CAMI dummy was used.

In preparation for testing, the platform and the baby walker friction pads were cleaned with water and mild hand soap.

Each test was conducted three times. In cases of some malfunction (e.g., operator error, improper functioning of the velocity gate), an additional test was conducted.

In some higher-velocity angled tests, after the front wheels had gone off the edge of the platform and the weight had dragged the baby walker for approximately 20”, the weight was arrested and the baby walker was allowed to continue moving under only its own momentum.

Finally tests with varying friction characteristics of the baby walker/test platform interface were conducted. The two conditions investigated were dusty (talcum power on the friction pad) and wet (moisture on the test platform)

ASTM specifies that a *tip test* (as specified in 7.6.3.5 and 7.6.4.5) be conducted every time the front wheels come off the platform. In a repetitive series of tests however, the ASTM tip test does not need to be conducted every time as an independent determination of the point at which the baby walker will tip, this can be determined once for each baby walker.

There is also a point, for each baby walker, where the front wheels have advanced sufficiently that it will tip then a 17-lb weight is applied as shown in Figure 3 with the X distance calculated according to the equation:

$$X = \frac{(32 - Y)}{2} - 1 \qquad (2)$$

where

X is the point for the application of the vertical 17 lb load

Y is the height of the table of the baby walker

The recorded data included:

- the angle at which the test was conducted,
- the drop height,
- test mass,
- times the first and second electric eye beams were cut, and
- whether baby walker stopped or tipped and, in cases where the baby walker did not

tip, the position and orientation of the baby walker at the end of the test

- for the 90° tests, the distance of the both front wheels from the edge of the test surface
- for the angle tests, an X and Y distance from the point where the left front wheel leaves the test surface and the orientation, θ, of the baby walker (Figure 13).

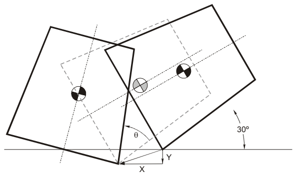

Figure 13: Descripiton of co-ordonates for angled tests

Equipment

The equipment used for the test program included the following:

- ASTM-like test platform consisting of:
  - 1 – 4 x 8 sheet of oak veneer plywood with 4 coats of flooring grade polyurethane varnish
  - an additional unfinished 4 x 8 sheet of G1S plywood to lengthen the test platform for some tests
  - A series of weights for accelerating a baby walker. In most cases, only an 8 lb weight was used and the velocity of the baby walker was adjusted by varying the drop height of the weight. In some cases, additional weight was used in order to achieve higher baby walker velocities. The weights used were: 8.0 (7.999) lb, 9.2 lb, 10.72 lb and 13.4 lb.

Figure 14: Weights used for testing

- A pulley and a method of fixing it relative to the test platform. The top of the pulley was approximately 2 ½” above the surface of the platform such that the pull on a baby walker was horizontal.

Figure 15: Pulley set up for angled tests

Figure 16: Velocity gate

Drawings of the setups used for the various configurations are shown in Appendix A.

- The velocity of a baby walker just prior to it reaching the edge of the test platform was measured when a light-weight aluminium bar fixed to a baby walker successively cut the beams of a pair of electric eyes. The average velocity through the gate is calculated by dividing the distance between the electric eyes by the time it took to cut the beams. A DaisyLab data acquisition card in a PC was programmed to handle that task.
- Two blocks, nominally 12” and 6” high, to stop or catch the falling weight(s) in some of the angled tests (Figure 17, Figure 18).
- Block to set the length of string connecting a baby walker to the test weight (Figure 19).

Figure 17: 12" block

Figure 18: 6" block (measured at 7")

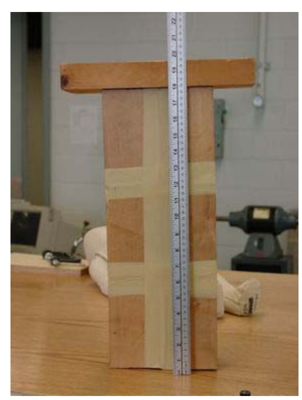

Figure 19: Block for setup

- Digital still and video camera were used to record the events.

Baby walkers tested

Table 1 presents basic data for the baby walkers tested.

Note: Although it is not common practice, the data was recorded in imperial units. This was done to facilitate any comparison with any outside test data that would most likely be from the U.S.

Table 1: Baby walker specifications[5]

Reference	Weight (lb)	Wheel-base	Front track	Rear track	Notes
Brand A	9.9	26.1	20.8	18.4	friction pads
Brand B	11.1	26.8	21.3	10.5	friction pads
Brand C	11.1	23.4	21.3	12.8	friction pads
Brand D	7.3	19.9	17.8	17.8	8 wheels
Brand E	8.4	21.9	17.8	16.3	6 wheels
Brand F	5.1	21.9	15.6	15.6	6 wheels
Brand G	6.2	11.0	7.9	9.1	convertible toy

RESULTS

The distance from the front wheels to the centre of gravity of the baby walker may be used to give an indication of how close, after a test, a baby walker is to tipping over. Clearly, a baby walker will tip once its centre of gravity (cg) is beyond the edge of the test table. This value was measured and was called *Tip Distance*.

The X and Y values were measured as discussed in the Methodology section above.

A measure of the sliding coefficient of friction between a baby walker and the test surface was also measured.

These data are presented in Table 2.

Table 2: Baby walker measured data

Reference	Tip Distance		X	Y	μ_k
	w/o dummy	w dummy			(approx)
Brand A	12.0	11.9	6.9	16.3	.106
Brand B	10.8	10.6	6.1	17.8	.032
Brand C	9.6	9.6	6.9	16.3	.055

A total of 211 tests were conducted. The data for 12 of these tests was not used as there was some immediately observable flaw in the test (e.g., operator error) itself or the data collected (e.g., improper functioning of the velocity gate). The remaining tests are distributed as shown in Table 3.

Table 3: Distribution of the tests conducted

Reference	90°	45°	30°	15°
Brand A	17	24	15	18
Brand B	16	15	15	12
Brand C	19	15	11	18
Brand D	1			
Brand E	1			
Brand F	1			
Brand G	1			
Total	**56**	**54**	**41**	**48**

Test variants are presented in Table 4 below.

Table 4: Test variants

Reference	90°	45°	30°	15°
Brand A	—	6” block 3 3–damp 3–9.2 lb 3–10.7 lb	6” block 3 12” block 3	6” block 3 12” block 3 talcum

[5] Although labelled as a specification, these data were measured.

Reference	90°	45°	30°	15°
		12” block 3		2 reverse 1
Brand B	—	6” block 3 12” block 3	6” block 3 12” block 3	6” block 3
Brand C	—	6” block 1 1–10.7 lb 1–13.4 lb 12” block 3	12” block 1	6” block 3 12” block 3

Although the original test matrix included a full series of tests in the reverse direction, only the one indicated in table 4 was actually conducted. The amount of laboratory time available was limited and since earlier testing had indicated that tests in a rearward direction were generally less severe, it was decided to forego this part of the test series.

DISCUSSION

Repeatability

With a well-controlled setting of the drop height, the recorded velocities are very consistent from test to test. Figure 20, Figure 21 and Figure 22, show the pre-event velocity of the different baby walkers for the 14.6”, 20” and 25” drop heights.

Although coefficients of variation (cv)[6] were not calculated, a remarkable repeatability is evident and each test variant is clearly identifiable.

It is not appropriate to directly compare the measured pre-event velocity from one series to another as no specific protocol was established to control the point during an event at which the velocity was measured.

In Figure 22, the tests conducted at the 25” drop height where extra weight was used to achieve greater velocity are readily identified as data points 15 – 20 in the front row for Brand A and as points 11 and 12 in the back row for the Brand C.

The difficulty in aligning the casters of the baby walkers is thought to be the greatest cause of test-to-test speed variability.

[6] The *coefficient of variation* is a measure of relative dispersion and is given by:

coefficient of variation = standard deviation ÷ mean

It is generally expressed as a percentage. The use of coefficient of variation lies partly in the fact that the mean and standard deviation tend to change together in many experiments. Knowledge of relative variation is valuable in evaluating experiments.—Rozgonyi, Tibor G., *Statistics for Engineers*, Wollongong University, 1995.

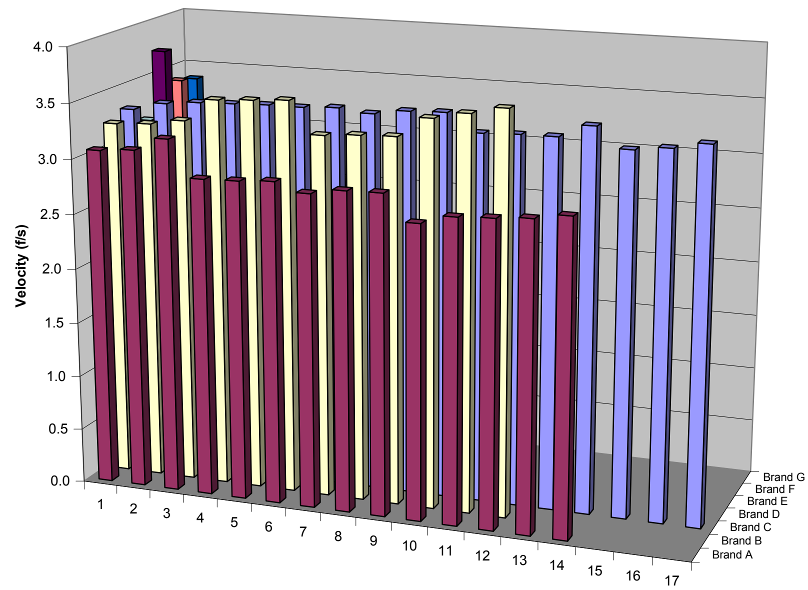

Figure 20: Measured velocities at 14.6" drop height

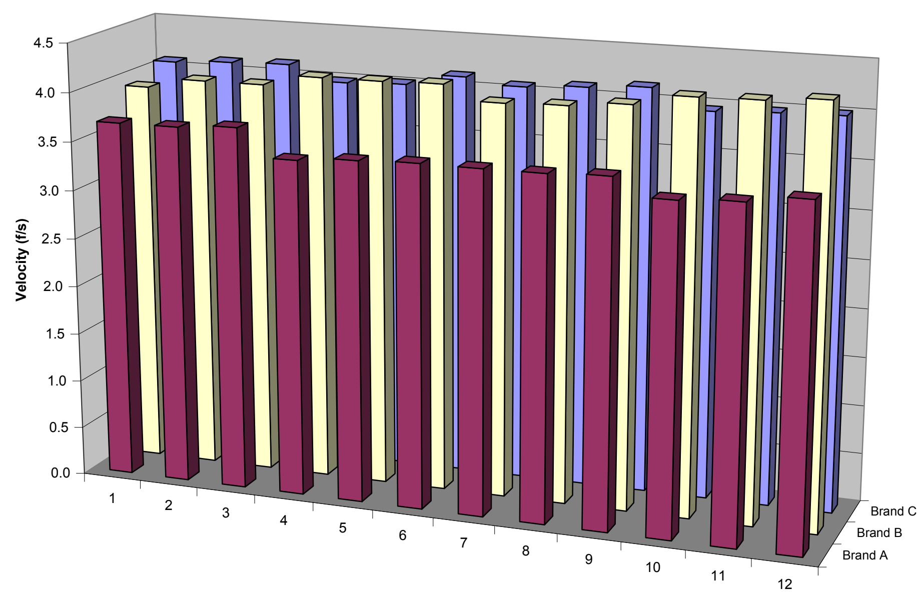

Figure 21: Measured velocities at 20" drop height

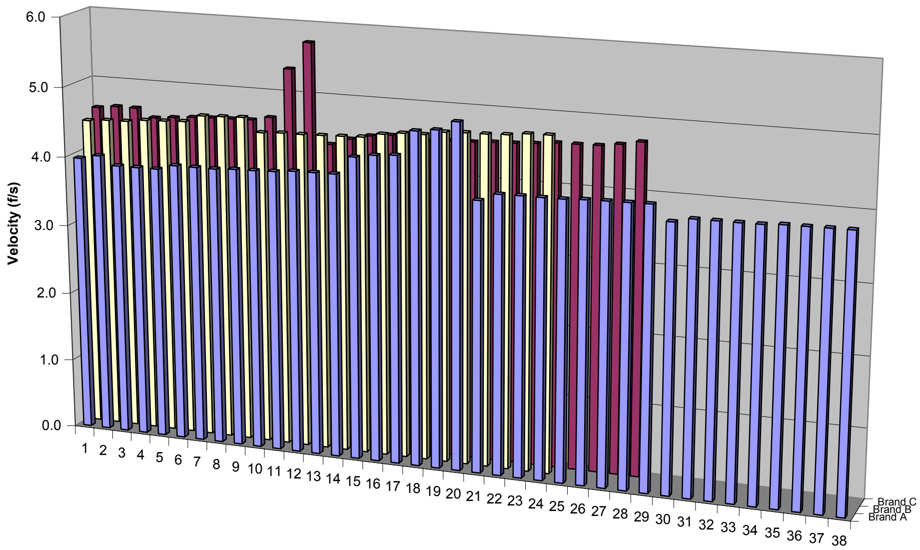

Figure 22: Measured velocities at 25" drop height

The ability to consistently reproduce input conditions is not always reflected in the test outcomes. There are several instances where both the input and the outcome were very similar. However, regardless of how the results were analysed, there was a marked tendency for a relatively large amount of scatter in the output. This is indicative of a lack of control over some parameter.

Early on during the angle testing, skid marks were observed on the test platform. From then on, the test procedure included an examination of the test surface for skid marks and if any were present, the test surface was cleaned.

Another manner by which the repeatability of the tests might be assessed is to characterize the overall events. The total distance travelled while under braking is one way of characterizing the tests.

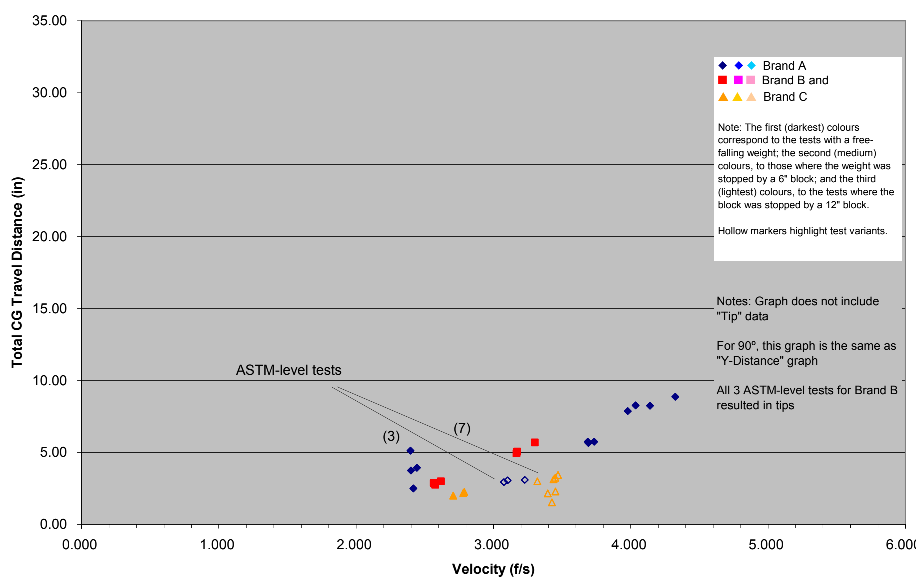

Figure 23: Total distance travelled vs velocity at 90°

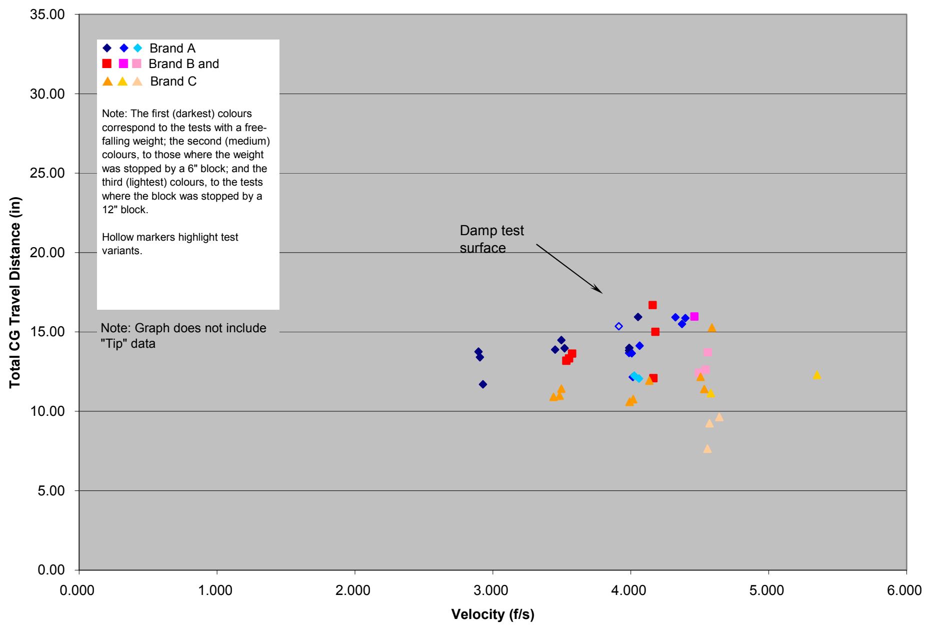

Figure 24: Total distance travelled vs velocity at 45°

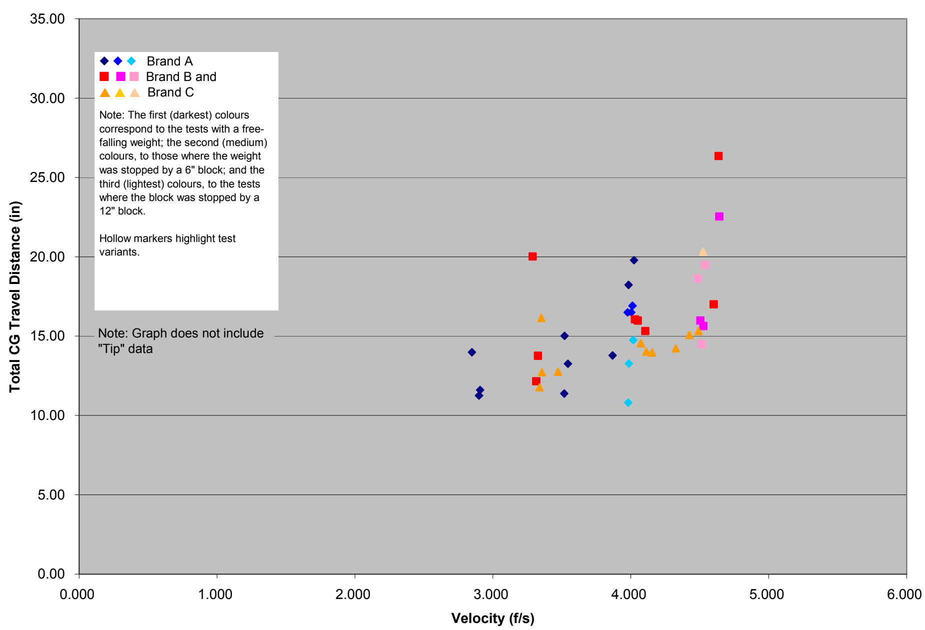

Figure 25: Total distance travelled vs velocity at 30°

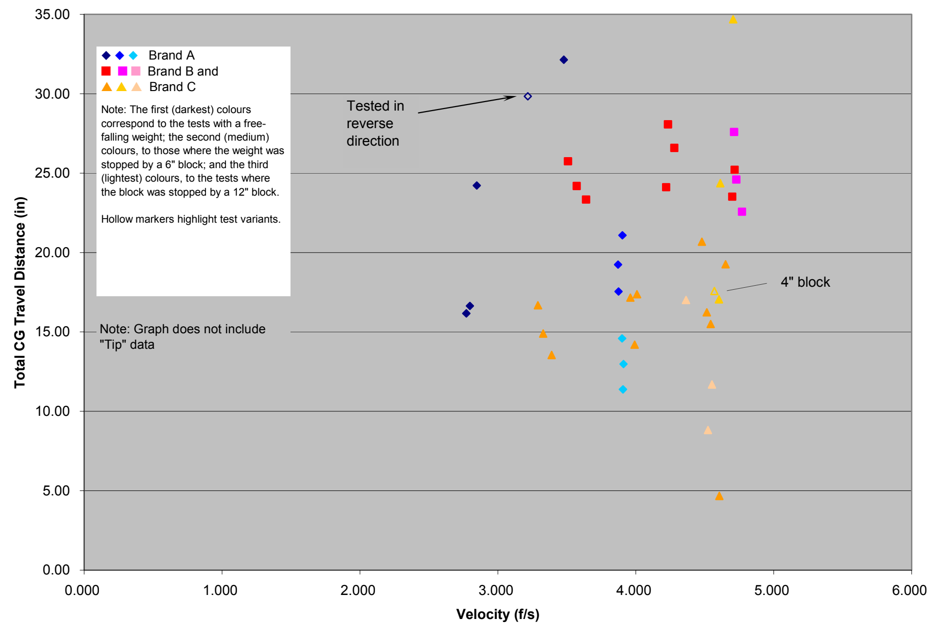

Figure 26: Total distance travelled vs. velocity at 15°

Perpendicular Tests

General

Table 5: Average velocities (f/s) for the 90° tests

Drop height	Brand A	Brand B	Brand C
10	2.41	2.59	2.76
14	—	3.21	—
14.6	3.14	3.29	3.42
15	—	3.33	—
16	—	3.55	3.61
20	3.70	4.01	4.12
25	4.01	—	4.62
27	4.27	—	—

The Brand A baby walker has a unique design feature which is the incorporation of an “always on” brake on its rear wheels. At any given drop height, this baby walker always has a velocity lower than that of the other two. Table 5 shows the average velocity[7] of the baby walkers for the 90° tests.

Brand A also exhibited a unique behaviour: From a starting point initially at rest with its front wheels just off the test table, under the static load of the 8 lb weight, this baby walker will slowly creep toward the end of the test table until it falls off. In essence, no matter how low the drop height, this baby walker will always fall off the table. In order to be able to gather more data on the behaviour of baby walkers, once this baby walker came to an initial stop, the weight was immediately removed in order to take post-test measurements.

Tests similar to those of the ASTM standard

It is the 90° tests that most closely resemble that specified by the ASTM standard. Although no inter-laboratory validation has been conducted, the tests conducted at the 14.6” drop height are in essence the ASTM test. The other drop heights used ranged from 10” to 27”.

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[7] In most cases, there are 3 data points. There was only 1 test done at the 15” drop height. The range for the others was from 2 to 7 data points.

As a matter of record, the older, non-braked baby walkers were each tested only once: at the configuration specified by the ASTM standard. They all fell off the test surface.

Out of the braked baby walkers tested, Brand B did not fall off the test surface at a drop height of 14” but did so consistently at the drop height of 14.6”. The Brand C did not fall off the test surface at a drop height of 14.6” but did so consistently at the drop height of 16”. The Brand A fell off the test surface 3 out of 4 times at a drop height of 27” but did not fall off at lower drop heights.

Figure 20 presents the velocities for all of the tests conducted at the 14.6” drop height. It is clear from the figure that none of the test velocities approached that of 4 f/s which, according to the ASTM rationale on the test development, is the target velocity for the test.

Angle of approach

General behaviour

There had been an initial concern that a wide opening such as that leading to an open staircase or a sunken living room might pose a greater danger to a child in a baby walker by allowing an approach to the step at an angle considerably shallower than 90°. A 6’-wide opening might allow a baby walker to approach the step at an angle approaching 15°.

Logistic regression

Of the many ways of looking at the data collected, a logistic regression[8] can be applied, looking simply at whether or not a baby walker fell off the test table or not. It is not a complete way of looking at data as it ignores much of what is known about the outcome of the test.

Viewed as a population, it can be seen from Figure 27 that at 90° the data collected show a 50% probability that a baby walker will fall off the test platform at approximately 3.6 f/s while for the 45° tests (Figure 28), the 50% probability of falling off the test surface occurs at approximately 4.9 f/s.

For the 30° data, the probability of a baby walker falling off the test platform is 0 until approximately 4.0 f/s and rises to only about 12% at 4.6 f/s, the highest velocity test for this angle. It should be noted that there was only one instance at this angle where a baby walker fell of the test platform.

For the 15° tests, the regression shows an inverse relationship between the probability of a baby walker falling off the test platform and event velocity.

Logistic regressions were not applied to each individual test series.

[8] “Logistic regression is a variation of ordinary regression, useful when the observed outcome is restricted to two values, which usually represent the occurrence or non-occurrence of some outcome event, (usually coded as 1 or 0, respectively). It produces a formula that predicts the probability of the occurrence as a function of the independent variables” John C. Pezzullo, from his web page on Logistic Regression.

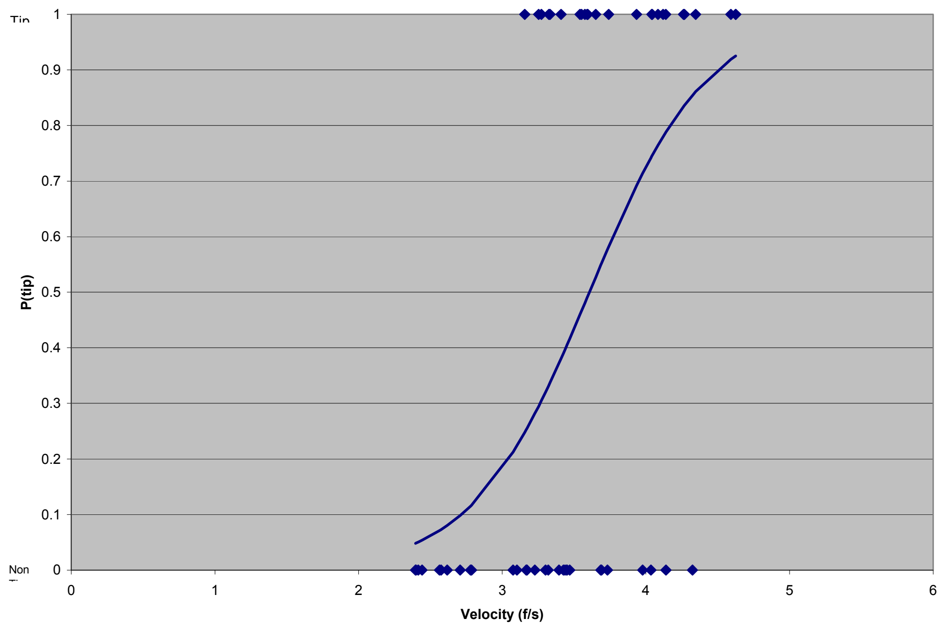


Figure 27: Logistic regression, all 90° data

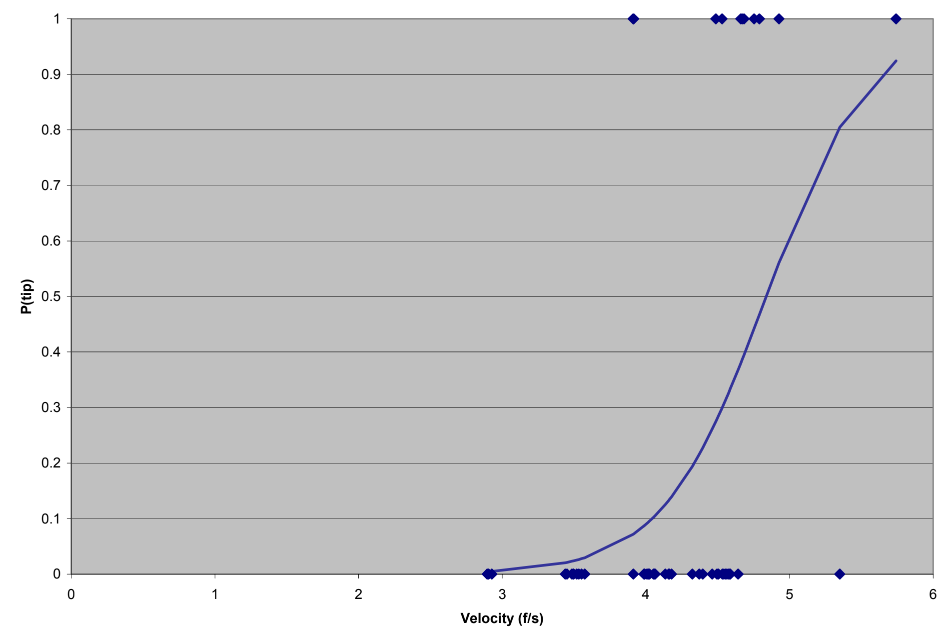


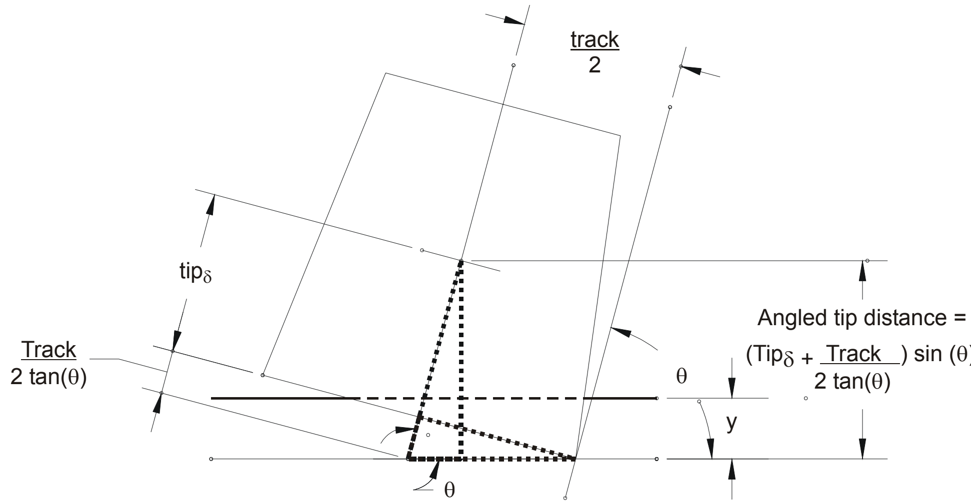
Figure 28: Logistic regression, all 45° data

Tip ratio

Other, more detailed manners of looking at the data is to consider the different baby walkers used, the different test conditions employed and information about the final resting position of a baby walker at the end of a test.

At the end of a test, the distance between the cg of a baby walker and the edge of the test platform is one indication of how close baby walker might be to falling off the test platform.

Normalizing the data to the distance from the front wheels to the cg of each baby walker eases the comparison. For the angled tests, a correction to the data is needed to account for the angle of the baby walker. The correction is illustrated in Figure 29.



where

tip$_\delta$ is the tip distance from Table 2

track is the front track from Table 1

θ is the orientation of the baby walker with respect to the edge of the platform

Figure 29: Corrected or angled tip distance

The following graphs, Figure 30, Figure 31, Figure 32 and Figure 33, present the *tip-distance ratio* or the normalized values of how close the cg of a baby walker was to the edge of the test platform.

These graphs present significantly increased complexity. The different markers represent the different baby walkers and the different colours represent different test conditions.

A close examination does reveal the emergence of patterns such as

- the clustering of velocities,
- general upward tendencies towards falling of the test table with increasing velocities, and ,
- the unmistakable effects of reducing the friction between the friction strips and the test table (Figure 31, Figure 33).

Specific measures such as the calculation of cv or other have not been examined.

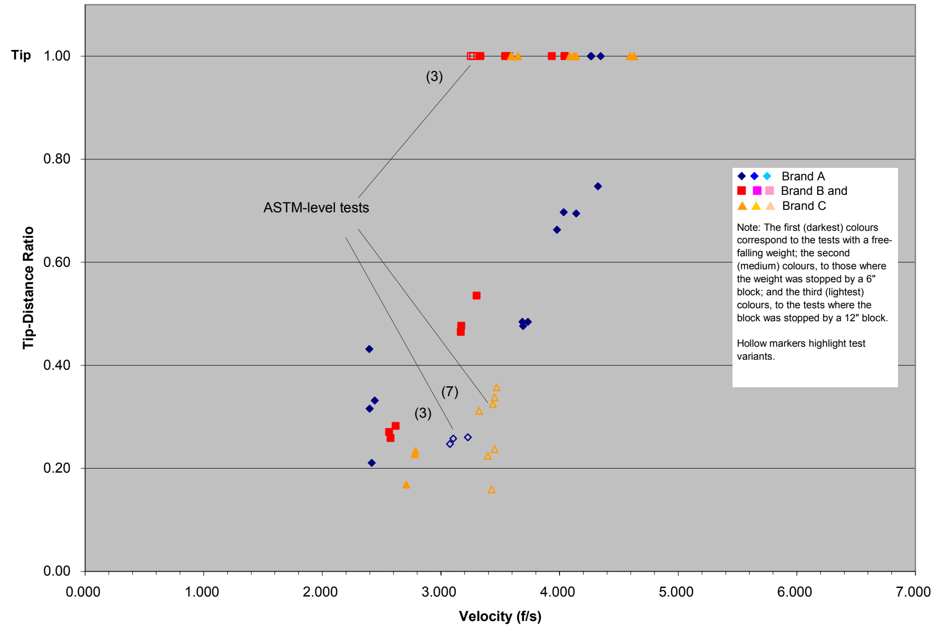


Figure 30: Tip-distance ratio vs velocity at 90°

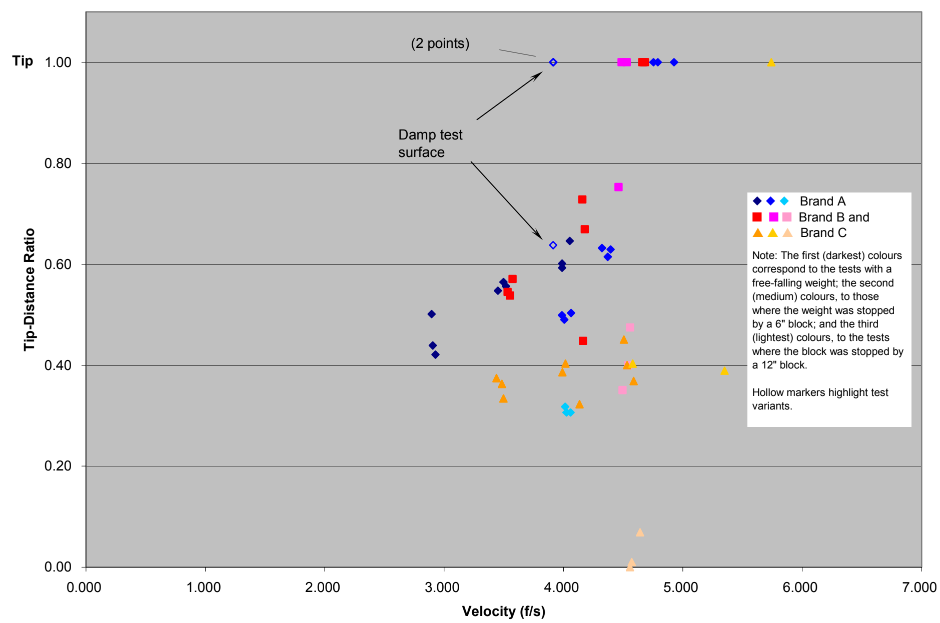


Figure 31: Tip-distance ratio vs velocity at 45°

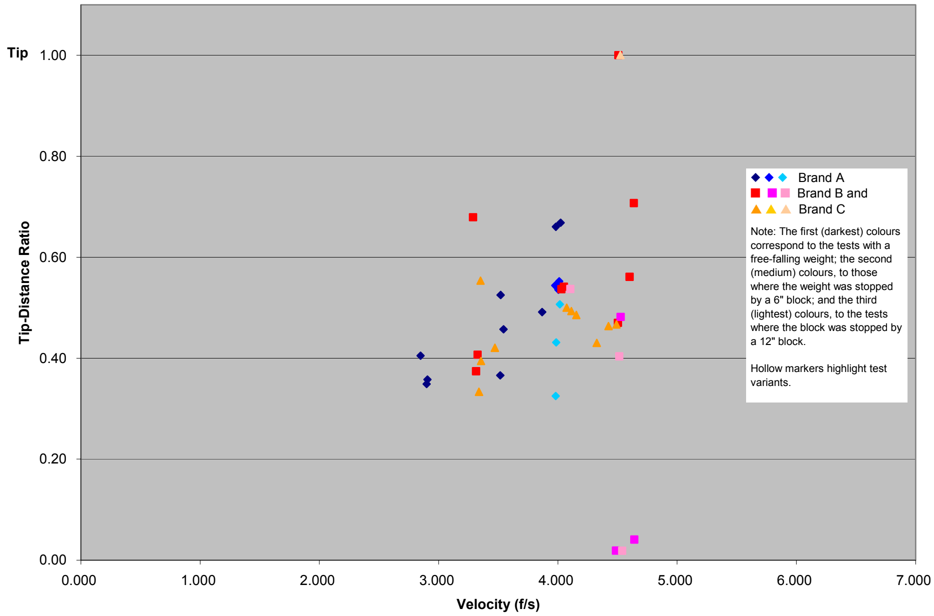


Figure 32: Tip-distance ratio vs velocity at 30°

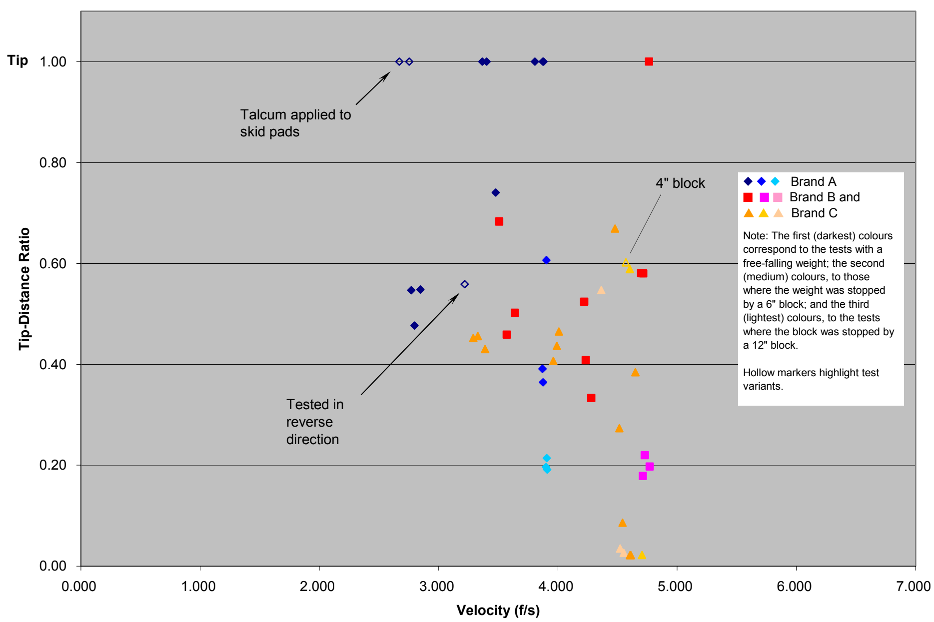


Figure 33: Tip-distance ratio vs. velocity at 15°

Artificiality of tests at shallow angles

The motion of the baby walkers during the angled tests was more complex than originally anticipated. After being accelerated toward the edge of the platform, the left front wheel of a baby walker would fall off the platform; soon after, the left front friction pad would contact the test surface and the baby walker would begin to brake. Because of the asymmetrical braking force, a counter-clockwise rotation of the baby walker ensues. In many instances, the test weight was not yet at rest and its line of application was no longer aligned with the baby walker's centerline. Although the continued application of a force may be legitimate, the effect of the essentially constant line of application of force applied with this test setup may be somewhat artificial.

To test this, in some tests of greater drop height, the weight was caught thereby eliminating its effect. The only forces in effect were then braking and the baby walker's momentum.

The overall effect of the reduced distance over which the force was applied is subtle and tends to be simply a reduction of the distance travelled under braking by the baby walker.

Other

Surface contamination and varying friction characteristics are difficult issues. Means by which these might be controlled are not immediately apparent from this test series. Certainly the tests with surface contamination (talcum powder, water) did exhibit a significantly different performance of the baby walkers.

Other potential contributors such as temperature and humidity were not recorded nor investigated. The only non-scientific applicable observation is that the investigators were comfortable in plain shirts and sweaters. This is at best an indication that the tests were run within the 23 ± 5 °C temperature range specified in ASTM F977 – 00.

Finally, if should be noted that while the graphs for total distance travelled vs velocity and for tip distance ratio vs. velocity identify the test variants, the data were for the most part not analyzed at that level.

RECOMMENDATIONS

Further testing of a similar nature to that conducted in this study is required for a more rigorous statistical analysis.

A further, more detailed investigation and understanding of the effects of surface contamination on the braking performance of baby walkers is required. If the braking performance cannot be controlled in a laboratory situation, it is difficult to imagine continued reasonable performance in a home.

A rational method of dealing with baby walkers that have built-in braking devices should to be considered. The tests with the baby walker so equipped are inconclusive. While it consistently reached the edge of the test platform at a lower velocity (Figure 20, Figure 21 and Figure 22); the friction between its pads and the test surface was insufficient to prevent it from slowly creep forward under the constant pull of the drop weight.

The initial test matrix incorporated a full series of tests with the baby walker travelling rearwards. Because of time constraints, these tests were not run. While preliminary testing conducted last year indicated that this posed a less severe test condition, this has not been verified.

The initial test matrix had also incorporated a complete repetition of the tests using the heavier CAMI dummy. The ASTM standard requires that the drop height be increased when using the heavier dummy. However, this variable was not included in the test program because of the lack of an 11-lb vest for the CAMI dummy, the inability of the test setup to compensate for the added mass at the greater drop heights, and the lack of time. The behaviour of baby walkers under higher inertial loads does need to be examined since a linear behaviour of the friction pads cannot be assumed.

An improved method of orienting the casters and a study of caster misalignment is also recommended as the acceleration distances are short and the baby walkers do not have enough distance over which to naturally correct any misalignment.

CONCLUSIONS

A primary objective of this test program had been to provide data that would assist in the assessment of options to address the safety of baby walkers. While far more is known about the behaviour of baby walkers, how they are and might be tested and of their performance, the data do not lead to strong conclusions on their performance.

This series of tests has shown that braked baby walkers can demonstrate a significant ability to stop at the edge of a step. The data does not show conclusively whether this ability is sufficient to protect children in all, or even most real-life instances.

The testing did provide valuable information about situations such as angled approaches to a step and contaminated braking surfaces apparently not contemplated by the ASTM standard.

Another objective had been the study of friction pad effectiveness. Indeed, the variability of test results would indicate that surface contamination has a significant effect on the braking ability of the baby walkers and warrants further investigation.

The third objective had been to develop an understanding of the relationship between the drop height for a test and the baby walker velocity achieved. While the analysis has not drawn a quantitative relationship between the two, there would seem to be enough data to do so. Although some variability exists, the recorded velocity clearly changes with drop height and repeatability is apparent.

The fourth objective was to investigate the behaviour of baby walkers at speed higher than that specified in the ASTM standard. The logistic regression does point to a seemingly unacceptable situation for the 90° and 45° tests. Conclusions, although directionally similar are less readily drawn from the other analysis.

Lastly, the tests did indicate that there was a decreased probability of a baby walker falling off a step with shallower approach angles. This observation may not be an indication of safer situations for baby walkers but may rather be an indication of the artificiality of the test or simply that tests were not conducted at sufficiently high velocities.

ACKNOWLEDGEMENT

The author would like to thank the staff at the Product Safety Laboratory. Without their assistance and commitment this project would not have been possible.

APPENDIX A: SETUP DRAWINGS

The following drawings represent the geometry for the different setups used in this test series.

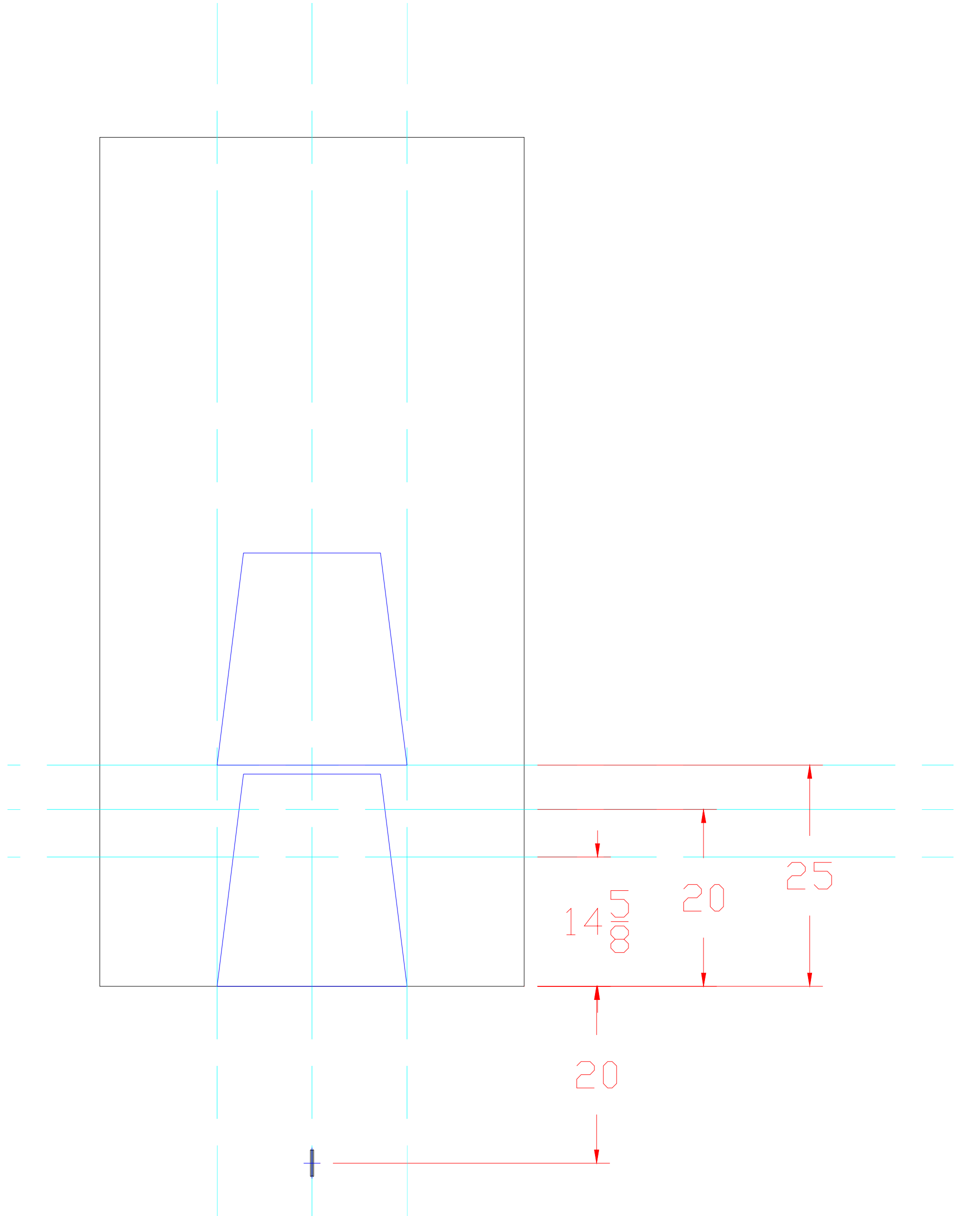


Figure 34: Setup for 90° tests

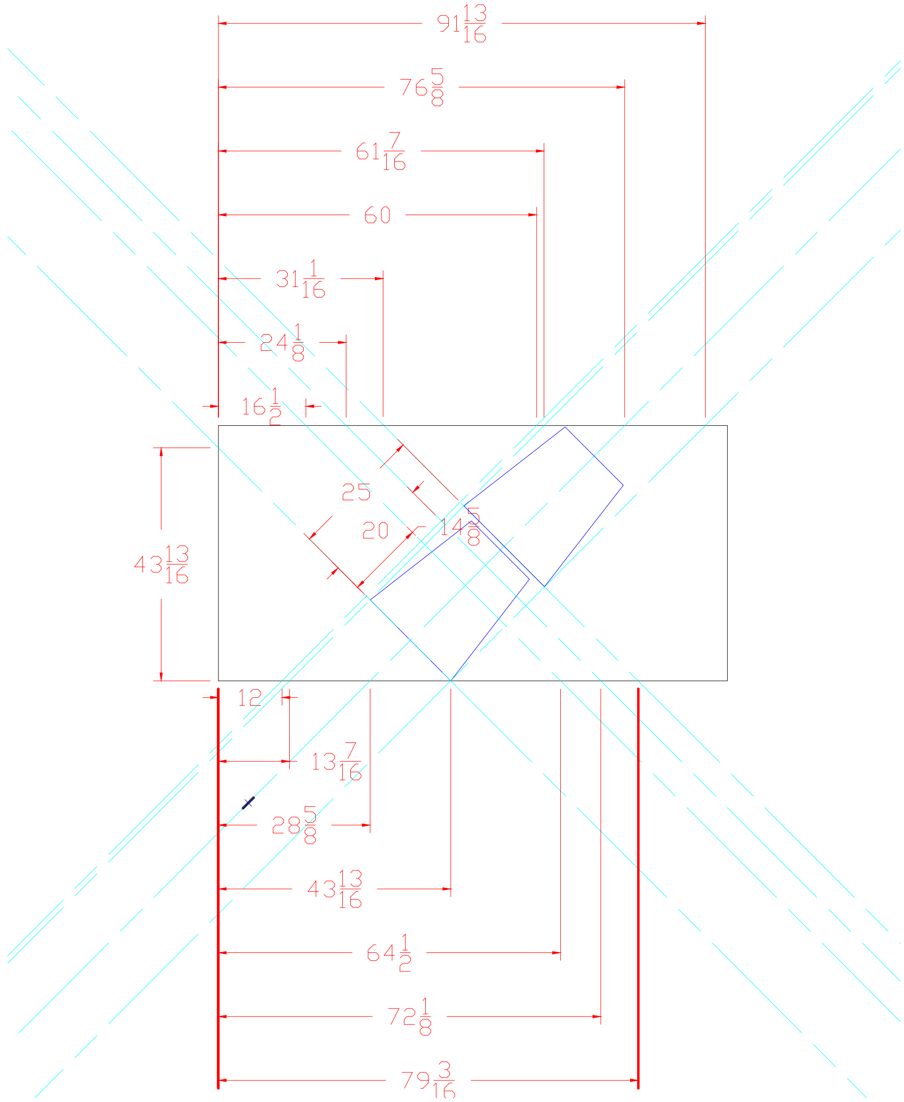


Figure 35: Setup for 45° tests

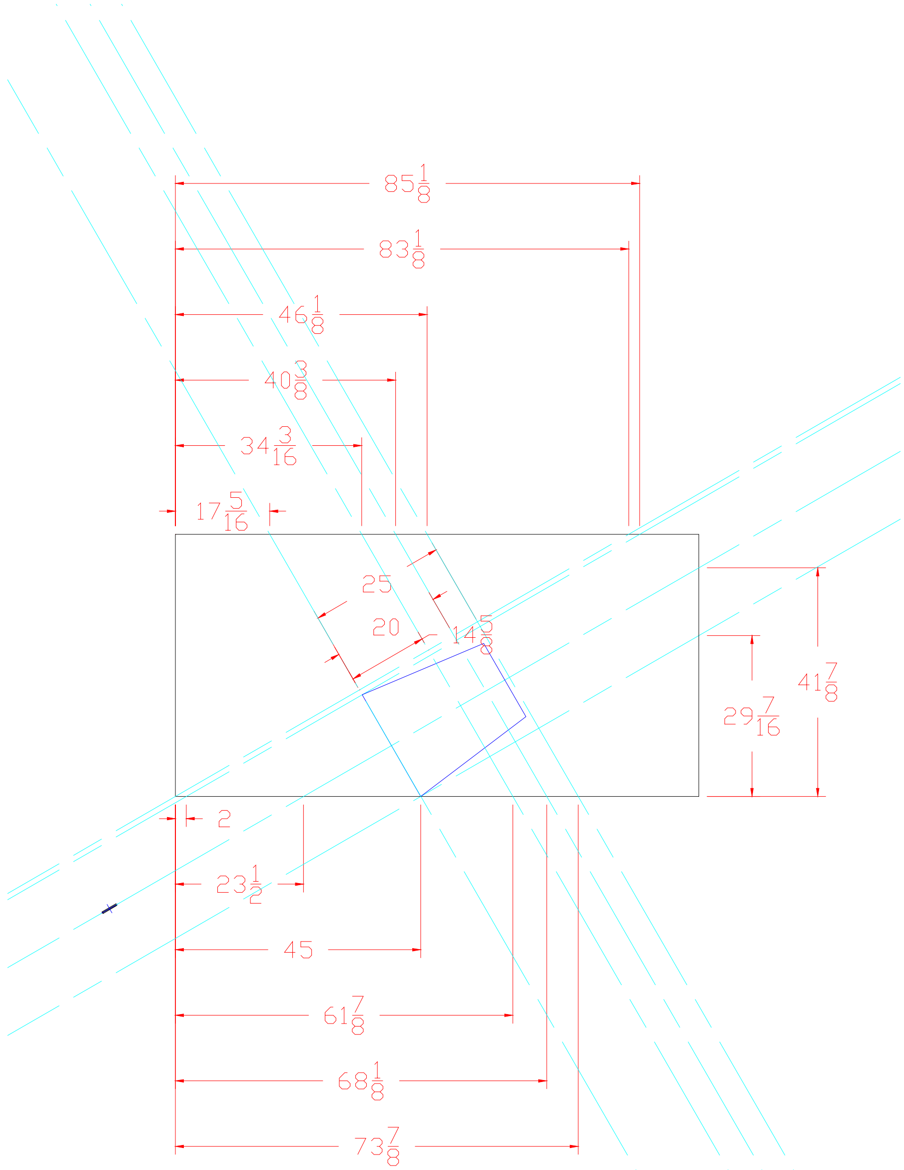


Figure 36: Setup for 30° tests

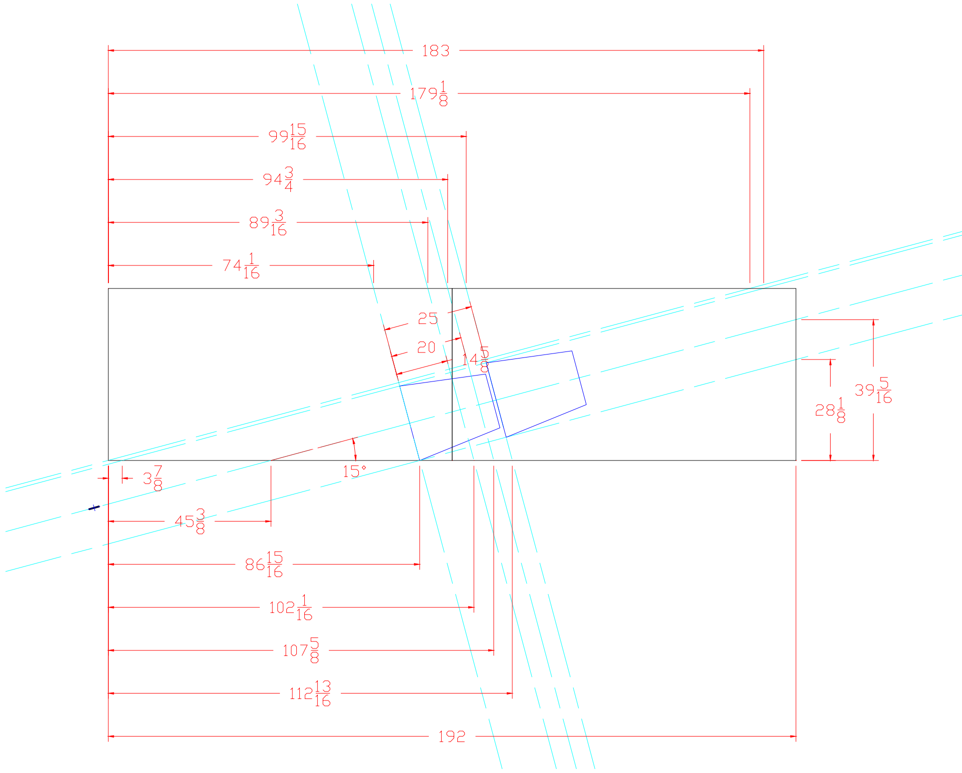


Figure 37: Setup for 15° tests