MEI-CHARLTON, INC.

2233 SW Canyon Road
Portland, OR 97201-2499

503-228-9663
Fax: 503-228-4065
E-mail: meic@meic.com
Internet: www.meic.com

AQUA BLAST™ SWIMMING POOL SLIDE;
SAFETY STANDARD TESTING,
16 CFR, CHAPTER II, PART 1207

S.R. Smith LLC

7 November 2005
Reference No. 7109006

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ENGINEERS and SCIENTISTS solving problems through APPLIED RESEARCH, CONSULTING ENGINEERING and CHEMISTRY

TO: S.R. Smith LLC
Attention: Bill Svendsen
PO Box 400
Canby, OR 97013

CLIENT NO.: 41220

REFERENCE NO.: 7109006

DATE: 7 Nov 2005

SUBJECT: AQUA BLAST™ SWIMMING POOL SLIDE;
SAFETY STANDARD TESTING PER CPSC
16 CFR, CHAPTER II, PART 1207

You asked MEI-Charlton, Inc. to run qualification tests for your Aqua Blast™ swimming pool slide according to the Consumer Products Safety Commission (CPSC) Specification 16 CFR, Chapter II, Part 1207, "Safety Standard for Swimming Pool Slides." The standard governs the design, materials, strength, and construction of the slide and contains nearly three dozen acceptance criteria.

We have previously tested the predecessor to this slide twice, once in October 1999, when it was referred to as the LP 4.5 (see Report 6503042) and again in May 2001, when it was referred to as The Flash™ (see Report 6611042). The LP 4.5 slide we tested in 1999 had been constructed by a process in which fiberglass was sprayed directly onto the underside of the acrylic top sheet. When we next tested the slide in May 2001 as The Flash, the construction method had been changed so that the fiberglass component was eliminated and replaced with an acrylic bottom sheet adhesively bonded to an acrylic top sheet. Additionally, the design of the stairs had been changed somewhat to accommodate the construction process, and the number of treads had been reduced from five to four.

In both instances, following some minor modifications, the slides were in conformance with the CPSC specification requirements.

The current version of the slide, now referred to as the Aqua Blast, has again been modified, such that it is now constructed from a single sheet of material rather than from laminated sheets. Additionally, instead of the runway being constructed as a single, one piece unit as was done before, the runway is now constructed as a front half and back half, bolted together in the middle. Additionally, the water lubrication jets have been moved from the sides of the runway near mid length of the slide to a recess in the bottom of the runway trough at the top of the sloped portion of the runway.

You have indicated that the Aqua Blast slide is primarily intended as a child slide. However, the CPSC specification makes no distinctions between slides of various sizes or the age or stature of intended users. In fact, the only age/size reference in the CPSC standard is the requirement that the runway slide geometry performance pool tests for all slides be done using a 50th-percentile adult male.

Two slides were provided for testing, one for laboratory testing and the other for pool testing; both were right curve slides. We conducted the full range of tests described in the CPSC specification. Most of the testing was done in our laboratory; however, the runway slide geometry performance tests, which require measuring the trajectory of a slider as he exits the slide, were run at the Canby Swim Center pool, in Canby, Oregon.

The governing specification is quite poorly written, with numerous contradictions, ambiguities, and nondefined terms. Where necessary, we interpreted the specification requirements using our engineering judgement and our expectations about what the intent of the specification's writers was. We also utilized the information gathered previously during our testing of another slide for you (the Frontier III) when we contacted CPSC for an interpretation involving the slider trajectory test.

The results of our testing are as follows:

1. The Aqua Blast slide was generally in conformance with the construction and performance requirements of the CPSC standard, with just two minor exceptions as follows:

2. The handrail fasteners were not in full conformance with the requirements of the standard. The standard requires that the handrail fasteners be "vibration proof, self-locking, and tamper proof." Although the fasteners were tamper proof and vibration proof, they were not self-locking.

Self-Locking

The standard does not define self-locking; however, common usage of the term denotes a fastener with some type of interference fit in the threads such that the fastener cannot be threaded on or off by hand (i.e., it does not turn freely, even in the nontorqued condition). This interpretation of self-locking is supported by the standard's requirement that the fasteners be capable of withstanding a 1 ft-lb "back-off torque." The term "back-off torque" is also not

defined, but common usage denotes the torque necessary to remove a fastener the rest of the way after it has been initially "broken loose" from its fully tightened position. The fasteners on the handrails could be removed by finger pressure alone once they had been broken loose and freed from their lockwashers; thus, the back-off torque was significantly less than 1 ft-lb.

Vibration Proof and Tamper Proof

The standard does not define vibration proof either; however, common usage of the term denotes a fastener with a lock washer or some other means to prevent it from loosening due to vibration. The handrail fasteners had lock washers and would thus be considered "vibration proof."

The standard does define tamper proof as a fastener that requires a tool to remove it; the fasteners required the use of a wrench to remove them, and hence, met the "tamper proof" requirement of the standard.

3. The only other deviation from the CPSC standard requirements was the absence of the manufacturer's identification on the slides we tested. Although we suspect the absence of manufacturer's identification may have been because these particular units were intended for our testing rather than consumer sale, you should be aware that such identification will be required on production units in order to comply with the CPSC standard.

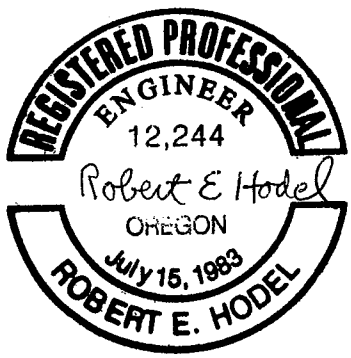
Discussion

The minor nonconformances of the slide should be fairly easy to correct. The problem with the handrail fasteners not being self-locking was encountered twice previously on this slide, when we tested it as the LP 4.5 and The Flash. In our 22 May 2000 report (6512042), we noted that to correct the handrail fastener nonconformance you reportedly specified that a threadlocking compound (Loctite™ 242) be used on the handrail fasteners when the handrails are attached to the slide. To accomplish this, a tube of the threadlocking compound was reportedly supplied along with the fasteners. (The handrails are reportedly attached at the end-user's site when the slide is installed.)

Subsequently, in our 14 May 2001 report (6611042), we reported that to increase the back-off torque, you drilled slightly undersize holes in the slide where the bolts pass through to the handrails, such that the bolts would "drag" in the holes.

As for the labeling nonconformance, the obvious solution is to affix appropriate labels to the production slides, as required by the standard.

Details of our test results are on the following pages. If you have questions or need further assistance, please contact us.



Expires: 6-30-07

Robert E. Hodel, PE
Project Director

REH:sas

2233 SW Canyon Road
Portland, OR 97201-2499
503-228-9663 www.meic.com

Section 1207.4 "Recommended standards for materials of manufacture" **Pass**

This section of the standard is quite short and covers the slide materials' chemical and environmental compatibility and toxicity. All but one of the items in this section were *recommendations* (i.e., "should be"), rather than *requirements* (i.e., "shall be").

We did not evaluate the recommendations in detail, but our observations indicate the slide was in general conformance with them. The only requirement in this section was in paragraph (d), *Toxicity*, which requires that paints and "finishes" comply with 16 CFR 1303.2(b)(2) and 1303.4(a); this section of the Federal Record restricts lead content to less than 0.06 percent. The lead content, as measured on the surface, was less than 0.01 percent, which meets the requirement of the standard.

Section 1207.5 "Design"

This section of the standard covers the majority of the testing and contains nearly three dozen requirements. The requirements and the results of our tests are listed in the following subparagraphs.

(a) "Strength" **Pass**

The standard requires that the strength of the slide be such that no structural failures of any component part cause failures of any other component part. The slide passed the structural tests described in the standard without failures to any other component part.

(b) "Edges" **Pass**

The standard requires that the slide be designed, finished, or protected in such a manner as to prevent cutting human tissue on causal contact. The slide met this requirement.

(c) "Ladders, steps, stairs, or ramps"

(1) "General" **Pass**

The standard requires that the slide ladder have treads, not rungs, if the angle of incline of ladder is 15 degrees or greater. The ladder had an angle of incline of 15 degrees, and it had treads, thereby meeting the requirement.

(2) "Angle" **Pass**

The standard requires that if treads are used, the user's center of gravity must be approximately positioned directly over each step during the use of the ladder, and that the minimum installed angle be not less than 15 degrees. During our testing, we found that the ladder could be easily ascended or descended, and the test subject was able to remain stable with his hands released from the hand rail; thus the ladder met the center of gravity requirement. The ladder angle was 15 degrees, thus meeting the 15-degree minimum requirement of the standard.

(3) "Steps"

(i) "Dimensions" **Pass**

The standard requires that the riser height be no more than 12 inches and no less than 7 inches, and that it be "constant" over the entire height of the ladder. The ladder has four molded-in treads and thus five risers, counting the step from the highest tread up to the slide's runway platform. The largest step deviation was 5/16 of an inch.

"Constant" is not defined in the standard. The Uniform Building Code (UBC) limits the riser height variation on stairways in buildings to 3/8 inch, so the slide's steps would meet the requirements of that specification. Thus, we judged the ladder to be in conformance with the CPSC standard.

(ii) "Tread curvature" **N/A**

The treads were not curved.

(iii) "Slip-resistant surfaces"

(A) "General" **Pass**

The standard requires that the tread surface have a slip-resistant surface that is either an integral part of or "permanently" attached to the ladder steps. The slide had adhesively bonded, slip-resistant surfaces attached to the treads. Although we did not evaluate the adhesive to determine its "permanence," we judged the tread surface to meet the requirements of the standard.

(B) "Performance test" **Pass**

This test requires that a 300-pound test load not move when it is loaded tangentially at 105 pounds. No motion occurred at the designated tangential load.

(iv) "Fastener requirements" **Pass**

The standard requires that the treads be attached to the ladder rails in such a manner that the fasteners not loosen, crack, or break under continued use and reasonably foreseeable abuse. Further, the attachment methods are required to be permanent and tamper proof. The ladder treads and ladder rails are a single-piece, integral part of the slide and thus met the requirements.

(v) "Aboveground pool ladders" **N/A**

This section of the standard addresses requirements for aboveground pool slides equipped with swing-up ladders, which does not apply to this slide.

(vi) "Ladder platforms" **N/A**

The standard requires that slides higher than 7.5 feet have a platform built into the ladder. The slide was 4 feet, 7 1/2 inches high and consequently, does not need a platform.

(vii) "Static load performance" **Pass**

The static load performance test requires that the treads be capable of supporting a 300-pound load in the center without failure or permanent deformation. The ladder tread met this requirement.

(d) "Handrails" **Pass**

The standard requires that slide ladders be equipped with handrails and that they extend no more than 18 inches above the top of the slide runway platform. The slide was equipped with handrails, and the top surface of the handrails extended 16 3/4 inches above the top of the runway platform, thus meeting both requirements.

(1) "Size" **Pass**

Handrails are required to have an outside diameter of between 1.00 and 1.90 inches. The handrails were between 1.001 and 1.003 inch in diameter and thus met the requirement.

(2) "Extent of handrails" **Pass**

Handrails are required to be parallel to the ladder rails, at a perpendicular distance of 4 to 6 inches. The handrails were parallel to the ladder rails, at a distance of 4 inches (inside measurement), and thus met this requirement. The handrails are required to begin 3 to 5 feet above the pool deck. The handrails began 3'-1" from the bottom of the slide, and thus also met this requirement.

In addition to the requirements for the extent and position of the handrails, this section of the specification has a requirement that the handrails "should not provide a means of entrapment". The rail design incorporated a standoff bar near mid height to prevent a slider from becoming trapped between the rail and the ladder. We judged the rails as meeting this requirement.

(3) "Bracing of handrails" **Pass**

The standard requires that if handrail braces are used, they withstand intended use and reasonably foreseeable abuse. The handrails were well attached.

(4) "Attachment and strength of handrails" **FAIL**

The standard requires that handrails and their fasteners withstand allowable shear, bending, and cyclical loading in intended use and reasonably foreseeable abuse. The standard also requires that fasteners be "vibration proof," "self-locking," and "tamper proof," and that they be capable of withstanding a 1 ft-lb back-off torque.

A tamper proof fastener is defined as one that requires the use of a tool to remove it; the fasteners required the use of a wrench to remove them and thus met this requirement.

The standard does not define vibration proof or self-locking; however, the fasteners had lock washers and could thus be considered "vibration proof".

Common usage of the term "self-locking" denotes a fastener with some type of interference fit in the threads such that the fastener does not freely turn in the non-torqued condition. This interpretation of self-locking is supported by an additional requirement in the standard that the fasteners be capable of withstanding a 1 ft-lb "back-off torque." The term back-off torque is also not defined, but common usage again denotes the torque necessary to remove a fastener the rest of the way, after it has been initially "broken loose" from its fully tightened position.

The fasteners were not a self-locking type, and the back-off torque after the fasteners had been broken loose and were not contacting the lockwasher was less than 1 ft-lb. **Thus, the fasteners did not meet this requirement of the standard.**

(i) "Sockets performance test" **Pass**

The specification requires that if handrail "sockets" are used, the handrails are required to be permanently fixed in the socket so they cannot be pulled out or bent at the socket by a moment of 233 ft-lbs parallel to the plane of the handrail.

The specification does not define what is meant by a "socket". We suspect that a socket is a separate fixture into which the handrail is inserted, which in turn, is attached to the slide; as such, the slide does not have sockets, so this test would not apply. However, because the intent of this section is to test the overall strength of the handrail, we ran the test anyway.

The test procedure is somewhat ambiguous, as it does not specify whether or not the bottom end of the handrail is supposed to be attached to the slide during the moment test, which, per the specification, is done at the top end of the handrail. We ran the test under both conditions.

The handrails did not pull out or bend with a 233 ft-lb moment (144 pounds at 19 1/2 inches) applied in the plane of the slide, either with the bottom end of the handrail attached or without it attached. Thus, the handrails met the requirement.

(ii) "Side forces" **Pass**

Handrails are required to be capable of withstanding all shear and bending forces induced by a 172 ft-lb moment perpendicular to the plane of the handrail. The handrail withstood a 172 ft-lb moment (230 pounds at 9 inches) perpendicular to the plane of the handrail, and thus met the requirement of the specification.

(iii) "Performance tests"

(A) "Strength for climbing and falls" **Pass**

Handrails are required to be capable of supporting, without permanent deformation or bending, a 162-pound weight hung by a cable from the point where a perpendicular line to the axis of the handrail passes through the attachment point. The handrail passed this test.

The handrails are also required to be capable of withstanding the same load for a period of 15 minutes after being subjected to a drop test in which the 162-pound weight is raised 1 foot and dropped. The acceptance criteria is that the handrail not bend more than 45 degrees from its original direction.

The drop test resulted in a minor crack (less than 1 inch long) in the slide where the bottom end of the handrail is attached; however, the handrail was still capable of withstanding the 162-pound load for 15 minutes afterward, bending only 12 degrees, well below the 45-degree maximum allowable.

The specification does not address the crack-type damage; thus, since the handrails met the less-than-45-degrees criterion, they were judged to pass this test.

(B) "Transition handrail strength" **Pass**

The handrails are required to be capable of supporting a 115-pound weight with the slide rotated into a horizontal position on its side. The handrail withstood this load with no visible deformation.

This is a confusing section of the specification, in that it duplicates the test geometry in the previous section, "*(ii) Side forces*", where a 172 ft-lb sideways moment was applied to the handrail. However, the performance test described in this section requires a specific test load of 115 pounds, rather than a load determined on the basis of the moment arm length. The required load of 115 pounds is *less* than the load necessary to apply a moment of 172 ft-lbs.

The problem appears to be the result of the specification apparently being written for a slide in which the handrails were 18 inches high and were mounted directly to the top runway platform. In that case, 115 pounds applied at a perpendicular distance of 18 inches equals the required moment of 172 ft-lbs.

For the Aqua Blast slide, however, the handrails were only 9 inches tall themselves but were mounted to the top of the slide's 6 3/4 inches high molded-in side rails.

As noted above in section *(ii)*, we ran the test in accordance with the 172 ft-lb requirement, and the slide met the requirements. We then reran the test using the 115 pound load requirement; as expected, it also met the requirements at the lower load.

(e) "Lubrication" **Pass**

Slides are required to either be equipped with a method of lubrication or "have a similar coefficient of friction." The nozzles and hoses for a water lubrication system are required to be recessed or otherwise designed in such a fashion as not to interfere or trip the slider.

The slides had a pressure-fed water lubrication system, and the water nozzles were recessed so they did not interfere with or cause a tripping hazard to the slider.

(f) "Runways"

(1) "Curvature" **Pass**

The slide curvature is required to be "consistent" with maintaining the slider safely on the slide during intended use and reasonably foreseeable abuse.

The slide curvature and runway rails maintained the slider on the slide during prone, stomach-down, head-first field tests.

(2) "Dynamic equilibrium" **Pass**

The slide runway is required to be designed such that a test fixture (as described in the standard) stays within a distance of ±41 percent of the runway width to the runway centerline at all points along the runway, without contacting the runway rails.

The test fixture stayed within 10 percent (1 5/8 inches) of the centerline of the slide and did not touch the "side rails" (as defined below); thus, the slide met the specification requirements.

(3) "Runway side rails" **Pass**

The standard requires that slide runways have "permanent runway side rails of at least 2 inches and height to prevent lateral discharge of the slider off the slide under intended use and reasonable foreseeable abuse." The specification defines runway rail as "a raised edge or guard that keeps the slider on the runway," and it defines slide width as "the width of the slide runway measured between the inside of the left and right runway rails."

Although the specification was apparently written for a slide with a flat runway and vertical side rails in mind, it does not actually describe any particular requirements for the cross sectional profile. The Aqua Blast slide runway cross sectional profile is a continuous, U-shaped curve, with no demarcation between the "runway" surface and the "side rails." Thus, the "height" of the "side rails" and the "width" of the "runway" are somewhat open to interpretation.

We used the specification's requirement that the side rails be at least 2 inches high as the governing requirement; as such, we classified the "side rails" as those portions of the U-shaped cross section which extended 2 inches below the top of the U; the "runway" width, then, was the remaining portion of the U-shaped cross section, 16 inches.

Based on this interpretation, the slide met the requirement for 2-inch high side rails. Also, because the side rails were an integral part of the slide, they met the requirement that they be permanent.

The U-shaped profile of the slide serves to prevent the lateral discharge of the slider off the slide. During our field testing, we found that in some cases, the slider's feet would slip over the top of the rails; this was due to the fact that a slider's body doesn't bend particularly well in a sideways orientation and thus didn't conform particularly well to the sideways curvature of the slide. However, regardless of what the slider's feet did during the testing, the slider's body was always retained well within the slide. Thus, the rails serve their intended purpose of preventing lateral discharge of the slider.

We used the above distinction between the side rails and runway in determining conformance with the requirements in the previous section of the specification, *(2) "Dynamic equilibrium"*, and in the following section of the specification, *(4) "Runway siderail heights."*

(4) "Runway side-rail heights" **Pass**

The standard requires that runway side-rail heights conform to the requirements of Table 2 in the standard, which shows side-rail height as a function of maximum slide slope angle. The maximum slope was 32 degrees, so the minimum side-rail height per Table 2 would be 2 inches.

As described in section *(3) "Runway side rails"* above, the slide met this requirement.

(5) "Slide geometry" **Pass**

Specification Requirements

The standard requires that the slide have a geometry such that: (1) the path of the center of gravity of the slider is not more than ±10 degrees from the horizontal at the center of gravity's exit off the slide, and (2) the slider's angle of attack be at least +15 degrees when the slider's feet leave the slide.

Specification Ambiguities

The requirements in this section of the standard, and the method of determining such, are not clear. The standard starts by listing two acceptance criteria (the ±10 degree center of gravity trajectory and the +15 degree angle of attack). But then, the standard describes only a single performance test, namely, the one for the +15 degree angle of attack criteria. The standard then states that if the angle of attack meets the +15 degree criteria, "the slide passes this performance test."

Center of Gravity Trajectory

Although the slide is presumably intended to meet both acceptance criteria (otherwise, why would both criteria be listed), no performance test is given for the center of gravity trajectory. Measuring the center of gravity's trajectory at the slide exit is not practical because the path of the slider's center of gravity is not visible while the slider is on the slide (because the slide's side rails block the view); thus, no measurements can be made on the center of gravity until after it exits the slide. Another problem with the specification is the absence of a concise definition of what is meant by the center of gravity's "exit off the slide." The exit lip line is defined as the point where the slide runway is tangent to the curved profile of the exit lip. If this is the point where the center of gravity "exits the slide", then the trajectory up until the point of exit will be the same as the angle of the runway leading up to it.

On the other hand, if the center of gravity's "exit off the slide" is defined as the point where a vertical line through the slider's center of gravity loses contact with the slide, then the situation is more complex and will depend on the slider's exit speed. That is, the slide has a rounded exit lip with a radius of 4 inches; if a slider travels slow enough, his center of gravity will remain in contact with the rounded exit lip beyond the tangent point between the rounded lip and the flat portion of the lower runway, and thus, when it does "exit" the runway, his center of gravity will be traveling downward at an angle which depends on his speed and the curvature of the lip.

We have interpreted the specification requirement as being governed by the definition of the exit lip line. Thus, because this slide has an exit angle of -5 degrees at its exit lip line, we have judged it, based on its construction, to meet the specification's center of gravity trajectory requirement.

Angle of Attack

The standard's requirement for the angle of attack measurement is also not clear. The primary difficulty is in establishing the slider's longitudinal axis. The standard defines this as the "vertical line that passes through his center of gravity when he stands erect." The problem with this definition, is that the body position of a test subject while standing erect is substantially different than the body position coming off the slide. That is, when standing erect with arms outstretched overhead, our test subjects' arms, head, torso, and legs were all aligned. However, when coming off the slide, this was not the case.

Instead of being straight, the test subjects had a "swaybacked" posture. With this body posture, the location of the "longitudinal axis" as described in the standard was no longer clearly defined, and this had a profound effect on the angle-of-attack measurement.

We resolved this issue during a previous slide evaluation for you (6405049, December 4, 1998) by calling the Consumer Product Safety Commission and asking for a clarification. They reported that they defined the longitudinal axis as the line passing through the subject's center of gravity and head, and that this was independent of body position.

Note that the slider's center of gravity is also a function of body posture. That is, when standing upright with arms overhead, a person's center of gravity is located close to a line through their hip bones. However, when in a swaybacked posture, the center of gravity moves toward (or even beyond) the person's back, in an amount which depends on the weight distribution in the person's body and the amount of "sway" in their back. Taking this into account would also have had an effect on the person's longitudinal axis by the CPSC definition. In accordance with CPSC input, we treated the center of gravity as remaining fixed at the location determined with the slider standing upright with arms overhead. Our written and e-mail correspondence with CPSC are in the appendix.

Test Conditions

For these tests, we used two test subjects, both of whom met the height and weight criteria listed in the standard. Each subject made about 20 runs. The tests were run with the slide attached to a 3/4-inch thick sheet of plywood, which was leveled on the sloped pool deck using wood shims. The plywood was then weighted down with several bags of sand to reduce motion of the slide during the testing.

According to the specification, the angle of attack measurements are supposed to be made after the slider's feet have "cleared the slide, the distance between the end of the slide and his feet being less than 8 inches". It is not clear what exactly is meant by this, nor is it clear what the intent of the specification is at this point. One possibility is that the measurement is simply intended to be made after the slider's feet are no longer pressing against the slide, thereby altering the trajectory. However, another possibility is that the measurement is intended to be made when the slider's center of gravity is a certain horizontal distance from the slide, with the reference being taken as the location of the slider's feet.

The reason this is important is that with the slide setting on the pool deck at its normal installation height, our test subjects had already hit the water with their arms and head by the time the horizontal position of their feet passed beyond the end of the slide. This is of concern because once the sliders' make contact with the water, their body position is altered and consequently, so is their angle of attack. Furthermore, with the slider's head underwater and no longer visible, we were unable to establish the longitudinal axis (which by CPSC definition is the line through the center of gravity and the head).

On the other hand, we found that when our slider's upper body left the slide, their upper body tended to rotate downward, such that their feet and legs rotated upward, thereby losing contact with the slide even though their feet had not yet passed beyond the end of the slide. Our test measurements were made at the point where the slider's head was just going underwater, and their feet had "cleared the slide" due to rotation of their body.

Body Posture

Another problem with the test specification, is there is no discussion of whether the divers should attempt to control their body postures upon exit, and if so, in what manner. This is important, because we found that our two test subjects had significantly different body postures when using the slide, even though both of them were attempting to slide in a "natural" position. The difference in posture resulted in significantly different angles of attack.

During previous testing of the predecessor to this slide, to evaluate the effects of body posture on the angle of attack, our test subjects each made several runs where they purposefully attempted to dive toward the bottom of the pool by bending their arms downward and pivoting their body's at the waist as soon as they left the slide. This had a profound effect on trajectory. That is, we found that both subjects entered the water at a much steeper angle than they did when sliding in a more "natural" profile.

Because the dive path was dependent upon whether or not the test divers were attempting to dive toward the bottom of the pool, and because the standard does not address the issue of body posture, we instructed the test subjects dive in what felt to be a natural body position.

Slide Test Results **Pass**

The standard requires that "at least five consecutive runs" be made with the same test subject in order that an average can be computed. The standard also states that the maximum "measurement variation" be 15 percent. We interpreted these requirements as indicating that out of all the test runs, only a single, five-consecutive run average meeting the requirements was necessary to pass the slide, even if other groups of five-consecutive run averages, or if the overall average, did not meet the requirements. Our two test subjects made a total of 42 runs. We did not compute the angle of attack for all the runs, but instead, ceased our analysis once we had obtained five consecutive runs with the same test subject which met the requirements.

On this basis, the slide met the specification requirements, having at least one, five consecutive-run average which simultaneously met the angle-of-attack requirement and the angle-of-attack measurement variation requirement. The average angle of attack for these five runs was 18 degrees, which is greater than the minimum requirement of 15 degrees, and the deviation of each run from the average ranged from -5.7 percent to + 3.4 percent, thereby meeting the maximum measurement variation of ±15 percent.

(6) "Runway exit lips" **Pass**

The standard requires that the radius of curvature of the exit lip be at least 2 1/4 inches. The radius on the slide was 4 inches, which meets the requirement.

(7) "Runway exit vertical angle" **Pass**

The standard requires that the exit angle of the runway be -3 to -11 degrees. The exit angle was -5 degrees, which meets the requirement.

(8) "Runway exit ramp lateral curvature and exit lip horizontal angle" **Pass**

The standard requires that the exit lip of the slide be level side-to-side. Because of the U-shaped runway cross sectional profile of the Aqua Blast slide, this portion of the specification is not directly applicable as written.

The specification was apparently written for slides having a flat runway cross section with vertical rails on both side. However, there are no requirements in the specification that require such a profile. Thus, we consider the U-shaped profile of the Aqua Blast slide to be acceptable, provided it meets all the performance requirements.

The apparent intent of the side-to-side levelness requirement is to assure that the users are not rotating or tilted sideways as they leave the exit. By this reasoning, the analogous requirement for a U-shaped slide, corresponding to the level (horizontal) requirement for a flat-runway slide, would be that a perpendicular line at the centerline of the U-shaped runway be plumb (vertical).

A line perpendicular to the runway centerline at the exit lip was within 1 degree of being plumb. As such, we judged it to be in conformance with the specification requirement.

This section of the standard also states that there shall be no net lateral forces on the slider in that portion of the runway exit ramp beyond the forward support points of the slide, and that the slide shall be designed so that any side forces on the user induced by prior lateral curvature will be reduced to zero upon exit from the slide runway.

The performance test for this requirement requires that the test fixture (which is also used for the dynamic equilibrium test), exits the slide within ±5 degrees of the slide centerline and not touch the side rails. The test fixture's exit angle had a three-run average of less than a quarter degree, and the test fixture did not touch the "side rails" (as defined in section *(f)(3)*). Thus, the slide met the requirements.

(9) "Strength of slide runways and supports"

(I) "Static loads" and (iii) "Performance tests" **Pass**

The standard requires that the slide runway be capable of supporting (for 10 minutes) a static load of at least 350 pounds "applied normal to the runway at any point along its length or width." This section of the standard is also poorly written.

That is, after first stating that the runway meet the loading criteria at "any point along its length," the performance test then specifies only that the upper runway platform and lower runway exit ramp be tested. Furthermore, the prescribed test does not assure that the load is applied "normal to the runway," as it simply requires that a 350-pound weight be set on the runway (using a 20-square inch pallet) at the prescribed locations. Because the slide exit ramp is not horizontal, the 350-pound load is being not applied "normal" to the runway at the exit ramp as required in the initial description of the test requirement.

We ran the test in accordance with the performance test description. That is, we tested only the upper runway platform and lower runway exit ramp, and we applied the load by setting a 350-pound weight (on a 20-square inch pallet) onto the slide at the prescribed locations.

The upper runway platform and lower runway exit ramp successfully supported the required load for 10 minutes without any cracks or permanent deformation.

(ii) "Dynamic loading" and (iii) "Performance tests" **Pass**

The standard requires that the upper runway platform and lower runway exit ramp be subjected to an impact load from a 45-pound steel billet dropped 10 feet. The upper runway platform and lower runway exit ramp are then subjected to a 350-pound static load and must not exhibit any further crack propagation.

The upper platform ramp withstood the impact without visible deformation or cracks. The lower exit ramp cracked due to the impact, developing a 5 ½-inch crack through the full thickness of the slide at the end of the exit ramp; however, when the 350-pound static load was reapplied, the crack did not visibly propagate. Thus, the slide met the requirement of the standard.

Section 1207.10 "Handling, storage, and marking"

(a) "Marking" **Fail**

This section of the standard requires that the manufacturer's or private labeler's identification appear on the slide and shipping container.

The slide did not have any labels, and as such, did not meet the requirement of the standard; however, you indicated there were no labels because this was a pre-production unit. You indicated that labels would be used in the production version.

We did not receive a shipping container for the slide and therefore did not determine if the shipping containers had the required labeling.

(b) "Shipping, handling, and storage" **Pass**

The standard requires that the slide be designed, constructed, or packaged so that reasonable foreseeable shipping, handling, and storage will not cause defects that will prevent it from complying with the standard. The size and shape of the slide runways make them inherently somewhat awkward to handle and ship, and thus, they require appropriate handling and shipping to avoid damage. However, we judged the slide to be well designed and soundly constructed, such that reasonable foreseeable shipping, handling, and storage would not cause defects that would prevent it from complying with the standard. Thus, the slide met the shipping, handling, and storage requirement of the standard.

APPENDIX

Written and Email Correspondance with CSPC

MEI-Charlton, Inc.
2233 SW Canyon Road
Portland, OR 97201-2499

FILE

Phone: (503) 228-9663
Fax: (503) 228-4065
Internet: http://www.meic.com
E-Mail: meic@meic.com

FAX COVER SHEET

DATE: 7 October 1998

COMPANY: Consumer Product Safety Commission

TO: Patrick Race

FAX NO.: 1 (301) 504-0359

TOTAL PAGES: 3

FROM: Bob Hodel

Patrick:

As we discussed, the following is a summary of my question about the angle-of-attack measurement for the swimming pool slide test, along with my understanding of the CPSC's interpretation. If you are in agreement, please acknowledge so; if not, please make any changes you feel are appropriate.

For my purposes, a handwritten acknowledgment on the second page of my letter, along with a date and signature, would be all I require to comply with my quality assurance documentation, and a faxed response would be satisfactory.

Thanks for your help.

Bob Hodel

M E I-Charlton, Inc.

2233 S.W. CANYON ROAD
PORTLAND, OR 97201-2499

(503) 228-9663
FAX (503) 228-4065

ENGINEERS AND SCIENTISTS solving problems through APPLIED RESEARCH, CONSULTING ENGINEERING AND CHEMISTRY

7 October 1998

Consumer Product Safety Commission
Attention: Patrick Race
Washington, DC

Subject: Part 1207 Safety Standard For Swimming Pool Slides;
Paragraph 1207.5 Design, (f) runways, (5) slide geometry,
Angle-of-Attack Measurement

Dear Mr. Race:

Thank you for your assistance in interpreting the angle-of-attack performance test requirements in the above referenced safety standard. Per our telephone conversation yesterday, I have drafted a summary of my understanding of the Consumer Product Safety Commission's interpretation. Please review this summary; if you are in agreement, please acknowledge the interpretation. If you feel any changes are appropriate, please make them and submit your revisions to me. As I indicated on the phone, I will be using your interpretation to determine the acceptance of a swimming pool slide my company has recently tested for a client.

Background

The slide geometry performance test requires that a test subject's angle-of-attack be measured. The angle -of-attack is defined as the angle between the slider's longitudinal axis and the tangent to the path of his center of gravity when he exits the slide. The problem in interpreting the standard arises in the definition of the slider's longitudinal axis, which is defined in the standard as the "vertical line that passes through his center of gravity when he stands erect".

Test Experience

In our tests, with two different subjects, we found that their body posture was significantly different when they exited the slide than it had been when they were standing erect. When standing erect with arms outstretched overhead, their hands, arms, head, torso, legs, and feet were all in a straight line, which clearly passed through their center of gravity. However, when exiting the slide, their body position was no longer straight; instead, they had a pronounced "sway backed" posture.

The change in body position causes two problems with locating the longitudinal axis. First of all, the center of gravity is no longer in the same position as it is when the subject stands straight. When standing straight, the center of gravity is very near the center of the body (in the front-to-back direction). However, when "swaybacked", or "bent over backwards", the center of gravity is shifted toward the subject's back.

Because the shift in center of gravity is relatively small, it does not have a very large effect on the slider's longitudinal axis. In contrast, the definition of the *second* point for the longitudinal axis *strongly* affects the longitudinal axis. That is, when the subject's body position is no longer straight, what is the second point for his "longitudinal axis"? His hands? His arms? His head? His upper torso? His lower torso? His legs? His feet? In our tests, the choice of the second point for the line is critical, affecting the angle of the longitudinal axis by as much as 30 degrees.

Interpretation

The following is my understanding of the Consumer Product Safety Commission's interpretation of the standard:

1. Once the center of gravity is established while the subject stands erect, the location of that point shall not be changed, regardless of body posture during the test. That is, locate the center of gravity while the test subject stands erect per the standard, mark that point on the test subject, then use that point for the subsequent measurements.

2. The second point for the subject's longitudinal axis shall be taken as the center of his head.

Again, I appreciate your help in this matter, and will proceed with my client's project once I receive your response to this letter. If you have any questions, please contact me.

Cordially,

MEI-Charlton, Inc.

Robert E Hodel

Robert E. Hodel, PE
Mechanical Engineer

Subject: **Re: Swimming pool slide test standard**
Date: Tue, 13 Oct 98 15:30:04 -0500
From: prace@ntmail.cpsc.gov
To: <reh@meic.com>

I did get it but have been out of the office. I'll get it back to you this week.

thanks,

Pat

_____ Reply Separator _____
Subject: Swimming pool slide test standard
Author: Bob Hodel <reh@meic.com> at INTERNET-MAIL
Date: 10/13/98 8:19 AM

Hi Patrick,

I'm checking to see if you received my fax last Wednesday, 7 October, regarding our phone conversation about the CPSC interpretation of the swimming pool slide test standard. I'm waiting for your response to the fax before I submit my report to my client. If you didn't receive the fax, please call or e-mail me immediately so I can resubmit it.

Thanks for your help.

Bob Hodel

Subject: Re: CPSC Swiming Pool Slide Specification
Date: Thu, 22 Oct 98 17:07:44 -0500
From: prace@ntmail.cpsc.gov
To: <reh@meic.com>

I forwarded to the engineer familiar with the statute. I'll check w/ him again and get back to you on Friday.

Pat

_____ Reply Separator _____
Subject: CPSC Swiming Pool Slide Specification
Author: Bob Hodel <reh@meic.com> at INTERNET-MAIL
Date: 10/22/98 11:55 AM

Hi Patrick,

I haven't received a reply yet to the fax I sent you on 7 October about the CPSC interpretation of the swimming pool slide standard. I'm waiting for your reply so I can complete my report on the slide we tested recently. Again, I'm not looking for anything complicated in terms of a response--just an acknowledgment that you are in agreement with my description (assuming you are, in fact, in agreement). Something as simple as a dated/signed hand-written note on my fax would meet my needs.
Thanks again for you help.

Bob Hodel

Subject: Re: CPSC Swimming Pool Slide Specification
Date: Mon, 02 Nov 98 12:18:43 -0500
From: prace@ntmail.cpsc.gov
To: <reh@meic.com>

Bob,

Your letter is an accurate characterization of the way our engineering staff interpets that regulation. Hard copy to follow.

Pat

_____ Reply Separator _____
Subject: CPSC Swimming Pool Slide Specification
Author: Bob Hodel <reh@meic.com> at INTERNET-MAIL
Date: 10/30/98 8:08 AM

Patrick,

I still need CPSC's interpretation of the swimming pool slide specification in order to complete my evaluation and report on the slide I tested back in August; my client is pressing me for an answer. Please prompt the engineer again for a response.

Thanks,

Bob

MEI-CHARLTON, INC.

2233 SW Canyon Road
Portland, OR 97201-2499

503-228-9663
Fax: 503-228-4065
E-mail: meic@meic.com
Internet: www.meic.com

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Directions to

MEI-Charlton, Inc.
2233 SW Canyon Road
Portland, OR 97201-2499
Phone: 503-228-9663
Fax: 503-228-4065
Internet: www.meic.com
E-mail: meic@meic.com

From the Airport

Take I-205 south to I-84 west to I-5 south; cross the Marquam Bridge; take I-405.*

From the East

Take I-84 west to I-5 south; cross the Marquam Bridge; take I-405.*

From the North

Take I-5 south;cross the Marquam Bridge; take I-405.*

From the South

Take I-5 north to I-405.*

From the West

Take US 26 (Sunset Hwy) eastbound; one mile past the zoo overpass take the Stadium-Canyon Road exit; proceed under the Vista Bridge; before the BMW dealership, turn left into our parking lot.

*Exit onto 12th Avenue, go 5 blocks; turn left on SW Jefferson, which changes into Canyon at the Vista Bridge.