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CLIENT NO.: 42308-S

REFERENCE NO.: 7136003

DATE: 5 Apr 2006

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

MEI-Charlton, Inc. was retained to run qualification tests on S.R. Smith's Cyclone™ 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.

The Cyclone is constructed from low density polyethylene (LDPE) and has three components: a molded ladder/rail assembly, a mid-section consisting of top platform and upper slide, and a lower slide portion. All sections are bolted together.

You have indicated the Cyclone slide is 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 50^{th}-percentile adult male. Thus, we subjected the slide to all the tests and measurements described in the CPSC specification.

Three slides were provided for testing: two for laboratory testing and the other for pool testing. All were right curve slides. 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 conducted at the Canby Swim Center pool, in Canby, Oregon.

The first slide submitted for laboratory testing did not comply with the CPSC ladder requirements because of nonuniform riser height. After adjustments were made to the mold, a second slide was submitted which complied with the requirements.

The governing specification contains numerous contradictions, ambiguities, and undefined terms. Where necessary, we interpreted the specification requirements using our engineering judgement and reasonable assumptions regarding the writer's intent.

Results

In its final test configuration, the Cyclone slide was in conformance with the construction and performance requirements of the CPSC standard.

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

Robert E. Hodel, PE
Project Director

REH:sas

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 slide surface was not painted nor did it otherwise exhibit a "finish/.

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 the ladder is 15 degrees or greater. The ladder had an angle of incline of 19 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 19 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. On the first slide submitted for evaluation, the riser height was 7 5/8 inches on the first four risers, but only 6 15/16 inches on the top riser, for a variation in riser height of 11/16 inch.

"Constant" is not defined in the standard, but the Uniform Building Code (UBC) limits the riser height variation on stairways in buildings to 3/8 inch, which is only about half the variation measured on the first slide. Thus, we judged the first slide as not being in conformance with the CPSC requirements.

S. R. Smith then reportedly slightly modified the mold for the steps and submitted a second slide with the modified step profile. The riser height on the first four risers was 7 5/8 inches and the riser height on the top riser was 7 3/8 inches, or a variation of 1/4 inch, which we judged to be in conformance with the CPSC requirements

The standard also requires that the steps have a minimum tread width of 2 inches and a minimum length of 12 inches. The steps on this slide had a tapered profile front-to-back, with a central textured portion, surrounded on both sides by a shallow, 1 1/2 inch wide trough (presumable for drainage of water.) The textured portions were 4 1/4 inches deep, and they were 14 ½ inches long at the back (heel

end) and 10 ½ inches long at the front (toe end). Although the minimum length of the treads in the textured portion at the front was less than the 12-inch minimum specified in the CPSC standard, we judged the steps to be fully in compliance with the requirements, as the total length (including the water trough) at the front exceeded the minimum requirement and the textured length at the 2-inch minimum width also exceeded the minimum requirement.

(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 a slip resistant surfaces texture-molded into the steps.

(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 were integrated as a single unit 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 3 feet, 1 1/8 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 molded handrails, and the top surface of the handrails extended 11 ½ 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" on the Cyclone were not configured in the conventional manner of tubular members that a person can close their hand completely around; instead, they were molded into the sides of the slide as rounded gripping surfaces which a user would grasp between their fingers and the palm of their hand. However, we judged them as meeting the intent of the specification's requirement for handrails, namely, to aid the slider in safely making the transition to the runway. The gripping surfaces were 1 ½ inches in diameter, thus meeting the diameter requirement.

(2) "Extent of handrails"

(i) "Maximum angle ladder" **Pass**

The handrails are required to begin 3 to 5 feet above the pool deck. As noted above, the Cyclone handrails are part of the molded LDPE slide. Below a height of 36 inches, the sides of the slide next to the ladder have smaller-diameter rounded lip surfaces, which, although capable of providing support to a user ascending the steps, we did not classify as "handrails". The portion of the molded surface that would be considered the "handrail" was located 36 inches above the pool deck, where the rounded gripping surface was much broader, with a diameter of 1 1/2 inches, thereby meeting the requirement for handrail diameter, and at the same time meeting the requirement for handrail height.

(ii) "Extent of handrails for ladders, steps, stairs, or ramps" **Pass**

The ladder incline was measured as 19 degrees from vertical and was thus subject to the requirements of section *(d)(2)(ii)*. Based on calculations in Table 1 of *(d)(2)(ii)*, the ladder rail-to-handrail distance must be 6.44 to 8.44 inches. Because of the diminutive stature of the slide, the handrails only extended for a short distance, from 36 to 47 inches above the pool deck. Only a small portion of this length was parallel to the steps, with the remainder of the length extending above the top platform to aid the user in making the transition to the runway. Along the portion parallel to the steps, the perpendicular distance was 6 3/4 inches, thus meeting the requirements.

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 solid molded handrail design had no holes or slots that could serve as locations for entrapment, and thus met 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, as molded-in components of the slide, were well attached.

(4) "Attachment and strength of handrails" **N/A**

The standard requires that handrails and their fasteners withstand allowable shear, bending, and cyclical loading in intended use and reasonably foreseeable abuse. The handrails were integrally molded to the ladder step assembly and were not removable; thus, there were no fasteners

(i) "Sockets performance test" **N/A**

This portion of the standard addresses bending moment attachment strength requirements for handrails that are attached with sockets. Handrail sockets are not used on this slide; thus, this section of the standard is not applicable.

(ii) "Side forces" **N/A**

Again, as with paragraph *(4)(i)* above, this portion of the standard addresses bending moment attachment strength requirements for handrail attached with sockets. Handrail sockets are not used on this slide; thus, this section of the standard is not applicable.

(iii) "Performance tests"

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

This section of the standard, *(iii)(A)*, and the following section, *(iii)(B)*, are intended to provide the performance tests to evaluate compliance with the two preceding sections. As stated in *(4)(i)* and *(4)(i)* above, the handrails are not attached with sockets; thus, certain test points defined in the CPSC specification do not exist, and therefore this test as written is not applicable. However, the apparent intent of the requirement is to assure that the handrails are securely fastened, to the extent that they would not fracture from the slide should a user slip and fall backward while ascending the steps, thereby exerting a large backward force on the handrails. Given that the handrails are an integral, molded-in component of the structure, we judged them as meeting the intent of this portion of the CPSC specification.

(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.

(e) "Lubrication" **Pass**

Slides are required to either be equipped with a method of lubrication or "have a similar coefficient of friction." It is not completely clear what the specification means by the phrase "have a similar coefficient of friction"; however, we expect that the intent is to provide for uniform, smooth sliding during use, without excessive friction or "slip-stick" characteristics. The slide did not have a method of lubrication (e.g., water jets); however, the runway had a smooth, uniform texture. During our user trajectory tests at a swimming pool, we judged the coefficient of friction to be uniform and to provide for smooth sliding motion, thereby meeting the apparent intent of the CPSC specification.

(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 (2 ½ 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 Cyclone 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, 23 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 side rail heights.*"

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

The standard requires that runway side-rail heights conform to the requirements of Table 2 in the specification, which shows side-rail height as a function of maximum slide slope angle. The maximum slope was 31 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.

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 20 runs. The tests were conducted with the slide mounted on a 24-inch high plywood platform, which was leveled on the sloped pool deck.

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%. 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 40 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 17.5°, which is greater than the minimum requirement of 15°, and the deviation of each run from the average ranged from - 6.2 % to + 9.7 % , thereby meeting the maximum measurement variation of ±15 %.

(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 2 ½ inches, meeting 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 -3 degrees, meeting the requirement.

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

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

The standard requires that no net lateral forces on the slider shall exist in that portion of the runway exit ramp beyond the forward support points of the slide. Forward of the support legs, the slide is not curved side-to-side, thus, no net lateral forces act on the slider

The standard also requires that the exit lip of the slide be level side-to-side. Because of the U-shaped runway cross sectional profile of the Cyclone 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 Cyclone slide to be acceptable, provided it meets all the performance requirements.

The apparent intent of the side-to-side levelness requirements is to assure that the user is not rotating or tilted sideways as he/she leaves 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).

This interpretation is complicated by the fact that the profile of the Cyclone slide is not symmetrical about the lowest point in the cross section, but instead, has a significantly higher side rail along the outboard side of the curve. To address this lack of symmetry, we set a level across the runway exit, with one side resting on the inboard rail. Using the intersection of this line with the outboard side rail as a point of symmetry, we measured the resulting arc length from the inboard rail to the intersection point on the outboard rail and treated the midpoint of that distance as the "centerline" of the slide at the exit point for purposes of this particular measurement. A perpendicular to the runway at this point was within 1 degree of being plumb. As such, we judged the slide to be in conformance with the levelness specification requirement.

(ii) "Performance Tests" **Pass**

The performance test 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 two-run average of 1.8 degrees, 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 portion of the standard is not entirely self-consistent. 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 not being 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. Cracking and/or other damage are permissible, but then, upon subjecting the upper runway platform and lower runway exit ramp to a 350-pound static load, they must not exhibit any further crack propagation.

The upper platform ramp and lower exit ramp withstood the impact without visible deformation or cracks, and they subsequently withstood the application of a 350-pound load, thus meeting the requirement of the standard.

Section 1207.10 "Handling, storage, and marking"

(a) "Marking" **Pass**

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

(b) "Shipping, handling, and storage" **N/A**

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 awkward to manipulate, requiring appropriate packaging and handling to avoid damage during shipping. 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 specification.