BRYANT-LEE ASSOCIATES
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Hair Entanglement/Entrapment Testing
of
ASME-A112.19.8 Suction Covers
using
Human Subjects and Wigs

for

Mr. Leif Zars
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TEST CONCLUSIONS

Testing of suction fittings under actual pool conditions demonstrates that some ASME A112.19.8-approved covers can cause entrapment of humans by means of entangling hair or creating high suction forces on the hair. When tested with human subjects and wigs, most of the nine tested ASME A112.19.8-approved covers created hair release forces greater than 5 pounds at the flow rate specified in the ASME A112.19.8 Standard ("Standard"). Some covers created release pull forces of 20 pounds or greater, severe hair entanglement, or complete inability to release the hair without turning off the pump and removing the cover.

Testing with humans and wigs demonstrates that the hair entanglement test procedure of ASME A112.19.8 may be inadequate in predicting hair entanglement and/or hair entrapment under real-world conditions. This is probably due to use of insufficient hair volume in the Standard. The two ounces of hair attached to a one-inch dowel rod in the Standard does not appear to predict the potential for excessive suction force or entanglement of a human head of hair.

Testing with a natural hair wig correlated roughly with entanglement/entrapment potential of human hair when tested at 25% above the manufacturer's rated flow, which is the same test flow rate specified in AME A112.19.8. The use of a wig without a head form may explain why test behavior did not correlate with a human head in all cases. The natural hair wig is, however, superior to the Standard's two ounces of natural hair on a dowel rod in predicting the hair entanglement and/or hair entrapment characteristics of a human head of hair. Attaching the wig to a head form should bring the performance of a wig closer to that of a human head of hair. A synthetic-hair wig is not predictive of the hair entanglement and/or hair entrapment of a human head of hair.

Lowering the velocity through suction fitting covers is a method of lowering the entanglement/entrapment potential of most covers. Lowering the velocity through the tested covers to 1.5 ft/sec + 25% reduced hair entanglement and/or entrapment for all but one of the nine tested suction covers.

The above findings of severe hair entanglement and/or very high hair release forces of ASME A112.19.8 covers were also demonstrated in a previous test using human test subjects under actual pool conditions. Thus, the above results have been replicated and are not a one-time occurrence.

RECOMMENDATIONS

A review of statistics of any hair entanglement and hair entrapment incidents involving ASME A112.19.8-approved suction fitting covers could be used as a guide to revision of the hair entanglement/entrapment portion of the Standard. The revised Standard should incorporate hair entanglement/entrapment testing that reasonably simulates and safeguards against the specifics of any such entanglement/entrapment incidents. Based on the results of the testing described in this report, testing with 2 oz. of hair on a dowel rod does not appear to be a reasonable simulation of the entrapment potential of a human head of hair.

The "lessons learned" in previous tests of suction covers by other entities, and perhaps other countries, could be incorporated in the revised Standard. The Consumer Product Safety

Commission conducted testing of an ASME A112.19.8-approved suction fitting cover in 1997 using 2, 4 and 8 ounces of blond human hair attached to a dowel. A dramatic increase in the failure rate occurred when 4 oz. of hair was used rather than 2 oz. Failure was defined by a hair release force of 5 pounds or greater with either manual or pneumatic pull at flow rates ranging from the rated flow to 25% above the rated flow. The overall failure rate with 4 oz. was 78% vs. 24% with 2 oz. Increasing the weight of hair to 8 oz. did not produce additional failures (63% failure rate). Based on these tests, 4 oz. of hair is superior to 2 oz. of hair in predicting the entanglement/entrapment potential of a suction fitting cover.

TEST PROCEDURE

Nine suction covers and matching sumps previously certified to ASME Standard A112.19.8, *Suction Fittings for Use in Swimming Pools, Wading Pools, Spas and Hot Tubs*, were tested in San Antonio, Texas on September 5, 2002. These nine covers are made by six different manufacturers. Tables 1 and 2 show the manufacturer, the model, the measured open area and the manufacturer's rated maximum flow rate in gallons per minute.

The suction fittings were installed one at a time with the cover of the fitting horizontal and six inches underneath the water surface in a residential swimming pool. A plate was used around each fitting to simulate a pool floor. As specified in ASME A112.19.8, a 90 deg. elbow the same size as the fitting was installed as close to the sump outlet as possible and at least 16" of straight, Sch. 40 plastic pipe the same size as the fitting was attached to the elbow. The test setup is shown in Figure 1.

A pump and digital ultrasonic flow meter were attached to each of the suction fittings in turn. Tests were conducted at two different flow rates:

Table 1: The water flow rate used in the hair entanglement test of the ASME A112.19.8 Standard. This flow rate is 25% above the manufacturer's rating of each cover. The Standard specifies that at this flow rate the pull force to release the 2 oz. of natural hair be less than 5 pounds.

Table 2: A water velocity of 1.5 ft/sec + 25% based on the measured size of all openings of the suction cover.

Two human subjects floated backward over each suction cover. Subject A had 8-inch long brown hair and Subject B had 14-inch brown hair (measured from back center of head). After allowing the hair to be drawn through the cover and waiting approximately 10 seconds, the subject attempted to stand up on the pool floor, which was 3 feet deep at that location. Each test subject then gave a rating from 1 to 10 reflecting the perceived effort necessary to withdraw her hair from the suction cover. This perceived effort is tabulated in Tables 1 and 2 as the Human Escape Force Rating. Figures 2 and 3 show testing using the human subjects.

Two wigs were allowed to float down to each suction cover. One wig was natural (human) hair, blond, 17-inch-long and one was synthetic, black, 17-inch-long (measured from back center of head location). Two approaches to the cover were used for each test: downward to the cover and from the side toward the cover. The wig was allowed to sit for approximately 10 seconds and then pulled vertically up as well as up to 30° from vertical with a spring scale and the maximum linear pull force recorded on a spring scale. These results are tabulated in Tables 1 and 2 under Wig Release Force. Figure 4 shows testing using a wig. Figures 5 through 7 show the severe

entanglement that can occur with some ASME A112-19.8-approved covers, necessitating removal of the covers to entangle the hair.

PERSONNEL OBSERVING THE TESTS

Observing the tests were Geert H. Aerts, P.E. of Bryant-Lee Associates, Leif Zars and Rudy Herrera of Gary Pools and Robert Rung, P.E. of Hayward Pool Products.

SIGNIFICANT FINDINGS OF TESTS

Human tests:

In one instance reflected in Table 1, the human subject was unable to pull her hair from the suction cover without pain, and the pump was stopped to allow the cover to be removed and the hair to be manually removed from the cover. This occurred at the flow rate specified for testing in the ASME Standard. One cover trapped hair between the arms of the fitting and the simulated pool floor under certain circumstances. It is not known if the trapping between cover and pool floor would occur under actual installation conditions.

Natural hair wig tests:

The natural hair wig tests correlated roughly with the entanglement/entrapment potential of human hair when tested at 25% above the manufacturer's rated flow of the fitting. Several of the tests in which the wig became severely tangled were also the tests with the highest human escape force rating (Table 1).

Testing at a water velocity of 1.5 ft/sec + 25% resulted in freedom from tangling with the natural hair wig for all but one fitting (Table 2).

Whether or not blond hair is entangled or entrapped more easily than brown or black hair has not been tested. Blond hair is reported to be finer than brown or black hair, and this may make blond hair more likely to be entangled/entrapped.

Synthetic wig tests:

The synthetic wig was not used for all tests since it became clear that it released relatively easily under most conditions and did not clearly correlate with the entanglement/entrapment potential of a human head of hair (Tables 1 and 2). The relatively low release force is due to the physical characteristics of the synthetic fibers that are different from natural hair and possibly a lower number of synthetic fibers. The synthetic fibers likely have less friction and are stiffer than human hair.

Table 1

TEST RESULTS AT 25% ABOVE MANUFACTURER'S RATED FLOW

Manufacturer	Model	Rated GPM	Test GPM	Human Escape Force Rating					Wig Release Force (lbs.)				
				Subject A 8-inch hair		Subject B 14-inch hair			Natural hair Wig			Synthetic Wig	
Hayward	88D9	108	133	6		7			6.5	5			
Triodyne	Anti-Snare	109.6	135	6	3	9	10	3	17+	Severe Tangle[2]			
Hayward	Flapper	92	118	6 to 7		9			17+	10+	5+		
Hayward	88D9	148	135[1]	6	6	6 to 7	7		10.5	Severe Tangle[2]	Severe Tangle[2]		
HydroAir	Oct006	80	100	8		8			Severe Tangle[2]	Severe Tangle[2]			
StaRite	07017-0751	80	100	2	2	2	2		2	8	12	1	2.5
StaRite	07017-0741	60	75	4	5	7			6	7.5	15+	2.5	7.5
Waterway	2K39	95	119	3		2	6	7	4.5	5.5	13+	3	3
WW Sports	Star 100	80	100	2	2	5	7		2.5	10+[3]		6.5	12

Note 1: Maximum Available for Test.

Human Escape Force Rating

1 No Capture or Draw Into Outlet
2 No Capture with Slight Draw Into Outlet
3 No Capture with Heavy Draw Into Outlet
4 Unsure if Captured
5 Some Capture with Under 5# Removal Force
6 Some Capture with 5# Removal Force
7 Capture with 10# Removal Force
8 Capture with 20# Removal Force
9 Capture with Heavy Removal Force
10 Totally Captured Requiring Hand Strand Removal

Note 2: Cover Removed from Sump to avoid breaking hair.

Note 3: Hair Snagged between Cover and Floor

Table 2

TEST RESULTS AT 1.5 Ft/Sec + 25%

Manufacturer	Model	Rated GPM	Open Area (in^2)	Test GPM	Human Escape Force Rating				Wig Release Force (lbs.)				
					Subject A 8-inch hair		Subject B 14-inch hair		Natural-hair Wig			Synthetic Wig	
Hayward	88D9	108	7.48	44	2	2	3	3	1				
Triodyne	Anti-Snare	109.6	6.79	40	3		3		1	1			
Hayward	Flapper	92	7.26	45	2		2		1	1			
Hayward	88D9	148	11.6	68	3	5	2	2	3.5	15+	Severe Tangle[1]		
HydroAir	Oct006	80	3.93	23	1	1	1	1	1.5	2			
StaRite	07017-0751	80	13.83	81	6	6	7	7	2	5	7	2	2
StaRite	07017-0741	60	8.15	48	2	2	2	2	5	4		2	2
Waterway	2K39	95	7.32	43	NA		NA		3	2	2.5	2	2
WW Sports	Star 100	80	18.24	107	NA		NA		NA			NA	

NA – Not tested due to time constraint.

Human Escape Force Rating

1 No Capture or Draw Into Outlet
2 No Capture with Slight Draw Into Outlet
3 No Capture with Heavy Draw Into Outlet
4 Unsure if Captured
5 Some Capture with Under 5# Removal Force
6 Some Capture with 5# Removal Force
7 Capture with 10# Removal Force
8 Capture with 20# Removal Force
9 Capture with Heavy Removal Force
10 Totally Captured Requiring Hand Strand Removal

Note 1: Cover Removed from Sump to avoid breaking hair.

Figure 1 – Test set-up in a residential pool. At left (arrow) is a suction fitting installed horizontally 6 inches below the surface of the pool. The 2" suction line runs to a pump and an ultrasonic, digital flow meter (under the awning). A black plate was installed around each fitting to simulate a pool floor.

Figure 2 – Test with human subject with 14-inch long brown hair. The subject in this test was pulling uncomfortably against a suction fitting and cover that was exerting significant suction on her hair. This is not necessarily the suction cover in any other figure(s).

Figure 3 – Another test with human subject with 14-inch long brown hair. The subject in this test was pulling uncomfortably against a suction fitting and cover that was exerting significant suction on her hair. This is not necessarily the suction cover in any other figure(s).

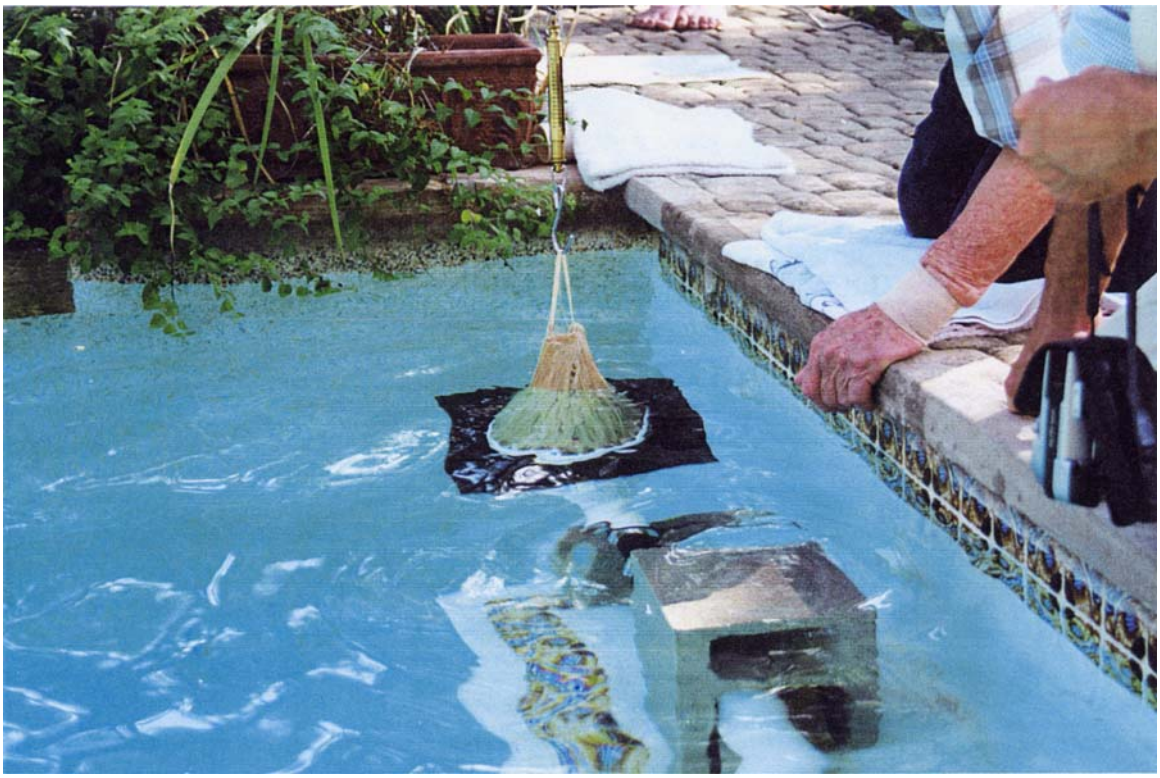

Figure 4 – Test with natural hair, 17-inch-long wig. This is not necessarily the suction cover in any other figure(s).

Figure 5 – Failed attempt to manually extract the natural hair wig after the scale pull was stopped to prevent breaking the hair. This is not necessarily the suction cover in any other figure(s).

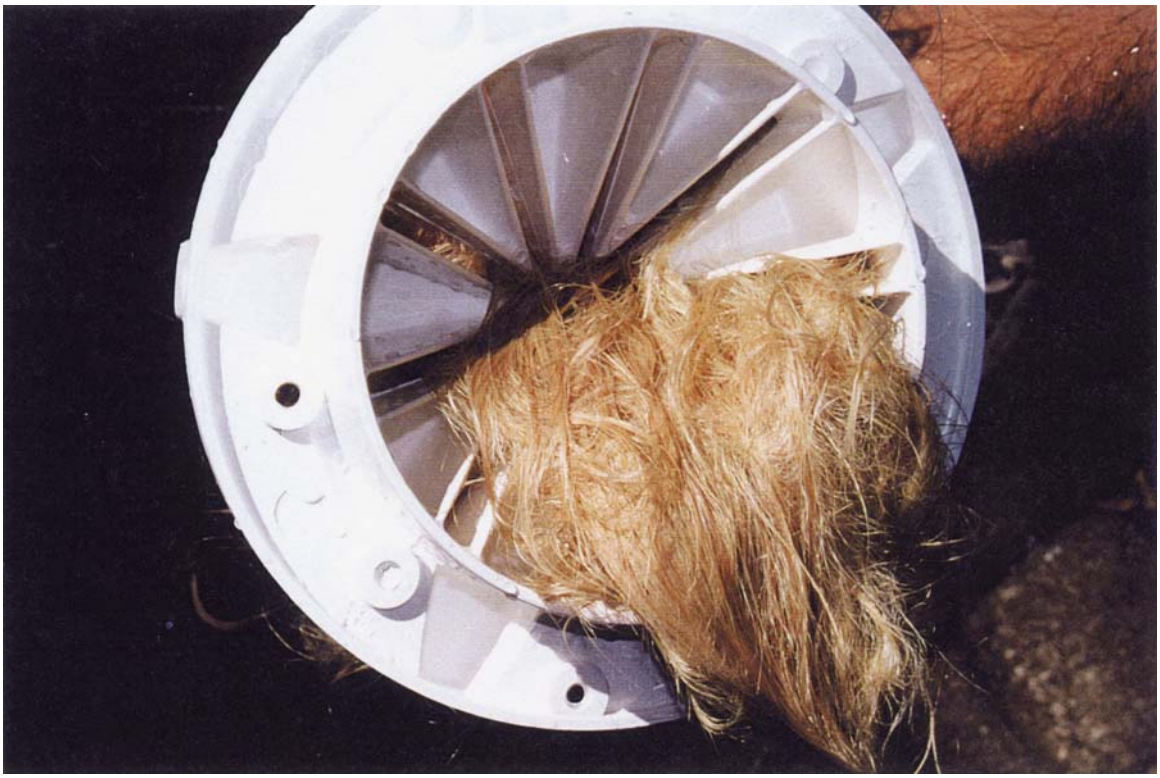

Figure 6 – Underside of a suction cover after attempts to dislodge the tangled natural hair wig by pulling up with the scale and by hand failed. This is not necessarily the suction cover in any other figure(s).

Figure 7 - Underside of a suction cover after attempts to dislodge the tangled natural hair wig by pulling up with the scale and by hand failed. This is not necessarily the suction cover in any other figure(s).