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Forensic Engineering Investigation of Above-Ground Pool Submersion Accidents

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Abstract

In the United States, approximately 35 children under the age of five years old drown each year after accessing above-ground pools via pool ladders. Consumer Product Safety Commission (CPSC) data also shows that approximately 486 additional children sustain submersion-related injuries after accessing above-ground pools via pool ladders. In many cases, these events occurred during brief lapses of adult supervision. This paper focuses on potential product defect issues related to child submersion accidents, including the role of user manuals, alternative designs, warnings, instructions, and child behavior testing. The authors examine the issues related to the investigation of above-ground swimming pool submersion accidents. In addition, procedures and steps are outlined that may be useful in analyzing whether the swimming pool is defective and unreasonably dangerous.

Keywords

Swimming pool, above-ground pool, submersion, drowning, defective product, unreasonable dangerous product, pool ladder, guarding

Introduction

Young children have been known to drown while using pool ladders to gain unauthorized access to above-ground pools; evidence of this dates back to the 1960s when the hazard was specifically mentioned in several patents. For example, a patent issued in 1966 discusses the hazard[1] as follows:

> *"However, a problem is presented with the use of regular stepladders for such purposes because young children have climbed up the ladder when no adults were present and have fallen into such pools and have drowned."*

Using the combination of data published by the CPSC[2] and a pediatrics journal article[3], it is estimated that there are 35 submersion-related deaths and an additional 486 submersion-related injuries associated with children under the age of five gaining unauthorized access to above-ground pools using pool ladders.

In general, safety is a combined effort of a designer, manufacturer, user (operator), and employer (if involved). However, if something goes wrong, the highest price (injury or death) is paid by the user/operator. Therefore, it is essential to design and manufacture the product as safely as practical.

In many cases, an equipment designer and manufacturer heavily rely on instruction manuals, warnings, and proper training of potential users. They downplay the importance of the hazard and risk analyses that may detect safety issues. Some reasons for this type of approach, which (if unsuccessful) may result in serious injury or death, include a lack of safety knowledge, an aversion to including more costly safety features, or simple recklessness.

Occasionally, when serious injury or death occurs, the injured party or his/her estate brings a lawsuit against the designer, manufacturer, and/or distributor under the claim of a "defective and unreasonably dangerous product." After analyzing the accident, an expert witness is asked whether a product is defective and if the designer, manufacturer, distributor, or operator contributed to the incident causation.

In simple terms, a product may be defective and unreasonably dangerous if it can cause an injury or death, and it is technologically and economically feasible to design the hazard out of the machine or to guard against that hazard. Technologically feasible means that before the product was manufactured, there was technology available to make the product safer and to eliminate (or guard against) the hazard. Economically feasible means that a safer design can be achieved at a reasonable cost.

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A product can be unreasonably dangerous if it is defectively designed, manufactured, or maintained — or if it has defective warnings and instructions.

Background

The parents of a two-year-old child purchased an above-ground pool package from a store, which included both a pool and ladder (**Figure 1**). They installed the pool with the ladder in the backyard of the residence.

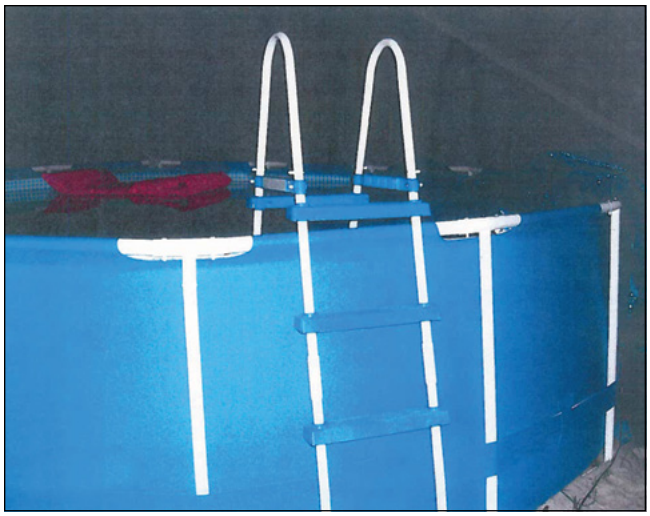

Figure 1
Above-ground swimming pool involved in the accident.

According to the police report, the accident occurred when the mother got out of the pool and briefly went inside the residence while the child was playing in the sandbox in the backyard. After spending three to five minutes inside, the mother went outside to check on the child and found the child floating in the pool. The mother yelled for the child's father, and the father performed CPR on the child. As a result of the accident, the child sustained permanent brain injuries. Apparently, the child climbed the A-frame ladder and fell into the pool.

Manufacturer Literature

The manual for the metal-frame above-ground pools and ladders provided with the manufacturer's pool packages had some warnings pertaining to parental supervision and removal of the ladder from the pool. For example, one warning stated:

> "NEVER LEAVE CHILDREN UNATTENDED WHILE IN OR NEAR THE POOL."

The warning is an indication of a hazard recognized by the manufacturer as having the potential for serious injury or death. In this case, the hazard is the need for constant supervision. Another warning example in the ladder manual stated:

> *"Remove and secure ladder away from the pool when the pool is not in use to prevent unauthorized, unintentional, or unsupervised pool entry."*

The warning is a further indication of a recognized hazard requiring users to take the ladder out of the pool after each use.

According to the manufacturer's director of risk assessment (in his deposition), "the A-frame ladder is lightweight. It's easy to remove from the pool."

Anthropometric Testing

Anthropometric testing was performed on an exemplar ladder to determine the forces and mechanics involved with lifting the ladder out of the pool. The anthropometric study was used to determine whether requiring users to lift the ladder out of the pool after each use was acceptably safe.

The lifting mechanics of an actor shown in the safety DVD provided with the exemplar pool purchased were analyzed. The ladder shown in the safety DVD was much shorter than the subject ladder.

A female and male test subject lifted an exemplar ladder above the barrier height of the pool with similar lifting mechanics as the actor in the safety DVD. Photographs were taken of the test subjects lifting the ladder above the barrier. The lifting mechanics involved with lifting the ladder above the barrier were compared to safe lifting weight limits published by the Health and Safety Executive (U.K.)[4].

In this testing, the minimum lifting force required to lift the ladder out of the pool was 84 percent more than the acceptable lifting limit for females and 22 percent more than the acceptable lifting limit for males. Therefore, the lifting force required to lift the ladder out of the pool was unreasonably heavy, according to the Health and Safety Executive guidelines.

The authors of this paper concluded that lifting the ladder out of the pool is a cumbersome process that, by industry standards, requires an unreasonable amount of lifting force. According to a safety engineering textbook[5],

> *"It is known that a person will generally tend to follow those procedures, which involve minimal physical and mental effort, discomfort, or time. Any procedure contravening this basic principle is certain to be modified or ignored by the persons supposed to carry it out."*

Therefore, the burdensome process of removing the ladder from the pool after each use has the potential to be ignored by users. When the process of removing the ladder is ignored by users, young children may be needlessly exposed to the pool accessibility hazard.

It was apparent that instead of mitigating the hazard, the manufacturer showed disregard for engineering safety and human life by dismissing the pool-access hazard associated with the A-frame ladder. In addition to simply dismissing the hazard, the manufacturer has attributed the cause of above-ground pool child drowning and near-drowning to improper adult supervision.

Published Literature

A detailed analysis of publically available sources[3,6] and CPSC data shows that, in many cases, child drowning and near-drowning events occurred due to a lapse of adult supervision of under 10 minutes.

For example, SafeKids International safety literature[6] states that in the time it takes for a parent to take his or her eyes off a child to perform a mundane yet quick task, such as sign for a package at the front door, "*a child can become submerged and sustain permanent brain damage or die*":

> "*Drowning is quick and silent. In the time it takes to… cross the room for a towel (10 seconds), a child in the bathtub can become submerged.*
>
> *Answer the phone (2 minutes), and that child can lose consciousness.*
>
> *Sign for a package at your front door (4-6 minutes), and a child submerged in a bathtub or pool can sustain permanent brain damage and die*."

A pediatrics journal article published in 2010 further shows that 32 percent of children involved in portable pool-related submersion events had been left unattended for less than 5 minutes, and a majority of children (56 percent) had been left unattended for less than 10 minutes[3]. Therefore, the study (which used data readily available to the manufacturer) along with the SafeKids safety literature both show that a brief lapse in parental supervision is not only foreseeable, but it is also a frequently occurring hazard associated with above-ground pools.

The authors of the pediatrics journal article also analyzed the method of access to portable pools. The study found that a majority of children who drowned in above-ground pools (67.5 percent) accessed the pool by means of a ladder[3]. The above statistical data clearly shows that the ladder accessibility hazard is a highly probable event. Other entry methods included climbing on objects placed near the pool, accessing the pool by stairs, climbing over the edge of the pool, and being placed in the pool by another person.

It is apparent that removing the ladder completely from the pool is a cumbersome process, requiring an unreasonable amount of lifting force. Therefore, alternative safer ladders (as discussed below) were researched and inspected. The alternative safer ladders required less physical or mental effort and did not involve awkwardly lifting the ladder out of the pool.

Alternative Ladder Designs

The authors inspected a commercially available flip-up ladder in 2008 (alternative 1). This ladder (as designed) includes a moveable ingress ladder section that pivots about the top platform of the A-frame ladder. The moveable ingress ladder section may be positioned in the down position when the pool is in use and in the up position when it is not. Furthermore, when the ingress ladder section is in the up position, it can be secured into place by means of a padlock included with the product (**Figure 2**).

An updated version of the ladder (**Figure 3**) is currently commercially available (alternative 2). The presence of the ladder on the market in the United States for several years indicates that it is not only a commercially viable product, but also that the manufacturer is providing engineering updates to the ladder to improve its design.

The authors also inspected another model by the same manufacturer of alternative 1 and 2 (alternative 3), which has a built-in ladder shield (**Figure 4**). The ladder shield is designed to slide over the steps when the pool is not in use, thus blocking entry to the pool. A padlock is provided as an additional means to lock the shield into place.

Figure 2
Alternative ladder 1 inspected by the authors in 2008.

Figure 3
Alternative ladder 2 inspected by the authors in 2014.

Figure 4
Alternative ladder 3 inspected by the authors in 2014.

Figure 5
Alternative ladder 4 inspected by the authors in 2014.

Another commercially available safety ladder (alternative 4) has a door assembly that encloses the ladder steps (**Figure 5**). The ladder door is hinged on one side, allowing the door to open and shut. The hinged side of the door is spring-loaded so that the ladder door biases into the closed position when it is not in use. In addition, a spring-loaded latch secures the door into the closed position when not in use. In order to open the door, the user has to release the latch by engaging the handle located near the top of the door while simultaneously opening it.

The ladder's self-closing and self-latching door is a passive safety guard because it is automatically activated without intervention of the user. Passive safety guards, such as the self-closing and self-latching ladder door, are preferable over active safety guards from a safety engineering perspective because they most nearly eliminate the risk of human error.

The manufacturer of the pool package involved in the subject incident also makes a "deluxe" A-frame ladder, but continues to sell A-frame ladders similar to the one involved in the submersion accident. Both ladders are depicted side by side in **Figure 6**.

Figure 6
Comparison between A-Frame ladder included with pool (left) and "deluxe" manufacturer ladder (right).

The "deluxe" ladder is intended to be used in two positions — the down position when the pool is in use and the up position when it is not. When the ingress ladder section is in the down position, the bottom of the legs of the ingress section fit into slots near the base of the ladder, and the top of the legs snap into grooves near the top of the platform. Two clips add additional securement to the top of the legs of the ingress section.

In order to detach the ingress ladder section, the user releases the clips that secure the top of the ladder legs and then depresses two buttons that release the top of the ladder legs from the grooves. The ladder can then be removed, and two slots located on the ladder's top platform allow the ingress ladder to be stored in the up position.

The "deluxe" design in the United States is currently sold by the manufacturer as part of standard packages in France. Therefore, the design is both technologically and economically feasible. However, the manufacturer consciously chose to continue distributing the cheaper (and more cumbersome) A-frame ladder in the United States.

Testing of Children Behavior

The authors tested the safety features of several commercially available alternative ladders with guards. During the testing, young children between two and three years old were incentivized with candy or other objects to access an exemplar pool using the alternative ladders with guards. For example, a 35-month-old boy is depicted attempting to bypass the ladder guard in **Figure** 7. None of the children involved with the testing were able to access the pool with any of the commercially available alternative ladders with guards.

Figure 7
A 35-month-old boy attempting to access exemplar pool using alternative ladder 2.

Industry Codes and Regulations

During analysis, industry standards and local building codes regarding ladder, barrier, and pool safety were reviewed. The purpose of reviewing the standards and building codes was to determine whether the subject ladder and exemplar ladders were compliant.

The permitting process in place in the county where the pool was installed requires homeowners to submit "manufacturer's specifications on how to erect the pool and specifications on self-locking ladders."

The requirement of homeowners to send specifications on self-locking ladders indicates that officials in the county believed self-locking ladders were the standard of care, which is consistent with the engineers' opinion.

Further research shows that other counties within the United States establish that a removable ladder does not constitute an acceptable alternative to barrier requirements for an above-ground pool. For example, the Douglas County, Nebraska Requirements for Private, Residential, or Family Swimming Pools state:

> *The pool structure may be acceptable as a barrier, provided the 48-inch minimum height requirement is met, or if the barrier is mounted and sturdy on top of the pool structure. A removable ladder shall not constitute an acceptable alternative to barrier requirements. When the pool structure qualifies as the barrier, the ladder access area shall be enclosed with an approved minimum 48-inch-high fence with self-closing and self-latching gate or door. The self-latching device shall be located at least 45 inches above grade level for keeping the gate or door securely closed at all times*[7].

As another example, the Township of Wall, New Jersey Pool Fence Requirement states that (bold and underlined text written within requirement):

> *Barriers are required for above-ground pools;* ***a removable ladder is not an acceptable barrier*** *for the above-ground pool*[8].

In addition to building codes in the United States, there were various other resources that discuss whether a removable ladder is an acceptable barrier. Three examples are shown below:

Canadian Residential Swimming Pool Safety Regulation states:

> *6. An above-ground pool with a wall height of at least 1.2m from the ground at any point or a portable pool with a wall height of 1.4m or more is not required to be surrounded by an enclosure if access to the pool is by (1) a ladder equipped with a self-closing and self-latching safety gate, preventing its use by children. (2) A ladder or a platform access to which is protected by an enclosure having the features described in Section 4 & 5. (3) A patio attached to the residence and laid out so that the part giving access to the swimming pool is protected by an enclosure having features described in Section 4 & 5*[9].

The Australian Standard 1926 states:

> *The sides of above ground pool can be accepted as being part of a pool safety barrier, provided they comply with the Australian Standard 1926. However, a barrier must also be provided around the ladder. (It's not good enough to say the ladder will be removed when an adult is not present) as well as pipes, pumps, or anything else that can be climbed on*[10].

Therefore, it is clear that some local codes within the United States and international standards/regulations acknowledge that removable ladders are not safe and should not be used with above-ground pools. Further, the self-locking and self-latching ladder is an acceptable passive safety device that meets various local and international codes.

Summary

The authors' inspections, analysis, and testing show that several safer alternative designs were technologically feasible at the time the manufacturer made the subject pool and ladder.

Further, the authors concluded that the passive safety guard (self-closing and self-latching ladder guard) offered a higher level of protection of the alternative products commercially available.

Several local building codes in the United States and international standards/regulations acknowledge that general removable A-frame ladders (such as the ladder involved in the accident) are not safe, and certain regulations require passive safety devices, such as the self-closing and self-latching ladder guards.

As discussed above, the manufacturer relied on parental supervision to provide guarding against the hazard of drowning. As shown through the published literature, such reliance is not dependable and has led to many child drownings. It is more prudent for the manufacturer to follow proven safety methods and guard against the hazard of drowning by providing a proper ladder that prevents children from accessing the pool without parental assistance.

Conclusions

- Drowning and near-drowning events involving young children often occur during a brief lapse of adult supervision.
- Instead of mitigating the hazard through guarding or access prevention, the manufacturer supplied the unprotected A-frame ladder, easily climbable by children, with its above-ground pool packages.
- Accident statistics show reliance on parental supervision as guarding against the hazard of drowning is not effective.
- The self-closing and self-latching ladder guard is a passive safety device that offers a high level of protection for small children.
- The self-locking and self-latching ladder is an acceptable passive safety device that meets various local and international codes.
- Several safer alternative designs were technologically feasible at the time the A-frame ladder was manufactured.
- Relying on instructions and warnings may not be an effective procedure in preventing drowning accidents.

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