

SAFETY BRIEF

MECHANICAL ENGINEERING:

Triodyne Inc.

(Est. 1969)

Officers

Ralph L. Barnett
Dolores Gildin
S. Carl Uzgiris, Ph.D.

Mechanical Engineering

Ralph L. Barnett
Dennis B. Brickman
Michael A. Dilich
Christopher W. Ferrone
Suzanne A. Glowiak
John M. Goebelbecker
Audra E. Gray
Crispin Hales, Ph.D.
Dror Kopernik
Woodrow Nelson
Cheryl A. Pattin, Ph.D.
Peter J. Poczynok
Audrone M. Stake, Ph.D.
William G. Switalski
George J. Trezek, Ph.D.
S. Carl Uzgiris, Ph.D.
James R. Wingfield, Ph.D.

Library Services

Marna S. Sanders
Betty Bellows
Donna Klick
John Kristelli
Florence Lasky
Donna Spencer
Jackie Schwartz
Joyce Styler

Information Products

*Expert Transcript
Center (ETC)*
Marna S. Sanders

Graphic Communications

Robert Koutny
Charles D'Eccliss

Training and Editorial Services

Paula L. Barnett

Vehicle Laboratory

Charles Sinkovits
Matthew J. Ulmenstine

Model Laboratory

2721 Alison Lane
Wilmette, IL 60091-2101
Bill Brown

Photographic Laboratory

7903 Beckwith Road
Morton Grove, IL 60053
Larry Good

Business Systems

Chris Ann Gonatas
Cheryl Black
Rita Curtis
Sandra Prieto
Anita J. Almormary

Facilities Management

Peter W. Warner

SAFETY PRODUCTS:

Triodyne Safety**Systems, L.L.C.**

(Est. 1998)

5950 West Touhy Avenue
Niles, IL 60714-4610
(847) 677-4730
FAX: (847) 647-2047

Officers/Directors

Ralph L. Barnett
Paula L. Barnett
Joel I. Barnett

President

Peter J. Poczynok

Vice President of Operations

Peter W. Warner

Senior Science Advisor

Theodore Liber, Ph.D.

Mechanical Engineering

Ralph L. Barnett
Peter J. Poczynok
Aquatics Safety Consultant
Ronald M. Schroeder

February, 2002

**Triodyne Inc.**

Consulting Engineers & Scientists - Safety Philosophy & Technology

5950 West Touhy Avenue Niles, IL 60714-4610

(847) 677-4730 FAX: (847) 647-2047

e-mail: infoserv@triodyne.com www.triodyne.com

Volume 19, No. 4

SAFETY RESEARCH:

Institute for Advanced**Safety Studies**

(Est. 1984)

5950 West Touhy Avenue
Niles, IL 60714-4610
(847) 647-1101

Chairman

Ralph L. Barnett

Director of Operations

Paula L. Barnett

Information Services

Marna S. Sanders

Senior Science Advisor

Theodore Liber, Ph.D.

MANUFACTURING:

**Alliance Tool &
Manufacturing Inc.**

(Est. 1945)

91 East Wilcox Street
Maywood, IL 60153-2397
(773) 261-1712
(708) 345-5444
FAX: (708) 345-4004

Officers

S. Carl Uzgiris, Ph.D.
Ralph L. Barnett

General Manager

Ramesh Gandhi

Plant Manager

Bruno Stachon

Founders/Consultants

Joseph Gansacz
Albert Kanikula

CONSTRUCTION:

**Triodyne-Wangler
Construction Company Inc.**

(Est. 1993)

5950 West Touhy Avenue
Niles, IL 60714-4610
(847) 647-8866
FAX: (847) 647-0785

Officers/Directors/Managers

Joel I. Barnett
William A. Wangler
Joseph Wangler
Ralph L. Barnett

BUILDING MAINTENANCE:

**Alliance Building
Maintenance Corporation**

(Est. 1999)

5950 West Touhy Avenue
Niles, IL 60714-4610
(847) 647-1379
FAX: (847) 647-0785

Officers

William A. Wangler
Joseph Wangler
David J. Smith
Joel I. Barnett
Ralph L. Barnett

CONSULTANTS:

Richard M. Bilof, Ph.D.

Electromagnetic Compatibility

Richard Gullickson

Industrial Hygiene/Safety/Chemistry

Beth A. Hamilton

Information Science

David W. Levinson, Ph.D.

Senior Metallurgical Advisor

Steven R. Schmid, Ph.D.

Food Processing Equipment

Diane Moshman

Chemical/Environmental

Engineering

Harry Smith

Electrical Engineering

Kim M. Mniszewski

Fire and Explosion

Critique: Drain Cover Standard ASME/ANSI - A112.19.8M-1987 (1996)

Case Study: Steering Wheel

By Ralph L. Barnett* and Peter J. Poczynok P.E.**

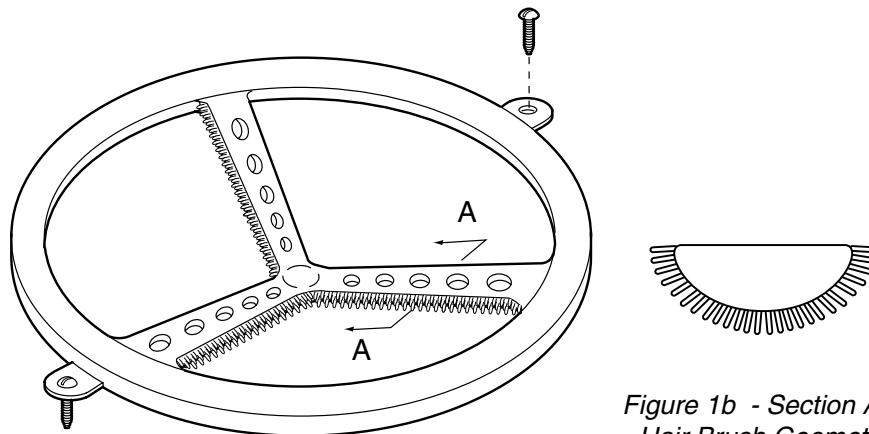


Figure 1a - Steering Wheel Type Drain Cover

Figure 1b - Section A-A
Hair Brush Geometry

Abstract

The current ASME/ANSI standard for pool/spa drain covers is relied upon as an effective guideline for drain system safety by pool industry practitioners, state building code commissions, the Consumer Product Safety Commission, the National Spa and Pool Institute, and a myriad of pool safety sophisticates. In fact, it is a license to kill. To demonstrate its shortcomings in the dawn of its next revision, an ordinary steering wheel is shown to satisfy the current standard while exposing bathers to every known fatal drain cover scenario. The paper raises a new issue: ASME, ANSI and pool professionals may all be in legal jeopardy.

I. Introduction

The candidate steering wheel drain cover depicted in Fig. 1a is constructed from ABS plastic with a trace amount of UV inhibitor. The two round-head slotted screws used to retain it are made from uncoated carbon steel. The spokes in the steering wheel contain a series of elliptical holes whose minor axes vary from 8mm to 25mm. The grip resistance of the spokes is enhanced by forming their sides and bottoms in the shape of a stubby plastic hair brush as shown in Fig. 1b. Two mounting tabs, one-sixteenth of an inch thick, are molded into the wheel flange to secure the drain cover to the main sump. The bottom of the flange has molded lettering, to wit,

Mfg.: Kervorkian Mfg. Co.
Model Identification: Reaper
Flow Rate: 0.5 gal./min.

No Charge

* Professor, Mechanical & Aerospace Engineering, Illinois Institute of Technology, Chicago, IL; Chairman, Triodyne Inc., Niles, IL

** Senior Mechanical Engineer, Triodyne Inc., Niles, IL.

Death and serious injuries associated with pool/spa drain systems arise from eight hazards that have been identified by the national and international aquatic industry. The first four deal with mechanisms that directly injure bathers, i.e.,

- Hair Entanglement
- Body Entrapment
- Evisceration
- Finger Entrapment

The second group of hazards directly affect the viability of the drain cover itself:

- Environmental Degradation
- Broken Covers
- Vandal Resistance
- Missing Covers

Using a steering wheel as an example, this paper explores the extent to which the drain standard, ASME/ANSI A112.19.8M-1987 (1996) [1], addresses the foregoing hazards.

II. Failure Modes and Effects

This section focuses on the errors of omission and commission associated with the ASME/ANSI drain cover standard promulgated in 1987 and reaffirmed in 1996. The reader may wish to contrast the U.S. standard with the functional code governing the safety of swimming pools in New Zealand, "Code of Practice for Swimming Pools," NZS 4441: 1985 [2]:

- 8.1.2 All materials used within the pool shall be corrosion-resistant.
- 8.1.3 All facilities within the pool shall be designed to avoid the possibility that bathers, children in particular, might be trapped.
- 8.1.5 Orifices shall not be large enough to readily engage a finger or toe. The least dimension should not exceed 8mm.

A. Hair Snare

Ensnaring hair is the drain hazard that occurs with the highest frequency [3]. The standard treats hair entrapment primarily as a problem of hydrodynamic drag on a water saturated hair sample comprised of two ounces of natural, medium-to-fine, straight, light-colored hair that is sixteen inches in length. The sample is insinuated into the apertures of a working drain cover in accordance with a specific protocol. Eighty percent of the flow rate that produces a maximum drag force of five pounds on the hair sample in ten trials is called the maximum allowable rating of the fitting or cover. The standard specifies that the drain cover be permanently marked with this flow rate in GPM; no other labeling is recommended [1].

The following observations about hydrodynamic drag are noteworthy:

1. Neither the standard nor the drain cover marking restricts the user to the flow rate indicated on the fitting. The standard speaks only to the manufacturer of the cover; it does not tell the user not to exceed the maximum allowable rating. All the user sees on the part is a flow rate, e.g., 30 gal./min. In the case of the steering wheel with its aggressive spoke design, hundreds of gallons per minute may be drawn through this fitting which is rated at only 0.5 GPM. This will, of course, greatly increase the hydrodynamic drag on a swimmer's hair.
2. Every drain cover that merely records the maximum allowable flow rate will satisfy the hair entrapment portion of the standard.
3. The aquatic literature does not record a single incident where excessive drag has caused an accident.
4. The Consumer Product Safety Commission (CPSC) has indicated that every hair snare accident involves hair entanglement which is not addressed in the standard. [3].
5. It is reasonably foreseeable that pool installers will select a pump size without regard to the drain cover flow rating. Local laws prohibiting this practice would be difficult for inspectors to enforce with respect to the unfamiliar steering wheel drain cover whose flow rate is marked on the bottom of the flange.
6. The specification for the hair sample as light-colored and straight is both silly and politically incorrect.

Hair entrapment by hydrodynamic drag can always be dislodged given sufficient force. In contrast, hair entanglement involves the wrapping and knotting of hair strands around the drain cover elements and increases the grip on hair the harder the swimmer pulls away. This hazard is illustrated in Fig. 2 using the steering wheel. Escape usually necessitates scalping the victim which is beyond the pale of most rescuers.

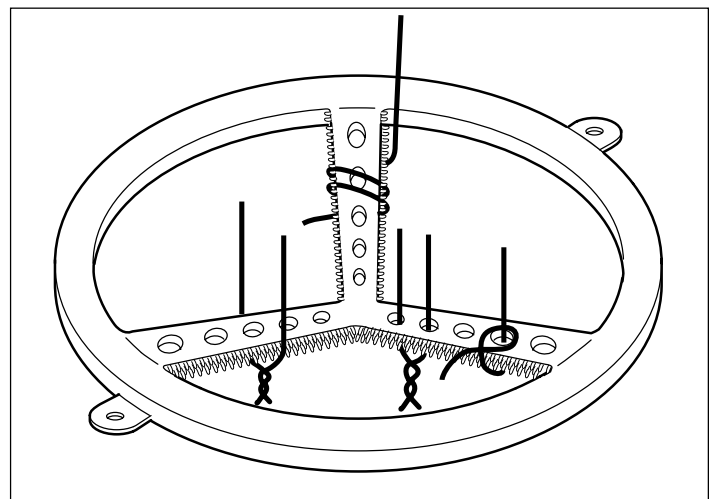


Figure 2 - Hair Entanglement Modes

B. Broken Covers

The structural integrity of drain covers is treated comprehensively in the standard which provides performance criteria for static loading, impact loading, deflection, and ductility under a central point load applied through a specified two inch diameter tup. In addition, a cover must resist a vacuum applied by covering the drain fitting with a plastic film. As shown in Fig. 3, a steering wheel is ideally suited for dealing with axisymmetric loads; the thickness of the spokes can be proportioned to provide any level of resistance.

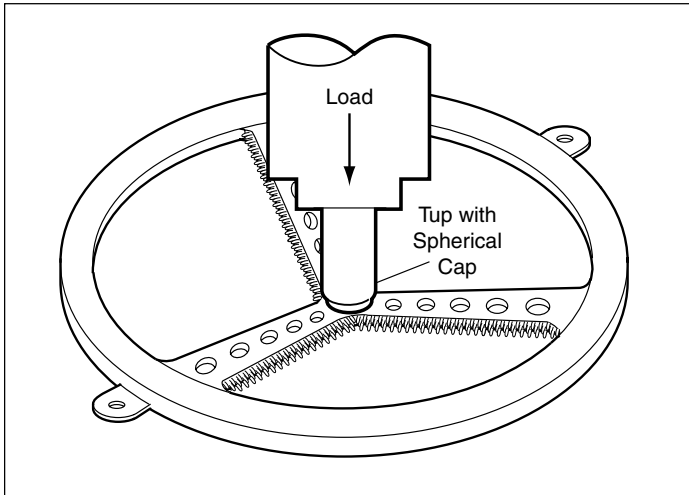


Figure 3 - Central Tup Loading

C. Body Entrapment

Vacuum entrapment of the torso or limbs is the second most prevalent pool/spa drain hazard [3]. When the torso seals the entire drain cover, a full vacuum creates 400 to 700 lbs. of suction force on a bather entrapped on an ordinary residential pool drain cover. Normally, broken drain covers allow access to sump drain pipes that may draw in a swimmer's arms or legs.

The standard addresses body entrapment with a single sentence:

"The structural integrity testing as required in paras. 4.1 through 4.2.3 is intended to evaluate the fitting for the prevention of body entrapment."

Clearly, only limb entrapment is envisioned by the standard; torso entrapment is ignored. This is particularly poignant for the steering wheel drain cover which easily satisfied the structural integrity criteria. Observe that the pie-shaped apertures are large enough to admit an adult's limbs. In addition, the circular concave profile is the easiest for a child to seal with his or her buttocks. The rim or flange of the steering wheel is six to eight inches in diameter and presents a flat surface that may readily be sealed by the back, chest, or stomach. In short, the steering wheel appears to maximize body entrapment.

D. Evisceration

The standard is silent on evisceration which is the third most frequent cause of pool/spa injury [3]. Children are usually the victims. Children typically sit on a coverless sump where their buttocks form a seal; they are disemboweled in a fraction of a second. The steering wheel is a perfect evisceration machine.

E. Mechanical Finger Entrapment

The standard does not consider the hazard of mechanical finger entrapment. The 8mm Rule promulgated in New Zealand since 1985 has no equivalent in the U.S. standard. This implies that any grating, no matter how egregious the design of its apertures, will not violate any pool/spa criteria. The steering wheel drain cover furnishes one example of an especially unsafe design since the graduated decorative elliptical holes in its spokes have the capability of twist locking and wedging fingers of every size.

F. Environmental Degradation

A single sentence in the standard dismisses this hazard which compromises the long-term strength and safety of gratings:

"When plastic materials are used, UV inhibitors shall be added to the polymer mixture."

Undetectable small amounts of inhibitors will satisfy the standard which provides no performance criterion. The material chosen for the steering wheel is ABS plastic, which is notorious for its poor UV resistance even when formulated with optimum amounts of inhibitors. ABS plastic may lose half its strength in two years of outdoor service.

It should be emphasized that grating fasteners are not covered by the standard; e.g., there is no call for stainless steel screws. The steering wheel drain cover design utilizes uncoated carbon steel slotted screws which have particularly poor corrosion resistance when exposed to pool chemicals.

G. Vandal Resistance

Tamper resistance is well known in the safety industry as a desirable property for protecting safety devices. With respect to gratings, children must be frustrated in their efforts to remove fasteners from the drain covers and in their rambunctious attempts to rip gratings from their moorings. The 1987 and 1996 standards do not speak to this problem.

Returning to the steering wheel design, the spokes provide perfect handholds for gripping the drain cover and ripping it from the sump. The thin tabs molded into the steering wheel flange will provide very little hold-down resistance.

H. Missing Drain Covers

Degradation, inadequate strength, and vandalism are the usual reasons why drain covers are missing from pools and spas. Less frequently, they were never originally installed or they were not replaced after maintenance. Their absence generally gives rise to evisceration and body entrapment.

There is no reference to missing gratings in the standard in spite of its prevalence in pool accident scenarios. No on-product or in-manual warnings are suggested to admonish users to keep drain covers securely in place. To deal with missing covers, there is no obligation imposed on the steering wheel grating by the current standard. The only requisite markings are the manufacturer's name, model number, and flow rate.

Conclusions

1. The ASME/ANSI A112.19.8M-1987 (1996) is so completely impoverished that literally any drain cover design that is sufficiently strong will satisfy its requirements.
2. Candidate designs, such as the steering wheel, will satisfy all of the requirements of the standard and still be capable of ensnaring hair by either entanglement or hydrodynamic drag, entrapment of both limbs and torsos, evisceration, and mechanical entrapment of toes and fingers. Furthermore, such designs may rapidly degrade, have minimal tamper resistance, and provide no assistance in the fight against missing drain covers.
3. All sufficiently strong gratings, including the steering wheel design, may be third party certified as satisfying the standard.
4. An uncovered sump will not entangle hair or entrap fingers. It is safer than the steering wheel design which satisfies the standard.
5. Under the heading of "General Requirements," the standard makes the following declaration:

3.1 Fitting Use

The fittings covered in this Standard are identified for use in swimming pool, wading pool, spa, hot tub, and whirlpool bathtub appliance installations to provide for a maximum degree of safety from body and hair entrapment. *Fittings* shall be defined as all components, including cover and hardware.

In fact, the necessary conditions supplied by the standard may not provide any safety at all from drain system hazards.

6. Pool builders, condominium managers, and state building commissions depend on the standard to provide an adequate level of safety. The actual protection is gossamer.
7. The shortcomings of the ASME/ANSI standard are easy to demonstrate. Based on the recent Meneely Decision [4], both ANSI and ASME may be liable for the inadequacies of their standard.

References

1. ASME/ANSI A112.19.8M:1987. *Suction Fittings for Use in Swimming Pools, Wading Pools, Spas, Hot Tubs, and Whirlpool Bathtub Appliances*, American Society for Mechanical Engineers, New York, 1987
2. NZC 4441:1985. *Code of Practice for Swimming Pools, Metric Units*, Standards New Zealand, Wellington, 1985
3. *Guidelines for Entrapment Hazards: Making Pools and Spas Safer*, United States Consumer Product Safety Commission, 1988
4. Meneely vs S.R. Smith, Inc. 101 Wn. App. 845 (WA 2000)

SAFETY BRIEF

February, 2002 – Volume 19, No. 4

Editor: Paula L. Barnett

Illustrated and Produced by

Triodyne Graphic Communication

Copyright 2002© Triodyne, Inc. All Rights Reserved. No portion of this publication may be reproduced by any process without written permission of Triodyne, Inc. 5950 West Touhy Avenue, Niles, IL 60714-4610 (847) 677-4730. Direct all inquiries to: *Library Services*.