

**Guidelines for Entrapment Hazards:
Making Pools and Spas Safer**

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1. INTRODUCTION

The *Guidelines for Entrapment Hazards: Making Pools and Spas Safer* (guidelines) provide safety information that will help identify and eliminate dangerous entrapment hazards in swimming pools, wading pools, spas, and hot tubs. They address the hazards of body entrapment, hair entrapment/entanglement, and evisceration/disembowelment. These guidelines are intended for use in building, maintaining, and upgrading public and private pools and spas. They are appropriate for use by parks and recreation personnel, public health organizations, equipment purchasers and installers, pool and spa owners, inspection officials, code officials, and others who are responsible for pool and spa safety.

The guidelines are based on information assembled by the U. S. Consumer Product Safety Commission (CPSC) from many sources, including the Association of Pool and Spa Professionals (APSP) [formerly, National Spa and Pool Institute (NSPI)], the National Swimming Pool Foundation (NSPF), swimming pool and spa equipment suppliers and maintenance firms, state health officials, and voluntary standards organizations. There are several voluntary standards for pool and spa construction and equipment. These are referenced in Appendix A. These voluntary standards contain more technical requirements and specifications than CPSC's guidelines and are primarily intended for use by designers, builders, equipment installers, manufacturers, and code officials.

In these guidelines, the term "public pool and spa" refers to facilities intended for use by the public in such areas as parks, hotel/motel facilities, institutions, multiple family dwellings, resorts and recreational developments, and other areas of public use. The term "residential pool and/or spa" refers to a pool or spa located within the confines of a residential property and intended for the private use of the owner and/or the home's occupants. A glossary of other terms used in these guidelines can be found in Appendix B.

These guidelines are recommendations; they are not intended as a CPSC standard or mandatory federal requirement. The CPSC originally issued these guidelines in January 1998. The revisions incorporated in this version of the guidelines reflect changes in codes and voluntary standards, and other operational considerations. The revisions primarily pertain to the recommendations found in Guideline #1 and focus on the development of performance standards for safety vacuum release systems (SVRS) and alternative methods for avoiding entrapment.

The Commission believes that following these guidelines can reduce the possibility of body entrapment, hair entrapment/entanglement, and evisceration, which can have life-threatening consequences. However, these guidelines do not contain all possible approaches for addressing the identified hazards.

2. WHY THE GUIDELINES WERE DEVELOPED

Although current codes and standards for pools and spas contain requirements to prevent body entrapment, hair entrapment/entanglement, and evisceration, incidents and deaths continue to occur. Since the release of the first edition of the guidelines, changes have been made in codes and new standards for SVRS have been developed.

2.1 Pool and Spa Entrapment Injuries

Body Entrapment

CPSC is aware of 74 cases of body entrapment, including 13 confirmed deaths, between January 1990 and August 2004. The deaths were the result of drowning after the body, or a limb, was held against the drain by the suction of the circulation pump (Ref. 1). The incidents occurred in both residential and public settings. Twenty-two incidents occurred at a residential location, and 31 at a public facility. In 21 cases, the location was not specified. Thirty-nine of the incidents occurred in spas, hot tubs, or whirlpools, 31 incidents occurred in swimming pools and three occurred in a wading pool (one location was reported as "unknown"). In one of the spa incidents, a 16-year-old girl became trapped on a 12" by 12" flat drain grate in a large public spa and died.

The reported incidents involved people ranging in age from 22 months to 89 years. Most incidents were to older children (8 to 16 years of age); 77% of the victims were under the age of 15 years with a median age of 9 years. In some of the cases, it appears that the child was playing with the open drain, including inserting a hand or foot into the pipe, and then became trapped by the increased suction and resulting tissue swelling.

There are potentially many different circumstances of design and maintenance that can produce the conditions for this hazard, which can occur in either pools or spas. The scenarios suggest that any open drain, or any flat grating that the body can cover completely, coupled with a plumbing configuration that allows a strong suction force to persist if the drain is blocked, can present this hazard. Drain covers available on the market since 1982 generally have a domed shape, which may offer some protection against body entrapment. Depending upon the plumbing configuration and pool maintenance conditions, a single bottom drain can serve as the sole water inlet to the pump. This condition becomes dangerous if there is an inadequate or missing drain cover.

Hair Entrapment/Entanglement

CPSC is aware of 43 incidents of hair entrapment or entanglement in pools, spas, and hot tubs between January 1990 and August 2004. Twelve of the incidents resulted in drowning deaths, as a result of hair becoming entangled in the drain grates. Thirty-eight incidents occurred in spas, including hot tubs, and five occurred in a pool. The victims' ages were between 4 and 42, with a median age of 9 years – 92.5% were under the age of 15 (Ref. 1).

Typically, these incidents involve females with long, fine hair, who are underwater with their head near a suction outlet (drain). The water flow into the drain sweeps the hair into and around the drain cover, and the hair becomes entangled in and around holes and protrusions on both sides of the cover. Entrapment occurs because of the tangling and not necessarily because of strong suction forces, although the suction forces initially draw the hair into the drain cover.

Since about 1982, industry voluntary standards for pools, spas, and hot tubs require drain covers to be certified. The certification includes a maximum flow rate, in gallons per minute (GPM), which should never be exceeded, as this increases the possibility for hair entrapment/entanglement. The design of a drain cover in association with the flow rate through it has been found to relate to the cover's ability to entrap hair. Large openings in the covers in combination with high flow rates can pull hair through the cover and cause entanglement in the turbulence behind the cover. Reduced flow rates and smaller holes in the drain cover can make entanglement less likely to occur. However, it can be difficult to determine actual flow rates in pools and custom-built spas, and thus to know if they are equipped with the

proper fitting to prevent hair entanglement. Drain covers available on the market since 1982 are supposed to conform to a standard that provides hair entrapment/entanglement protection.

Evisceration/Disembowelment

From January 1990 through August 2004, CPSC has reports of two incidents of evisceration/disembowelment. CPSC is not aware of any associated deaths, but the injuries are irreversible and have a devastating effect on the victim's future health and development (Ref. 1). These cases, in addition to cases prior to 1990, include incidents of young children sitting on and being "sucked into" drain sumps with missing covers, and suffering rectal lacerations and partial and nearly complete eviscerations.

The scenario leading to disembowelment typically involves a young child, 2 to 6 years old, who sits on an uncovered drain. The incidents occur primarily in public wading pools where a floor drain cover is broken or missing. Young children have direct access to the bottom drain in wading pools because of the shallow water. Generally, drains are equipped with either flat grates or dome-shaped covers. The domed shape helps to prevent sealing of the pipe opening by the body. However, if the grate or cover is unfastened, broken, or missing, the potential for an incident exists. When the child's buttocks cover the drain opening, the resulting suction force can eviscerate the child through the ruptured rectum. A small change in pressure is sufficient to cause such injury extremely quickly (Ref. 2).

Other/Unknown Cases

The CPSC is aware of 11 other cases of drain entrapment occurring between January 1990 and August 2004; two of these cases resulted in death. In nine cases, the particular body part or object caught in the drain is unknown. There are two reports of drain entrapment where something being worn by the person became caught, neither resulted in death. In one case, a 43-year-old woman's necklace became caught. The other case involved a 21-year-old man's swim trunks.

2.2 Codes and Standards

Several voluntary standards currently in existence for swimming pool and spa construction and equipment are referenced in Appendix A. New ASTM International and American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI) standards regarding the performance of SVRS have been developed. The National Electrical Code (NEC) has adopted language requiring an emergency shutoff switch within sight of a spa or hot tub (in public facilities only) to allow for easy removal of power from the circulation system (Ref. 3). The International Code Council (ICC), a nonprofit organization established in 1994 to develop a single set of comprehensive national construction codes, has also begun to address aspects of pool safety in its International Building Code (IBC) and International Residential Code (IRC). The creators of the ICC are the Building Officials and Code Administrators International, Inc. (BOCA), the International Conference of Building Officials (ICBO), and the Southern Building Code Congress International, Inc. (SBCCI), three nonprofit organizations responsible for the development of three separate sets of regional model codes used throughout the United States.

Some state and/or local building codes may have adopted requirements found in these standards. Check with your local authorities to determine what the specific requirements are in your community. Many communities also require inspections of new and existing facilities before they are opened to the public or at the time of residential sale. These inspections involve the general pool filtration system (pumps, filters, and skimmers), drain covers and fencing, if required. Periodic inspections during the operating season of public facilities may also be required to ensure that the facility is properly operated and maintained according to local regulations.

While the voluntary standards primarily address new construction, these guidelines were developed to also address potential entrapment hazards that may exist with older pools and spas that were built prior to the effective date of the relevant standard.

2.3 CPSC Guidelines

The approach taken in the guidelines is to present various options to attain “layers of protection” against entrapment in all pools and spas. The options available depend on whether entrapment hazards are being addressed in new construction or an existing facility. Entrapment hazards can be addressed in new construction by several options, including alternative gutter or overflow circulation systems that eliminate the main drain altogether, or the use of multiple main drains to prevent sole source suction in combination with appropriate drain (pool outlet) covers. Options for existing pools include reconfiguring the circulation system to include multiple main drains with proper drain covers, installing SVRS that respond to an increase in pump suction associated with entrapment and remove the suction forces, or other technology capable of recognizing a potentially hazardous situation such as a sudden increase in pump suction or missing drain cover(s) and responding to remove or prevent the hazard (hereafter referred to as “other technology”).

Due to the “human element” involved in the care and maintenance of pools and spas, it is strongly recommended that consideration be given to including an additional and final layer of protection in all pools and spas that use submerged suction outlets, to relieve an entrapping suction force should outlets become blocked or if covers are broken or removed. Options for new construction include, but are not limited to, a properly designed atmospheric vent system, SVRS, or other technology. For existing facilities, options include the installation of an SVRS or other technology. This is especially important in wading pools and older pools with single main drains.

3. GUIDELINES FOR ADDRESSING POTENTIAL ENTRAPMENT HAZARDS

Guideline #1

For new construction that includes fully submerged suction outlets, a minimum of two outlets per pump, with pipe centers at least 3 feet apart, is one approach to reduce the likelihood of entrapment. Outlet covers listed and approved in accordance with ASME/ANSI A112.19.8 performance requirements are recommended.

The use of alternative designs is another recommended option, such as 18" x 23"¹ or larger covers, long channels that cannot be blocked by the body, gravity feed systems, atmospheric vent systems, or engineered, tested, and approved designs that prevent

¹ This aspect ratio is currently being considered by the ASME/ANSI A1 12.19.8 project team and relates to the torso size of a 99th percentile male, age 20-65, weighing 244 pounds.

entrapment hazards from occurring, including designs that do not include fully submerged suction outlets (see Appendix B).

Due to care and maintenance concerns associated with circulation systems that include suction outlets and covers, consideration should be given to the installation of a back-up system that relieves entrapping suction and/or shuts down the pump when a blockage is detected [e.g., an SVRS²] or other technology, in case unanticipated conditions arise that may present an entrapment hazard. Tests should be conducted to verify entrapment does not occur.

If an existing pool, spa, or hot tub has a single suction outlet, with or without a skimmer, the following actions are recommended:

If conditions allow, rework the suction (drain) system to include either a minimum of two drains per pump with ASME/ANSI A112.19.8 listed covers or drain design configurations that prevent a seal from occurring (large aspect cover), and consider installing a secondary back-up system that relieves the entrapping suction and/or shuts down the pump should an unanticipated condition arise and a blockage occur [e.g., an S VRS³] or other technology, or

Where rework is not possible or practical, ensure that:

- an ASME/ANSI A11 2.19.8 listed cover is in place,*
- flow through the drain (outlet) grate does not exceed 1.5 feet per second (fps), and*
- a secondary back-up system that relieves the entrapping suction and/or shuts down the pump when a blockage is detected [e.g., an SVRS*] or other technology is installed.*

For wading pools that include a fully submerged suction outlet(s), install multiple drains with ASME/ANSI A 112.19.8 tested covers and an SVRS⁴ back-up system or other technology due to the shallow depth of water and easy access to the pool drains. Alternative designs that prevent entrapment hazards from occurring are also acceptable as noted above under new construction.

3.1 Information on Guideline #1

For new construction:

For new construction that includes fully submerged suction outlets, a minimum of two outlets per pump with covers listed and approved in accordance with ASME/ANSI A1 12.19.8 performance requirements is recommended.

Rationale: Providing multiple outlets from the pool to the suction side of the pump allows flow to continue to the pump and reduces the likelihood of an entrapping suction being generated when a body blocks one of the outlets.

The use of alternative designs is another recommended option, such as 18 " x 23 " or larger covers, long channels that cannot be blocked by the body, gravity feed systems, atmospheric vent systems, or engineered, tested, and approved designs that prevent entrapment hazards from occurring, including designs that do not include fully submerged suction outlets.

Rationale: Providing large aspect drain covers or channel type drains that cannot be covered by the body eliminates the potential for a suction entrapment to occur since the water will always have the ability to flow around the body and through the cover. Gravity feed systems remove direct pump suction from the pool by providing a second tank (known as a collector or surge tank – see Appendix C) from which the pump will draw. As the pump removes water from the tank, water from the pool will flow into and replenish the tank due to atmospheric pressure on the surface of the pool. A properly designed atmospheric vent system will introduce air into the pump suction line in the event an outlet is blocked, thus removing the entrapping suction and releasing the victim. Removing submerged drains and relying on an overflow or gutter system to circulate the pool water and strategically placing the water returns throughout the pool to ensure proper chemical circulation completely removes the entrapment hazard.

Due to care and maintenance concerns associated with circulation systems that include suction outlets and covers, consideration should be given to the installation of a back-up system that relieves entrapping suction and/or shuts down the pump when a blockage is detected [e.g., an SVRS] or other technology in case unanticipated conditions arise that may present an entrapment hazard. Tests should be conducted to verify entrapment does not occur.

Rationale: With options that include submerged outlets, consideration should be given to the installation of a back-up system that relieves entrapping suction and/or shuts down the pump when a blockage is detected [e.g., an SVRS] or other technology in case unanticipated conditions arise that may present an entrapment hazard. Data indicates that entrapment tends to occur where the wrong cover is used, missing or broken covers exist, and in some instances, a lack of proper maintenance procedures has left multiple drain configurations inoperative. There is also the potential for inadvertently blocking or disabling drains in a multi-drain system, which can present an unseen entrapment hazard to users.

In existing pools, spas, and/or hot tubs:

If an existing pool, spa, or hot tub has a single suction outlet, with or without a skimmer, the following actions are recommended:

- if conditions allow, rework the suction (drain) system to include either a minimum of two drains per pump with ASME/ANSI A1 12.19.8 listed covers or drain design configurations that prevent a seal from occurring (large aspect cover), and consider installing a secondary back-up system that relieves the entrapping suction and/or shuts down the pump should an unanticipated condition arise and a blockage occur [e.g., an SVRS] or other technology, or*

Where rework is not possible or practical, ensure that:

² The device should meet the performance requirements of the ASTM International F2387 and/or ASME/ANSI A1 12.19.17 standard referenced in Appendix A.

³ The device should meet the performance requirements of the ASTM International F2387 and/or ASME/ANSI A1 12.19.17 standard referenced in Appendix A.

⁴ The device should meet the performance requirements of the ASTM International F2387 and/or ASME/ANSI A1 12.19.17 standard referenced in Appendix A.

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- an ASME/ANSI A112.19.8 listed cover is in place
- flow through the drain (outlet) grate does not exceed 1.5 feet per second (fps), and
- a secondary back-up system that relieves the entrapping suction and/or shuts down the pump when a blockage is detected [e.g., an SVRS] or other technology is installed.

Rationale: Providing multiple outlets from the pool to the suction side of the pump allows flow to continue to the pump and reduces the likelihood of an entrapping suction being generated when a body blocks one of the outlets. Large aspect covers (e.g., 18” x 23”), long channels that cannot be blocked by the body, conversion to a gravity feed/collector tank system, or an engineered, tested and approved design that prevents entrapment hazards from occurring, including designs that remove a fully submerged suction outlet, are also acceptable.

While multiple drains or an alternate drain configuration providing entrapment avoidance are preferable solutions, it is recognized that rework may not always be a practical solution and a pool/spa owner may choose to install a back-up system rather than structurally renovate the pool/spa. As explained previously, consideration should be given to the installation of a back-up system that relieves entrapping suction and/or shuts down the pump when a blockage is detected (e.g., an SVRS) or other technology capable of recognizing a potentially hazardous situation in case unanticipated conditions arise that may present an entrapment hazard. This is especially important in wading pools and older pools with single main drains. Given the resources required to reconstruct the drain system and the difficulty in modifying a vinyl liner (complete replacement may be required) or altering a fiberglass shell, a secondary system that works with existing configurations may be desirable until time and funds are available to make permanent renovations. In some cases, environmental conditions might exist that preclude the renovation of a drain system. The inclusion of a back-up system to monitor the function of the drain(s) and respond to abnormal conditions provides an additional layer of protection to help prevent the occurrence of entrapments.

Wading Pools:

For wading pools that include a fully submerged suction outlet(s), install multiple drains with ASME/ANSI A112.19.8 tested covers and an SVRS back-up system or other technology due to the shallow depth of water and easy access to the pool drains. Alternative designs that prevent entrapment hazards from occurring are also acceptable (as noted under new construction).

Rationale: Young children can easily access the drain in wading pools, spas, and hot tubs because of the shallow water depth of these pools. Young children may be attracted to the drain cover itself or the feel of water flow through the drain. If the drain cover is a flat grate (8 inches or less in diameter), missing, broken, or not an anti-entrapment or anti-vortex cover (dome-shaped to prevent the entrainment of air into the suction line), the potential for an entrapment or disembowelment injury exists. Where water depths are greater than four feet, access is not as easy, but the potential for an entrapment still exists.

Additional Entrapment Avoidance Information:

There are several approaches available if a pool owner chooses to rework the drain system. These include the use of multiple drains or channels, the use of a larger suction area, a gravity fed circulation system, or atmospheric vents included in the circulation system. These options are discussed in greater detail in Appendix B.

First and foremost, a proper drain cover [with an ASME/ANSI A112.19.8 rating to address hair entrapment (Appendix A), a large area grate (preferably one with a diagonal measurement of at least 24 inches) and/or some type of channeling too large to be sealed by a human body] should be installed. Additionally, a sensing device that detects an increased suction associated with blockage and relieves the entrapping suction should be considered, especially in the case of a single drain. SVRS devices are available that can sense a small increase in suction at the inlet to the pump and shut off the power to the pump, or simply introduce air into the suction line, effectively removing the suction at the drain. Standards developed by ASTM International and ASME address the operation and performance of these devices under entrapment conditions.

In the case of body entrapment, the removal of the suction in the line between the pump and a blocked outlet can relieve the forces causing the entrapment, and therefore make rescue possible. For this reason, installation of a secondary back-up system that relieves the entrapping suction and/or shuts down the pump when a blockage is detected should be considered. It should be noted, however, that if a check valve is installed on the circulation system to prevent the backflow of water, it may also prevent the relief of the suction and the vacuum forces may remain in place and impede rescue efforts. The presence of a check valve in existing pools and spas may render an SVRS device ineffective. The manufacturer’s installation instructions should be consulted prior to the installation of the SVRS (or other technology) device. For new construction where a check valve is necessary due to elevation differences, the circulation system design should include considerations for entrapment avoidance.

In the case of evisceration/disembowelment, the amount of time between sensing the restricted flow, the shutdown of the pump(s) or the relief of the suction, and the ultimate relief of the suction forces at the source of the blockage may not be fast enough to eliminate all disembowelment injuries. The CPSC does believe, however, that injuries may be prevented because a child playing in the vicinity of the open drain fitting is likely to interrupt the flow and activate the release system before completely sealing the fitting. Further, CPSC believes that an SVRS or other technology, while not a substitute for proper drain covers required in the voluntary standards, is a reasonable system to have in place in the event of improper maintenance or tampering with the drain cover.

Regardless of the number of outlet drains provided, because of the shallow depths of wading pools, spas, and hot tubs, and the easy access to their suction outlets, the installation of a safety back-up system that monitors the function of drain outlet/circulation systems and relieves suction forces in the event of entrapment should be **seriously considered**.

For existing pools and spas where water depths are over four feet, a back-up system should be installed where a single drain currently exists, or a drain can become single upon activation of valves or as result of poor maintenance, and rework is not possible. While access to the suction outlets in deeper pools is less likely, the potential for a broken or missing cover(s) and subsequent entrapment still exists.

For deeper pools where rework or new construction has provided multiple suction outlets, backup systems should still be considered for installation. The system provides protection should multiple drains become blocked for any reason.

Where rework is not possible, install a back-up system to monitor the drain function. In addition, the flow through the outlet grate should be limited to 1.5 feet per second (fps) and serious consideration given to the installation of a large outlet grate (diagonal measure of 24 inches or more) or cover that cannot be sealed by the body and meets the ASME/ANSI A112.19.8 requirements (for hair entrapment). Studies by

NSPF have shown that by reducing the flow through the grate, hair entanglement/entrapment and body entrapment incidents are less likely to occur. By providing an outlet grate with a large diagonal measurement, body entrapment incidents are less likely to occur due to the inability of the body to completely seal such an area.

Another form of intervention required by the National Electrical Code (NEC) is an emergency cutoff switch in the line-of-sight of a spa, not less than 5 feet from the spa, that would allow a person to cut the power to the pump(s) in a life-threatening situation. **NOTE: A cut-off switch should not be considered in lieu of the solutions previously discussed and should only be considered as a solution to be used in combination with any of the alternatives previously mentioned, since a second person would need to be present to activate the switch.**

Guideline #2:
If the drain cover does not display the appropriate markings for maximum flow rate and labeling that indicate it has been tested to the ASME/ANSI voluntary standard, shut down the pump and replace the cover.

3.2 Information on Guideline #2

Rationale: An improper outlet cover can increase the likelihood of hair entanglement or entrapment. Covers are tested and rated for flow rates to prevent hair entrapment incidents from occurring. Flow rates in excess of the cover’s rated flow can pull hair through the cover and create tangling behind the cover, which can lead to entrapment. A qualified pool professional can determine if the flow rate through the fitting is adequately matched to the actual flow rate of the spa, hot tub, or pool. If not, changes should be made to achieve this match.

Additional Information: Installers, owners, maintenance personnel, and inspectors should ensure that drain covers are manufactured and installed according to the latest specifications set forth by the ASME/ANSI A1 12.19.8 voluntary standard (Appendix A) for suction fittings. The standard requires that the cover material be tested for structural integrity. The cover also must be tested for hair entrapment/entanglement potential and is required to display a flow value in gallons per minute (GPM) that indicates the maximum flow rate for which the cover has been approved. The use of a cover under conditions where the maximum allowable flow rate is exceeded can lead to entrapment hazards. Portable spas (including hot tubs) manufactured after 1982 are likely to have drain suction fittings that are appropriately sized for the flow rate.

Spas built on site may not have the quality and inspection controls to guarantee that the suction cover is correctly matched with the pump to provide a rated flow appropriate for that cover. One possible solution would be to provide a flow control valve that qualified pool maintenance professionals could set during installation to ensure that the rated flow for the drain cover is not exceeded. During regular maintenance, the flow can be checked, and adjusted as necessary. Should a pump need to be replaced, the flow can again be determined and adjusted as needed.

A pool professional should inspect spas or hot tubs that were manufactured prior to 1982, or if there is a question about the drain cover currently installed. Anti-vortex covers (dome-shaped covers) were developed to protect against air entering the circulation system due to swirling behind the covers. An added benefit of these covers appears to be the ability to address entrapment hazards when installed properly. Because of their water flow design and shape, the anti-vortex covers seem to be more difficult to seal with the body than are flat grates. The pool professional should determine if the covers meet the safety requirements outlined in the appropriate ASME/ANSI and ANSI/NSPI standards (Appendix A).

Guideline #3

Develop a comprehensive maintenance program for each facility. A checklist is provided in Section 5. to help implement this program. The maintenance program should address the following to avoid entrapment hazards:

- a. ***If the drain cover or grate is cracked, broken or missing, immediately shut down the pump(s) and replace the grate or cover.***
- b. ***The covers should be anchored in accordance with the manufacturer's specifications and supplied parts (e.g., non-corroding fasteners).***
- c. ***The practice of color coding or labeling plumbing and equipment should be incorporated into all facilities. The most important aspect of a labeling/coding program is to provide the location, identification, and marking of the On/Off switch for the circulation pump(s).***

3.3 Information on Guideline #3

Rationale: Inadequate maintenance of equipment and drain covers can lead to entrapment injuries. Because the safety of swimming pools, wading pools, and spas depends on good inspection and maintenance, the manufacturer's maintenance instructions and recommended inspection schedules should be strictly followed. Generally, all equipment, skimmers, and drain covers should be inspected frequently for corrosion, deterioration, missing or broken parts, or any other potential hazards. In case of emergency, a clearly labeled and accessible On/Off switch for the circulation pumps may make the difference between entrapment and rescue.

Additional Information: The frequency of thorough inspections will depend on the type of equipment to be inspected and the amount of its use. Inspectors should give special attention to moving parts, components that can be expected to wear, and drain covers. Trained personnel should conduct all inspections. Some manufacturers supply checklists for general and/or detailed inspections with their maintenance instructions. These should be used. A general checklist that may be used as a guide for frequent routine inspections of swimming facilities is included in these guidelines.

When installed and secured in accordance with the manufacturer's instructions, no fasteners used to affix drain covers should loosen or be removable without the use of tools. In addition, all fasteners should be corrosion resistant and should minimize the likelihood of corrosion to the materials they connect.

Public pool equipment rooms may color code or label the plumbing according to local code requirements. The coding or labeling can be helpful during maintenance procedures or during times of urgency, especially to those not familiar with the equipment. The On/Off switch for the

circulation pumps should be clearly marked. The ability to provide assistance to an entrapped victim depends on the ability to quickly remove the suction force. For hair entrapment, or entanglement, the ability to remove the victim depends on how quickly the hair can be removed, pulled, or cut from the outlet cover. With this in mind, a pair of scissors or a knife located in a First Aid kit or in close proximity to the outlet cover area (lifeguard stand, equipment room, office, etc.) should be considered.

Inspections alone do not constitute a comprehensive safety and maintenance program. Personnel conducting the inspections (pool operators, lifeguards, etc.) should also be made aware of the potential for entrapment hazards and the procedures necessary to perform a rescue. All hazards or defects identified during inspections should be repaired promptly before opening the facility to the public. Repairs and replacements of equipment parts should be completed in accordance with the manufacturer's instructions.

A summary of these guidelines as well as a checklist to help identify potential entrapment hazards is provided on the following pages. It is suggested that these pages be prominently posted as a constant reminder to the pool staff to regularly check for potentially hazardous conditions. The checklist in these guidelines addresses potential entrapment hazards, but is not intended to provide a complete safety evaluation of equipment design and layout. Complete documentation of all maintenance inspections and repairs should be retained, including the manufacturer's maintenance instructions and any checklists used. A record of any incidents and injuries reported to have occurred at the facility should also be maintained. This will help identify potential hazards or dangerous features that warrant attention.

4. SUMMARY OF GUIDELINES #1, #2, and #3

Guideline #1

For new construction that includes fully submerged suction outlets, a minimum of two outlets per pump, with pipe centers at least 3 feet apart, is one approach to reduce the likelihood of entrapment. Outlet covers listed and approved in accordance with ASME/ANSI A112.19.8 performance requirements are recommended.

The use of alternative designs is another recommended option, such as 18” x 23”⁵ or larger covers, long channels that cannot be blocked by the body, gravity feed systems, atmospheric vent systems, or engineered, tested, and approved designs that prevent entrapment hazards from occurring, including designs that do not include fully submerged suction outlets (see Appendix B).

Due to care and maintenance concerns associated with circulation systems that include suction outlets and covers, consideration should be given to the installation of a back-up system that relieves entrapping suction and/or shuts down the pump when a blockage is detected [e.g., an SVRS*] or other technology in case unanticipated conditions arise that may present an entrapment hazard. Tests should be conducted to verify entrapment does not occur.

If an existing pool, spa, or hot tub has a single suction outlet, with or without a skimmer, the following actions are recommended:

- if conditions allow, rework the suction (drain) system to include either a minimum of two drains per pump with ASME/ANSI A112.19.8 listed covers or drain design configurations that prevent a seal from occurring (large aspect cover), and consider installing a secondary back-up system that relieves the entrapping suction and/or shuts down the pump should an unanticipated condition arise and a blockage occurs [e.g., an SVRS⁶] or other technology, or***

Where rework is not possible or practical, ensure that:

- an ASME/ANSI A112.19.8 listed cover is in place***
- flow through the drain (outlet) grate does not exceed 1.5 feet per second (fps), and***
- a secondary back-up system that relieves the entrapping suction and/or shuts down the pump when a blockage is detected [e.g., an SVRS⁷] or other technology is installed.***

For wading pools that include a fully submerged suction outlet(s), install multiple drains with ASME/ANSI A112.19.8 tested covers and an SVRS⁸ back-up system or other technology due to the shallow depth of water and easy access to the pool drains. Alternative designs that prevent entrapment hazards from occurring are also acceptable as noted above under new construction.

Guideline #2:

If the drain cover does not display the appropriate markings for maximum flow rate and labeling that indicate it has been tested to the ASME/ANSI voluntary standard, shut down the pump and replace the cover.

Guideline #3

Develop a comprehensive maintenance program for each facility. A checklist is provided in Section 5. to help implement this program. The maintenance program should address the following:

- a. If the drain cover or grate is cracked, broken or missing, immediately shut down the pump(s) and replace the grate or cover.***
- b. The covers should be anchored in accordance with the manufacturer's specifications and supplied parts (e.g., non-corroding fasteners).***

⁵ This aspect ratio is currently being considered by the ASME/ANSI A1 12.19.8 project team and relates to the torso size of a 99th percentile male, age 20-65, weighing 244 pounds.

⁶ The device should meet the performance requirements of the ASTM International F2387 and/or ASME/ANSI A1 12.19.17 standard referenced in Appendix A.

⁷ The device should meet the performance requirements of the ASTM International F2387 and/or ASME/ANSI A1 12.19.17 standard referenced in Appendix A.

⁸ The device should meet the performance requirements of the ASTM International F2387 and/or ASME/ANSI A1 12.19.17 standard referenced in Appendix A.

- c. ***The practice of color coding or labeling plumbing and equipment should be incorporated into all facilities. The most important aspect of a labeling/coding program is to provide the location, identification, and marking of the On/Off switch for the circulation pump(s).***

5. POOL AND SPA ENTRAPMENT HAZARDS CHECKLIST

Pool Name:	Date:
	Completed by:
	Pool Builder:
Items to be Checked in Filter Room and Pool Before Filling and After Periodic Maintenance and Cleaning Procedures	
L] Proper suction drain covers installed and inspected for breakage (main and wading pools – covers should be labeled in accordance with ASME/ANSI A1 12.19.8)	
L] Suction drain covers firmly and properly affixed using manufacturer's recommended parts L] If applicable, SVRS or other device tested and operational according to the manufacturer’s instructions	
L] Proper return covers installed (main & wading pools)	
L] Skimmers checked (baskets, weirs, lids & flow adjustors) for blockage	
L] All skimmer throats checked for blockage (main & wading pools)	
L] All valves and filter lines labeled and functional	
L] Vacuum covers or fittings in place (if applicable)	
L] Location of the On/Off switch to circulation pump clearly and conspicuously identified	
L] On/Off switch to circulation pump clearly and conspicuously labeled	
Daily Checklist	
L] Main drain, vacuum, inlet covers and/or fittings in place, secured and unbroken (hourly) (main & wading pools)	
L] Skimmers checked (baskets, weirs, lids & flow adjustors) for blockage (hourly) (main & wading pools)	
L] Warning/alert signs in place around the pool with emergency instructions and phone numbers	
L] On/Off switch to pump clearly and conspicuously labeled and location of pump clearly identified	

6. REFERENCES

1.

CPSC Memorandum to Troy Whitfield, "Drain Entrapment in Spas, Swimming Pools and Wading Pools from January 1990 through October 2003," Natalie Marcy, EPHA, November 5, 2003. Addendum October 6, 2004.

2.

CPSC Memorandum to Ronald L. Medford, "Assessment of the Pool Pump Cutoff Device Presented by David Stingl," Roy W. Deppa, P.E., Suad Nakamura, PhD., and William Rowe, March 12, 1996.

3.

National Fire Protection Association Inc., National Electrical Code 2002, Article 680 – Swimming Pools, Fountains, and Similar Installations, August 2, 2001.

4.

National Swimming Pool Foundation, Dual Main Drain Suction Entrapment, Hair Entrapment/Entanglement Test Report, William N. Rowley, Ph.D., P.E. and Glen H. Egstrom, Ph.D., June 1997.

Appendix A: Applicable Standards

Standard: **Suction Fittings for Use in Swimming Pools, Wading Pools, Spas, Hot Tubs and Whirlpool Bathtub Appliances - ASME/ANSI A112.19.8.**

Standard: **Manufactured Safety Vacuum Release Systems (SVRS) for Residential and Commercial Swimming Pool, Spa, Hot Tub and Wading Pool Suction Systems - ASME/ANSI A112.19.17.**

Sponsored and Published by:
The American Society of Mechanical Engineers
United Engineering Center 345 East 47th
Street
New York NY 10017
www.asme.org

Standard: The following are American National Standards for Pools and Spas;
ANSI/NSPI-1-2003 Standard for Public Swimming Pools
ANSI/NSPI-2-1999 Standard for Public Spas
ANSI/NSPI-3-1999 Standard for Permanently Installed Residential Spas **ANSI/NSPI-4- 1992 Standard for Aboveground/Onground Residential Swimming Pools** **ANSI/N S PI - 5-2003 Standard for Residential Swimming Pools** **ANSI/NSPI-6-1999 Standard for Residential Portable Spas**
NSPI-7 Standard Entrapment Avoidance for Pool, Spa and Hot Tub Circulation System (In Progress)
ANSI/NSPI-8-1996 Model Barrier Code for Residential Swimming Pools, Spas and Hot Tubs
BSR/NSPI/WWA-9 Standard for Aquatic Recreation Facilities (In Progress) **BSR/NSPI-10 Standard for Public Swimspas (In Progress)**
BSR/NSPI-11 Standard for Residential Swimspas (In Progress)

Sponsor:
Association of Pool and Spa Professionals (APSP) formerly, National Spa and Pool Institute
2111 Eisenhower Avenue
Alexandria VA 22314
(703) 838-0083
www.theapsp.org

Standard: **Standard for Electric Spas, Equipment Assemblies, and Associated Equipment, UL 1563.**

Sponsor:
Underwriters Laboratories Inc. 1655 Scott Boulevard
Santa Clara CA 95050
(408) 985-2400
www.ul.com

Standard: **Standard Specification for Manufactured Safety Vacuum Release Systems (SVRS) for Swimming Pools, Spas and Hot Tubs – ASTM International F2387.**

Sponsor:
ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428 www.astm.org

Standard: **National Electrical Code 2002, Article 680 – Swimming Pools, Fountains, and Similar Installations**

Sponsor:
National Fire Protection Association Inc. One Batterymarch Park
Quincy, MA 02269
www.nfpa.org

Code: **International Building Code (IBC) International Residential Code (IRC)**

Sponsor:
International Code Council (ICC) 5203 Leesburg Pike
Suite 600
Falls Church VA 22041
www.iccsafe.org

Appendix B: General Entrapment Avoidance Information

B.1 Multiple Drains

Your pool maintenance professional may recommend completely reworking the suction outlet (drain) system. This may involve a major construction effort around the drain section of the pool and could involve providing two or more suction drains or a larger suction area to prevent entrapment by an existing single drain configuration. **This option should be strongly considered in the case of wading pools, spas, and hot tubs because of the ease with which young children have access to the drain cover.** Additionally, a channel type drain could be installed in such a way as to prevent the ability to "trap off" or block the main drain.

The principle behind installing a multiple drain system is to prevent a single drain opening from becoming the sole inlet to the suction side of the pump. By providing an additional drain, a blockage created by someone at one drain does not interfere with flow through the second drain. The installation of at least one additional drain effectively divides the suction between the drains, provided the piping is the same diameter and the "tee" is placed midway between the drains (See Figure 1). With the pump's ability to draw water from the unblocked drain, flow to the pump would remain unchanged. Therefore, there would be no increase in suction at the pump and no substantial entrapping forces created in the blocked drain. The main supposition in this configuration is that both drains are properly plumbed, maintained, and free from any debris behind the cover that may reduce flow on one leg of the configuration.

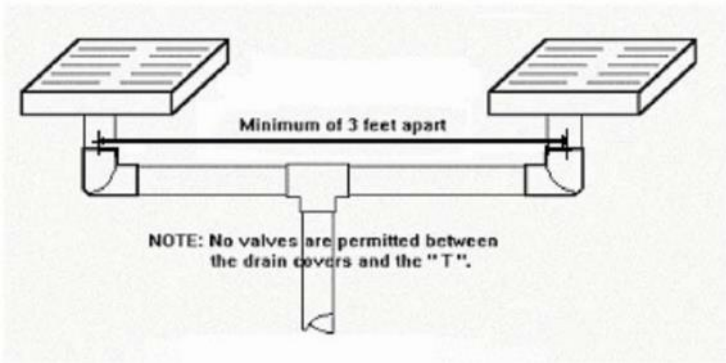


Figure 1. Dual Drain System

The state of North Carolina currently requires a minimum of two main drains per pump in the construction of new wading pools and is requiring that existing wading pools be retrofitted to meet a two outlet per pump minimum requirement. The state has accepted a single drain and skimmer line combination as long as neither can be isolated. However, beginning in April 2006, the state will be requiring both a safety vacuum release system (SVRS) and an anti-entrapment drain cover on all remaining single-drain pools. A point of contact for further information on the implementation and success of this requirement is:

James Hayes of the *N. C. Department of Environmental Health and Natural Resources*, (919) 715-0924.

The effective use of a skimmer line as the second suction or suction relief source for the pump should the main drain become blocked has not yet been established. It is theorized that the skimmer line will provide flow to the pump, thus preventing an entrapment at the main drain, but this depends on the plumbing configuration (See Figure 2). Some plumbing configurations may provide better entrapment prevention by removing direct suction from the main drain. However, depending on pipe sizes and flow status of the skimmer, there may not be enough relief provided by the skimmer line to release an entrapment at the main drain. By design, pool skimmer lines collect surface debris and are therefore expected to clog, or experience reduced flow. A complete blockage of the skimmer system leaves the main drain as a sole source of suction for the pump – an undesired condition.

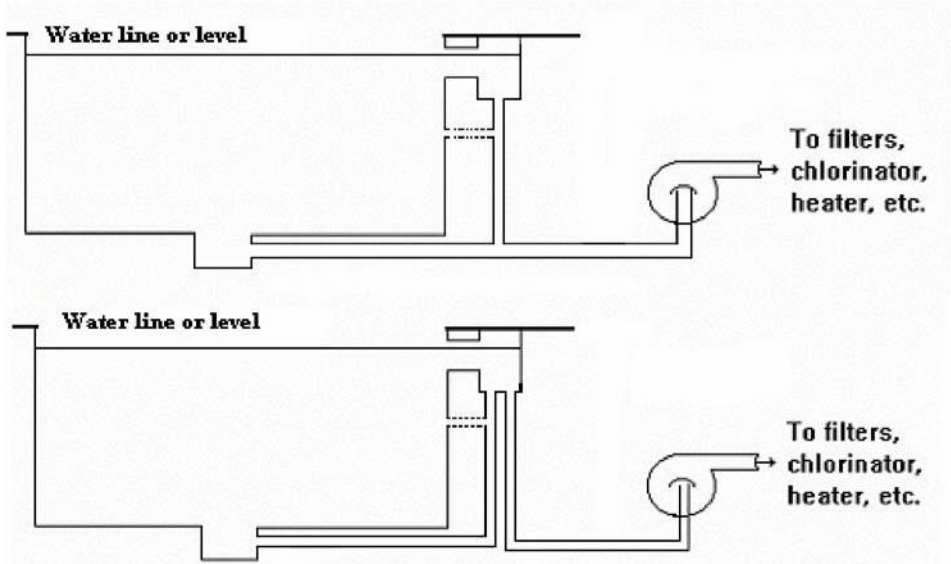


Figure 2. Skimmer Line Plumbing Options
(Note: an equalizer line may or may not be present on the skimmer)

B.2 Channel Systems

Alternatively, a channel type drain could be installed in such a way as to prevent the "trapping off" or blockage of the main drain (Figure 3). The channel, possibly retrofitted onto either or both sides of a 12" x 12" grate, would provide a larger surface area to maintain the desired flow without creating an entrapment hazard since it would be difficult to completely seal or trap off. Providing a large drain cover, similar to 18 " x 23", or one whose diagonal measurement is at least 24 inches (18 " x 18 " or 6" x 24"), can also reduce the likelihood of entrapment. These measurements provide drain (outlet) covers that should be large enough to prevent a body seal and thus body entrapment (based on the 99th percentile, 20-65 year-old male). CPSC is aware of a limited number of facilities that incorporate these kinds of designs. In some cases, the grating incorporates a "snap out" feature that also addresses the hazard associated with hair entrapment.

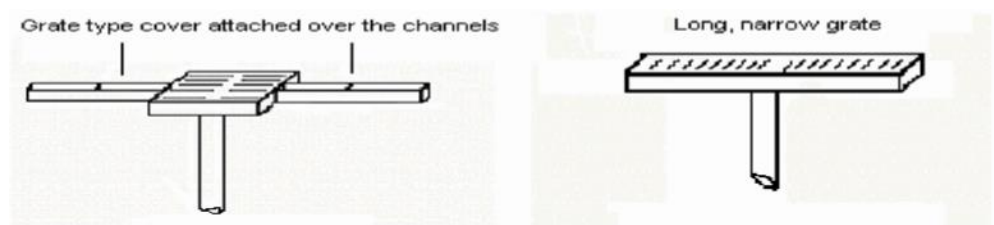


Figure 3. Alternate Drain Configurations

B.3 Assessment of Multiple Drain and Channel Systems

A multiple drain system, channel drain system, or large drain cover (diagonal greater than 24 inches) can greatly reduce the likelihood of body entrapment and subsequent drowning. In tests conducted by the National Swimming Pool Foundation (NSPF) on a multiple drain system similar to that shown in Figure 1, results indicated that no significant suction force was available to entrap a user if the user’s body covered one drain (Ref. 4). The lack of an appreciable suction force in a functioning multiple drain configuration would reduce the likelihood of body entrapment. The presence of multiple drains may also reduce the likelihood of hair entrapment incidents due to the lower flow rates through the drains resulting in less pull of hair into or against the drain cover. The use of drain covers that have been listed for the drain’s exit flow and passed tests against entrapment of hair will also influence the effectiveness of multiple drains against hair entrapment.

The effectiveness of these proposals against disembowelment injuries is not as clearly understood because of the lack of data surrounding the pressure differential and the duration of exposure to the available suction required to cause such injury. The disembowelment injuries are believed to occur "almost instantaneously" at a small pressure differential. Whether that small differential is present in a multiple drain system has not yet been established. The incorporation of a channel or 24” minimaldiagonal-measurement drain cover, which cannot be completely sealed by a single person, may be the best approach in preventing disembowelment injuries since the child would not be subjected to the full suction of the pump.

B.4 Gravity Feed and Vent Systems

One system, currently in use in Florida, is a gravity feed system. The system is based on pressure equalization, water seeking an equal level, between the pool or spa and the collection, or surge, tank. The tank collects water from the pool or spa and the suction side of the pump(s) then draws water from the tank rather than the pool or spa (Figure 4). This method of circulating, filtering, and/or heating and jetting the pool or spa water removes the direct suction from the main drains and skimmers and applies it to the tank, which is not occupied. Water flow through the suction outlet(s) is regulated by atmospheric pressure ‘pushing’ the water into the collector tank until equilibrium is reached. This type of system will not produce sufficient forces at the outlet(s) to present a hazard. A point of contact for further information on the implementation of this system is:

Robert S. Pryor of the *Florida Department of Health*, (850) 245-4444 x2369

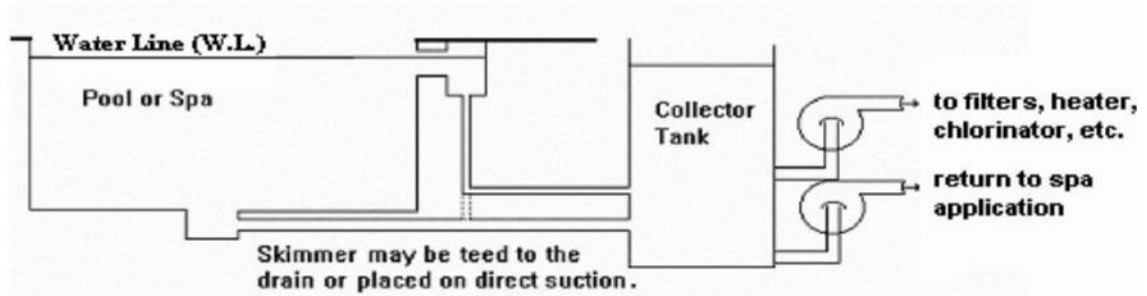


Figure 4. Gravity Feed System – Direct Suction Removed from the Pool

The use of an atmospheric vent may remove suction from the main drain or skimmer in case a blockage should occur. The vent would be connected to the main suction line between the outlet drain and the pump and would be open to the atmosphere (Figure 5). Similar to the principle behind the gravity feed system, the vent pipe will fill with water to a level equal to that of the pool. Should the outlet in a single main drain circulation system become clogged or obstructed, the pump begins to draw on the water from the vent pipe until air is introduced into the circulation system and the suction is broken (the pump loses prime). A point of contact for further information on the implementation of atmospheric vents is:

Carvin DiGiovanni, of the *Association of Pool and Spa Professionals*, (703) 838-0083

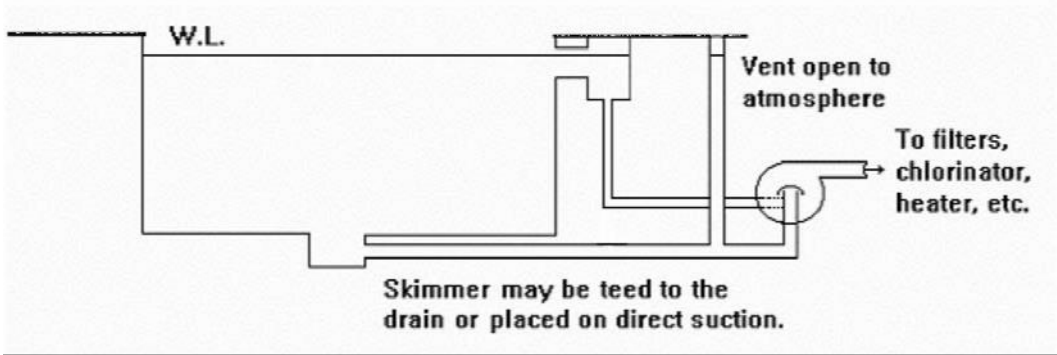


Figure 5. Vent System to Relieve Main Drain Suction B.5 Assessment of Gravity

Feed and Vent Stack Systems

The use of these gravity systems may reduce the likelihood of suction entrapment because direct suction at the main drain has been removed. The collector tank (or surge tank) is generally located near the equipment and is covered, but remains open to atmosphere. If a blockage occurs at the drain, water will be drawn from the tank until air is introduced into the suction line, but no direct suction is ever applied to the main drain.

Earlier concerns surrounding the ability to keep atmospheric vent systems clean of algae and other biological contaminants have been addressed through observation. An ASTM International voluntary standards task group is currently developing minimum requirements for field-fabricated vent pipes. The performance of the vent, the ability to prevent obstructions from occurring within the vent, and a test procedure are being addressed. Should the vent become obstructed, the safety system would be rendered ineffective unless procedures are in place to regularly test and maintain the system. There are additional concerns regarding manufactured vent systems versus field-fabricated units. The design and operation of the vent could be dependent on the depth of the pool or spa being protected and the vent location, unless specific design conditions were used to make the vent system function correctly regardless of pool depth and vent location. Consideration must be given to the length and location of the vent pipe so that the vent is not drained (introducing air into the system) with each start up of the pump.

To address concern about residual suction effects (water pressure) that may continue to hold an entrapped victim on the drain, even after the initial pump suction has been relieved, the ‘hydraulically balanced’ concept for a vent system has been discussed (See Figure 6) during ASTM International voluntary standards task group meetings. In the event of a blockage at the main drain, air would be drawn through the vent and into the suction line, effectively breaking the suction of the pump. The principle of this design is that the remaining water column in the drain line would be nearly equal in height to that in the pool, thus equalizing the pressure at the main drain and allowing a user to readily remove himself from the drain.

The extent to which the water pressure in a pool will hold a user to the main drain with an atmospheric vent line installed as illustrated in Figure 5 has not yet been established. Systems such as Figure 5 are currently installed in Florida and CPSC is not aware of any reported incidents.

Manufactured vent pipe designs exist that are independent of the pool depth. The effectiveness of either of these vent pipe designs against disembowelment injuries is not known because of the lack of data surrounding the pressure differential required to cause such an injury.

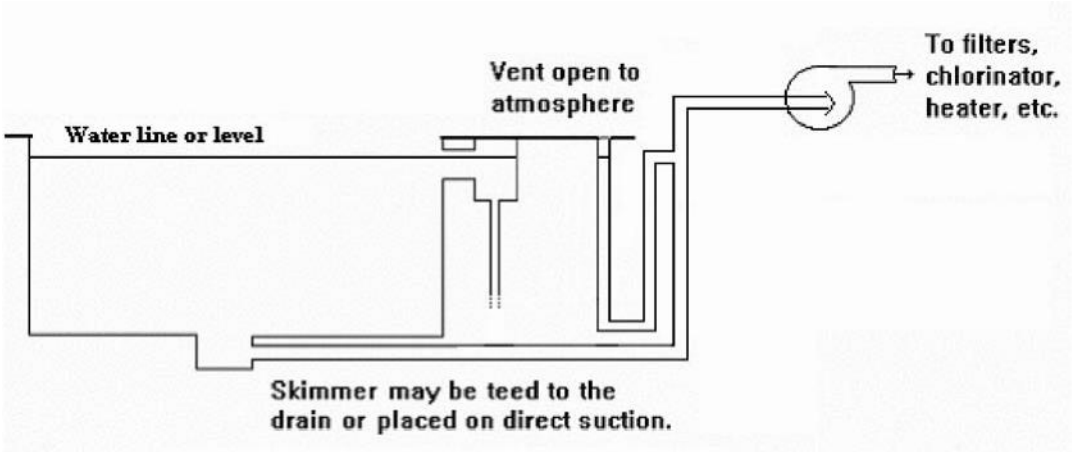


Figure 6. Hydraulically Balanced Vent System

Appendix C: Glossary

- **ANSI:** American National Standards Institute.
- **Anti-Entrapment Cover:** A drain fitting designed to prevent entrapment, typically dome-shaped to reduce the likelihood of creating a body seal.
- **Anti-Vortex Cover:** A drain fitting designed to prevent the circular or swirling motion of water that tends to form a vacuum or suction at the center and draws the body or hair into the drain pipe.
- **APSP:** Association of Pool and Spa Professionals, formerly the National Spa and Pool Institute.
- **ASME:** American Society of Mechanical Engineers.
- **Atmospheric vent:** Pipe teed to the suction side of the circulation system and open to the atmosphere at the opposite end. The pipe is full of water equal to the same height as the pool and drains when a blockage occurs at the main drain; thus introducing air into the suction line.
- **Backflow:** The backing up of water through a pipe in the direction opposite to normal flow.
- **Centrifugal Pump:** A pump to circulate water using an impeller fixed on a rotating shaft having an inlet and a discharge connection. The rotating impeller creates centrifugal force causing flow (suction) into the pump and pressure exiting the pump.
- **Check Valve:** A mechanical device in a pipe that permits the flow of water or air in one direction only.
- **Collector Tank:** A water storage vessel within the pool circulation system used to collect water displaced by bathers. The pool circulation pump draws water from this tank, thus removing direct suction from the pool. Also referred to as a Reservoir, Surge Tank or Surge Pit.
- **Drain:** This term usually refers to a plumbing fitting installed on the suction side of the pump in the deepest part of the pool, spa or hot tub. Main drains do not drain the pool, spa or hot tub, as a sink drain, but rather connect to the pump to allow for circulation and filtration.
- **Equalizer:** A pipe line below the pool water surface, usually on the side wall, connected to the body of a skimmer that prevents air from being drawn into the pump. The pipe line can also be used between two pools/spas to equalize water levels.
- **Filter:** A device that removes undissolved or suspended particles from water by recirculating the water through a porous substance (a filter medium or element). The three types of filters used in pools and spas are sand, cartridge and D.E. (diatomaceous earth).
- **Flow Rate:** The quantity of water flowing past a designated point within a specified time, such as the number of gallons flowing past a point in one minute - abbreviated as GPM.
- **fps:** An abbreviation for feet per second.
- **GPD:** An abbreviation for gallons per day.
- **GPH:** An abbreviation for gallons per hour.
- **GPM:** An abbreviation for gallons per minute.
- **Gravity Feed:** Circulation of water based on pressure equalization, water seeking an equal level, between a pool or spa and a collection or surge, tank. Flow is initiated, under gravity, due to atmospheric pressure and a difference in water height between the pool and surge tank created by the suction side of the pump drawing water from the tank rather than the pool or spa.
- **Gutter:** An overflow trough in the perimeter wall of a pool that is a component of the circulation system or flows to waste.
- **Hot Tub/Spa:** A warm water reservoir, manufactured from prefabricated materials at a factory with hydromassage jets. A portable hot tub/spa may be constructed of acrylic thermoplastic or fiberglass surrounded by within a cabinet of wood, wood alternative or thermoplastic. All the control, water heating, water circulating equipment are contained within the unit.
- **Hydrojet:** A fitting in the pool or spa on the water return line from the equipment that blends or mixes air and water, creating a high-velocity, turbulent stream of air-enriched water.
- **in Hg:** Unit of measure for vacuum – Inches of Mercury
- **Inlet:** A fitting in the pool or spa on the water return line from the equipment where water returns to the pool; also known as a return.
- **Main Drain:** A term usually referring to a plumbing fitting installed on the suction side of the pump in pools, spas and hot tubs. Sometimes referred to as the drain, it is normally located in the deepest part of the pool, spa or hot tub. It does not drain the pool, spa or hot tub, as a sink drain, but rather connects to the pump to allow for circulation and filtration.
- **Manifold:** A branch pipe arrangement that connects several input pipes into one chamber or pump or one chamber onto several output pipes.
- **NPSF:** National Swimming Pool Foundation.
- **NSPI:** National Spa and Pool Institute (see APSP).
- **psi:** An abbreviation for pounds per square inch, typically used to define a level of water or air pressure.
- **Pump:** A mechanical device, usually powered by an electric motor, which causes hydraulic flow and pressure for the purpose of filtration, heating and circulation of pool and spa water. Typically a centrifugal pump is used for pools, spas and hot tubs.
- **Rate of Flow:** The quantity of water flowing past a designated point within a specified time, such as the number of gallons flowing past a point in one minute (abbreviated as GPM).
- **Reservoir:** See Collector Tank
- **Skimmer:** A device installed through the wall of a pool or spa at the water surface that is connected to the suction line of the pump that draws water and floating debris in the water flow from the surface without causing much flow restriction.
- **Skimmer Basket:** A removable, slotted basket or strainer placed in the skimmer on the suction side of the pump, which is designed to trap floating debris in the water flow from the surface without causing much flow restriction.
- **Spa:** A warm water reservoir permanently installed, constructed out of concrete (gunite, shotcrete, etc.) with hydromassage jets. Spas may or may not be attached to a pool. Heating and circulation equipment are not an integral part of the product. (See hot tub)
- **Suction Outlet:** Any aperture or fitting through which the water under negative pressure is drawn from the pool or spa.
- **Sump:** The lowest point in a circulation system, usually consisting of a reservoir, where water is drained.
- **Surge Tank (Surge Pit)** See Collector Tank
- **SVRS:** Safety Vacuum Release System – Device that senses an increase in pump suction and responds by removing power to the pump(s) and/or relieving the potentially entrapping suction.
- **System Flow:** See Turnover
- **Tee:** A plumbing fitting in the shape of a "T" used to connect pipes.
- **Turnover (rate):** The period of time (usually in hours) required to circulate a volume of water equal to the volume of water contained in the pool or spa.
- **Vacuum:** This term can be used to define any number of devices that use suction (negative pressure) to collect dirt from the bottom and sides of a pool or spa. Most common is a vacuum head with wheels or brushes that attaches to a telescoping pole and is connected to the suction line with a hose usually via the opening in the skimmer. It must be moved about by a person, and debris is collected in the skimmer basket or filter. 2). The reduction of atmospheric pressure within a pipe, tank, pump, or other vessel. Vacuum is measured in inches of mercury (in. Hg).
- **Water Velocity (piping):** The speed at which the water flows between two specified points, measured in feet per second (fps).
- **Weir:** Also called skimmer weir – the part of a skimmer that adjusts automatically to small changes in water level to assure a continuous flow of water to the skimmer. The small floating "door" on the side of the skimmer that faces the water over which water flows on its

way to the skimmer. The weir also prevents debris from floating back into the pool after the pump shuts off.