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## INVITED REVIEWS

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# Escape and Rescue From Submerged Vehicles

**Gerald M. Dworkin**

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Each year, approximately 1,500 incidents and 600 deaths occur resulting from vehicles that have gone off the road and plummeted into water (Figure 1). The public needs to plan for these types of emergencies by rehearsing the steps necessary for a successful self-rescue from a vehicle in the water and having rescue/escape tools readily available for use during this type of emergency situation. In addition, first-responder agencies need to provide the training necessary to prepare their personnel to respond to these types of incidents and should provide the personal protective equipment and rescue tools necessary for a safe and effective response to vehicles in the water.

## Safety Facts

Public-service campaigns should be increased in an effort to educate the public about the risks of driving through flooded highways; driving in close proximity to bodies of water during snow, rain, or other slippery conditions; or driving over lakes, rivers, or ponds that have frozen over. The following information should be included in these efforts:

- It only takes 15 cm to 0.6 m (6 in. to 2 ft) of water to float a vehicle off its wheels. Heed warnings about low water crossings and do not attempt to cross flooded highways.
- Twenty to thirty centimeters (8–12 in.) of new, clear, hard ice is required to drive a small vehicle onto the ice. Thirty to thirty-eight centimeters (12–15 in.) of new, clear, hard ice is required to drive a medium-sized truck onto the ice. Old ice that potentially has gone through several thaw and freeze cycles can support much less weight.
- Wearing seatbelts will increase your chances of surviving a crash into the water.

If a vehicle leaves the road and lands in deep water, the vehicle's float time at the surface of the water might be as little as 30 s or as much as 4 min (Figure 2).

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**Figure 1** — Automobile unexpectedly entering deep water.



**Figure 2** — It is critical to escape from a vehicle that has entered the water within the first 30 s to 4 min.

Factors that affect the float time include closed, sealed, and intact windows and weather seals. Because the motor is located in the front of most vehicles, the vehicle will immediately assume an angled nose-down position in the water.

## Escape

Because of the relatively limited time frame for self-rescue, the decision to escape the vehicle must be made immediately. Because of the angled nose-down position

in the water and the pressure exerted by the water against the doors, as well as potential structural damage to the vehicle as a result of the crash, it might be extremely difficult or even impossible to open the driver's side and passenger doors of the vehicle in order to effect an escape. Therefore, the only avenue of escape might be through the car-door windows.

Studies have shown that a vehicle's electric power might stay on for as much as 10 min. Alternatively, the battery can short out immediately, making the electric window switches useless. Therefore, in order to escape through the car-door windows, the occupants must be able to break and punch out the windows. Because the door windows are constructed of tempered glass, they will easily shatter if one uses an appropriate rescue/escape tool such as a life-hammer device or a spring-loaded window punch. Many of the commercially available rescue/escape tools also have an integrated seatbelt blade that provides the ability to slice away a seat belt should its release mechanism fail or jam.

The decision to escape the vehicle must be made as soon as the vehicle leaves the road and enters the water. If the occupants delay their escape from the vehicle and the vehicle begins to sink, it might not be possible to make an escape until the water pressure has equalized inside the vehicle. In addition, should the vehicle land in deep water that is less than 4 m (14 ft), the vehicle will usually come to rest on the bottom on all four wheels, assuming there are no large rocks or other debris on the bottom. Water depths greater than 4 m (14 ft) usually result in the vehicle "turning turtle" and landing on its roof (Figure 3). Needless to say, being upside down in a dark environment with water rushing in completely disorients the occupants of the vehicle.



**Figure 3** — The need to escape a partially submerged vehicle rapidly is especially important in water more than 4 m (14 ft) deep, in which vehicles often invert, causing disorientation of submerged passengers and decreasing their likelihood of escape and survival.

We at Lifesaving Resources advocate the escape principles of **SOS-GO** as follows:

- S** = Stay calm, assess the Situation, and Slow your breathing
- O** = Open your window(s) or door(s)
- S** = disengage your Seatbelt
- GO** = Get Out

In order to accomplish the SOS-GO emergency procedures with good success, drivers and passengers should rehearse the steps before an emergency occurs. Use a body reference point to identify and locate the door latch, window crank, or electric window switch. As an example, the driver should practice finding the location of these by touching his or her knee or hip with the left hand and then move the hand laterally to the door. A rescue/escape tool should be immediately available for punching out the window and cutting seatbelts. This tool can be mounted on the sidewall of the driver's-side compartment, attached to the key ring, or located in some other conspicuous location that can be easily accessed during an emergency. Consideration should be given to locating additional escape tools for the passenger-side and rear-seat compartments, as well.

If there are multiple vehicle occupants, once an escape route has been opened, occupants should hold hands in a human chain and follow an escape route via the same point. If young children are secured in car seats, we found, based on an initial but limited study, that the car seats we evaluated were sufficiently buoyant to float a child to the surface of the water. Therefore, the car seat can be cut loose from the seat belt and removed from the vehicle with the child still secured in it.

There is no doubt that when a vehicle leaves the roadway and plunges into the water, this will be an extremely frightening experience, especially during the winter months with cold water posing additional risks and hazards to the occupants. By rehearsing the emergency escape and survival procedures and having the rescue/escape tools readily available, occupants can safely and rapidly extricate themselves from this situation before the vehicle begins to sink.

## Rescue

Public-safety and rescue personnel should be appropriately trained, protected, and equipped to effectively and safely respond to vehicles in the water. Besides the availability of personal flotation devices (PFDs), wetsuits, and/or dry suits, rescue personnel should have the tools readily available to punch in the car-door windows in order to rapidly extricate a victim or multiple victims from a vehicle in the water. Spring-loaded window punches or life-hammer-type devices with seat-belt cutters provide rescuers the opportunity to gain immediate access to the victims and to cut away their seatbelts for their immediate extrication from the vehicle.

As standard protocol, whenever a rescue agency is dispatched to respond to a vehicle in the water, the dispatch of a wrecker should be automatic in every community and emergency-response system. When the wrecker arrives, it can be used to help stabilize the vehicle during and after the rescue of the vehicle occupants.



**Figure 4** — Hammer-type escape/rescue tool. This was found to be the most effective and reliable tool according to our studies.



**Figure 5** — Two types of spring-loaded window-punch escape/rescue tools.

## Rescue and Escape Tools

We evaluated a number of escape/rescue tools. These tools are either hammer-type devices (Figure 4) or spring-loaded window-punch devices (Figure 5). Although both types of tools were effective in breaking door windows, we found that the hammer-type devices were more dependable. Each of the spring-loaded window-punch devices we tested was effective in breaking the windows when it was first removed from their packaging. After several practice drills, however, the points on these window punch devices became dull, which resulted in their failure to work and break the windows. Therefore, we caution against using the spring-loaded window punches for any purpose other than breaking the windows. Furthermore, using a spring-loaded window punch without appropriate hand protection increased the chance of suffering cuts on the hand over the use of the hammer-type device. Regardless, rescue personnel should always wear an appropriate water-rescue, neoprene, or fire glove when using any type of device to shatter vehicle door windows.

## Summary

An unexpected submersion of an automotive vehicle in water need not become a tragedy if the participants have the appropriate knowledge, the ability to think and

act quickly, a rehearsed action plan, and readily available escape tools as detailed in this article. Similarly, first responders need to have experience and training, as well as the necessary tools and equipment, to make successful rescues from submerged vehicles.

### **Acknowledgment**

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