U.S. Department
of Transportation

**United States
Coast Guard**

AUGUST 1996

Boating Safety Circular 78

LIFEJACKETS - THEY FLOAT, YOU DON'T

About 8:30 a.m. three men, ages 31, 37, and 38, left for a day of fishing on a lake aboard a 1988 18-foot, four inch bass boat. The weather was clear, the water was choppy (1.5 to 2 foot waves), the wind was seven to 14 miles per hour from the northwest, the air temperature was about 65 - 70 degrees Fahrenheit. A county employee who had been fishing on the lake at about 8:00 a.m. on the same day, reported whitecaps on the water and winds of 16 to 17 miles per hour.

"Contributing to the loss of life were the occupants' failure to wear Personal Flotation Devices (PFDs) . . . Had [they] worn PFDs, they might have survived."

About 10:30 a.m., two people also boating on the lake noticed the unoccupied open fiberglass bass boat circling at slow speed. The boat was retrieved and the identity of the owner was determined from State vessel registration records. No witnesses had seen the men in the boat after it got underway, or witnessed the accident.

Shortly thereafter, a Civil Air Patrol aerial search and a county sheriff department water search commenced and continued for four days, with no results. About 8:00 a.m. five days after the accident, a boater found the body of one victim. A water search located the two other victims about three and one-half hours later. None of the victims was wearing a Personal Flotation Device (PFD)[a Coast Guard approved lifejacket], and all were fully clothed. The autopsy did not indicate that alcohol or drugs were involved, nor was trauma indicated. All three men drowned.

A decal on the outboard engine cover read "150 HP," but the engine markings indicated a 200 horsepower outboard motor. The U.S. Coast Guard Maximum Capacities label, permanently attached to the port console, showed a rating for six persons or 810 pounds and a 175 horsepower motor. Fishing gear and five PFDs were found in seat lockers forward of the starboard console; one PFD had a cord with an engine kill switch clip attached to it.

According to a brother of one of the victims, who had been on the boat when it was being operated on a river about four weeks prior to the accident, the boat tended to wobble or rock from side to side, at a speed of 65 miles per hour. The boat builder's customer service manager stated that the boat was rated at 70 miles per hour with a 175 horsepower outboard motor.

The National Transportation Safety Board (NTSB) was unable to determine the probable cause of the accident; however, the NTSB stated that the accident was likely the result of: (a) the boat striking a wave while chine-walking, (b) a sudden turn by the operator at high speed, or (c) a sudden pitch or roll in response to striking a wave at high speed, or a combination of the three, throwing the occupants overboard. Contributing to the accident, according to the NTSB, was the operator's powering of the boat beyond the manufacturer's recommendation and the Coast Guard maximum guidelines. Contributing to the loss of life were the occupants' failure to wear PFDs, the operator's failure to

Inside:

use the boat's installed engine kill switch, and a sticking accelerator pedal, which allowed the boat to continue to operate. The operator and his two passengers may not have recovered from the impact of entering the water in time to prevent their drowning or, if they did recover, they may not have been able to board the boat. Had the occupants worn PFDs, they might have survived.

In its report, the National Transportation Safety Board recommended "that the U.S. Coast Guard publish a **Boating Safety Circular** that describes the circumstances of this accident, stressing the dangers of operating a boat at high speed and the phenomenon known as "chine-walking," the need to wear PFDs, and the use of engine kill switches.

This accident demonstrates that all persons may be unexpectedly ejected from a boat, leaving no one to stop it, and also the need to wear Coast Guard approved lifejackets. Today, the typical high performance boat may be a bass boat, a skiboat, a speedboat, or one of several combinations, and may be able to attain speeds as high as 70 to 100 miles per hour. Many high performance boats also have accommodation areas for sleeping and a galley for cooking.

With the innovations in boat and engine design and the greatly increased boat speeds, recreational boat operators have had to learn a whole new terminology, previously used only by raceboat drivers:

Chine-walking is a phenomenon associated primarily with V-bottom hulls, which are operated at high speed with only a minimum amount of hull area in the water. When chine-walking, the hull may have a tendency to roll or fall off to one side then the other. <u>This rolling action must be stopped or controlled if the oscillation appears to be intensifying. Unchecked, the boat may go out of control and flip over or eject the occupants</u>. Chine-walking is controlled by small, properly timed, and continuous steering corrections, by trim correction, or both. It also helps to have a very tight steering system with minimal backlash.

The chine of a boat refers to the edge on each side of the hull where the bottom meets the hull sides. **When you hook a chine**, the chine dips down far enough to dig into the water, usually in a turn. This can cause the boat to suddenly turn more sharply than anticipated and/or roll up on its outside edge. <u>In severe cases, the boat can roll over and the operator and any passengers might be ejected.</u>

Porpoising is a continual rhythmic up and down motion of the boat's bow, not caused by wave action. Porpoising is usually associated with over trimming the engine (too far out), weight distribution (center of gravity too far aft) or hull bottom design.

When a boat which is on plane suddenly turns sharply, it **spins-out**, often reversing direction. This is usually caused by a forward

YEAR	CAUSE	VESSELS INVOLVED	FATALITIES
1994	**High Speed Maneuver**	**71**	**18**
	Speeding	**733**	**46**
1993	**High Speed Maneuver**	**69**	**9**
	Speeding	**536**	**27**
1992	**High Speed Maneuver**	**110**	**17**
	Speeding	**429**	**27**
1991	**High Speed Maneuver**	**73**	**32**
	Speeding	**206**	**35**

See related story on pages 4 and 5

area of the hull digging into the water and veering to one side allowing the aft end of the boat to rapidly pivot around the bow. Spinning out can be associated with starting an intended turn, then compounded by a bow steer situation, running bow down, hooking a chine, or even hooking an inside sponson of a true tunnel hull boat.

When a high speed boat is **squirrelly,** it has unpredictable running characteristics which may give the operator an uneasy feeling as to the handling and control at a specific speed, balance and trim setting. <u>This condition requires the boat operator's undivided attention at all times.</u>

When there is **steering backlash** there is play or lost motion in the steering system between the engine steering arm and the steering wheel. Minimization of steering backlash is always desirable, but particularly with high performance boats. Dual steering cables, correctly adjusted, used with outboards and single sterndrives, or hydraulic steering systems are excellent installations for minimizing backlash.

High performance V-bottom hulls often have a tendency to chine walk or rock from side to side at high speeds. As speeds increase there is less boat hull in the water, and with V-bottom hulls, the supporting surface becomes narrower. Depending upon the design of the boat and the load it is carrying, at some point the hull falls off to one side, the port side for example, and the aft end of the boat's chine on the port side strikes the water surface. Then, with a small steering correction by the boat operator, the boat will fall off to the chine on the opposite (starboard) side. This oscillating motion (chine-walking) will continue until the operator either slows down, or makes some other change to the trim of the boat, like lowering the outboard motor back in the water a small amount with the power trim switch or hydraulic jack plate. Several other factors can cause chine-walking, such as motor setup, propeller design, play in the steering system and soft or loose motor mounts.

While many slower runabouts can be equipped with single cable steering systems, high-speed bass boats and other performance craft must use a more precise dual-cable system. Dual-cable steering reduces the slop or "play" inherent in a single helm and cable merely by adding a second cable which is in tension against the other. Most engine manufacturers offer solid motor mounts through their high performance divisions.

Passengers usually have a disadvantage the operator doesn't have -- the operator knows when he or she is going to make a sharp turn -- passengers usually do not. Passengers who are moving about a boat, or who are improperly seated on the bow, a gunwale or a seatback, are ejected from the boat or fall overboard when boat operators are wake jumping, are in sharp turns or are performing other maneuvers at speeds which are dangerously fast for the prevailing conditions. Some victims are ejected from boats by collisions with another boat or a submerged or fixed object. Ejections from a boat are also caused by sudden acceleration or deceleration.

(continued on page 6)

DROWNINGS AS COMPARED TO OTHERFATALITY TYPES IN RECREATIONAL BOATING ACCIDENTS 1989 - 1994

YEAR	DROWNINGS	OTHER DEATHS	TOTAL
1994	613	171	784
1993	667	133	800
1992	673	143	816
1991	739	185	924
1990	707	178	865
1989	753	143	896

While preparing this article for the **Boating Safety Circular**, we contacted Mercury Marine engineer, Mr. Richard Snyder, a recognized expert on hydrodynamics, boat testing, and high performance boating and racing, and asked him a number of questions about the operational phenomenon called chine-walking. What follows are Mr. Snyder's answers to our questions:

What is chine walking?

Chine walking is a rhythmical roll from side to side (chine to chine) encountered usually at higher on-plane speeds on some V-bottom boats, more often when powered by a single outboard motor. It might be thought of as the lateral version of "porpoising" which is longitudinal, on-plane pitching or rhythmical bouncing (up and down bow motion) that can be encountered with many boat bottom designs.

What causes chine walking?

As any planing boat, but in particular a V-bottom boat, is powered to higher speeds, the boat is supported increasingly by the velocity pressure of the water touching the hull, and decreasingly by the static pressure of displacement. With a V-bottom boat, that means that the center portion of the bottom touching the water is becoming narrower. There will finally come a point where the boat will roll or fall to the side, away from its former balanced position. This imbalance can be initiated by a simple slight movement of the steering wheel when putting the boat, intentionally or not, into a slight turn.

Now comes the part not well known. Because the center of gravity of the outboard (or sterndrive) lies behind the steering (swivel or rudder) axis, the outboard will want to fall in the direction of the roll. This fall, due to gravity, will accentuate or magnify the roll since in a small way it's trying to make the boat turn slightly in that roll direction.

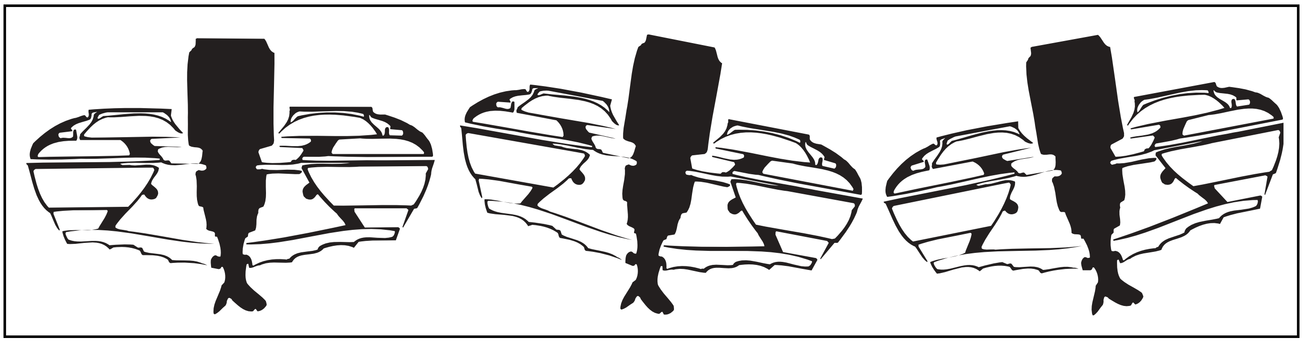
Because of the spring in the steering system and often some counter input to the steering wheel by the operator, the hull will bounce back over center to roll in the opposite direction. Then the outboard, due to gravity, flops back over center to the opposite side, thus accentuating the opposite roll. This action can continue to cycle and grow to a greater and greater magnitude if nothing different is done.

What does the operator feel when a boat is about to start chine-walking?

What the operator originally feels, usually, is a very mild, rather stable level of this cyclic roll if the operator does not increase speed, change boat trim, or put incorrect input into the steering wheel.

What can the operator do?

Plenty. The novice operator can reduce speed a little or trim the bow down a little. But what just about all faster V-bottom drivers quickly learn is how to make little rhythmical corrections to the steering wheel which can level the boat out immediately and permit the operator to safety continue to increase speed. This proper steering technique coupled with a simple search for the optimum engine trim, and thus boat trim, will allow the boat to be safely operated at its maximum speed, given the existing engine height, propeller and boat load.



But of course there is one major adjustment that can greatly help the chine walking situation. And that is taking all practical steps to remove the free play from the steering system. The usual first step, if it isn't present, is to install dual cable steering and correctly adjust out as much of the free play as possible. There are also relatively new hydraulic steering systems (both manual and power) that have addressed the free play problem very well.

On the lighter, faster boats the outboard motor (or sterndrive) installation height can be raised a little to reduce the amount of rudder in the water. As boat speed increases the most desirable size of rudder decreases and excessive rudder definitely adds to the likelihood or severity of chine walking.

Are certain types of boats or boats with various types of propulsion more susceptible to chine walking than others?

As discussed earlier, V-bottom boats possess the only bottom design where the boat can ultimately fall off a narrowing center strip of water contact. Although single outboards are the most common propulsor where chine walking is present, multiple outboards and single or multiple propulsors of other types are not exempt, if sufficient speed and steering free play is present.

Will power trim equipment or after-market equipment such as hydrofoils or trim tabs make a boat more susceptible to chine walking?

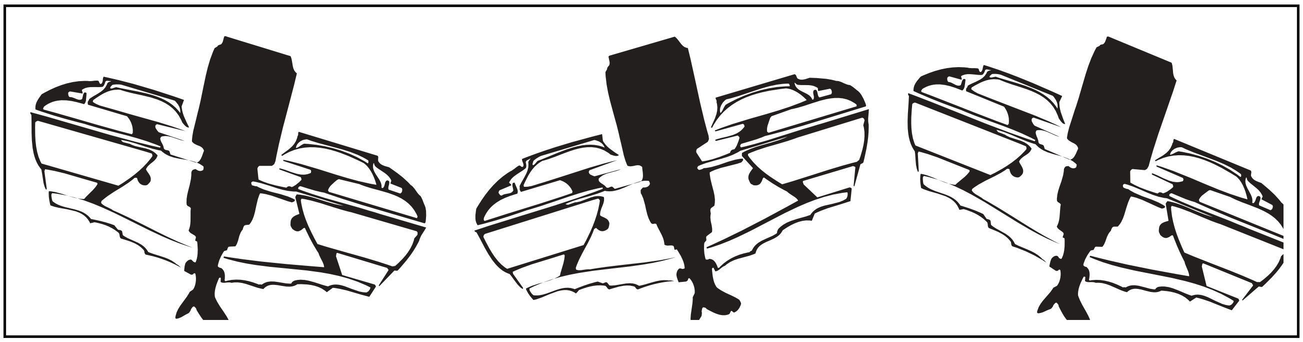
Power trim has long been an essential to achieving the most efficient, comfortable, even safest ride as the many recreational boating variables change. However, as an operator reaches for higher speeds, this is achieved by both throttle and hull attitude adjustments. Basic hull physics dictates that a boat bottom will run most efficiently (achieve the greatest lift to drag ratio) when the bottom is operating at a four to five degree angle to the water. Faster boats tend to run flatter than that. Thus power trim plays a major role in giving the operator a tool to trim the propulsor out thus lifting the bow.

Generally, add on "hydrofoils" are not considered to be much of a chine walking factor. However, at some trim settings, "hydrofoils" can cause some V-bottom boats to roll sharply over on one side creating a hazardous condition.

While the Coast Guard does not have sufficient accident statistics to justify a regulation requiring the use of kill switches, many engine manufacturers, including your company, offer them as optional equipment. Does Mercury Marine have any specific recommendations about the use or maintenance of kill switches or dead man throttles, e.g., foot throttles?

Kill switches ("lanyard operated ignition interruption switches" or more simply "lanyard stop switches") are contained in most manufacturers' control boxes and as a dash mounted accessory. We think that they are generally a good safety device to use. Although Mercury has made them a part of our control boxes for 17 years, operator usage is not very high.

Foot throttles are generally thought of as a plus for boat control in that, obviously, both hands are then available for steering control. However, foot throttles do create the possibility of shifting into gear with too much throttle (RPM), and have thus been involved in serious gearcase damage. Also, occasionally when coming down hard off of a wave, an operator's foot may inadvertently, though briefly, depress the foot throttle, giving the boat an unexpected burst of speed.



Among the materials in the appendices to the National Boating Safety Advisory Council (NBSAC) Report of the Propeller Guard Subcommittee is a pamphlet published by Mercury Marine titled "Hi-Performance Boat Operation," which contains a variety of important information which might be of intertest to our readers. Is the pamphlet still published, and how might interested individuals obtain a copy?

The Mercury pamphlet entitled "Hi-Performance Boat Operation" now in its 4th edition is, I believe, a useful teaching tool. I wrote this booklet originally in 1977 and have updated it on several occasions. It is included with every engine sold (outboard and sterndrive) by Mercury's High Performance Division. A copy can be purchased through Mercury, Mariner, Force and MerCruiser dealers. A copy can also be purchased from Mercury Marine in Fond du Lac, Wisconsin by writing to: Mercury Marine, Publications Department, P.O. Box 1939, Fond du Lac, Wisconsin 54936-1939. The current price is $0.40.

Coast Guard Approved Lifejackets:

In 1994, the Coast Guard received reports of 6,906 recreational boating accidents which resulted in 784 fatalities, 613 of which were drownings. Coast Guard Approved lifejackets could have saved the lives of at least 550 boaters who drowned in 1994, including approximately 30 children who were 12 years of age or younger. The primary causes of the accidents were operator inattention or carelessness and speeding.

During this year's National Safe Boating Campaign, the Coast Guard and other recreational boating safety organizations are urging all recreational boaters to wear their lifejackets, instead of simply storing them on board for the purposes of meeting minimum equipment carriage requirements.

Historically, the major obstacle to encouraging the recreational boating public to wear lifejackets while boating, was the fact that the currently Coast Guard approved, inherently buoyant lifejackets were too bulky and therefore uncomfortable. On March 28, 1996, the Coast Guard published a final rule in the Federal Register establishing structural and performance standards for inflatable lifejackets for recreational boaters, as well as the procedures for Coast Guard approval of inflatable lifejackets. The regulations in the final rule are intended to allow approval of lifejackets which may be more appealing to boaters, than currently approved, inherently buoyant lifejackets, thereby increasing the percentage of lifejackets actually used by the boating public and saving lives. Several manufacturers will have Coast Guard approved inflatable lifejackets on the market this summer.

Kill Switches

Emergency shut off switches otherwise known as kill switches have been in use on racing boats for many years. Several companies offer kill switches for sale to the public or as optional equipment. Kill switches can be attached or wired into most engine control systems which are equipped with remote electric starting.

Most kill switches have a lanyard with a snap or hook which is intended to be fastened to some part of the operator's clothing or lifejacket. If the operator falls overboard, or leaves the helm station without disconnecting the lanyard, it will turn off the ignition or open a special switch in the ignition circuit, thereby stopping the engine.

In general, it can be expected that a boat will come to a stop within 50 to 75 feet of an operator who goes overboard with the kill switch operating properly. In such a situation, some persons would still drown due to the lack of swimming ability (failure to wear a lifejacket) or injuries received while being ejected from the boat.

Although accident data does not support the need for a Federal regulation requiring the installation or use of kill switches, the Coast Guard recommends the use of such devices.

NEW FUEL TANK FILL AND VENT SYSTEMS REDUCE WATER POLLUTION

Several boat manufacturers are now using a single fitting which incorporates both the fuel fill and the fuel tank vent. If fuel comes out of the vent, it simply flows back down the fuel fill. Some boat owners have complained about overfilling tanks on boats equipped with new fuel fill fittings.

Because gasoline spilled into a boat can lead to a significant fire or explosion hazard, the Coast Guard Fuel System Standard in Subpart J of Part 183 requires manufacturers of boats with permanently installed gasoline engines (except outboards) to design fuel tank fill and vent systems so that if there is an overflow from the fill or the vent, gasoline doesn’t go into the boat. The American Boat and Yacht Council’s voluntary industry standard, H-24, has the same requirements, and they also apply to many outboard powered boats.

For many years the typical fuel tank fill and vent system has consisted of a fuel fill located somewhere on the deck or gunwale, and a vent fitting located on the topsides. When the tank is full, liquid fuel squirts out of the vent. Many boat owners look for overflow from the vent as an indication that the tank is full. However, some States have recently passed laws making fuel spills as small as these illegal, and the Environmental Protection Agency (EPA) is considering similar regulations.

Boat owners who have been using overeflow from the vent to determine when their tanks are full are contributing to water pollution and risk creating an explosive condition. Low cost after-market devices are available (such as an in-line whistle) which will indicate when a fuel tank is almost full.

There are obvious advantages for boat manufacturers who use the new fittings:

(1) one fitting, instead of two, reduces inventory and costs; and

(2) repairs are cheaper, because only one part needs to be replaced.

Owners and operators of boats equipped with the new combination fuel tank fill and vent fittings are reminded to be careful and to avoid overfilling the tank when they are refueling.

CONSUMER ADVISORY - DANGER OF EXPLOSION IF SEALED VALVE REGULATED (SVR) GEL CELL BATTERIES IMPROPERLY RECHARGED

The American Boat and Yacht Council (ABYC) Project Technical Committee for DC Electrical Systems recently informed the Coast Guard that an explosion can occur when gel cell batteries are recharged with battery chargers which are not **automatic temperature-sensing voltage-regulated chargers**.

According to East Penn, a manufacturer of gel cell batteries, SVR (Sealed Valve Regulated) batteries work on the "recombination principle." This means that the hydrogen that is normally produced on the negative plate in all lead-acid batteries, recombines with the oxygen produced on the positive plate to form H_20 or water. This water replaces the moisture in the gel.

The oxygen is trapped in the cell by special pressurized sealing vents. If an SVR gel cell battery is overcharged, the hydrogen and oxygen will be produced faster than they can recombine, and will be driven out of the sealing vents and lost to the atmosphere.

Hydrogen gas released by a battery is extremely flammable and requires only a source of igniton to set it off. Some explosions have occurred.

SVR gel cell batteries are advertised as "maintenance free" and as "sealed," which may lead boat owners to believe that gel cell batteries do not emit hydrogen gas during charging and are completely safe to put anywhere on a boat. These claims are true as long as the manufacturer's instructions for charging are carefully followed.

Automatic, temperature-sensing, voltage-regulating battery chargers must be used. Charge voltage must be limited to 13.8 to 14.1 volts maximum. Constant voltage chargers must never be used.

In addition to the explosion dangers associated with recharging with the wrong equipment, overcharging or undercharging an SVR gel cell battery also reduces performance and battery life. Before using and recharging gel cell batteries boat owners should read the instructions, or contact the manufacturer, to be sure they have the correct type of battery charger, and are recharging it in accordance with the manufacturer's specifications.