IOWA

IIHR—Hydroscience and Engineering

Boat Safety Guidelines

River and lake research for hydrologists, geologists, biologists, and other scientists often involves the use of boats under a variety of conditions. Working on a floating platform can present unusual problems compared to other work environments. The safety of all personnel working with and around boats is of primary importance. The contents of this document pertain to work by IIHR and LACMRERS personnel and their use of boats and floating platforms for river and lake work activities. During all boat-based work, UI personnel must comply with the requirements outlined in this document and policies set forth by the U.S. Coast Guard (USCG) and the state of Iowa.

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INTRODUCTION

Information supporting the contents of this document as it relates to IIHR—Hydroscience and Engineering (IIHR) and LACMRERS work incorporating boats is taken from several sources. Among these are training publications by the U.S. Coast Guard (USCG) and Power Squadrons, the Department of the Interior motorboat safety course, and the Iowa Department of Natural Resources (IDNR) guide to responsible boating. The present document is compiled for IIHR and LACMRERS personnel and is not meant to be comprehensive, but rather a concise primer to highlight key and critical information for those who work on the water using boats, either on a routine or occasional basis. If questions arise, safe boating rules established by U.S. Coast Guard and Iowa Department of Natural Resources are the final determination.

Before going out on a boat, IIHR and LACMRERS personnel are required to read the boat safety guidelines and to file a fieldwork plan. A responsible party must be told where you are going and when you are expected back, so they can take action if you fail to return on time. The fieldwork plan may be completed on the IIHR website.

Purpose:

The purpose of this document is to identify and specify minimum requirements for the safe operation of IIHR and LACMRERS boats; these requirements are often unique to scientific research. In addition, this document provides requirements for the training and certification of boat operators for IIHR and LACMRERS.

Boat Stability, Motors, and Safety Equipment

Boat Stability

The stability of a boat depends first and foremost on load and the static and dynamic stability of the hull design configuration. Static stability is the ability of the hull to return to its original waterline position after being disturbed while the vessel is floating at rest in calm water. The geometric center of the total weight of the vessel (center of gravity) is typically positioned in line with and above the geometric center of the underwater volume (U.S. Power Squadron [USPS] 1991). Static stability can be maintained if the vessel is loaded within the recommended limits and trimmed to float evenly on its waterline. Dynamic stability is the ability of the vessel to return to its original waterline position while underway and subjected to the external forces of wind and waves (USPS, 1991). Load and trim can be varied to enhance or degrade the dynamic stability. The external configuration of the hull design acting on the water it passes through provides a constant effect relative to the dynamic stability. In some cases, dynamic stability can be improved by changing speed or engine trim to vary the hull's angle of attack.

In all cases, the ultimate stability of the vessel is to right itself under extreme conditions. In small watercraft typical of IIHR and LACMRERS work, personnel should keep in mind that the ultimate stability may be a only a few inches of freeboard for any given hull design. Load, trim, and placement of onboard equipment can greatly reduce the ultimate stability of the vessel. Sudden movements of personnel and equipment should be avoided.

In general, a catamaran (commonly known as a pontoon boat) provides a stable work platform on the water. The pontoon boat has two side-by-side parallel hulls with a raised deck structure bridging the space between them. The pontoon's advantage is its high degree of transverse stability and its adaptability as a good work platform. Operators should be aware that pontoons have the disadvantage of being more easily grounded in shallow water and are often harder to extract from shallow water sandbars when compared to tunnel hull or "vee" hull designs

Load Capacity

On boats built since 1978, the capacity plate indicates the maximum combined load of passengers, motor, and gear for which it is certified. The maximum number of passengers that should be aboard is shown separately. In the case of older boats in which no capacity plate is present, a good estimate of the maximum number of people allowed can be made using the USPS formula (United States Power Squadrons, 2004): the passenger load accounts for about half of the maximum combined load. To approximate the maximum combined load, multiply the number of passengers from the formula by 150 pounds, and double the product. Remember to avoid exceeding the maximum combined load, the sum of the actual weights of individual passengers, motor, fuel, and gear when loading the boat.

Equipment

Cranes and booms that may be used in IIHR and LACMRERS applications can raise the center of gravity and may reduce the initial and ultimate stability. Therefore, careful consideration must be given to placement of on-board equipment used to control any equipment suspended overboard. Class A (less than 16 feet in length) and class 1 (16 to 26 feet in length) watercraft should have equipment mounted over the bow or over the side. Equipment should never be mounted or used over the stern on class A or class 1 watercraft. An additional configuration is possible if a "well" is constructed on the centerline of a catamaran or pontoon boat to allow equipment to be raised and lowered through the middle of the boat.

Typically, the deployment of equipment over the bow is the most desirable equipment position as this does not disrupt the transverse stability of the watercraft. This allows the operator to maintain the highest degree of control while working with overboard equipment. If the overboard equipment is hit by debris or becomes lodged in the streambed, the operator has the best chance to maintain a neutral position with the bow into the flow. This places the vessel and crew in a safe position while attempts are made to clear or retrieve the fouled equipment, or the cable is cut to escape the danger.

However, in some cases hull configuration or boat space dictates that equipment be suspended over the side of the boat. This is the second best overboard deployment position. Equipment placed over the side has a greater potential to affect the transverse stability of the watercraft, particularly toward the side where it is suspended. In this case, permanently mounted crane and boom assemblies must be forward of the beam (middle of the hull) and on the centerline or near it to protect transverse stability. For wide hulls, the crane and boom assembly will necessarily be mounted toward one side or the other. However, this may limit some of the positive stability characteristics gained with the wider hull. Handling of the boat with equipment over the side can be adversely affected by drag toward the equipment side, which degrades directional control and tends to make the boat ferry off course in that direction. If over-the-side equipment is hit by debris or equipment becomes lodged in the streambed, the operator must carefully balance steering and throttle to maintain control of the watercraft as the material is dislodged.

In an extreme case, the best course of action is for the crane operator to immediately cut or release the sounding cable to free the boat and crew from harm.

Motors

The horsepower or thrust rating of the propulsion system must never exceed the recommended maximum engine size indicated on the boat's capacity plate. Exceeding the maximum rated engine size could result in poor handling because of excess weight in the stern, rapid uncontrollable acceleration, or damage to the boat. At the very least, it can threaten the safety of the crew and others operating in close proximity on the same waterway. On the other hand, an inadequate sized engine also can compromise safety and maneuverability. Engine horsepower or thrust must be adequate to drive the boat on a smooth and even plane and should be sized according to manufacturer specifications. This is essential, and in some flow conditions, it could be as critical to the safety of the crew as overpowering the boat. Most "planing hulls" are designed to plane at approximately 12 miles per hour (USPS, 89). Therefore, the engine size should be adequate to propel the boat to this speed under normal load conditions. A smaller secondary motor or "kicker motor" is required of IIHR boats in the event the main motor fails. In particular, when working in swift current or upstream of bridges, piers, or snags during high flow conditions, the secondary motor should be operational in the event immediate backup power is needed. Otherwise, delaying the work for more favorable conditions is the best course of action for the safety of crew and craft.

Safety Equipment

Certain safety equipment is required onboard any time a boat is underway. This equipment list is relatively consistent for all classes of boats and will be required for all IIHR boats more than 16 feet in length (Class 1 boats). A permanent checklist of all USCG-required equipment for that vessel class should be mounted on each IIHR boat. This provides a quick reference and allows the operator and crew to board the boat and accurately inventory equipment to ensure that USCG regulations are met prior to leaving the dock.

Personal flotation devices (PFD)	Marine radio
Weather radio	Dewatering device and backup
Oars	Wire/cable cutter
Anchor and line	Fire extinguishers
Navigation lights	Navigation rules
State/local requirements	Registration/documentation
Flashlights/marine lantern	Proper display of numbers
Visual distress signals (VDS)	Sound producing device
Overall vessel condition	

Personal Flotation Device

Each person on the boat is required to wear a personal flotation device (PFD) (Type I, II, III, or IV) that is USCG-approved. In addition, one throwable PFD (Type IV) is required to be carried in the boat. In addition, carrying one or two extra PFDs onboard is generally a good standard practice in the event a crew member forgets to bring a PFD or a visitor is authorized to be onboard.

Fire Extinguishers

The USCG requires Type B onboard extinguishers that are capable of extinguishing fires involving flammable liquids such as gasoline, kerosene, diesel fuel, oil, or grease. The size or minimum weight of the extinguishing agent and the number of extinguishers required varies for vessels more than 26 feet in size. However, all Class A (less than 16 feet) and Class 1 (16 to 26 feet) watercraft (which include all IIHR and LACMRERS boats) are required to have a single type B, size I, extinguisher onboard. Replacement of the required type B, size I, with a type B, size II, or two type B, size Is, would significantly increase the chances of extinguishing an onboard fire to maintain the safety of crew and vessel. Operator certification and basic boat safety training will include a demonstration (and if possible, hands-on practice) of firefighting procedures using portable extinguishers. Careful consideration should be given to the onboard location of extinguishers to ensure they are easily accessible and away from the most probable source of fire.

BOATING CERTIFICATION AND FLOAT PLANS

The use of boats in IIHR and LACMRERS research requires a boat operator who has successfully passed a boating certification class. Two classes are available to meet this requirement: 1) the United States Power Squadron Boating Course; or 2) the Iowa Department of Natural Resources Course on Safe Boating. Boat operators must be certified to operate the boats. In addition, a new boat operator who has passed the course will need to have four hours of boating time under the supervision of a more experienced boat operator to make sure that the new operator can safely perform all necessary boating skills.

Before going out on a boat, IIHR and LACMRERS personnel must file a float plan. A responsible party needs to know where you are going and when you are expected back, so he or she can take action if you fail to return on time. The float plan can be a web-based or paper form that will be left with a responsible party at IIHR or LACMRERS. The float plan form includes the following information:

- Description of the vessel, including its registration number, length, make, horsepower, and engine type;
- Description and license plate of the tow vehicle and trailer;
- The number of passengers, their names, addresses, and a contact in case of emergency;
- Where you are going, the detailed route, and your expected return time;
- The location of all stopping points, dates, and times, if possible; and
- Contact numbers for the U.S. Coast Guard and local authorities in case you fail to return.

Several float plan forms are available. All require the name and contact information for people on the boat (including those who may be boarding later) and trip expectations (departure and return times). The most critical part of the float plan is communication with a responsible person who can be the point of contact if an accident or delay occurs.

BOAT WORK SAFETY

Docking

Among the many maneuvering techniques necessary to safely handle a boat while performing work duties are the steps required for docking. Coming into a dock too fast or at the wrong angle in a current can be dangerous to those in the boat and others nearby. Each docking situation is slightly different, but for all IIHR boats (which are less than 26 feet long), the following procedure is given:

Docking Procedure

Slowly approach the dock at about a 45-degree angle with fenders over the side next to the dock.

- The boat should stop parallel to and about an arm's length from the dock.
- Aim the bow just ahead of the center of the space to be occupied at the dock.
- Approach with the bow into the current and wind if possible.
- Place the engine in neutral when the boat is about two or three boat lengths from the dock.
- Allow the momentum of the boat to carry it close to the dock.
- At about one-half boat length from the dock, begin to gently steer the bow away from the dock using the lower end of the outboard or outdrive as a rudder.
- As the boat slows, its response to steering will diminish. Briefly place the engine in forward and return to neutral to keep the boat moving slowly so it will respond to steering commands as needed.
- As the bow falls away from the dock and the stern begins to slide in, turn the wheel hard toward the dock and momentarily shift the engine into reverse and then back to neutral at idle speed to stop the boat's forward movement.
- Secure bow and stern lines to the dock.

Undocking Procedure

Untie and stow the bow and stern lines to ensure that they don't foul the propulsion system.

- Steer hard into the dock and briefly place the engine in forward and back to neutral to move the stern away from the dock. (Note: The stern is always the first part of a boat to move in reaction to the controls.)
- Steer hard away from the dock, place the engine in reverse, and slowly back clear.
- Once clear of the dock and other boats, place the engine in neutral and steer in the desired direction.
- Place the engine in forward and slowly motor away until well clear and in the channel where the boat can be brought onto plane. (Note: Remember, the operator is always responsible for any damage caused by the wake thrown from the boat.)

Fueling

Taking on fuel for a boat can be a hazardous part of boat operation; it is a procedure that must be taken seriously to ensure the safety of those involved. Fuel containers and fuel lines should be inspected for wear and leaks. Exposure to the outdoor elements may dry and crack rubber fuel lines over time.

When taking on fuel at a fuel dock, slowly come alongside the dock and securely tie up. Shut down all engines and electrical instrumentation. Do not smoke. If portable tanks can be easily disconnected from their fuel lines, then move the tanks to the fuel dock to be filled. Boat operators and crew need to make sure they know the fuel requirements of their boat motors (two-cycle or four-cycle engines). Carefully monitor the level of fuel in the tanks, leaving room for the correct volume of two-cycle oil to be added (if required). Make sure that the two-cycle engines are equipped with oil injection systems; fill the oil reservoirs to the correct level, taking care to avoid overfilling.

Note: **Four-cycle (or four-stroke) engines do not require oil to be mixed with the gas**. After filling and adding oil carefully, wipe down the outside of the fuel tanks and dispose of the oily rags in the proper place on the fuel dock. Place the fuel tanks back on the boat, reconnect the fuel lines, and pump up the primer bulbs to deliver fuel to the engines. Open all hatches for ventilation, start the engines, untie dock lines, stow them, and carefully maneuver away from the dock. When fueling a boat equipped with permanent tanks, carefully fill the tanks while holding a rag or absorbent material under the vent. When the tank is full, replace the cap on the filler tube and clean up any spilled fuel and oil. Dispose of oily rags on the fuel dock. Untie the dock lines, stow them, and carefully maneuver away from the dock.

Anchoring

Anchoring the boat may be necessary for certain IIHR work activities, such as coring and sampling bottom sediment, placing sensors, and water-quality sampling. The boat operator should ensure that the anchor and associated tackle are kept onboard when they are needed. The appropriate tackle must include an anchor of sufficient size and design to hold the watercraft in the bottom conditions present in the waterways commonly frequented, a length of anchor chain at least equal to the length of the boat to be anchored, and nylon anchor line of sufficient length the equal to three to five times the water depth commonly encountered. In addition, when working in shallow water (less than five feet deep) the use of a “spud pole” attached to the boat that is driven into the bottom sediment can help stabilize the boat during working conditions. In general, during bottom sediment coring operations, the boat (typically a pontoon boat) will need to use a two- or three-point anchoring system for maximum stability.

Sampling

Suspended sediment and water-quality sampling may require heavy samplers suspended overboard and moved through the entire depth of flow. This equipment could become entangled with objects or the streambed. Either of these situations demands careful attention on the part of both the boat operator and the sampling crew and should be avoided if possible. In the event the overboard equipment is fouled, the boat crew must work as a team to free the equipment or cut it free to save the boat and crew.

Sampling for bedload and bed material presents other safety concerns. Bedload sampling from a boat is least hazardous when the boat is moved into the desired sampling location prior to placing the sampler in the flow. Once the sampler is lowered into the flow, it should be placed on the bottom as quickly as possible. The boat operator should then hover above the sampler’s position for the desired sampling period. When the sampling period is complete, the sampling crew should quickly snatch the sampler off of the bottom and raise it through the water column as the boat operator allows the boat to drift to minimize the drag on the sampler in transit.

Bed material sampling is another matter. Physically scooping, dredging, or coring material from the streambed puts stress on the watercraft. Caution must be exercised on the part of the boat operator and sampling crew to avoid exceeding the design limits of the boat. The safest technique for dredging or scooping a bed material sample from a small boat in moving water is to lower the sampling equipment from the bow to the streambed while keeping the bow upstream. To dredge a sample, let the boat drift or slowly power downstream in reverse dragging the dredge along the bottom. Then quickly lift the sample and sampler to the surface. In the case of a scoop-type sampler, lower it until it firmly impacts the streambed, then immediately retrieve the sampler and sample after the impact triggers the spring-loaded scoop. Bed material coring should be done from a pontoon boat or large stable platform. Except in the case of coring devices that only penetrate the streambed to depths of several inches, highly buoyant floating platforms are necessary to work against the suction forces to break the coring unit free of the bottom for retrieval.

Geophysical and Discharge Measurements

Generally, waterborne geophysical or discharge measurements involve remote-sensing techniques that look through the water column in some manner. Equipment is placed onboard with only the various transducers exposed to the potential hazards overboard. Overboard configurations may include equipment along the side the boat, or in the case of some geophysical equipment, towed arrays at the surface, at some depth in the flow, or even in contact with the streambed.

Discharge measurements with IIHR boats using Acoustic Doppler Current Profiler (ADCP) measurements are by far the safest. The only overboard equipment is the transducer protruding into the flow to a depth slightly below the lever of the hull. This minimizes its exposure to debris entrained in the flow and greatly reduces the likelihood of safety problems. Geophysical towed arrays would require a higher level of safety awareness for the boat and crew. Geophysical equipment towed at some distance behind a boat can be affected by currents at its location, and a careful and attentive boat operation is needed to minimize fouling on fixed obstructions. Arrays at intermediate depths or in contact with the streambed are at higher risk of fouling because the boat operator has a more difficult time of knowing what the conditions are at the transducer locations.

POTENTIAL SAFETY HAZARDS

Many potential safety hazards can affect boat operation. Three main conditions often encountered while operating a boat will be discussed: weather, flow conditions, and structures in the water. A critical part of the boat safety plan is a well-informed boat operator and crew who understand these potential hazards and plan ahead.

Weather

Slight changes in weather conditions can adversely affect a body of water in a relatively short time period. If a boat and crew are in an exposed position, this change could seriously jeopardize their safety. A boat operator should understand the weather patterns typical of the area where work is to be done and be able to identify rapidly approaching frontal systems that could place the boat and crew in danger.

Wind

Heavy wind is one of the greatest hazards to a small boat on a large body of water. Wind can quickly whip the water surface into a severe chop with breaking white-capped waves. The greater the fetch (upwind distance over water) from the boat's position, the worse the wind-driven surface waves can be. If the boat is located in a shallow area downwind from deeper water, the height of the wind-driven waves can be expected to increase dramatically as they enter the shallows. Wind blowing in opposition to the direction of flow can create large swells and threaten the safety of boat and crew. A boat operator must carefully assess wind conditions in the area upon arrival and determine if a significant hazard exists — one that could be avoided on a calmer day. A rule-of-thumb for estimating wind speed is to look for white caps, which generally begin to appear at wind speeds approaching 20 miles per hour over calm water. If possible, working with the bow into the wind is the safest position for the boat in windy conditions. However, working in a river requires that the bow be held against the direction of flow. If the wind opposes the current, this could place the boat and crew in jeopardy, as the steep wind-driven swell will impact the boat's stern. This situation could potentially swamp the boat if the waves steepen and begin to break over the transom.

Rain

Aside from personal discomfort, light rain does not present an extreme hazard to crews in small boats. However, heavy rain over long durations can constitute a significant hazard if allowed to accumulate in the bottom of the boat. If the boat is transporting a load near maximum for its hull configuration, the weight of accumulated rainwater could adversely affect stability or significantly reduce freeboard (distance from the waterline to the gunwale). Either of these could result in swamping or capsizing.

In addition, lightning storms are common in some locations and must be considered a serious threat to the safety of boat and crew. Again, it is the operator's responsibility to assess the severity of the situation and react to protect the safety of the boat and crew. This action could be nothing more than pumping the excess rain water overboard on a periodic basis, or it may require that the work effort be temporarily aborted until the rain or lightning dissipates to a non-threatening level.

Heat and Cold

Weather extremes range from hot temperatures and sun exposure to cold temperatures and freezing conditions. Most often, small work boats do not provide protection from the elements. Working in the middle of a body of water almost always means complete exposure to the existing weather extremes. The hazards here may be health risks, as well as some potential for physical injury. In the case of extreme heat and sun exposure, the crew should always carry drinking water to help minimize the potential for dehydration. Some form of protection from the sun is essential and will aid in reducing the potential for dehydration, in addition to minimizing the harmful effects of ultraviolet rays on human skin. Extreme heat combined with high wind can increase the rate of dehydration.

Extreme cold and freezing conditions can be more hazardous than heat. In addition to the more obvious concerns about hypothermia, dehydration is still a potential problem. Protective clothing is essential to minimize the effects of hypothermia. An accidental fall overboard could prove fatal if the victim is not properly clothed. Water robs the body of heat *25* times faster than air, so the immediate problem is rescuing the overboard victim. Remember the **50/50 rule** (i.e., an unprotected overboard victim in water less than or equal to *50* degrees Fahrenheit has a *50* percent chance of surviving for *50* minutes). In addition to these potential health risks, a boat operator working in extreme cold and freezing conditions must watch for ice build-up on the boat's hull. Even though ice floats, its mass above the waterline adds to the weight of the boat and its load. If ice is allowed to accumulate above the waterline as a result of splash from the wake or spray from wind-blown waves, the boat can become overloaded and settle in the water to a point where an otherwise insignificant volume of water could swamp and sink the boat.

Restricted Visibility

The most common cause of restricted visibility is fog. Heavy rain and snow, or in some areas, blowing dust, can reduce visibility in the extreme as well. Being caught out on the river after dark can compromise safety. Operation during periods of extreme restricted visibility is not advised, particularly in areas frequented by large commercial vessel traffic. When operation is essential during periods of restricted visibility, standard navigation lights must be displayed. Also, proper horn or bell signals should be given as required by inland or international navigation rules for the size of vessel underway or anchored during periods of restricted visibility.

Flow Conditions

Even though it is never good to become complacent when operating a boat, there are flow conditions with which an operator may feel comfortable. Generally, this comfort zone exists when an operator is in an area frequently visited and the flow conditions are those normally experienced. However, extreme flow conditions diverging from the norm can change a familiar area altogether.

Low Flow Conditions

Operation may be hampered by extreme shallows and obstructions along the bottom. In particular, wing dams common along the Mississippi River shoreline may be only a few feet from the surface of the water. Successfully traversing an area may require the use of a boat equipped with high trim. If the lower end of an outboard shaft strikes the bottom or some submerged object abnormally close to the surface, the boat may run aground and sustain damage. A slow safe speed while looking for obstructions is needed.

High Flow Conditions

These conditions may include water spilling onto the floodplain, high flow velocity and turbulence, and/or unusually heavy debris loads in transport. The debris is normally entrained in the flow when it is picked up from the stream banks or scoured from the streambed, as the water surface elevation (stage) and flow velocity increase. Operation under these conditions requires concentration and skillful boat handling. Also, care must be exercised if it becomes necessary to traverse areas along the stream banks, where objects normally exposed at lower stages may become dangerous submerged obstructions.

Fast Water

Fast water may be associated with seasonal high flows or flooding. Some streams are characterized by high flow velocities and debris. Operating a motorized boat in fast water conditions requires an understanding of the hydraulics associated with flow around in-channel obstructions and an ability to recognize problem areas. Often this is known as “reading the river.” The object is to identify the clearest path so the boat can be kept in the safest position while traversing through pool and riffle sequences typical of most river reaches. Experience is the best teacher here, but on-the-job training pairing an experienced operator with a less-experienced operator, or advanced-level operator training, can improve fast-water operator proficiency. Also, repetitive operation in the same streams allows an operator to develop the local knowledge necessary to expand his/her comfort zone.

In general, white water at the surface is an indicator of some submerged condition. A continuous white-water trace remaining in one area nearly always indicates a fixed submerged object (i.e., rock, log, etc.). When white water appears to be intermittent at the surface or shifts slightly in relation to a point in the flow, it is most likely the result of some hydraulic action associated with the configuration of the streambed (i.e., standing waves, etc.). Nearly every stream has some specific flow characteristic associated with the existing white-water reaches. These are generally tied to geomorphic conditions in the channel that may range from large rocks disbursed on the streambed, to rock ledges protruding into the flow below the surface, to sand and/or gravel bars. Flows around stationary rocks and ledges are relatively consistent for any given stage. Once local knowledge is acquired in these flows, an operator can traverse familiar river reaches with a high level of confidence.

Acquiring local knowledge in flows controlled by sand and gravel bars is more difficult. In this case, the channel may migrate in response to geomorphic changes as the bed material is scoured and redeposited with changes in the stage and flow velocity.

Structures

Fixed structures, including bridges and dams, are of particular concern to operators and crews working from boats. As mentioned earlier, the wing dams commonly used along the shoreline of the Mississippi River for channel stabilization may be only a few feet below the water surface. Boat operators should always familiarize themselves with any in-channel structure that could ultimately threaten the safety of their vessel and crew. Charts or maps of an area can provide valuable information related to the size and location of a structure across the channel. Regulatory agencies such as the state Department of Transportation, U.S. Army Corps of Engineers, Bureau of Reclamation, etc., can generally provide more detailed local information.

Bridges

Bridges can be a major hazard to the boating public by restricting overhead clearance, generating extreme turbulence in the vicinity of bridge piers in the flow, or trapping debris and reducing the space available between piers. During high stages, overhead clearance may be minimal for the passage of river traffic.

If work must be done downstream of a bridge, one of two courses of action are necessary to protect the safety of vessel and crew: 1) find an alternate launch location below the bridge; or 2) call the bridge tender and request an opening of the lift or swing span, if so equipped. In general, try to avoid working from a boat in close proximity to and upstream of an excessively submerged bridge structure. The following list of actions will help to ensure the safety of the vessel and crew when working in the vicinity of bridges:

- If it is necessary to work from a boat upstream from a bridge during high flow or anytime the structure presents a threat to safety, two sources of power (main engine plus auxiliary or twin engines) should be onboard and running in the event the backup is needed immediately.
- Always carry an anchor of adequate size and design securely attached to a length of chain equal to one boat length. A length of nylon line equal to three to five times the anticipated depth should also be carried to stop the vessel and hold it against the flow. This equipment must be ready to deploy in an instant, with the end of the line attached to the boat.
- Cutting devices adequate to clear any line that becomes fouled on the boat and threatens its safety must be at the ready. These should include, but are not limited to, garden loppers, bolt cutters, cable shears, and a hatchet or machete.
- Avoid working in close proximity to bridge piers if possible. If it is necessary to work close to a bridge pier, approach the pier in the tail-wake from downstream, keeping a sharp lookout for debris caught on the pier. Carefully work along the side of the pier and inside the wake or eddy line generated by its upstream face.

- Never put the boat across the upstream face of the pier where it could become trapped by the force of the current.
- If the pier structure includes a web wall between an upstream and downstream pier, the operator must carefully assess the turbulence and potential suction created by flow being forced under the web wall before committing the vessel and crew to this potentially dangerous situation alongside the pier.
- If the flow strikes at an angle other than parallel to the pier, carefully approach from the tail-wake side while watching for debris.
- Always hold the stern of the boat away from the pier during the approach to maintain steerage. When leaving, move the stern away and back clear, as when leaving a dock.

Dams

Dams impounding the flow are another source of hazards for boats operating in their vicinity. Dams are generally of two types, which present different hazards to boat operators and crews.

The first to consider is the large structure tens or possibly hundreds of feet high that impounds a large reservoir for the purpose of power generation and/or flood control. These structures may have a lock channel to allow passage of vessels from one pool level to the next in the upstream or downstream direction. Boat operation in the vicinity of these large structures should be limited to the approaches to the navigation lock. Operation near any intake structure or in the tail race channel should be avoided, as flow volumes, stream velocities, river stages, and associated turbulence can change unexpectedly.

As an example, a small boat can be easily swamped or capsized by an unexpected wave surging from the outflow as the gates are reset to increase power generation, or when flows are increased to pass storm runoff.

Low-Head Dams

These structures are a special category and may constitute one of the most dangerous man-made obstruction a boat operator may encounter. Most low-head dams span the entire width of the channel, usually to pool the flow for diversion into an irrigation system or for some other purpose requiring a low hydraulic head as the driving force. Water passing over the face of these structures appears as a smooth even flow across the entire stream width, usually falling 10 feet or less.

To the uninitiated, there doesn’t seem to be any hazard, because the flow appears to be benign and almost tranquil. The danger here is real and extreme. The plunging water creates a turbulent zone of reverse current (a hydraulic) at the downstream base of the dam. A boat can be drawn into the falling water and easily swamped. The tumbling action will then roll the boat over, submerge it, and push it away from the dam below the surface only to pull it and its occupants back into the falling water as they reach the surface. This continuous action can easily trap the boat and crew at the face of the dam with no hope of escape. **Working above, below, or in close proximity to a low-head dam should be avoided.**

Important safety points to remember for low-head dams:

- If it is essential to work well above a low-head dam, always use a boat equipped with a second source of power (main engine with auxiliary, or twin engines) and have both running in the event the backup is needed in an emergency.
- Always carry an anchor of adequate size and design securely attached to a length of chain equal to the length of the boat as well as a length of nylon line equal to three to five times the anticipated depth to stop the vessel and hold it against the flow. This equipment must be ready to deploy in an instant, with the end of the line attached to the boat.

- Cutting devices adequate to clear any line that becomes fouled on the boat and threatens its safety must be at the ready. These should include, but are not limited to, garden loppers, bolt cutters, cable shears, and a hatchet or machete.
- Never approach the face of a low-head dam from downstream. The hydraulic eddy current can extend many feet from the face of the dam and can pull the boat into the dam.

BOAT TRAILER SAFETY

IIHR and LACMRERS boat operators often use trailers to transport watercraft to a point of water access near the potential work site. All IIHR and LACMRERS personnel who operate boats must show a level of proficiency in handling a tow vehicle and boat trailer as part of their certification training. This should not be interpreted as an indication that all boat operators have highly-developed trailer skills, however. This brief discussion is taken largely from Unites States Power Squadron educational literature (2004) and provides information essential to developing and maintaining safe trailer practices. Improved trailer handling skills will develop over time with additional practical experience.

Trailer Towing

When towing any trailer, the driver should take several things into consideration:

- Always start in low gear and accelerate smoothly through the gears to the posted speed.
- Observe speed limits. In some states, speed limits for vehicles towing trailers are lower than for vehicles not towing.
- Maintain a greater following distance. With a trailer in tow, stopping distance is greatly increased over that of the tow vehicle alone.
- During cornering, the trailer tracks through a smaller radius circle than the tow vehicle, so turns must be wider.
- At highway speeds, cross wind and turbulence from large passing vehicles may cause the trailer to fishtail out of track with the tow vehicle. Maintaining a firm grip on the wheel, the driver should relax and avoid over-correction while easing off the power slightly. Do not brake hard under these circumstances.
- The driver should always think ahead to avoid getting boxed in when towing a trailer in a congested area. This will reduce the possibility of driving into trouble and can minimize the need to perform difficult backing maneuvers to get out of tight places. If possible, a spotter should always be used to help direct the driver during trailer maneuvering unless the area is open and clear of obstructions.

Towing Vehicle

Any vehicle to be used for trailer towing must be of adequate size and load capacity to accommodate the added strain that will be placed on the suspension and drive train. A vehicle can be obtained from the manufacturer with a towing package in place, or these items can be added to improve the towing capabilities. Vehicles equipped for towing usually have a nonslip differential, a heavy-duty cooling system, a heavy-duty transmission, a transmission cooler, an increased fuel capacity, a larger and more powerful engine, a heavy-duty suspension, a heavy-duty brake system, a heavy-duty flasher unit, an oversized battery, special wiring, a special rear-axle gear ratio, and larger tires and wheels.

Trailer Hitch

The trailer hitch installed on any towing vehicle must be of adequate load rating to accommodate the trailer load in tow. The IIHR and LACMRERS towing vehicles use a frame hitch or weight-distributing hitch to ensure the safest towing system under all possible conditions. A bumper towing hitch is never to be used. The key point of contact between any tow vehicle and trailer is the hitch ball, which slips into the socket of the coupling on the trailer tongue. This coupling allows for free suspension movement and turning between the tow vehicle and trailer, while providing a secure attachment. Three hitch ball sizes are available for use: Class I is 1-7/8-inch diameter for loads up to 2,000 pounds; Class II is 2-inch diameter for loads up to 3,500 pounds; and Class III is 2-5/16-inch diameter for loads up to 10,000 pounds. When selecting a hitch ball for use, consideration must be given to the shank diameter used to attach the ball to the tow bar. Some two-inch hitch balls come with 3/4-inch shanks like the 1-7/8-inch hitch balls. These should not be used for loads exceeding 2,000 pounds. Otherwise, the load limit for any given hitch ball or hitch tow bar manufactured since 1973 should be stamped on it.

Lights

A plug receiver must be tapped into the existing wiring harness on the tow vehicle. This will provide a connecting point for energizing the signal, stop, and taillights required on the trailer. A heavy-duty flasher unit should replace the original unit in the tow vehicle to slow the signal flash rate enough to allow identification as directional or emergency signal by other drivers.

Boat Trailer

A boat trailer is a specialized vehicle designed for the sole purpose of transporting a boat from location to location behind a tow vehicle. Trailers should be constructed to provide adequate support to the bow, keel, hull, and transom. Rollers and padded bolsters or bunks are the two types of hull supports used on boat trailers. Rollers facilitate ease of loading and launching, but must be carefully positioned to provide adequate support to the hull. Bolsters or bunks provide maximum support, but loading and launching may be more difficult. Boat trailers have little in the way of flexible suspension, resulting in the constant road vibration transmitted through the trailer to the boat. To properly maintain a boat trailer, all structural members secured with bolts or screws should be tightened at least once a year. Other regular maintenance checks include verifying tire pressure, ensuring that the winch is free and working properly, tightening the wheel lugs, and packing the wheel bearings with a marine grade wheel bearing grease. Installation of bearing buddies helps facilitate wheel bearing lubrication without having to dismantle the bearing assembly for packing.

Load Rating

Trailers are divided into four load rating classes based on total weight of the trailer and its load. These classes and maximum gross weights are: Class I to 2,000 pounds; Class II to 3,500 pounds; Class III to 5,000 pounds; and Class IV to greater than 5,000 pounds. The load capacity of a trailer is displayed on the capacity plate as required by federal law.

Lights

All states require trailers to have signal lights, stop lights, and taillights. Trailer-light wiring harnesses are standardized throughout the industry as follows:

- WHITE wire as ground

- BROWN as tail
- GREEN as right turn
- YELLOW as left turn

Therefore, if the tow vehicle wiring does not match the trailer, it is advised that either a pigtail adapter be constructed or the wiring changed at the plug on the tow vehicle. Light fixtures vary, but the best configuration is one that traps air as it is submerged. This will minimize light bulb loss as a result of hot bulbs breaking on contact with cold water. To avoid breaking light bulbs, some operators disconnect the lights from the tow vehicle while launching and retrieving. **However, the operator must remember to reconnect the lights prior to leaving the ramp area.**

Brakes

Some states require that all boat trailers have brakes. Laws differ, however, and brake requirements are often tied to gross vehicle weight limits. Surge hydraulic, electric, and electrically actuated hydraulic brakes are the three most common brake systems used on boat trailers. Regardless of the system used, the trailer should be equipped with an emergency breakaway system even if it is not a state requirement.

Safety Chains

Two chains should be permanently attached to the trailer tongue for use as safety chains to prevent the trailer from pulling away from the tow vehicle if the coupling separates. The chain ends connected to the tow vehicle should terminate in hooks to facilitate easy attachment. These chains should be long enough to allow them to be crossed under the trailer tongue, attached to the vehicle, and still allow free movement during even the tightest cornering. The safety chains must be crossed so they will support the trailer tongue and prevent it from hitting the ground if the hitch breaks or is accidentally disconnected.

BOAT LAUNCHING AND RETRIEVAL

Launching and retrieving a boat on a trailer can be accomplished nearly anyplace the trailer can be safely backed into the water, where the depth is adequate and the tow vehicle can maintain the traction necessary to haul the boat and trailer out. It is safe to say that experienced boat operators have a set procedure they follow meticulously any time they launch or retrieve a boat. The following is a generalized procedure for launching and retrieval that is used by many operators. Deviations from this procedure may be necessary because of specialized equipment characteristics, but will not be addressed here.

Launching Procedure

1. Install the drain plug(s) in the hull.
2. Remove safety straps from the boat's stern and trailer.
3. Place dock lines on bow and stern.
4. Place fenders on the side to go against the dock.
5. Load equipment into the boat.

6. Remove travel support and tilt the motor into the vertical position, as long as the lower end of the shaft has adequate ground clearance to allow maneuvering on the launch ramp.
7. Connect and prime the engine fuel line.
8. Boat operator puts on personal floatation device (PFD) and gets in the boat.
9. Back the boat into the water until the lower end of the engine is submerged and the stern begins to float.
10. Prime or choke the carburetor, depending on equipment.
11. Advance the throttle in neutral and start the engine.
12. Allow the engine to warm up until it runs smoothly at idle.
13. Unhook the bow safety chain.
14. Disconnect the winch cable from the bow eye.
15. Place the engine in reverse and advance the throttle to back clear of the trailer.
16. Place the boat alongside the dock while a second crew member parks the tow vehicle and trailer.
17. Crew members put on PFDs and get in the boat.
18. Back clear of the dock and proceed to work site.

Retrieval Procedure

1. Return to the dock from the work site and maneuver alongside.
2. Crew members climb out of the boat.
3. Have a crew member back the trailer into the water.
4. Back the boat clear of the dock.
5. Line the bow up with the middle of the trailer and slowly power it on, placing the bow in the forward cushion.
6. Have a crew member attach the winch cable and cinch the bow in place.
7. Attach the bow safety chain.
8. Tilt the engine out of the water.
9. Have the crew member pull the trailer and boat up the ramp to a place where it can be prepared for the road.
10. Place travel support under the engine.
11. Turn off battery switch, if so equipped.
12. Remove drain plug(s).
13. Unload equipment or secure it for the road.
14. Remove fenders.
15. Remove dock lines.
16. Secure tie down straps to stern and trailer.
17. Connect trailer lights.
18. Walk around the trailer and check all connections to ensure that everything is ready for the road. Wipe down boat as needed.

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