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## **WHOLE-BODY VIBRATION: Guidance on Mitigating Against the Effects of Shocks and Impacts on Small Vessels.**

**Notice to all builders, owners, managers and operators of all small vessels.**

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### **PLEASE NOTE:-**

Where this document provides guidance on the law it should not be regarded as definitive. The way the law applies to any particular case can vary according to circumstances - for example, from vessel to vessel and you should consider seeking independent legal advice if you are unsure of your own legal position.

### **Summary**

This guidance note provides guidance on mitigating, where there is a risk of injury, the effects of whole body vibration on small vessels, and in particular severe shocks as a result of impacts.

Guidance is provided to assist in improving the design of vessels to reduce the severity of the impact and to provide a suitable postural position for those onboard to enable them to brace effectively.

There is also guidance for operators on reducing the impact through training, pre-departure briefing and ensuring that the vessel is operated considering the demographic and medical history of those onboard.

Advice is provided on the correct posture to take when you are likely to be exposed to shocks as a result of impacts.

## **1. Introduction**

- 1.1 There have been a number of incidents over the past few years involving small craft, travelling at a wide range of speeds, which have received a predominantly vertical shock impact when coming off a wave, resulting in injury to one or more persons on board. Incidents have occurred on inland waters, as well as at sea, and to a wide demographic of the population. Injuries sustained range from spinal compression injuries, broken bones in the leg and pelvic area and serious damage to joints. When such injuries occur they can be life-changing for those injured.
- 1.2 It should be recognised that the sea and inland waters are inherently risky places in which to work or spend time for sport and pleasure. This guidance note does not aim to provide a solution to preventing further accidents, because all circumstances cannot be foreseen, but does aim to provide some basic guidance, where there is risk of injury, on

best practice for boat designers, builders, managers and operators to reduce the likelihood of such injuries occurring.

- 1.3 Consideration should be given to the vessel moving not just vertically, but in a wide range of planes. Persons onboard will experience not only vertical and horizontal movement but also torsion and a combination of all three.
- 1.4 This guidance applies primarily to powered craft, however the Control of Vibration at Work regulations (see paragraph 6.1) apply equally to sailing vessels and the general principles should be applied as far as practicable.

## **2. Background**

- 2.1 When a boat comes off a wave and falls into the next wave the forces and accelerations generated have been shown to be much higher than those found in other modes of transport.
- 2.2 Current research suggests that there is no definitive design of craft or seating which is guaranteed to mitigate all the effects of whole body vibration (WBV). There are, however, some basic principles which if followed may assist in reducing the effects of whole body vibration and in particular the impact of the craft slamming.

## **3. Posture**

- 3.1 The design of the craft should allow the occupants to maintain their postural stability at all times during a voyage.
- 3.2 Design features to support the individual's postural stability should be provided. This may include seating, foot straps and handholds.
- 3.3 An upright posture, with the spine in neutral alignment (natural 'S' shape) should be maintained whilst facing in the direction of travel, i.e. sitting or standing sideways generally results in the occupant adopting a twisted spine thus increasing the stress on the spine and increasing the risk of injury.

## **4 Vessel design**

### **4.1 Layout of the vessel**

- 4.1.1 By design, the vertical motion experienced onboard a powered craft is generally greater in the bow area than at the stern. Many small craft are currently designed with the conning position towards the stern with seating in front for passengers. The result of this is that the person conning the vessel has less exposure to the vertical impacts experienced than others on board, and may drive the vessel in a manner comfortable for them rather than others onboard.
- 4.1.2 By moving the conning position forward, the person at that position is exposed to the greatest forces and will adjust the speed and movement of the vessel accordingly to reach a comfort level for themselves. Others onboard should then experience a lower level of vertical impact than the person at the conning position. It should however be borne in mind that this increases the risk to workers who may spend long periods of time onboard the vessel, and also limits their supervision of passengers.

### **4.2 Hull shape**

- 4.2.1 The shape and hydrodynamic performance of the hull can reduce the impact of vertical movements. A deep-V shape hull will cut through the water better than a flatter bottomed vessel. However if the vessel heels significantly as it falls off the wave the vessel will land on a flat part of the hull and a severe slam may be experienced. The

use of multihulls and hydrofoil appendages to the vessel may provide a more comfortable ride, where such design features are compatible with the overall purpose and environment of the vessel's operation.

### **4.3 Seating**

- 4.3.1 There are a wide range of seats available for small craft, such as bench seats, jockey seats, suspension seats or other energy-attenuating designs. Each type of seating should be suitable for the application for which it was designed. Choosing the correct type of seating for the craft's intended operation may reduce the likelihood of injury to those on board.
- 4.3.2 Where lateral forces are experienced each seat should provide an appropriate amount of postural stability/lateral support.
- 4.3.3 Seating should be situated correctly to allow the person occupying the seat to be in the best possible posture. Squeezing an extra seat into the bow of the vessel may leave the occupant in an awkward position which means that they will not be able to brace themselves effectively.
- 4.3.4 The type of seating used should be appropriate for the use of the craft. The greater the exposure to repeated shock and WBV, the greater the requirement for the adoption of shock mitigation equipment and systems specifically designed to cope with the level of exposure experienced.
- 4.3.5 When choosing seating, the manufacturer's advice should be sought, and the type of intended operation should be considered. It should be borne in mind that if the coxswain/crew have different seating from the passengers this may affect their perception of the exposure of passengers.
- 4.3.6 In some circumstances it may be appropriate to fit seatbelts/restraints. The design, operation and use of such restraints should be appropriate to the design and use of the craft, and the crew and passengers should receive the appropriate training on their use. Consideration should be given to the need to escape quickly in an emergency.

### **4.4 Handholds and foot-straps**

- 4.4.1 To allow persons onboard the vessel to brace themselves effectively handholds and foot-straps can assist in the maintenance of postural stability.
- 4.4.2 If used, foot-straps need to be placed in a suitable position and with a suitable anchoring point to allow the person occupying that position to take up the correct posture and to enable that person to use them to brace themselves.
- 4.4.3 Handholds should be situated to allow the occupant of the seat to take up a suitable posture and have suitable anchoring and strength to assist that person to brace themselves, with the upper body maintained firmly upright and facing in the direction of travel, in the event of a sudden vertical deceleration. The material from which handholds are made should take into account the extremes of the operating temperatures in which the vessel will be used. They should also have a texture suitable for providing a secure and comfortable grip by users of various physical builds.
- 4.4.4 The position of the handholds should provide the appropriate lateral and longitudinal postural stability. This may be achieved by having the handholds in front of the body roughly shoulder-width apart and at a height between the shoulders and abdomen of the seat occupants.
- 4.4.5 If foot-straps and handholds are adjustable they should be fit for purpose and maintained appropriately.
- 4.4.6 Expert advice should be sought to ensure that handholds and foot-straps are appropriate.

## **4.5 Decks and wheelhouses**

- 4.5.1 Suspended decks or wheelhouses are starting to be considered for vessels that are going to be used in a more extreme manner. This is an expensive option, but movement of the deck in reaction to the forces exerted may cushion the shock of impacts on persons on board.
- 4.5.2 Deck matting designed to reduce vibration exposure may be fitted to the boat deck.
- 4.5.3 Deck surfaces should be covered in a non-slip coating to allow persons onboard to get traction between their footwear and the deck.

## **4.6 Navigation equipment and controls**

- 4.6.1 The instrumentation and equipment provided to con the vessel should be suitable for the intended purpose and the layout of the instrumentation should allow the person conning the vessel to maintain a suitable posture.
- 4.6.2 When the vessel is moving across the water the instrumentation should provide a display that is of a size to allow the person conning the vessel to easily read the icons, text and images from their conning position. This allows them to spend more time concentrating on the water they are about to travel across and also to keep a suitable posture without leaning in or adopting an awkward posture to read the instrumentation and operate the controls.

## **5 Operating the vessel**

### **5.1 Training**

- 5.1.1 The person conning the vessel should undertake training in handling vessels at high speed and in a relevant range of operating conditions. This should reduce the likelihood of an incident occurring.
- 5.1.2 Training should also incorporate an awareness of the requirement under health and safety legislation to assess the risks, including WBV exposure, and practicable means of reducing them, and the duty-of-care of the operator to the passengers and crew.
- 5.1.3 Risk of injury to those on board may be reduced by regular breaks from work. During voyages it may be appropriate to provide opportunities to allow those on board to rest and adjust their posture during 'throttle-off' moments where it is safe to do so.

### **5.2 Use of the throttle and steering**

- 5.2.1 Investigation has been undertaken which indicates that throttle use has a greater effect on reducing the impact of vertical movement of the vessel than steering the vessel. Attention should therefore be given to improving the coxswain's throttle control when operating in waves or choppy conditions.

### **5.3 Demographics of those onboard**

- 5.3.1 When planning a voyage of any kind, the demographics of those on board should be considered. In some cases it may be necessary to refuse to allow certain people onboard the vessel or it may be necessary to adjust the voyage style to suit those onboard.
- 5.3.2 Children and adults of a small stature may be unable to maintain the necessary postural stability and make effective use of the foot-straps and handholds. Older adults may be at a greater risk as their bones can be more brittle. Those that have certain

medical conditions such as osteoporosis may be more likely to be injured. Those that have been taking certain types of medication, such as steroids, may be more susceptible to injury. Operators should ask passengers whether they have any health condition for which the motions of the vessel may present a risk to health and then carefully consider those onboard and their susceptibility to injury when undertaking voyages and adjust their voyage accordingly. In some cases it may be necessary for operators to refuse to take certain people on a voyage. Operators should make those on board their vessels aware of the risks involved.

#### **5.4 Pre-departure briefing**

- 5.4.1 Operators and owners of all vessels should brief those onboard prior to departure on the inherent risk and the correct posture to reduce the likelihood of injury and where handholds and foot-straps are.

#### **5.5 Exposure**

- 5.5.1 Those that spend long periods on vessels that experience shock impacts regularly may not receive a serious acute injury on any single voyage but, over time, may feel the cumulative effects of repeated WBV exposure resulting in chronic musculoskeletal injuries.
- 5.5.2 Where workers undertake regular transits where WBV exposure is experienced the appropriate health monitoring process is required. See MGN 353 (M+F).

#### **5.6 Speed perception**

- 5.6.1 It should be noted by operators that are providing “experience rides” that those onboard are likely to perceive that they going considerably faster than they are. Therefore operators should consider travelling at slower speeds than they themselves may perceive as fast. This will reduce the likelihood of injury to those onboard.

### **6 Regulations and further guidance**

- 6.1 The Merchant Shipping and Fishing Vessels (Control of Vibration at Work) Regulations 2007, SI 2007/3077, provide requirements which the advice above may be used to meet. The Maritime and Coastguard Agency has published MGN 353 (M+F) which provides further guidance on these regulations.
- 6.2 The MCA has also published the Code of Practice for Controlling Risks due to Whole-body Vibration on Ships (ISBN No. 9780115530760) which is the official guide to complying with the Merchant Shipping and Fishing Vessels (Control of Vibration at Work) Regulations 2007. This document also provides an extensive bibliography for further guidance. It can be purchased from The Stationary Office ([www.tsoshop.co.uk](http://www.tsoshop.co.uk)). Guidance on High Speed Craft Human Factors Engineering Design can be found at [www.highspeedcraft.org](http://www.highspeedcraft.org). The following publication may be of use: Nieuwenhuis, M. (2005) The ultimate performance of fast RIB's – an experimental investigation into the influence of the helmsman. Conference Proceedings, Rigid Inflatables, RINA, Cowes, UK.
- 6.3 Further best practice guidance for operators can be found in Small Passenger High Speed Experience Rides Guidance ([http://www.dft.gov.uk/mca/small\\_passenger\\_high\\_speed\\_craft\\_experience\\_rides\\_guidance.pdf](http://www.dft.gov.uk/mca/small_passenger_high_speed_craft_experience_rides_guidance.pdf)) and Passenger Safety on Small Commercial High Speed Craft published by the Royal Yachting Association

<http://www.rya.org.uk/SiteCollectionDocuments/training/Web%20Documents/RYA%20Training/Training%20centres/Powerboat%20PW%20and%20IW/Passenger%20Safety%20on%20Small%20High%20Speed%20Craft.pdf>.

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