MARINE OCCURRENCE REPORT
M98C0040

TAKING ON WATER

PASSENGER HYDROFOIL “SUNRISE VI”
LAKE ONTARIO,
8 MILES NORTH OF PORT DALHOUSIE
18 AUGUST 1998

Marine Occurrence Report

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Summary

On the morning of 18 August 1998, the "SUNRISE VI" departed Toronto bound for Port Dalhousie, Ontario, with four passengers on board. As the voyage proceeded, the waves increased in height such that the vessel was forced to reduce speed from foil-borne to displacement mode. Soon thereafter, the port front window in the forward passenger compartment was stove in by a wave and lake water entered the passenger compartment. Upon discharging the flood water, the escorted vessel proceeded at "dead slow ahead" to Port Dalhousie. One passenger was injured.

Other Factual Information

	"SUNRISE VI"
Port of Registry	Toronto, Ontario
Flag	Canada
Official Number	720516
Type	Voskhod-2 Passenger Hydrofoil
Gross Tons[1]	53
Length	23.3 m
Draught	2 m in displacement mode, 1.1 m in foil-borne mode
Built	Leningrad, Russia, 1989
Propulsion	One M-401A diesel engine, 809.6 kW @ 1,600 rpm
Crew	4
Passengers	4 during this voyage (maximum of 66)
Registered Owner	1293728 Ontario Ltd. Mississauga, Ontario
Operator	Shaker Cruise Lines, Toronto, Ontario

Description of the Vessel

The "SUNRISE VI" is a passenger hydrofoil with a welded aluminium-magnesium alloy hull and superstructure. The forward and after foils are constructed of stainless steel. The vessel has eight double-bottom tanks below the forward and after passenger compartments. The bridge is located forward and the machinery space aft. Main propulsion power is provided by one high-speed marine diesel engine driving a single highly skewed propeller through a "V" drive reduction gear. The vessel is equipped with a graduated sounding pole approved by Transport Canada Marine Safety (TCMS) for determining water depth when travelling in the displacement mode, and portable electric bilge pumps. The bow height above the design waterline in displacement mode is approximately 1.65 m, and approximately 2.0 m from the waterline to the centre of the front window. Although required by the *Code of Safety for Dynamically Supported Craft* (DSC Code) to be constructed of a material that would not break into dangerous fragments when fractured, the front window broke into several large sharp-edged pieces.

[1] Units of measurement in this report conform to International Maritime Organization (IMO) standards or, where there is no such standard, are expressed in the International System (SI) of units.

Description of the Voyage

In June 1998, the "SUNRISE VI" was introduced into service for fast transit of passengers across Lake Ontario between Toronto and the Niagara region. Certified to carry a maximum of 66 passengers, the ferry is permitted to operate at foil-borne speeds of up to 32 knots (kn) in wave conditions not exceeding 1.3 m in height. The vessel's schedule varies from day to day. Weekday trips of about one hour's duration between Toronto and Port Dalhousie and Niagara-on-the-Lake provide commuter service from 0700 to 2200 eastern daylight time (EDT)[2]. On weekends, the vessel usually transits between Toronto and Lewiston, New York, from 0900 to 0130 the next morning.

On 18 August 1998, the "SUNRISE VI" departed Toronto at 0930 with four passengers on board on an unscheduled promotional voyage to Port Dalhousie. The vessel proceeded across Lake Ontario in foil-borne mode until, in mid-voyage, wave heights of 2 m to 3 m were encountered. Speed was reduced to 15 kn, and the vessel came off her foils into the displacement mode. At 1015, approximately eight miles north of Port Dalhousie, the vessel encountered a series of large waves which caused the bow to pitch downward. Water broke over the bow and onto the forward windows, shattering the port window into a number of sharp fragments, allowing water to enter the passenger compartment.

Under the instructions of the master, passengers and crew donned lifejackets, and one of the passengers (a shore-based company employee) fell and twisted his knee while attempting to plug the broken window with the cover from a lifejacket locker. The master initially attempted to regain foil-borne mode, but the weight of water in the passenger compartment and the high waves prevented the vessel from attaining adequate lift. Instead, the speed was further reduced to 9 kn and the master set a course which allowed the vessel to run before the prevailing waves.

A "MAYDAY" was broadcast by the master at 1019, and the ferries "LAKE RUNNER" and "WATERWAYS I", which were in the immediate area, changed course and headed towards the "SUNRISE VI". The distress call was received by the Canadian Coast Guard station at Port Weller, Ontario. The Rescue Coordination Centre at Trenton was advised and the rescue vessel "CGR 100" responded.

The entrapped flood water in the passenger compartment was approximately 10 cm to 15 cm deep and had accumulated aft due to the vessel's trim. The chief engineer rigged a portable electric bilge pump (16.8 m^3/hr capacity) to pump the water from the passenger compartment. The pump was powered from a 24-volt DC outlet located approximately 45 cm above the deck, and the discharge hose was led overboard through an open window in the bar area. After losing suction with the pump, the remaining water was drained into a double-bottom space through a manhole which was opened for the purpose.

The "SUNRISE VI" was escorted to Port Dalhousie by the "LAKE RUNNER", "WATERWAYS I" and "CGR 100".

Certification

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[2] All times are EDT (Coordinated Universal Time (UTC) minus four hours) unless otherwise noted.

The vessel carried a master, mate, engineer, and purser. Minimum required certification for the master is a master home trade 350 tons certificate, and the engineer requires a second class motor certificate. If the vessel carries more than 50 passengers, the mate must hold at least a watchkeeping mate's certificate, otherwise no qualifications are required for the mate.

At the time of the occurrence, the master, mate, and engineer held qualifications appropriate for the class of vessel on which they were serving and for the voyage being undertaken. The purser held no marine qualifications nor was she required to.

The master had over 20 years' experience as a ship's officer, mainly on the Great Lakes. He had worked for the owner during the previous year as captain on board the conventional ferry "LAKE RUNNER". His first operational experience with hydrofoils began with his training on board the "SUNRISE V" in May 1998, one month before the vessel's formal entry into passenger service. Following this, he sailed for two weeks under the supervision of the managing owner before receiving a Master's High Speed Craft (HSC) endorsement from TCMS. At the time of the occurrence, a syllabus for training and certification of HSC crew had not been developed; however, since that time, TCMS has recognized the need for the development of standards in accordance with the DSC Code.

The vessel was issued a certificate (SIC 54) as an HSC by TCMS even though she was inspected under the provisions of the DSC Code.

Weather

At the time of the occurrence, the wind was from the north-east at 25 kn to 30 kn. As a result, the "SUNRISE VI" encountered larger waves as she approached the south side of the lake. Notwithstanding the Environment Canada (EC) marine weather forecast which predicted waves of 1 m or less, it is reported that the vessel encountered sustained seas of 2 m and several somewhat larger waves approaching 3 m in height when the window was stove in.

When he came on duty for the trip at 0700, the master had listened to the marine weather forecast which called for 20 kn winds from the north occurring later in the morning. The "SUNRISE VI" made the scheduled 0700 crossing of Lake Ontario from Port Dalhousie to Toronto without incident, although it was noted that the wind was strong and waves were 1 m high at seven miles from Toronto. Upon departure from Toronto, the wind speed had not changed; however, over-lake winds on Lake Ontario may be up to 30 per cent stronger than land winds during the summer months.

It is estimated that, from May through to September during an average year, the maximum wave heights likely to be encountered on Lake Ontario can exceed the hydrofoil's 1.3 m operating limit 20 to 25 per cent of the time[3]. Also, winds which are predominantly from the south-west can reach 10 kn to greater than 20 kn with similar frequency. During the summer months, about 60 per cent of prevailing waves have crest-to-crest lengths less than the length of the vessel, in which circumstances, the hydrofoil would tend to plane horizontally through small, short waves. However, 30 to 40

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[3] Derived from data in "Wind and Wave Climate Atlas," Vol. III (TP10820) and Marine Environmental Data Service (MEDS) for Station MEDS065 Toronto.

per cent of the waves could well exceed 20 m in length, in which case the vessel would tend to follow the contour of a long wave.

Subsequent to the occurrence, the vessel's HSC certificate (SIC 54) was endorsed with the condition that: "When the winds are over 16 mph / 25 kph from a North or Southerly direction for a prolonged period, Master is to check the wave height of the ports at the receiving end i.e. winds Northerly check Port Dalhousie / Niagara on the Lake entrances."

Design of the Vessel

The "SUNRISE VI", being a Soviet-type Voskhod-2 passenger hydrofoil, was built to comply with the Russian Rules of River Register for a class "O" vessel. The various Russian class designations are set to determine the structure of a ship and a range of water areas where the ship is permitted to operate. The areas of operation for the various classes take into account wind and wave climate conditions likely to be encountered during navigation. Class "O" hydrofoil vessels must be capable of operating in areas having waves with a 1 per cent probability of reaching a height of 1.3 m, and a recurrence of not more than 4 per cent during the period of navigation. Class "O" operational areas within Russia are specified for numerous portions of rivers, several reservoirs on rivers, and two small lakes. Lake Teletzkoe, one of these lakes, is approximately 50 km long and less than 3 km wide. Lake Ontario by comparison is approximately 290 km long by 50 km wide (between Toronto and Port Dalhousie/Niagara Region) with a depth of 110 m.

The hull below the enclosed passenger deck is subdivided into eight watertight compartments designed to allow the vessel to remain afloat in calm water following damage to the machinery space or to any other single watertight compartment. However, both the DSC Code and the *International Code of Safety for High Speed Craft* (HSC Code) call for assumed damage to occur anywhere on the periphery or bottom of the hull; i.e., the vessel must be able to remain afloat when the watertight integrity of any two adjacent compartments is breached. In order to have the "SUNRISE VI" class of hydrofoil comply with the two-compartment standard of subdivision for Canadian operations, the double-bottom compartments on either side of the "V" drive space and just forward of the engine-room were filled with plastic bags containing polystyrene beads to reduce permeability.

Although required by the DSC Code[4], the vessel was not equipped with a fixed bilge pumping system which, when in use, would prevent the unintentional flow of water from one compartment to another. Instead, two portable electric pumps were carried on board. Pump access to the double-bottom spaces is possible only by opening the manholes to the double-bottom tanks.

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[4] DSC Code, Section 10.6.3, "Bilge Pumping and Drainage Systems."

The speed of the vessel in displacement mode ranges from 0 kn to 11 kn[5]. When power is increased, the vessel passes through a transition zone as the hull begins to lift from the water and speed increases until she is fully foil-borne at a maximum speed of 32.4 kn. The transition zone is a most intricate and important period in ship control as the main engine load sharply increases and the metacentric stability decreases. Within this control-sensitive transition zone, statical stability is reduced as the hull lifts, and simultaneously, the hydrodynamic forces on the foils progressively develop sufficient stability as higher speeds are attained. At slower speeds, the foils become submerged and have a dampening effect on hull motion relative to the behaviour of a similar standard hull having no foils.

Most of the pieces from the fractured window were recovered and forwarded to the TSB Engineering Laboratory for analysis. Visual and optical microscope examination indicates that the window failed from an overstress. The failure originated near the top centre of the window and radiated downward and inboard. The remains of the window showed a yellowish discolouration and crazing, which are indicative of deterioration due to exposure to sunlight.[6]

In its investigation of a separate occurrence where the Canadian ferries "QUEEN OF SAANICH" and "ROYAL VANCOUVER" collided at the northern entrance to Active Pass, British Columbia, on 06 February 1992, the Board found that the operation of HSC is usually more demanding than that of a conventional vessel, and that the crews must possess the knowledge, qualifications and training consistent with the special features of HSC (TSB report No. M92W1012). The Board recommended that:

> The Department of Transport establish guidelines for the operation of high-speed passenger craft taking into account local operating conditions and the overall navigational infrastructure.
>
> (M94-28, issued July 1994)

At present, no Canadian regulations exist for the inspection of high-speed vessels. Since 1996, the Board of Steamship Inspection (BSI) has allowed the use of the HSC Code[7] for the inspection, certification and approval of Canadian HSC. Because passenger vessels being transferred to Canadian registry are deemed to be "new ships," the HSC Code may be applied to high-speed vessels built or imported into Canada after 01 January 1996. However, TCMS does not apply the HSC Code to non-Solas (International Convention for the Safety of Life at Sea) vessels operating in the Great Lakes. As a result, the "SUNRISE VI" was inspected under the provisions of the older DSC Code, and the company was not required to have a quality management system in place.

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5 "VOSKHOD-2" Control and Safety-in-Operation Instructions 352-070-103.

6 TSB Engineering Branch Report No. LP 41/99 on "Window Failure" is available upon request from the Transportation Safety Board of Canada.

7 International Maritime Organization, 1994

Analysis

For a hydrofoil such as the "SUNRISE VI" to operate safely, it is important to ensure that the forecast weather conditions are within the operating limits of the vessel. In the event that the vessel encounters severe unpredictable conditions when under way, prudence dictates that the vessel seek safe anchorage or shelter close by. The "SUNRISE VI" was designed and built to Russian Class "O" requirements for operation on rivers, reservoirs and small fresh water lakes. However, the wind and wave conditions which can be encountered during the summer months on Lake Ontario are frequently much more severe than those specified for Russian Class "O" navigational areas, and the mid-voyage distance to shore or shelter is also much greater. Consequently, there is a much higher risk of encountering conditions that exceed the hydrofoil's design capabilities at a greater distance from a port of safe refuge.

Contrary to the weather forecast on the morning of the occurrence, conditions on Lake Ontario steadily worsened until the "SUNRISE VI" was caught in waves reaching 2 m to 3 m in height. Such conditions are well beyond the design limits of 1.3 m maximum wave height at foil-borne speeds, and 2.0 m maximum wave height in displacement mode. When the vessel's speed was reduced to 15 kn, the speed was still higher than that of displacement mode, i.e., less than 11 kn. Consequently, the vessel was in the transition zone whereby the vessel's speed was too fast for optimum hydrostatic stability, yet too slow to attain sufficient foil lift for hydrodynamic stability.

When the foils became fully submerged, they had a dampening effect on hull motions and the bow was unable to lift as waves higher than 2 m were encountered. In following seas, the vessel would have tended to pitch, especially if the forward foil broke clear through a long wave. Also, when running before a following sea, the vessel would tend to dive into the trough of a wave. This would cause the wave to break over the bow onto the front windows of the superstructure.

The exact quantity of flood water that entered the passenger compartment is not known. However, based on a reported average of 5 cm to 7.5 cm of water on the passenger deck (approximately 2 m^3 to 3 m^3 of water), it would have caused a reduction in the vessel's stability due to her weight and free surface effect.

Immediately following the shattering of the window, the master attempted to regain foil-borne mode. The combination of fluctuating stability encountered in the transition from displacement to foil-borne mode and the free surface effect of the accumulated water on the passenger deck further reduced stability. Reducing the speed to 9 kn (full displacement mode) improved stability and control of the vessel; however, this action was taken too late as the window had been broken and the passenger deck partially flooded.

The use of a portable bilge pump was not an expedient method to remove the accumulated water from the main deck. Bilge pumps normally operate in wells, and as a result, the pump would not remove all the water from the passenger compartment. The open window that was used as a path overboard for the pump discharge hose posed a risk of further flooding in the prevailing weather conditions. Opening the double-bottom hatch allowed the double-bottom and passenger spaces to become contiguous which, in combination with one open and one broken window, further compromised the vessel's watertight integrity and subdivision.

Findings

1. The vessel encountered wave heights of 2 m to 3 m which exceeded both the EC forecast of 1 m waves, and the vessel's operating wave height limitation of 1.3 m.

2. As the hydrofoil was operating at a speed higher than that recommended for displacement mode, the bow and forward windows were engulfed by waves.

3. The port forward window failed when it was overstressed by the force of the waves breaking against it, causing water to enter the passenger compartment.

4. The broken window material showed signs of deterioration from exposure to sunlight and was constructed of a material which broke into several large sharp fragments when fractured.

5. The accumulation of water shipped and retained on the passenger deck reduced the stability of the vessel.

6. Attempting to regain foil-borne mode with an accumulation of water on the passenger deck further reduced the stability of the vessel.

7. The procedures used to operate the portable pump carried on board (instead of a fixed bilge pumping system) compromised the watertight integrity and subdivision of the vessel.

8. Following the damage, the vessel's speed was reduced to the slowest (approximately 9 kn) preventing further water from entering the passenger compartment during the remainder of the voyage.

9. The vessel was not built to a standard of subdivision which complied with the damage stability requirements of the DSC Code; however, she was modified by the addition of polystyrene-filled plastic bags in several compartments.

10. The Voskhod-2 class of hydrofoil is not designed for operation in the weather conditions that may be encountered on the open waters of Lake Ontario.

Causes and Contributing Factors

The "SUNRISE VI" took on water when the vessel's bow was engulfed by waves two to three metres in height causing a forward window to be stove in. Contributing to the occurrence was the vessel's high speed and her unsuitability for service on the exposed waters of Lake Ontario where wave heights frequently exceed the vessel's safe operating limits.

Safety Action

Action Taken

Window Replacement

Both forward windows on the "SUNRISE VI" have been replaced with "Cyrolon ZX" polycarbonate panels that were tested by TCMS.

Inspection and Certification Procedures

As a result of several incidents involving high-speed craft operations and the Class "O" hydrofoils in particular, TCMS initiated a review of its operations on Lake Ontario. TCMS will no longer certify the Voskhod-2 class of hydrofoil for cross-lake service.

Also, following the review of high-speed craft operations, TC issued instructions to HSC operators to ensure that:

- they exchange information regarding adverse weather;
- a warning sign is posted regarding the dangers of operating in shallow or hazardous waters; and
- operations manuals include adequate instructions consistent with a quality management system.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 14 October 1999.

Appendix A - Photograph and General Layout