Transportation Safety Board of Canada | Bureau de la sécurité des transports du Canada

MARINE INVESTIGATION REPORT
M04F0017

GROUNDING

TANK BARGE *KTC 115*
WITH
TUG *SALVOR*
ALEXANDRIA BAY, NEW YORK, UNITED STATES
27 JULY 2004

Canada

Marine Investigation Report

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with
Tug *Salvor*
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Report Number M04F0017

Summary

On 27 July 2004, at 0445 eastern daylight time, the Canadian tug *Salvor*, pushing the single-hull tank barge *KTC 115*, loaded with approximately 9117 metric tons of liquefied calcium chloride was exiting American Narrows at Alexandria Bay, New York, United States, when it experienced a steering failure that shifted the rudder hard to starboard. A chain securing the starboard face wire failed, causing the tug to break free from the barge. The barge continued downstream and grounded on the north side of the channel, spilling approximately 60 tonnes of calcium chloride.

Ce rapport est également disponible en français

Other Factual Information

Particulars of the Vessels

	Salvor	***KTC 115***
Official Number	0822510	0825107
Port of Registry	Hamilton, Ontario	Hamilton, Ontario
Flag	Canada	Canada
Type	Tug	Single-hull tank barge
Gross Tonnage[1]	407	5662
Length	34.14 m	120.00 m
Draught Forward	4.57 m	5.33 m
Draught Aft	5.00 m	5.48 m
Built	Oyster Bay, New York, 1963	Avondale, Louisiana, 1968
Propulsion	Two EMD diesel engines totalling 4297 kW driving two fixed-pitch propellers	N/A
Cargo	N/A	Liquefied calcium chloride
Crew Members	9	Unmanned
Passengers	0	0
Owners	McKeil Marine Limited (formerly Evans McKeil Work Boats Limited) Hamilton, Ontario	McKeil Marine Limited (formerly Evans McKeil Work Boats Limited) Hamilton, Ontario

Description of Tug and Tow

[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 of units.

The *Salvor* is of conventional design with the wheelhouse forward and an upper wheelhouse located approximately 45 feet above the waterline. The main towing winch is located aft of the accommodation on the main deck.

The *KTC 115* is a single-hull tank barge with 10 tanks (five port and five starboard) with a total capacity of 11 176 tonnes. The barge is equipped with a notch aft into which the tug is fitted when in the pushing mode. A single danforth anchor is located forward. If the barge becomes separated from the tug, the anchor cannot be dropped remotely.

Description of the Voyage

On 24 July 2004, the Canadian tug *Salvor*, pushing the single-hull tank barge *KTC 115*, loaded with approximately 9117 tonnes of liquefied calcium chloride, departed Amherstburg, Ontario, bound for Montrçal, Quebec. As per company procedures, the crew tested and visually inspected the steering gear before departure, and found it to be satisfactory. Due to weather conditions, the barge was separated from the tug, and towed across Lake Erie. Before entering the Welland Canal, the tug re-assumed its pushing position in the notch of the barge. After passing through the Welland Canal, the passage across Lake Ontario was conducted with the *Salvor* pushing the barge *KTC 115*.

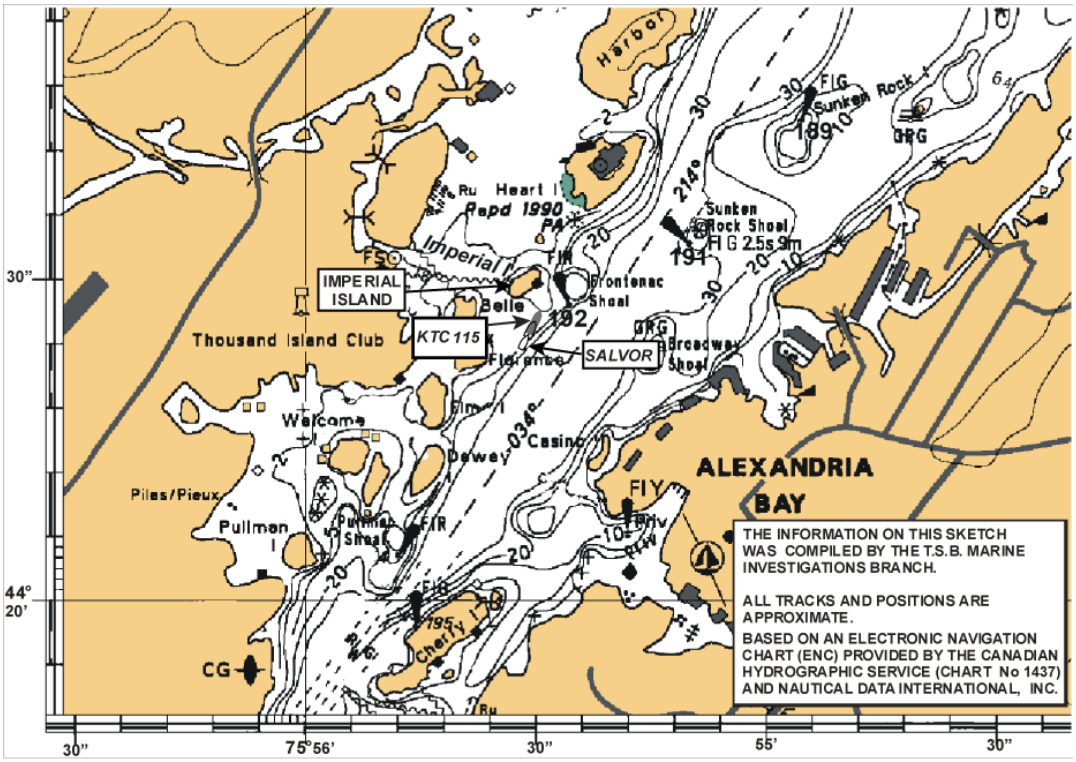
On July 27, at 0445 eastern daylight time,[2] the tug/barge, on autopilot and under the conduct of the mate, who was officer of the watch (OOW), was exiting American Narrows at Alexandria Bay, New York, along the south side of the river when a loud "thump" was heard from the aft part of the tug, following which the barge took a slight sheer to port. The deckhand on watch in the wheelhouse was sent to investigate the source of the noise, and the OOW attempted to correct the perceived swing to port. When the vessel did not respond, the OOW attempted to override the autopilot, switched to the backup hydraulic pump, and then to the non-follow-up (NFU) steering. When these systems proved ineffective, he called the master and the engine room to report that the steering had failed.

The tug's stern swung further to port, parting the 2½-inch hawsers securing the vessel to the notch of the barge. The tug swung free of the notch, heeled sharply to port, and was dragged backwards by the port face wire. The wire was kinked across a sharp edge of the bulwark and subsequently parted, releasing the tug. Subsequently, the crew found that the chain connecting the starboard face wire to the tug had parted.

Arriving on the bridge, the master called the approaching tanker *Thalassa Desgagnes* (laden with heavy fuel oil), informing them that the tug had separated from the barge and that he did not have control of the barge. The master then placed a radio call to Seaway Clayton apprising them

[2] All times are eastern daylight time (Coordinated Universal Time minus four hours).

of the situation. Seaway Clayton then contacted the *Salvor* requesting clarification. Free of the tug, the barge continued downstream and grounded on the north side of the channel adjacent to Imperial Island in position 44°20'25" N, 075°55'30" W. During this time, the crew of the *Salvor* was unaware of the position of the barge until it was located by the passing *Thalassa Desgagnes*.



In the engine room, the chief engineer took steering control and switched the engine room control first to emergency and then to the NFU steering. However, the rudder did not respond to commands. Steering with engines, the tug proceeded to the south side of the channel near the entrance to Alexandria Bay. When the chief engineer inspected the steering gear, he found that the telemotor feedback rod had broken. Following the installation of a temporary replacement rod, steering was regained and the vessel proceeded across the channel to locate the barge. After sending out crew members in a small boat to take soundings around the grounded barge, the *Salvor* proceeded to reconnect to the barge.

Traffic was suspended in the American Narrows area of the St. Lawrence Seaway from the time of the occurrence until 1820 on the same day.

Environmental Conditions

At the time of the occurrence, the wind was calm and visibility was six miles in intermittent showers. The vessel was proceeding along the extreme southern edge of the channel in approximately 8 m of water.

Damage to the Vessels

A damage survey of the barge by divers revealed inset bottom plating and three cracks in the bottom of the forward-most starboard tank. A rope was found entangled in the port propeller of the tug, and the tips of the starboard propeller blades were found to be damaged.

Damage to the Environment

By the time measures had been instituted to stop the egress of cargo, approximately 60 tonnes of calcium chloride solution was released into the river. The spill was unrecoverable; however, responders judged that it posed no threat to the environment.

Vessel Track Before the Occurrence

In accordance with Seaway regulations,[3] the *Salvor* was equipped with an automated identification system (AIS) that transmitted data including vessel speed, position, and identity to both Seaway Traffic Control, and to other vessels in the vicinity. As the *Salvor/KTC 115* exited American Narrows just west of Alexandria Bay, the *Thalassa Desgagnes* was approaching upbound 1 km to the east.

Following the occurrence, a copy of the St. Lawrence Seaway Management Corporation (SLSMC) electronic traffic control recordings of the *Salvor*'s track before and during the occurrence was obtained. The *Salvor*'s displayed position on the SLSMC playback was of poor quality and lacked accuracy. Subsequently, an electronic download from the electronic chart system (ECS) installed on the *Thalassa Desgagnes* was obtained, which accurately showed the track of the *Salvor* for several hours leading up to the occurrence.

Information from the playback indicated that, at the time of the occurrence, the vessel was at the extreme south side of the channel passing over the edge of a shoal extending outwards from Cherry Island.

Crew Qualifications and Experience

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[3] St. Lawrence Seaway Management Corporation, *Joint Practices and Procedures Respecting the Transit of Ships on the St. Lawrence Seaway*, Section 20.

The master held a valid certificate for master, ship of not more than 350 tons, gross tonnage, or tug, local voyage, issued by Transport Canada (TC) in June 2004. He graduated from the Georgian College marine program in 2002. All of his sea experience had been obtained with McKeil Marine Limited. In accordance with the *Great Lakes Pilotage Regulations*,[4] he had been granted an exemption from taking a pilot aboard. This assignment to the *Salvor/KTC 115* was the master's first experience as captain and his first experience on board the combination of *Salvor/KTC 115*.

The mate had worked for McKeil Marine Limited for 10 years and had approximately one month of experience on board the *Salvor/KTC 115*. He held a valid certificate for restricted watchkeeping mate, issued by TC in September 1999, and had been granted a pilotage exemption. The chief engineer held a valid certificate for first-class engineer, motor ship, issued by TC in January 1999, and had worked for two months with McKeil Marine Limited on board the *Salvor*.

Vessel Certification and Inspection

The *Salvor* was imported into Canada from the United States in August 2000 and had been inspected and certified by TC for home trade, Class II voyages. The most recent annual inspection of the vessel was conducted on 02 October 2003. This inspection included an operational test of the steering gear since the next four-year periodic inspection was not due until July 2005.

The barge *KTC 115* was imported from the United States and registered in Canada on 16 June 2003. The barge had been classed by the American Bureau of Shipping (ABS) under its previous ownership; however, its classification had lapsed at the time of the occurrence. It was subsequently inspected by TC in April 2004 and was issued a temporary load line certificate on 29 July 2004.

Domestic Canadian and United States vessels, which are trading inland and are not *International Safety Management Code* (ISM Code)–certified, are required to undergo an inspection by either the SLSMC or the Saint Lawrence Seaway Development Corporation (SLSDC) every two years. Conventional tug/barge units such as the *Salvor/KTC 115* are required to be inspected before every Seaway transit.[5] Consequently, the *Salvor* was inspected and approved for passage by the SLSMC during a transit of the Welland Canal on 22 July 2004. However, as the *KTC 115* was inspected by the Seaway in 2003, at which time it was still in class, it was not due for another Seaway inspection until 2005. As a result, the scope of the Seaway inspection did not include the *KTC 115*. The *Salvor*'s steering gear was functionally tested in all modes from the wheelhouse. The inspection noted the following deficiencies:

- a compass deviation card was not on board,
- charts and publications/Seaway notices were not up to date,

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[4] *Great Lakes Pilotage Regulations*, Section 4 (1)(c)(iii)(C)

[5] *St. Lawrence Seaway Inspection and Marine Services Procedure Manual*, 22 July 2004, Edition 1, Rev 1, Procedure 1: Seaway Inspections.

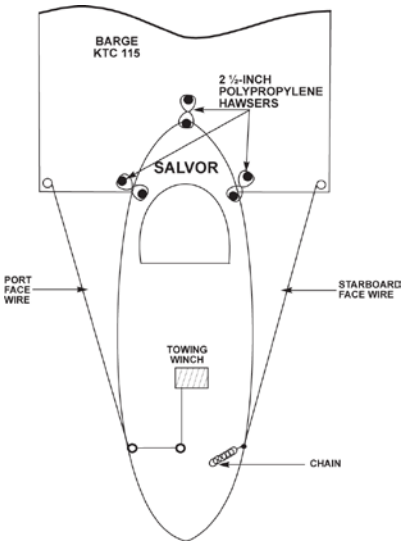
- the rudder angle indicator in the wheelhouse was defective, and
- the steering station in the engine room lacked a rudder angle indicator.

Three of these were cleared before 26 July 2004, while one remained to be cleared in 15 days. With respect to crewing, Seaway regulations require that, while transiting the sections of Montrcal to Lake Ontario and Welland Canal, the wheelhouse of the ship be crewed at all times by either the master or certified deck officer and by another qualified crew member, and that sufficient, well-rested crew members be available for mooring operations and other essential duties.[6]

At the time of the SLSMC inspection, the complement on board the *Salvor* consisted of a master, mate, chief engineer, second engineer, three deckhands, pumpman, and cook. The master and mate, and chief and second engineer each stood watch six hours on, six hours off. The three deckhands stood watch four hours on, eight hours off. The cook and the pumpman were day workers and did not stand a watch.

Connection of the Tug to the Barge

The towing arrangement comprised a notch in the transom of the barge that housed the bow of the tug (see Photo 1). The securing arrangement comprised a 2½-inch braided polypropylene hawser from the bow of the tug to a bitt on the barge and similar hawsers, one at each corner of the barge's notch to the port and starboard shoulder of the tug (see Figure 2). To facilitate steering and backing, single 1c-inch-diameter, 6 x 36 face wires were rigged between quarter bits on the barge and the after deck of the tug. The starboard wire was shackled to a 2-inch steel stud chain, which, in turn, was shackled to a fairlead mount on the deck of the tug. The port face wire was connected through a fairlead to the tug's towing winch that was used to tension the tug in the notch.



[6] St. Lawrence Seaway Management Corporation, *Joint Practices and Procedures Respecting the Transit of Ships on the St. Lawrence Seaway*, Section 35. The referenced requirements became effective 01 October 2003.

Post-occurrence examination of the rigging found that two links of the chain connecting the starboard face wire had failed, and that the port face wire had also parted at the point where it would normally lead through the port bulwark fairlead. Tests on the failed chain links indicate that they failed from sudden overstress.[7] The tests found that there were no significant corrosion or defects in the failed chain links and that the breaking strength was consistent with standards for that size chain. No certification, inspection, or maintenance records were available on board for either the chain or wire, although a certificate from the wire rope manufacturer was produced by the owner some three months after the occurrence. The history of the failed chain could not be determined by the company; however, it was in poor overall condition with studs loose or missing from some links. Indications are that it probably came from a marine salvage yard.

The size of the face wires was chosen by the company based on tables provided by the Oil Companies International Marine Forum. The complete design of the physical connection between the *Salvor* and the *KTC 115* (including the chain and bow notch connection), and the handling characteristics of the mated pair were not subject to any formal analysis by the owner, TC, or the SLSMC/SLSDC, nor were they required to be by regulations. Although the condition of the tow line was visually checked by the SLSMC/SLSDC during its inspection on 22 July 2004, the condition of the tackle used in the connection was not verified by TC, nor was it required to be by regulation.

Steering System

The *Salvor* is equipped with an electro-hydraulic steering system powered by two independent electrically driven hydraulic pumps in the engine room. The steering gear is comprised of two hydraulic rams that are connected to rudder quadrants via one-inch-diameter, 6 x 36 wire-core wire rope. Control of the steering is provided by follow-up ComNav 101 remote control and NFU electrical control systems that actuate solenoid valves to direct oil to the appropriate hydraulic ram. Follow-up rudder position sensing is achieved by means of a brass telemotor feedback rod connected to an electronic rudder position sensor.

Post-occurrence inspection of the system revealed that the telemotor feedback rod had failed at the adjustable threaded toggle connecting it to the rudder quadrant. Laboratory examination of the failed rod showed that it failed from damage due to fatigue.[8] The pivot pin that transmits the quadrant motion to the telemotor feedback rod was misaligned, and the rod was found to bind as the rudder moved between midships and hard over position in each direction. The mounting of the pivot pin on which the rod mounts had been modified at some time in the past; however, no records were available to indicate when and by whom. Tests of the steering system showed that both the bridge rudder angle indicator and the NFU steering system did not function when the telemotor feedback rod was disconnected.

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[7] TSB Engineering Laboratory Report LP 102/2004.

[8] TSB Engineering Laboratory Report LP 111/2004.

Since being imported into Canada in 2000, the *Salvor* has experienced at least three steering-related incidents. On 28 November 2001, a steering cable separated while the vessel was transiting the St. Lawrence Seaway. On 05 October 2002, a steering cable slipped off a rudder quadrant due to excess free play. More recently, in June 2004, during a voyage to New York, the crew discovered that a steering cable had become slack. Post-occurrence inspection of the system on July 27 revealed that the steering cables had deteriorated, and TC requested that they be replaced. Subsequent laboratory examination indicated that the steering cables had deteriorated from in-service fatigue.[9]

Company Safety Management

The company had adopted the ISM Code on one of its tug/barge combinations that was on a dedicated charter carrying jet fuel. While the company had not applied the ISM Code safety management system (SMS) to other vessels in the fleet, some documented procedures had been developed and introduced fleet-wide including a written policy and procedure for navigation in confined waters. This procedure did not address the use of the autopilot. In addition, the company had implemented an internal system for reporting and following up on marine occurrences.

Analysis

Steering Failure

An analysis of the electronic playback of the *Salvor/KTC 115* track as taken from the *Thalassa Desgagnes* just before the occurrence shows that the vessel was proceeding along the extreme south edge of the channel. As the vessel was adjacent to Cherry Island, New York, the vessel's bow began to swing to port, possibly as a result of bank interaction with the adjacent shoal. As the vessel was on autopilot at the time, the automatic pilot would have attempted to correct the swing by applying starboard rudder. As the rudder moved to starboard, the steering telemotor feedback rod failed and the rudder continued to move until it reached the hard-over starboard position.

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[9] TSB Engineering Laboratory Report LP 111/2004.

The TSB Engineering Laboratory examination of the failed telemotor feedback rod indicated that pre-existing fatigue cracks were present at the location where the rod failed. Fatigue is commonly referred to as the phenomenon that leads to fracture under repeated or fluctuating stresses having a maximum value less than the tensile strength of the material.[10]

The telemotor feedback rod on a vessel operates as a push/pull rod to transmit the position of the rudder to the steering control mechanism. Under normal circumstances, when the rod moves freely throughout its full range of travel, the repetitive stresses on the rod are relatively small, and it may be expected to have a long service life. However, the configuration of the feedback rod and tiller head mounting pivot pin had been modified at an unspecified time in the past from its original configuration. The source of the fatigue was determined to be a misalignment between the feedback rod and the tiller head mounting pivot. As the rudder moved throughout its full range of travel, the misalignment resulted in the rod binding, which exacerbated the stress and, ultimately, led to the fatigue failure.

NFU steering systems are designed to operate independently of the main steering system, including the telemotor feedback rod. When the steering failed, the OOW switched to NFU steering; however, there was no response. Post-occurrence examination of the NFU steering system disclosed a flaw in the wiring of the NFU control that prevented its use without the telemotor rod input. As a result, the NFU steering control was not available when main steering control was lost.

Inspection of Steering Gear

Steering gears and their associated machinery play an essential role in the safe operation of a ship, particularly in confined waters such as the St. Lawrence Seaway. Both TC and the SLSMC had inspected the *Salvor*'s steering gear in the previous nine months. The SLSMC inspection had taken place five days before the occurrence. However, these inspections were limited to operational tests. As per the company's procedures, the crew also tested and visually inspected the steering gear before departure. Additionally, the steering gear was subject to monitoring during routine engine room watchkeeping activities.

Nonetheless, these inspections did not detect

- the misalignment and binding of the *Salvor*'s telemotor feedback rod,
- the defect in the NFU steering system, or
- the defects in the steering cables.

[10] American Society for Metals, *Metals Handbook*, 8th Edition, Volume 1, 1961, p. 16.

The scope of inspections conducted by TC , the SLSMC, and company personnel was not sufficient to identify defects that led to the failure of the steering control system and that prevented the crew from immediately regaining control of steering (using NFU) once the rod failed.

Separation of the Barge

In the *Salvor/KTC 115* towing arrangement, face wires are used to hold the tug into the barge notch and provide a resistance to the turning moment applied by the tug's rudder. Chain provides a chafe-resistant, strong terminal connection between the starboard face wire and the tug. If both face wires are in tension, with no free play, the system does not allow movement between the tug and barge and serves to transmit the turning moment of the tug to the barge. Testing indicated that the chain broke in a brittle manner, which was likely due to the failure load being applied as a shock load. In order for such a shock load to be applied to the chain, it is most probable that the face wires and chain were initially slack.

The rate of movement of the rudder is governed by a hydraulic solenoid valve that operates either in the open or shut position. As such, the rate of rudder movement would not have exceeded that found in a normal hard-over helm manoeuvre. When the steering failure caused the rudder to go hard-to-starboard, the *Salvor*'s stern moved unchecked to port until it was fetched up by the starboard face wire and chain, causing the chain to fail. The depth of the notch on the *KTC 115* allowed only a small portion of *Salvor*'s hull to be accommodated. Once the starboard chain failed, the tug's stern slewed further to port. The hull of the tug pivoting in the notch acted as a fulcrum, overstressing and snapping the polypropylene hawsers on the bow, resulting in the separation of the tug from the notch. As a result, only the port face wire was left connecting the tug to the barge. The tug was briefly towed backwards by the barge and was at risk of being swamped until the port face wire, which was kinked over the bulwark, failed and the tug separated.

Use of Autopilot in Confined Waters

Since 2002, the TSB has investigated at least three occurrences in which the use of autopilots in confined waters has been a contributing factor.[11] Autopilots are intended to be used to relieve bridge crew of the burden of steering while in open waters. Several Canadian and international regulations[12] indicate that automatic steering should be switched to manual steering and tested in sufficient time to allow for a potentially hazardous situation to be safely dealt with, particularly in areas of high traffic density, restricted visibility, and other hazardous navigational situations. Potentially hazardous situations may include close-quarters situations with other vessels, propulsion failures, and, in the case of this occurrence, failure of the steering

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[11] TSB Occurrence No. M03M0040 (*Shinei Maru*); TSB Occurrence No. M04F0016 (*Evans McKeil*); TSB Occurrence No. M02L0039 (*Vaasaborg*).

[12] International Convention for the Safety of Life at Sea, 1974 (SOLAS) as amended, Chapter V, Regulation 24, *International Safety Management Code*, and Canadian *Code of Nautical Procedures and Practices* and *Steering Appliances and Equipment Regulations* made pursuant to the *Canada Shipping Act*.

gear. While use of the automatic pilot frees up the bridge watch to concentrate on other essential duties, the bridge watch may lose awareness of how the vessel is manoeuvring or responding to helm commands.

The steering was set on autopilot and, in the initial stages of the failure, the OOW had no indication that the steering had failed. It is most probable that the bang heard by the *Salvor*'s bridge crew was the sound made by the chain parting. The crew reported that, after hearing the noise of the chain parting, the barge began to swing to port; however, this was most likely an illusion created by the bow of the *Salvor*, under the influence of the hard-over rudder, swinging to starboard in the notch of the barge. This resulted in critical time being lost between the actual steering failure and the time that the OOW became aware of the steering failure.

Equivalent Level of Safety

While the size of the Canadian domestic merchant fleet has decreased in the past decade, the use of barges (pushed or towed by tugs) has increased. An analysis of tug/barge traffic through the St. Lawrence Seaway indicates that it has increased from 3.7 per cent to 4.3 per cent of total tonnage from 1999 to 2003.[13] The use of tug/barge units offers operators both flexibility in meeting customer demand and the economic benefits of smaller crew sizes. Despite operating differences between tug/barge units and conventional vessels, it is expected that an equivalent level of safety should be inherent in tug/barge units.

Regulatory Oversight

Conventional commercial vessels operating in the St. Lawrence Seaway are subject to regulatory overview by TC and the SLSMC/SLSDC to maintain and enhance safety, and to protect life, health, property, and the marine environment.

Through a process of monitoring and enforcement (inspection), TC and the Seaway authorities ensure that a minimum safe level of vessel condition, equipment, and personnel competency are in place relative to the size and type of vessel, the risks inherent with its operation, and cargo being carried. In the case of tug/barge operations, the operating environments are similar to those experienced by conventional vessels; however, their operation is compounded by the complexities of connecting and operating heterogeneous tug/barge combinations.

Some barges, such as crewed barges and those carrying oil,[14] are required to be inspected by TC. Requirements for these tug/barge combinations include the following:

- The master of any tug used for oil barge towing is required to ensure that the tug and towing equipment are in all respects capable of maintaining safe control over the oil barge in all foreseeable circumstances.

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[13] TSB analysis of the St. Lawrence Seaway traffic statistics, 1999-2003.

[14] TP 11960E, *Standards and Guidelines for the Construction, Inspection and Operation of Barges that Carry Oil in Bulk*, 1995.

- Safe tug/barge matching decisions require the assessment of a number of variables related to the characteristics of the vessels concerned.
- A formal towline inspection schedule and procedure should be established for each tug.
- Provisions should be made for the inspection of the hulls of barges.
- Guidelines should be established for the strength of towlines and other rigging gear.
- Emergency towlines should be provided.

Additionally, TC has recognized the benefits of rigging inspections for all tug/barge operations in a Notice to Surveyors, which states that "All gear used for towing, including the towing cable, and bridle chains should be tested and stamped and covered by a certificate from a recognized authority, such as a classification Society or Tackle Inspector."[15]

Notwithstanding the requirements for oil barges, TC and SLSMC/SLSDC inspection of other tug/barge operations deemed to be of lower risk is limited to inspecting the tug. As such, tug/barge combinations are not considered "together" for regulatory purposes. On its own, the tug presents little risk; however, when attached to a barge, the combined size and tonnage of the two is similar to that of a conventional cargo-carrying vessel. The characteristics of a composite tug/barge should afford an equivalent level of manoeuvring performance as a conventional vessel of equivalent size. An effective system connecting the tug to the barge is therefore fundamental to safe operation. This premise is recognized by TC in TP 11960, which requires that the construction, inspection, operation, and connecting systems of every integrated tug and oil barge be specially considered by TC, and that the inspection certificate of the oil barge shall identify those tugs that have been approved as suitable for operation with the barge.

Unlike inspected integrated tug/oil barge units, conventional tug/barge units operating in the pushing mode rely on either mechanical or wire and chain systems to connect the propulsion and steering system (tug) to the cargo-carrying hull (barge). The operating loads between the conventional tug/barge units are similar to those experienced by an integrated unit. However, the design of the rigging, and the connection of conventional pusher tug/barge combinations, is not required by TC to undergo an engineering evaluation to ensure that it is strong enough to carry all anticipated loads and that a sufficient factor of safety exists for unanticipated emergency situations.

An examination by the TSB of tug/tow rigging failure occurrences since 1990 indicates that the towing industry has experienced failures of wire, chain, and other tackle, often in normal service conditions.

- On 13 August 1990, the barge *Mcallister 131* partially separated from the tug *Wilfred M Cohen* when the port face wire failed. The barge sheared to starboard and

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[15] Notices to Surveyors IX-1, Transport Canada. The purpose of the Notices to Surveyors is to disseminate ship safety information of a general nature and to provide guidelines on miscellaneous ship safety matters.

struck a pier. (TSB Occurrence No. 1300-5-90)

- On 18 December 1999, the barge *Seaspan 630* separated from the tug *Seaspan Trojan* when the starboard towing bridle failed. The barge struck and damaged the bulk carrier *Gull Arrow*. (TSB Occurrence No. M99W0239)

- On 17 December 2002, the barge *PML 9000* partially separated from the tug *Reliance* when a face wire failed. The barge became uncontrollable and struck shore structures. (TSB Occurrence No. M02C0092)

- On 14 March 2003, the barge *Tartlip* separated from the tug *Fraser Yarder* when the towline failed. The barge struck a dock and a pleasure craft. (TSB Occurrence No. M03W0043)

- On 03 June 2004, the tug *Akhtiar* lost the towed bulk carrier *Algosound* after the towline failed. The *Algosound* subsequently grounded. Testing by the TSB Engineering Laboratory concluded that the cable failed because of the presence of broken and abraded wires, which reduced the strength to below that necessary to react to service loads.[16] (TSB Occurrence No. M04L0059)

- On 06 November 2004, the tug *Manson* was towing two barges when the towing arrangement connecting one barge failed. While attempting to reconnect the tow, the tug sank and two crew members were lost. (TSB Occurrence No. M04W0235). This investigation is ongoing.

Such failures indicate that either substandard rigging material is being used, or inadequate attention and safeguards are being applied to the design, engineering, and inspection of the connection system. The rigging used in the towing industry for certain barges continues to go unregulated and uninspected by TC.

While existing regulatory provisions only apply to tugs/barges carrying oil products, all tugs and barges present a risk to safety that is similar to or greater than that of a comparable, conventional vessel, considering the added probability of rigging failure.

Subsequent to the separation of the *Salvor* from the *KTC 115*, the barge proceeded across the channel where it subsequently grounded. The barge was equipped with a bow anchor; however, since the barge was unmanned, the anchor could not be deployed once separation had occurred.

Unlike conventional vessels of homogeneous construction, anchors on unmanned barges may not be easily accessible for operations should the tug be separated from the barge for any reason. Furthermore, there are no Seaway or TC requirements for unmanned barges to be equipped with systems to remotely deploy the anchor. Given the absence of regulatory requirements for the certification and inspection of rigging and tackle systems, the lack of remote anchor deployment systems places barges at increased risk of grounding, striking, or

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[16] TSB Engineering Laboratory Report LP 080/2004.

collision should they become separated from the tug.

A level of safety equivalent to conventional vessels should be inherent in tug/barge units. Nevertheless, in the absence of effective regulatory measures respecting the design, construction, and ongoing inspection of the rigging systems, conventional tugs and barges may not be operating with such an equivalent level of safety.

Safety Management

In the absence of regulatory oversight, the role of the company managing the vessel takes on an increased importance in conducting a safe and accident-free operation. By applying sound safety management principles through the provision of adequate policies, procedures, and training, vessel operators help the ship's crew make correct day-to-day operational decisions. A company with a strong safety culture and a commitment to safety, as exhibited through an effective SMS, may expect to see a lower incidence of occurrences.

A key requirement of an SMS, and one of the preliminary steps in setting one up, is the identification of safety-critical tasks, equipment, and situations that may pose a risk if not effectively managed. In the case of tug/barge operations, while the tasks and operating environments are similar to those experienced by conventional vessels, they are compounded by the complexities of connecting and operating heterogeneous tug/barge combinations. There are no mandatory requirements for companies operating tugs and barges in the Canadian domestic trade to have a formal SMS. Given the paucity of regulations governing conventional tug and barge operations, the application of an effective SMS to tug/barge operations takes on an increased importance.

At the time of the occurrence, the company operating the *Salvor/KTC 115* had been experiencing rapid growth. While one company vessel was ISM compliant, and a rudimentary SMS had been introduced throughout the company, the complexity of the company's operations, combined with rapid growth, had reduced the effectiveness of the system within fleet operations. As a result, key safety-critical elements were not afforded special attention. These elements included

- the evaluation of tug/barge combinations and their connection systems,
- the inspection of rigging and tackle, and maintenance of records,
- procedures for disconnecting and reconnecting tows,
- the evaluation of safety-critical onboard tasks and their relationship to the vessel's level of manning, and
- the use of autopilot in confined waters.

The failure of a single face wire or connecting chain should not result in the tug separating from its barge, providing that all of the potential forces acting on the connections have been analyzed, and the design of the resulting arrangement connecting the bow of the tug to the barge notch made sufficiently robust. In the case of the *Salvor/KTC 115*, a full analysis had not been carried out on the connection system as a whole. No load analysis was carried out nor

were safety factors calculated taking into account potential shock loading when determining the size of the chain connecting the starboard face wire to the tug. As a result, the chain, while of adequate strength for normal service, failed when a shock load was applied.

The *Salvor*, as is common with tugs operating in towing mode, was equipped with an emergency disconnect system for rapidly releasing the barge. However, the connection between the *Salvor* and the *KTC 115* was such that, although the port face wire was connected to the towing winch (and hence to the emergency disconnect), the starboard face wire had no emergency disconnect. Therefore, the vessel could not be rapidly released from its barge if the port wire failed or another emergency occurred, placing the vessel and crew at increased risk.

Commercial chain used in marine service is usually certified by various marine classification societies. Chain from unknown or non-marine sources that is unmarked or whose origin cannot be identified should not be used in towing.[17] Certification records for the rigging chain and wire were not kept on board and were not readily available ashore. The company SMS did not have procedures to ensure that the chain and other rigging materials used were from certified sources, or that they were regularly inspected and tested to ensure their continuing adequacy for service.

Formal safety management systems have policies and procedures for inspecting and maintaining safety-critical equipment and machinery. The system connecting the tug and barge is safety critical. The *Salvor* and the *KTC 115* had been connected before the voyage, disconnected for the tow across Lake Erie, and reconnected for the remainder of the voyage. However, the company did not have formal procedures or checklists to ensure that the connection between tug and barge was adequately configured, completed, and checked each time it was re-rigged, nor did it have watchkeeping procedures to verify that the connections between the tug and barge remained secure throughout the voyage.

In accordance with company policy and Seaway regulations, two qualified people must be in the wheelhouse at all times when transiting the confined waters of the Seaway. During a typical night watch, this would require both the OOW and a deckhand to be in the wheelhouse at all times. No other crew members were assigned to deck watch duties during the 1800 to 2400 or the 0000 to 0600 watches. An effective SMS is intended to identify safety-essential duties, including such tasks as fire and security rounds of the tug/barge, and routine checks of the connection rigging.

Although not specifically required by the *Crewing Regulations*, the Seaway Practices and Procedures state that vessels must have a sufficient number of well-rested crew members available for mooring operations and other essential duties. However, the company had not adequately assessed the essential duties to be conducted relative to the number of available onboard personnel.

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[17] *US Navy Manual of Towing*, Revision 3, Appendix D-2

Rigging inspections could not be routinely carried out without additional personnel being not only available on board, but awake and alert. Consequently, with the level of crewing, and the watchkeeping system used on board, there existed no practical way to follow both the two-person wheelhouse policy and the Seaway requirement for personnel being available for safety-related duties such as fire watch or checking the connections between tug and barge.

These collective weaknesses in the company SMS resulted in a system that neither adequately assessed the risks inherent in the company's fleet operations nor provided effective procedures to reduce the risk of occurrences.

Carriage and Playback of Automatic Identification Systems

Carriage of AIS on vessels within the St. Lawrence Seaway became mandatory at the opening of the 2003 shipping season. By transmitting and receiving information pertinent to safe navigation of ships, the AIS can enhance the safety, efficiency, and security of shipping within the Great Lakes. To do so, information is transmitted both from ship to ship and from ship to shore, in particular to shore stations where vessel traffic is monitored in real time. The information transmitted to these shore stations is recorded and available for playback in the event of an accident.

In contrast to conventional vessels, tug and barge combinations may change configuration from towing to pushing, be anchored separately, or as seen in this and other occurrences, inadvertently separate. Consequently, carriage of the AIS on the tug alone does not always represent the accurate position of the barge, which, depending on the nature of its cargo, may present a higher risk than the tug. Seaway AIS carriage requirements[18] require that the lead unit of combined or multiple units (tugs and tows) be equipped with an AIS. At the time of the occurrence, the *KTC 115* (the lead unit) was not equipped with an AIS. Following separation from the *Salvor*, the position of the barge was unknown to the tug, to Seaway traffic controllers, or to the approaching traffic, and presented a navigation hazard.

The software system, using raster charts used by the SLSMC/SLSDC to monitor, record, and playback AIS information transmitted from vessels, is such that the recorded playback is of poor quality and may not be providing the intended benefits of enhancing safety, efficiency, and security, or improving performance through occurrence investigation.

The following TSB Engineering Laboratory reports were completed:

LP 102/2004 - Examination of Fractured Marine Chain, M/V *Salvor*

LP 111/2004 - Examination of Steering Gear, M/V *Salvor*

These reports are available upon request from the Transportation Safety Board of Canada.

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[18] Seaway Notice No. 1, 2003, Paragraph(A) (2).

Findings as to Causes and Contributing Factors

1. Modifications to the telemotor feedback rod to tiller head mounting pivot resulted in misalignment between the rod and the pivot, which caused the rod to bind and subsequently fail from fatigue.

2. It is most likely that the tug's face wires were slack, resulting in a sudden overload on the connecting chain when the steering failed and the rudder went hard over.

3. With the level of crewing, combined with the onboard watchkeeping system, there existed no practical way to follow both the two-person wheelhouse policy and the Seaway requirement for personnel being available for safety-related duties such as fire watch or checking the connections between tug and barge.

Findings as to Risks

1. The design of the rigging connecting tugs and barges is not required by Transport Canada to undergo an engineering evaluation to ensure that it is strong enough to carry all anticipated loads and that a sufficient factor of safety exists for unanticipated emergency situations.

2. In the absence of effective regulatory measures respecting the design, construction, and ongoing inspection of the rigging systems, conventional tugs and barges may not be operating with a level of safety equivalent to conventional vessels.

3. The lack of remote anchor deployment systems places barges at increased risk of grounding, striking, or collision should they become separated from the tug.

4. The scope of inspections conducted by Transport Canada, the St. Lawrence Seaway Management Corporation, and company personnel was not sufficient to identify defects that led to the failure of the steering, and that prevented the crew from immediately regaining control of the steering (using non-follow-up steering) once the rod had failed.

5. The vessel had no way to rapidly release itself from its barge in the event of a failure of the port wire, or other emergency, placing the vessel and crew at increased risk.

6. Collective weaknesses in the company's safety management system resulted in a system that neither adequately assessed the risks inherent in the company's fleet operations nor provided effective procedures to reduce the risk of occurrences.

7. The *KTC 115* (the lead unit) was not equipped with an automatic identification system (AIS). Following separation from the *Salvor*, the position of the barge was unknown to the tug, to Seaway traffic controllers, or to the approaching traffic, and presented a navigation hazard.

Other Finding

1. The software system used by the St. Lawrence Seaway Management Corporation/Saint Lawrence Seaway Development Corporation to monitor, record, and playback AIS information transmitted from vessels is of poor quality and may not be providing the intended benefits of enhancing safety, efficiency, and security, or improving performance through occurrence investigation.

Safety Action Taken

Subsequent to the occurrence, the TSB sent a Marine Safety Advisory (MSA 08-04) to Transport Canada (TC). The advisory suggested that TC, in conjunction with the St. Lawrence Seaway Management Corporation (SLSMC) and the Saint Lawrence Seaway Development Corporation (SLSDC), may wish to take measures to ensure that the methods used to connect tugs and barges are assessed on a continuing basis, and that tug/barge units can manoeuvre with a level of safety equivalent to conventional vessels. The advisory further suggested that TC may wish to take steps to ensure the continuing adequacy for intended service of the wire, chain, and other tackle used to connect tugs and barges.

In response, TC indicated that an internal Tug/Barge Task Force has been established representing all TC regions. The task force is mandated to

- develop a guidance document for TC inspectors, to allow consistent interpretation and application of the *Canada Shipping Act* (CSA) respecting tug/barge combinations; and

- provide recommendations to the CSA 2001 regulatory reform team on amendments to the related regulations.

The Tug/Barge Task Force submitted its report to TC head office in December 2005. The recommendations of the report included the following statements:

- The examination of best operational practices from Class and International Maritime Organization (IMO) is recommended. A guidelines/standards approach incorporating aspects of various Class or IMO documentation is recommended, bearing in mind the complexity and variance in the Canadian towing industry. There may well be different standards for different areas within Canadian waters with another standard for adherence to international voyages.

- Mooring winches, tow cut-offs, cables, chains, towlines etc. should be recognized as vessel's equipment and be properly examined and documented. This applies to both the tug and barge. This would also include operations items such as pick lines and retrieval devices.

- Bollard pull-on tugs should be determined by a common method and officially recorded. This will assist in the matching of tugs to tows, both in regular practice and emergency situations.

- A standard of construction concerning barges should be published. Board of Steamship Inspection Decision No. 5787 concerning barges that carry oil should be expanded to include chemical and non-liquid bulk barges.

At the Canadian Marine Advisory Council (CMAC) national meeting in November 2006, a Tug/Barge Working Group was formed with participation from 13 marine industry organizations, labour unions, and TC. Consideration should be given to creating a CMAC standing committee to deal solely with tug/ barge issues and to deal with the following initiatives:

- Develop a comprehensive set of regulations or standards dealing with the construction and operation of combination tug and barge systems in Canada based on the United States Coast Guard document "Navigation and Vessel Inspection Circular 281." This would include developing definitions for tugs, barges, and combination tug and barge systems.

- Develop common definitions for the purpose of the *Collision Regulations* and rescind the licensing of tug and barge operations under these Regulations pursuant to Board Decision 6001.

- Develop safe crewing guidelines for all operations, cargoes, and operating conditions.

- Develop construction standards for all barges, including those carrying oil, covered by the *Oil and Barge Standard* (TP 11960), pursuant to Board Decision 5787.

- Develop operational practices for tug and barge operations, which would include operational hazards and safety standards as well as operation in ice.

- Examine whether oil recovery barges should be covered by the *Oil and Barge Standard*, and if these barges cannot be covered by the Standard, then develop a separate standard.

- Develop guidelines for barges used as storage facilities.

The SLSMC/SLSDC indicated that, in response to the occurrence, they had

- hosted an "after action meeting" with responding agencies, including the TSB, to critique the response to the incident. A few areas for improvement were identified and some changes are being incorporated into the SLSDC Emergency Response Plan.

- conducted a comprehensive review of joint SLSMC/SLSDC regulations dealing with tug/tows. Regulations 33 and 34 of the *Joint Practices and Procedures Respecting the Transit of Ships on the St. Lawrence Seaway,* were amended to read:

  > 33. No ship of unusual design, ship or part of a ship under tow or ship whose dimensions exceed the maximum ship dimensions prescribed in section 3 shall transit the Seaway except in accordance with special instructions of the Manager or the Corporation given on the application of the representative of the ship.
  >
  > 34. No vessel that is not self-propelled (including but not limited to tug/tows and/or deadship/tows) shall be underway in any Seaway waters unless it is securely tied to an adequate tug or tugs, in accordance with special instructions given by the Manager or the Corporation pursuant to section 33.

McKeil Marine Limited has amended its standing order to prohibit the use of the autopilot in confined waters. Additionally, captains and mates have been sent for Bridge Resource Management training, and the crew complement has been increased by at least one on each of its tugs.

The master has implemented a procedure on all vessels on which he sails whereby the chain links are replaced by certified shackles, thereby ensuring documented proof of the safe working load for the entire connection system.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 01 February 2007.

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