MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

ACCIDENT REPORT

SERIOUS MARINE CASUALTY REPORT NO 31/2014 NOVEMBER 2014

Failure of the controllable pitch propeller of the chemical tanker *Key Bora*, resulting in heavy contact with the jetty in the port of Hull 20 December 2013

SUMMARY

At 1840 on 20 December 2013, the 93m chemical tanker *Key Bora* made heavy contact with the western approach jetty at Alexandra Dock, Hull. The vessel's CPP[1] system had a history of responding slowly to demands for astern pitch, and did not respond in time to the pilot's order of full astern to prevent the bow striking the quay. The bulbous bow was holed above the waterline, there was no pollution.

The MAIB investigation identified that:

- The pilot was aware of the vessel's poor astern response but did not test the engine prior to manoeuvring.
- The master was unaware of the function of the CPP backup control system, which could have been used to bring the situation under control.
- The crew at the anchor station had difficulty hearing the master's order to drop the anchor over the hand-held UHF[2] radio.
- Fault finding and assessment of the CPP system performance was hampered by the lack of installation records against which to judge the system's response.

The port authority, ABP[3], has taken steps to ensure that astern propulsion is tested and ready for use before departure or arrival from any berth, regardless of the vessel's size.

[1] Controllable pitch propeller

[2] Ultra High Frequency radio

[3] Associated British Ports

The vessel's manager, V.Ships, has been recommended to investigate and rectify the anomaly with the CPP system on *Key Bora* and to include in its safety management system a requirement for bridge watchkeeping officers to familiarise themselves with the emergency backup control of their CPP system.

Following a recommendation from the chief inspector, BV[4] has requested IACS[5] to include response times in its forthcoming unified requirement for commissioning trials on CPP systems.

FACTUAL INFORMATION

Background

Key Bora had visited the Humber on many occasions and, following a call at Hull in November 2010, the pilot had made an entry on the port's Pilot and Vessel Information System (PAVIS) stating that the vessel had *very slow astern power*. The vessel was in Rotterdam in December 2013 when *Key Bora*'s master was replaced by a new master who had not worked on the vessel before. During the handover from his predecessor, the new master was informed that the astern response of the CPP was very slow, and while still in Rotterdam he experienced a near collision due to this slow astern response. He did not inform the vessel's managers of the incident.

Narrative

On 19 December 2013, the pilot tasked to bring *Key Bora* alongside Alexandra Dock, Hull, accessed PAVIS and read the note regarding the vessel's slow astern response. This was confirmed by the master the next day when, at 1615, the pilot joined the vessel at the Chequer Light Buoy in the Humber.

As part of the subsequent master/pilot exchange the pilot agreed with the master that, to compensate for the slow astern response, he would stop the vessel immediately after passing the Hook Buoy **(Figure 1)**, and asked for the anchors to be made ready.

Around 18:29:25 as the vessel passed north of the Hook Buoy, the CPP pitch was set to zero and the pilot asked the master to transfer the manoeuvring controls to the port wing console. The vessel's speed over the ground at the time was 4.4kts[6], which included a tidal stream of 2.2kts from the stern. The master and pilot were on the bridge and the third officer was in charge of the forward mooring station. The starboard anchor was ready to let go.

Shortly after shifting control to the port wing the pilot ordered full astern. The master placed the pitch control to full astern, and the vessel continued to move ahead while the propeller pitch indicator was seen to move very slowly astern. When the vessel's bow was 40m from the western approach jetty for the Alexandra dock, the pilot realised that an impact was inevitable so he asked the master to drop the starboard anchor and applied maximum starboard thrust on the bow thruster in an attempt to maintain control of the vessel. The master instructed the third mate, by UHF radio, to drop the anchor. He had to repeat this order five times before the third mate acknowledged him and dropped the anchor.

At about 18:38:47 *Key Bora*'s bow made heavy contact with the jetty. Following the impact, the anchor was recovered and *Key Bora* was manoeuvred away from the jetty and into the open lock gate. The astern response remained very slow, but the vessel was successfully berthed at the designated berth.

The impact caused a hole, approximately 90cm in diameter, in the bulbous bow 1m above the waterline **(Figure 1 inset)**. There was no pollution but the jetty suffered damage to the wooden fenders and piling on the west lead-in section.

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[4] Bureau Veritas

[5] International Association of Classification Societies

[6] knot, speed in nautical miles per hour

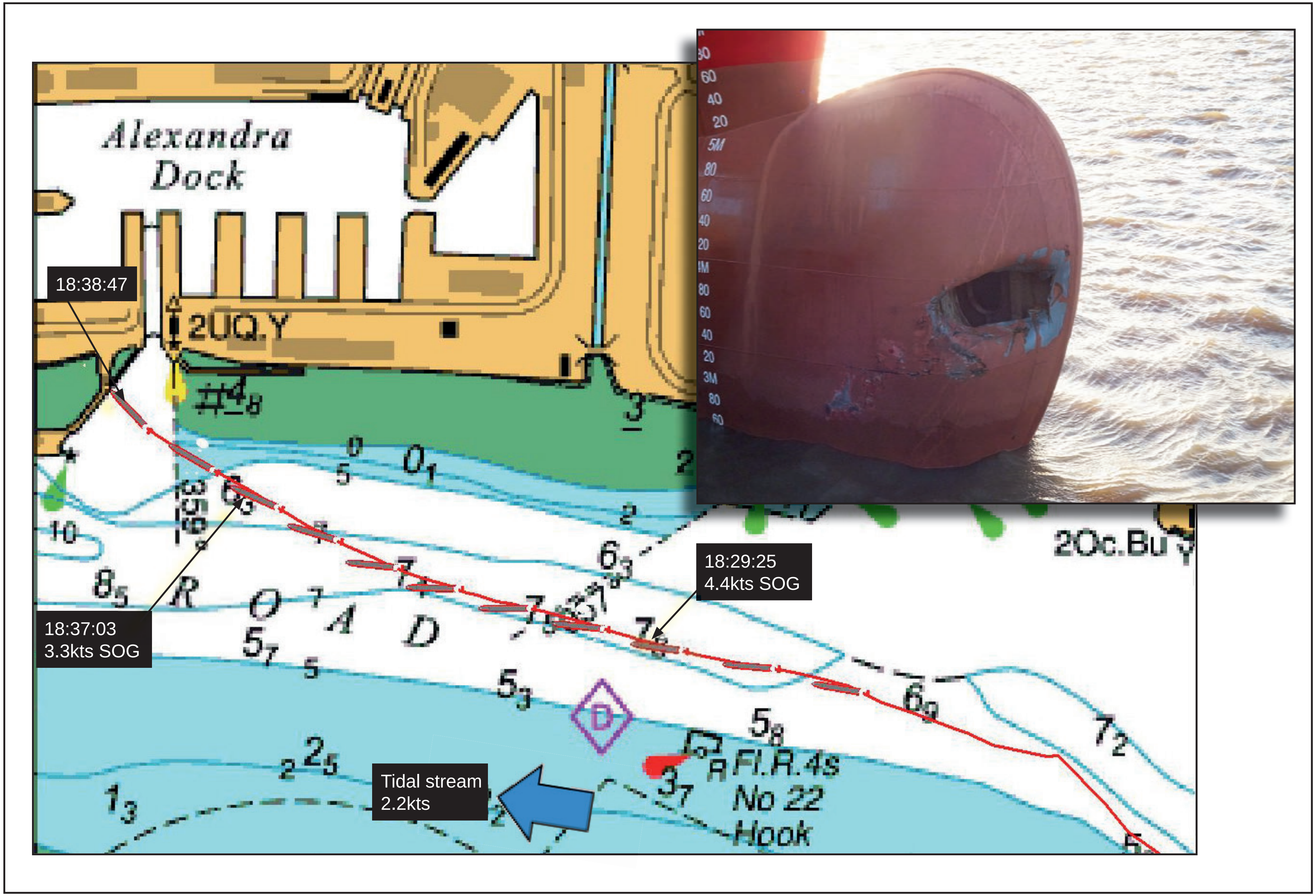

Figure 1: Approach to Alexandra Docks, showing *Key Bora*'s position, speed and tidal stream

Company and crew

Key Bora was purchased by Key Shipping AS of Norway in March 2013 and joined a fleet of nine other vessels in the company. Technical management was provided by V.Ships UK from 2007 to 2011 and from October 2012 onwards.

There were 12 crew members on board at the time of the accident all of whom held appropriate qualifications. The master was a Norwegian national with 40 years' experience in the rank of master. The six other officers were from Bulgaria, Latvia and Ukraine and the ratings were all Philippine nationals.

Propulsion system

Key Bora had an MaK 6 M 25 main propulsion engine and a KH 960 CPP system manufactured by ZF Marine[7]. The propeller shaft and shaft generator were driven through a common gear train with the propeller shaft being clutched to enable it to be disengaged. The propulsion system was operated at a constant shaft speed of 170rpm[8].

The CPP control system was an ECS 4000 supplied by NORIS[9]. It consisted of a central unit that integrated the signals from all the sub-systems including the bridge controls **(Figure 2)**, engine control room control and the local emergency control, and a PLC[10] that translated the pitch demand into electrical signals for ahead and astern pitch solenoid valves. These in turn controlled the flow of high pressure hydraulic oil to the CPP pitch actuator. This actuation was controlled by the PLC through a closed loop feedback system. An LCD[11] touch-screen provided a user interface to the central unit and was used to set the PLC's control parameters.

In the event of a malfunction, the feedback system could be bypassed by activating one of the backup control buttons, located at the central console on the bridge and in the engine control room, enabling direct joystick control of the solenoid valves. A notice containing detailed instructions for operating in the backup control mode was displayed at the central console on the bridge. The pitch control levers at the central console and the bridge wings had labels pasted on the astern sections of the graduated scales stating *max astern 7* **(Figure 2 inset)**.

Master/pilot exchange and engine testing

The 'Master/Pilot Exchange of Essential Information' document completed and referred to during the pilotage on 20 December 2013, contained a line that stated *Astern Power 50% ahead.*

Key Bora's SMS[12] contained a pre-arrival checklist that required the engines to be tested. The requirement to test and prepare the engines for manoeuvring was also reinforced in the ICS[13] publication 'Bridge Procedures Guide (Fourth Edition)'. However, as the vessel had anchored briefly before picking up the pilot, engine movements were deemed to have been tested. ABP did not require the port's pilots to test the propulsion system on vessels the size of *Key Bora* before commencing pilotage.

Factory test and commissioning of the CPP system

The ECS 4000 control system was factory tested and adjusted by NORIS in 2004 before commissioning on board. The factory settings were recorded in a spreadsheet, which included the response time for

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[7] ZF Marine, a department of ZF Friedrichshafen AG, Germany.

[8] revolutions per minute

[9] NORIS Automation GmbH

[10] Programmable Logic Controller

[11] Liquid Crystal Display

[12] Safety Management System

[13] International Chamber of Shipping

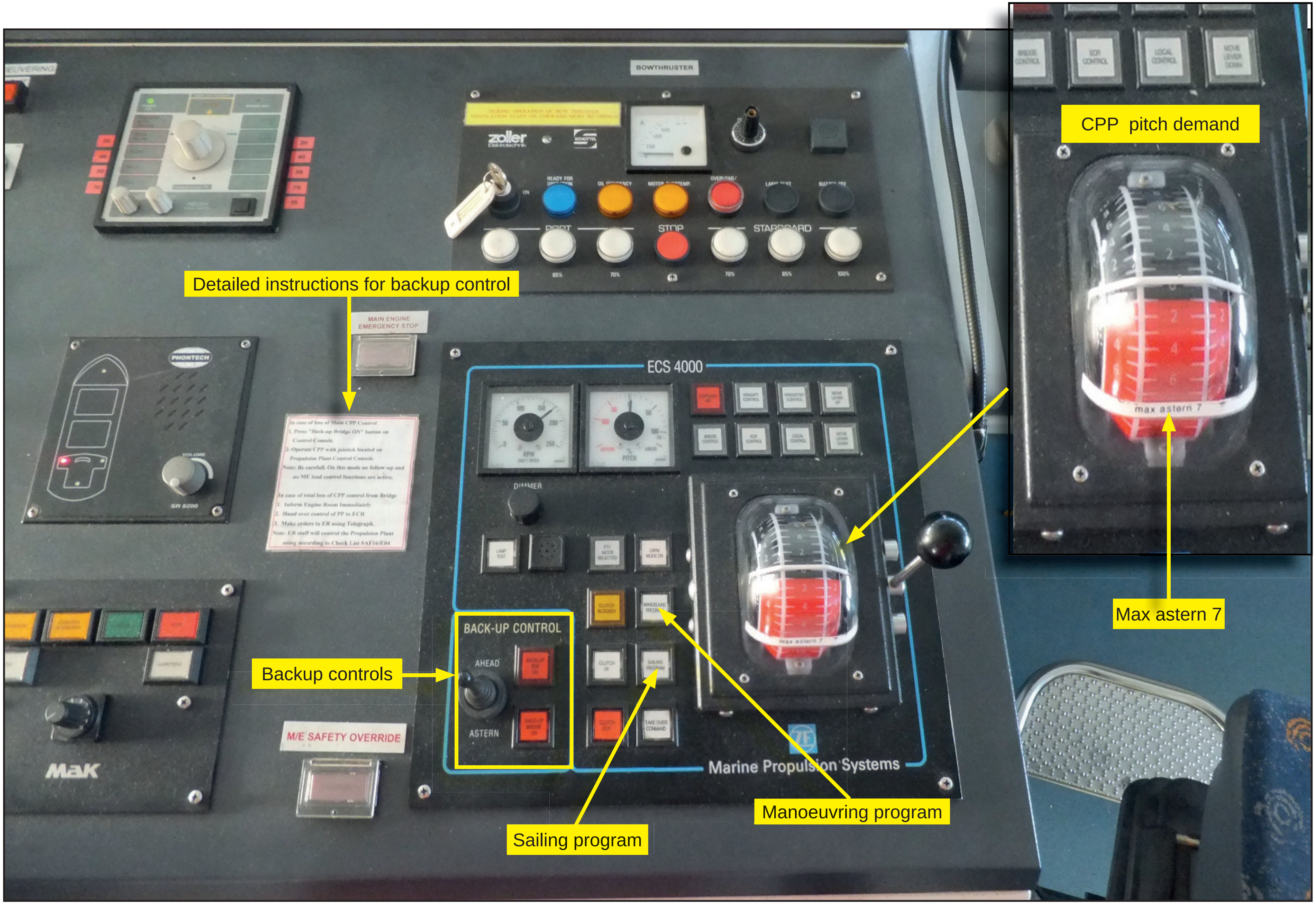

Figure 2: Bridge central control unit

the system to achieve the complete range of ahead and astern movements in both the sailing and manoeuvring modes. The settings were delivered to ZF Marine with the system and were intended to be used as the basis for setting the system parameters during commissioning.

During the sea trials conducted in August 2005, the CPP system was commissioned and tested by local service agents for ZF Marine in the presence of BV surveyors. The full range of ahead and astern movements in the constant engine speed mode was tested. The response times to attain the various pitch positions were not recorded; BV's rules for classification of ships did not require the response times to be recorded.

During the investigation, an undated record of a crash stop test was found on board the vessel. BV was unable to confirm when this data was acquired and there were no other records available on board or with BV regarding any other crash stop tests carried out on *Key Bora.* The time taken for the pitch to change from full ahead to stop was recorded as 19.6 seconds, and from stop to full astern as 14 seconds. The full ahead pitch was indicated as 90% and full astern pitch as -50% **(Figure 3)**.

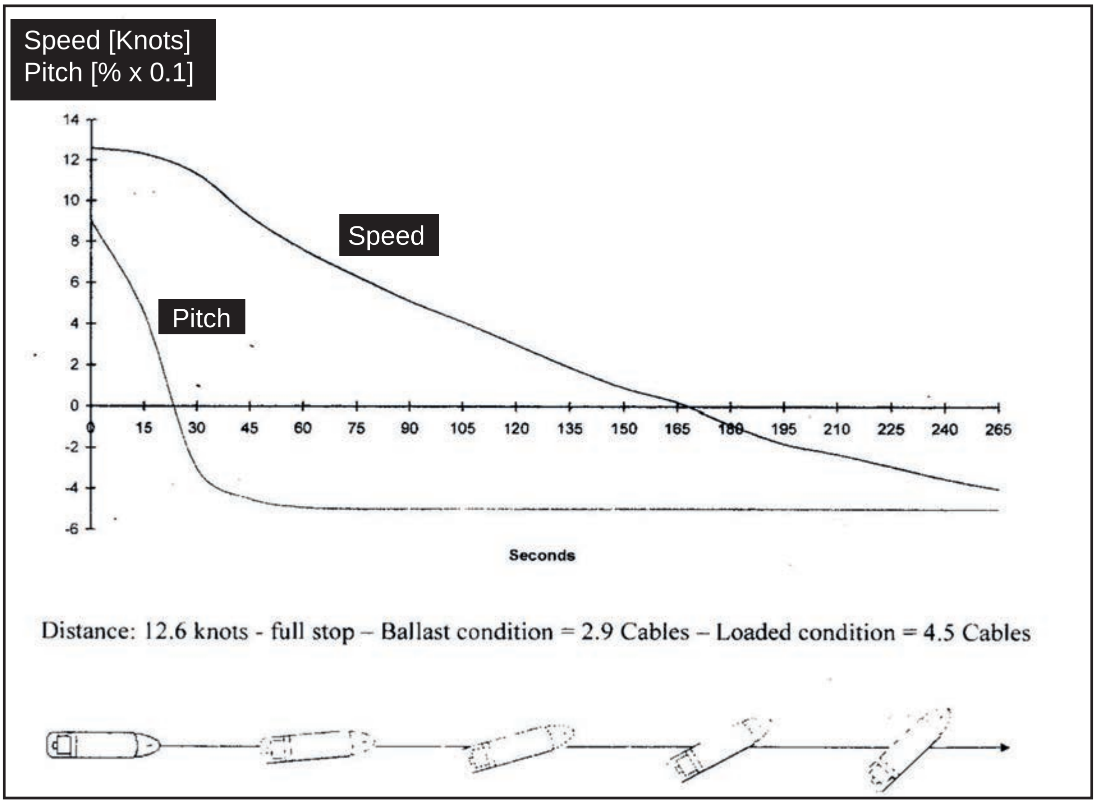

Figure 3: Crash stop tests (as displayed on the bridge of *Key Bora*)

Post-accident survey and tests

On 21 December 2013, the day after the accident, MAIB inspectors and a surveyor from BV witnessed manoeuvring operations from the bridge while *Key Bora* shifted to a repair berth. During this time, despite the pitch control lever being set to 70% astern for over 75 seconds, the pitch achieved did not exceed 50%.

Once alongside, tests to compare the response times for ahead and astern pitch were carried out with the clutch disengaged. The time taken to achieve 50% ahead pitch was 5 seconds, whereas it took 21 seconds to obtain a 50% astern response. When the system was set to backup control, the response time for both 50% ahead and astern was 3 seconds.

Following these tests, the BV surveyor issued a document to the master identifying the work to be completed before leaving port. This work included:

- *Temporary repairs to the stbd side of the bulbous bow…*
- *Fault finding and repairs as appropriate to the CPP system following unsatisfactory tests carried out…*

On 23 December, further tests were carried out on the system by electrical technicians in the presence of the master, chief engineer and a BV surveyor. These tests did not include a check of the time delay between pitch demand and response. Following these tests, BV concluded:

Occasional survey of the machinery installation carried out to verify the operation of the CPP. Extensive testing carried out from all remote locations, back up controls and locally and no defect could be identified at this time. The system was additionally checked by electrical technitian [sic] *from the shipyard who confirmed the system operated as required. No further action deemed necessary at this time*.

Service agent's analysis of CPP behaviour and repair

Berg owns the after sales business for ZF Marine CPP systems. Upon studying the timing tests and a video footage of the pitch response of 21 December, Berg's service department stated that the system appeared defective and may require their technician to carry out repairs followed by a sea trial. These repairs did not take place.

Berg stated that the PLC where the CPP control parameters were set could only be accessed after the correct password was entered. They further stated that the vessel's crew had never been provided with the password, and therefore could not have changed these parameters.

Onboard checks and tests

On 13 March, *Key Bora*'s master and chief engineer carried out a timed test to replicate the CPP response timing test, carried out on 21 December 2013. The results were almost identical, with the system taking 5s and 20s to reach 50% pitch ahead and astern respectively.

By way of a comparison, the crew of *Key Marmara*, which was fitted with a very similar propulsion and CPP control system, reported that the response times for their CPP system to achieve 50% pitch ahead and astern were 3 seconds and 3.1 seconds respectively.

Key Bora's chief engineer was also asked by ZF Marine for a set of response parameter readings from the system in order to compare them with the factory settings of 2004 in both manoeuvring and sailing modes. The two sets of data are compared in the table below.

Demand %	Manoeuvring mode Response parameter in seconds		Sailing mode Response parameter in seconds	
	2004	2014	2004	2014
100	25	80	400	80
90	15	60	240	60
80	10	35	50	50
50	5	5	15	15
0	0	0	0	0
-50	5	15	5	5
-80	10	40	10	10
-90	15	50	30	30
-100	25	60	60	60

Table 1: *Key Bora* CPP system data for the manoeuvring and sailing modes, showing the parameter settings during the factory trial in 2004 and those recorded by the chief engineer in March 2014.

This data was analysed by NORIS, who stated that several parameters of the CPP system on *Key Bora* were set incorrectly. In particular they pointed out that in the manoeuvring mode, the response time for 50% pitch in either ahead or astern directions should have been 5 seconds and that the manoeuvring mode response times should not have been set longer than those of the sailing mode.

Communications on board

The vessel was fitted with a Phontech CI 3100 talkback system, with an audio output of 10 watts and with repeater stations forward and aft. It was not used on the day of the accident as it was defective.

During manoeuvring and cargo work, the crew communicated with each other using UHF radios of 1- 4 watts adjustable output. It was not possible to establish the output wattage of the UHF radios at the time of the accident.

Previous CPP related accidents

MAIB report 9/2012[14] into the CPP failure on board *Saffier* resulted in several recommendations. One of these[15] recommended that BV make a submission to IACS proposing a unified requirement for CPP systems to be comprehensively tested during commissioning trials. This was accepted and a unified requirement is expected to be issued by IACS before the end of 2014.

Regulations and requirements

The MAIB report into the CPP failure on *Saffier* contains the regulations and requirements applicable to CPP systems. There were no stated requirements regarding the response times of CPP systems.

ANALYSIS

Accident mechanism

Key Bora made heavy contact with the jetty because its CPP did not respond adequately to the full astern order from the pilot. The strong tidal stream and the delay in dropping the anchor caused by the communication difficulties between the bridge and the anchor station were contributory factors.

CPP history and sea trial

Key Bora's recorded history of inadequate astern response dates back to November 2010. However, it is almost certain that the CPP anomalies were introduced when the system was commissioned. NORIS confirmed that the values of the CPP control parameters recorded in March 2014 were incorrect. These parameters were most likely set during commissioning as the vessel's crew were never provided with the password to access the system, and the only time a CPP service engineer had visited the vessel since commissioning was after the accident.

The crash stop test was most probably carried out during the sea trials in 2005, as there were no other records of further sea trials or tests on the CPP system. Full astern pitch was recorded as -50% in the crash stop trial, demonstrating that the vessel was unable to achieve an astern pitch larger than 50% **(Figure 3)**. It is highly likely that the statement regarding astern response in the 'Master/Pilot Exchange of Information' document was derived from this crash stop test.

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[14] Report on the investigation of the failure of the controllable pitch propeller of the cargo ship *Saffier,* resulting in heavy contact with a berthed tug in Immingham harbour.

[15] MAIB recommendation 2012/113

In the absence of guidance, regulation or records indicating the required behaviour of the CPP system, the classification society accepted and signed off the sea trials.

At the time of delivery and for the 7 years since, the crews who operated *Key Bora* treated the poor astern response as a characteristic of the vessel and did not challenge it.

Tests on the CPP system

The tests and observations carried out immediately after the accident demonstrated that *Key Bora*'s astern response was four times slower than the ahead response up to 50% pitch demand. This was further confirmed by technical specialists from Berg and NORIS. The successful test of the backup control established that the closed loop control system was the source of the delay.

The tests completed for the BV surveyor on 23 December did not include response times since there was no guidance, regulation or records to indicate the required behaviour of the system. Therefore, the BV surveyor concluded that the system was functioning correctly and that no further action was required.

At the time of writing, the poor astern response of *Key Bora*'s CPP system had still not been rectified.

Fault finding and assessment of the CPP system's performance by the crew, the operator, independent technicians and surveyors was ineffective due to the lack of a performance standard against which to judge the system's response.

Pilot's actions

The ABP pilot tasked with bringing the vessel into port took note of the 2010 observation in PAVIS regarding the vessel's slow astern response. He was subsequently given the same information by the master. The remark in the Master/ Pilot Exchange of Information document pertaining to the astern power being only 50% of the ahead power, and the label on the pitch control lever limiting pitch control to 70%, should have further alerted him to the compromised state of the propulsion system. However, despite these warnings and in the absence of any requirement to test the propulsion system for vessels of *Key Bora*'s size, he did not consider it necessary to test the astern propulsion. His plan to stop the vessel at the Hook Buoy and to ready the anchors proved insufficient mitigation for the degree of poor astern response experienced.

Having not tested the propulsion system, the pilot was unable to fully assess the risks presented by the poor astern response and so did not put in place sufficient control measures.

Emergency response

A notice containing detailed instructions on the use of the backup system control was displayed prominently on the central console on the bridge **(Figure 2)**. Had the master been familiar with this control mode, he would have known that a faster, more effective response could have been achieved by using it. However, the vessel's safety management system contained no requirement for deck officers to familiarise themselves with this mode of control or to conduct propulsion failure drills, and no such drills or familiarisation had been completed.

The master's lack of familiarity with the backup control system meant that he was unable to intervene effectively to prevent the vessel striking the quay once it was clear that *Key Bora* was not slowing quickly enough.

Communication

It is difficult to estimate whether dropping the anchor would have stopped *Key Bora* before it hit the jetty. However, the impact would have definitely been reduced had it been dropped earlier.

The master had to repeat his order to drop the anchor five times. As the bow thruster was thrusting at full power during the final moments leading up to the accident, it is possible that the resulting high noise level at the mooring station made it harder for the crew to hear the master's commands over the UHF radio. Had the much louder talkback system been functioning and used, the command to drop the anchor would probably have been heard clearly and implemented much sooner.

CONCLUSIONS

- *Key Bora* made heavy contact with the jetty because the CPP's astern response was inadequate and did not develop sufficient astern thrust in time to stop the vessel.
- The CPP control system astern response was four times slower than the ahead response to 50% demand.
- It is almost certain that the poor CPP astern response was introduced at the time the system was commissioned in 2005.
- Fault finding and assessment of the CPP system's performance by the crew, the operator, independent technicians and surveyors was ineffective due to the lack of a performance standard against which to judge the system's response.
- Having not tested the propulsion system, the pilot was unable to fully assess the risks presented by the poor astern response and so did not put in place sufficient control measures.
- The master's lack of familiarity with the backup control system meant that he was unable to intervene effectively to prevent the vessel striking the quay once it was clear that *Key Bora* was not slowing quickly enough.
- Had the talkback system been functioning and used, the command to drop the anchor would probably have been heard clearly and implemented much sooner.

ACTION TAKEN

The chief inspector of MAIB has written to Bureau Veritas with the following recommendation:

2014/113 Request IACS to include in the forthcoming unified requirement being implemented in response to MAIB Recommendation 2012/113 that, during commissioning trials of new and existing CPP systems, the response times for ahead and astern pitch demand are also recorded and verified to be in accordance with the values expected by the CPP system manufacturer.

BV has accepted the recommendation and has raised the matter with the IACS General Policy Group.

Associated British Ports has:

Issued a notice to pilots and pilot exemption certificate holders informing them of this accident and stressing the importance of ensuring that astern propulsion is tested and ready for use before departure or arrival from any berth, regardless of the size of the vessel.

RECOMMENDATIONS

V.Ships UK Ltd is recommended to:

2014/150 Investigate and rectify the poor astern performance of *Key Bora*'s CPP system.

2014/151 Ensure that the CPP control parameters on its managed vessels are set in accordance with the equipment manufacturer's guidance and that performance standards are available to technical staff responsible for monitoring the systems.

2014/152 Improve the effectiveness of the safety management systems on board the vessels under its management by:

- Requiring ships' crews to carry out periodic drills to practise the correct response to propulsion system failures and regularly test the associated backup control systems.

- Ensuring that all communication systems are functioning and used appropriately.

Safety recommendations shall in no case create a presumption of blame or liability

SHIP PARTICULARS	
Vessel's name	*Key Bora*
Flag	Gibraltar
Classification society	Bureau Veritas
IMO number/fishing numbers	9216024
Type	Chemical tanker
Registered owner	Key Shipping AS, Norway
Manager(s)	V.Ships UK Ltd
Year of build	2006
Construction	Steel
Length overall	86.9m
Gross tonnage	2627
Minimum safe manning	10
Authorised cargo	Type 2 chemicals
VOYAGE PARTICULARS	
Port of departure	Rotterdam
Port of arrival	Hull
Type of voyage	Short International
Cargo information	Ballast
Manning	12
MARINE CASUALTY INFORMATION	
Date and time	20 December 2014, 1840
Type of marine casualty or incident	Serious Marine Casualty
Location of incident	West Approach jetty: Alexander dock, Hull
Injuries/fatalities	None
Damage/environmental impact	Bulbous bow breached above waterline, damage to jetty fenders and piling / none
Ship operation	Manoeuvring
Voyage segment	Arrival
External & internal environment	Southerly force 5, visibility good, tidal stream 2.2kts flood, high tide 1952
Persons on board	12