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“The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an such investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame.”

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 14(14) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

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Catastrophic engine failure, resulting in a fire on board *Windcat 8* off the Lincolnshire coast 7 September 2017

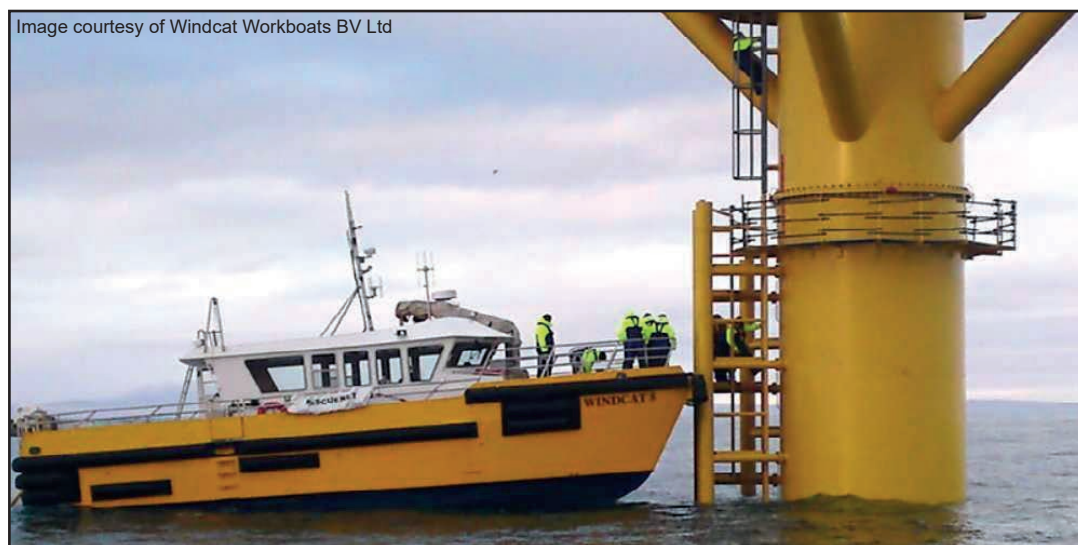
SUMMARY

On 7 September 2017, the 15.87m crew transfer vessel, *Windcat 8*, was on passage to Grimsby, UK, from the Lynn Wind Farm in the North Sea with two crew and eight windfarm technicians on board. Shortly after setting off, the vessel's port engine suffered catastrophic damage and caught fire. The passengers were quickly transferred on to *Windcat 31* and the fire was contained within the port engine space and soon extinguished. *Windcat 8*'s port engine was badly damaged and the vessel was towed to Grimsby by *Windcat 30*. There was no pollution and no injuries.

The MAIB investigation identified that the catastrophic damage to *Windcat 8*'s port main engine was caused by the failure of a piston connecting rod big end shell bearing, which resulted in the connecting rod assembly releasing and penetrating through the engine crankcase. The investigation also identified that:

- A high oil temperature alarm prior to the engine failure warranted a more cautious approach to the use of the engine until a deeper technical investigation could be conducted.
- The fire resulted from the ignition of oil vapour released from the damaged crankcase and did not spread beyond the port engine.
- The fixed fire extinguishing system was rendered ineffective because not all the port engine space vents were closed prior to its release.
- The safety of the passengers was given a high priority.

A recommendation has been made to *Windcat 8*'s owner, Windcat Workboats BV Ltd, which is aimed at improving its crews' reactions to engine alarms and engine space fires.



Windcat 8

NARRATIVE

At approximately 1620¹ on 7 September 2017, the crew transfer vessel² *Windcat 8*, owned and operated by Windcat Workboats BV Ltd (Windcat Workboats), departed wind turbine LN09 on the Lynn Wind Farm (**Figure 1**) to return eight technicians to Grimsby, UK. The vessel's crew comprised a master and a deckhand. It was daylight with a gentle breeze and slight seas.

As *Windcat 8* cleared the windfarm, the master increased the vessel's speed to 21 knots (approximately 1840rpm). At 1638, a high engine oil temperature alarm activated on the port engine indication panel on the forward console in the main cabin (**Figure 2**). The master immediately set both engines to idle and told the deckhand to go to the port engine space to investigate. The deckhand checked the port engine's cooling system and oil level but he did not identify anything unusual. He returned to the cabin, closing the port engine space deck hatch behind him (**Figure 3**), and reported his findings to the master. As the high oil temperature alarm on the indication panel had now reset, the master decided to resume passage. At 1640, he increased the vessel's speed back to 21 knots and monitored the port engine temperature, which remained normal.

Reproduced from Admiralty Chart 1190-0 by permission of HMSO and the UK Hydrographic Office

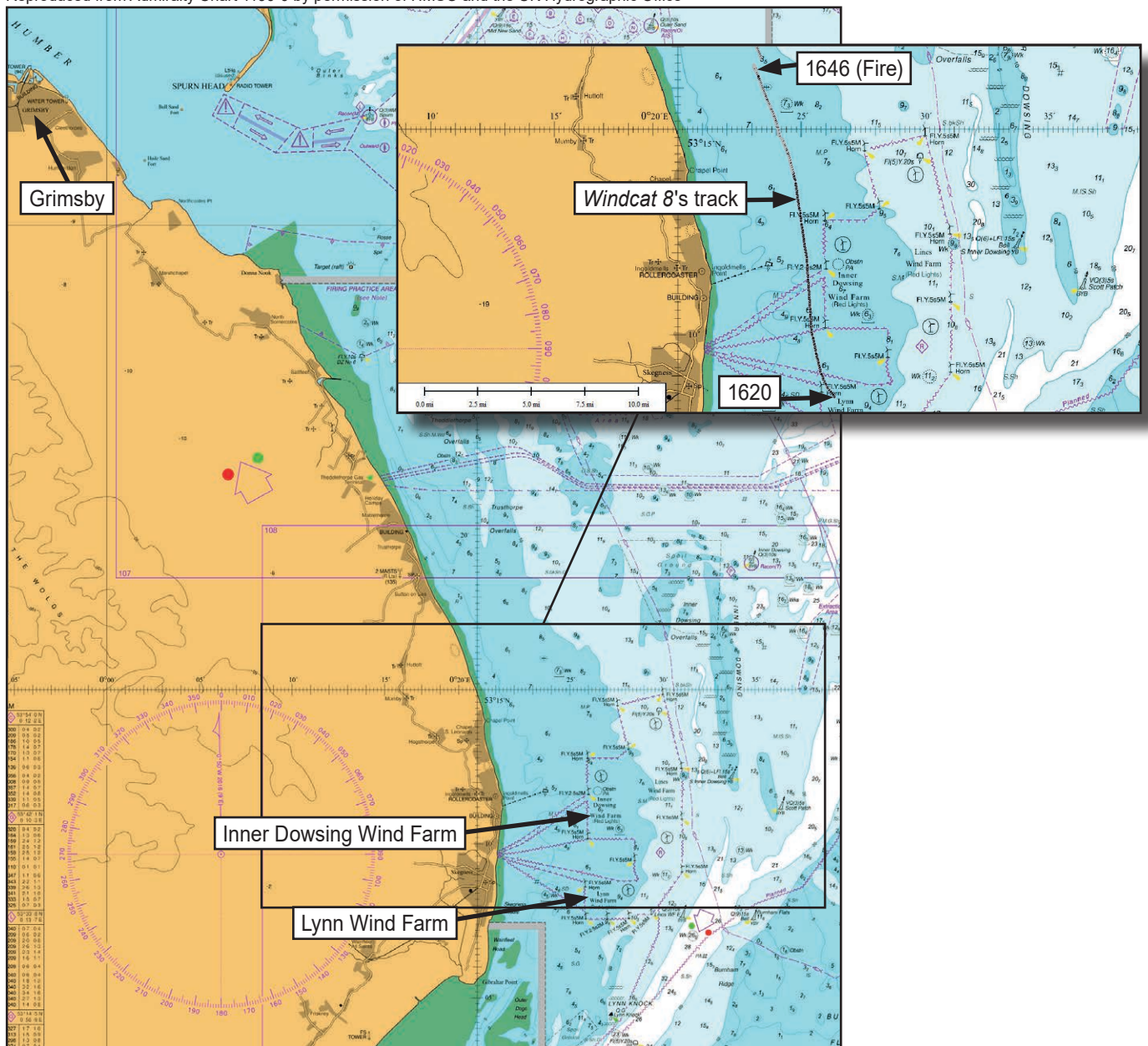


Figure 1: Extract of Admiralty Chart 1190-0 showing accident location

¹ All times are UTC(+1)

² Crew transfer vessels are used to provide support services to offshore windfarms

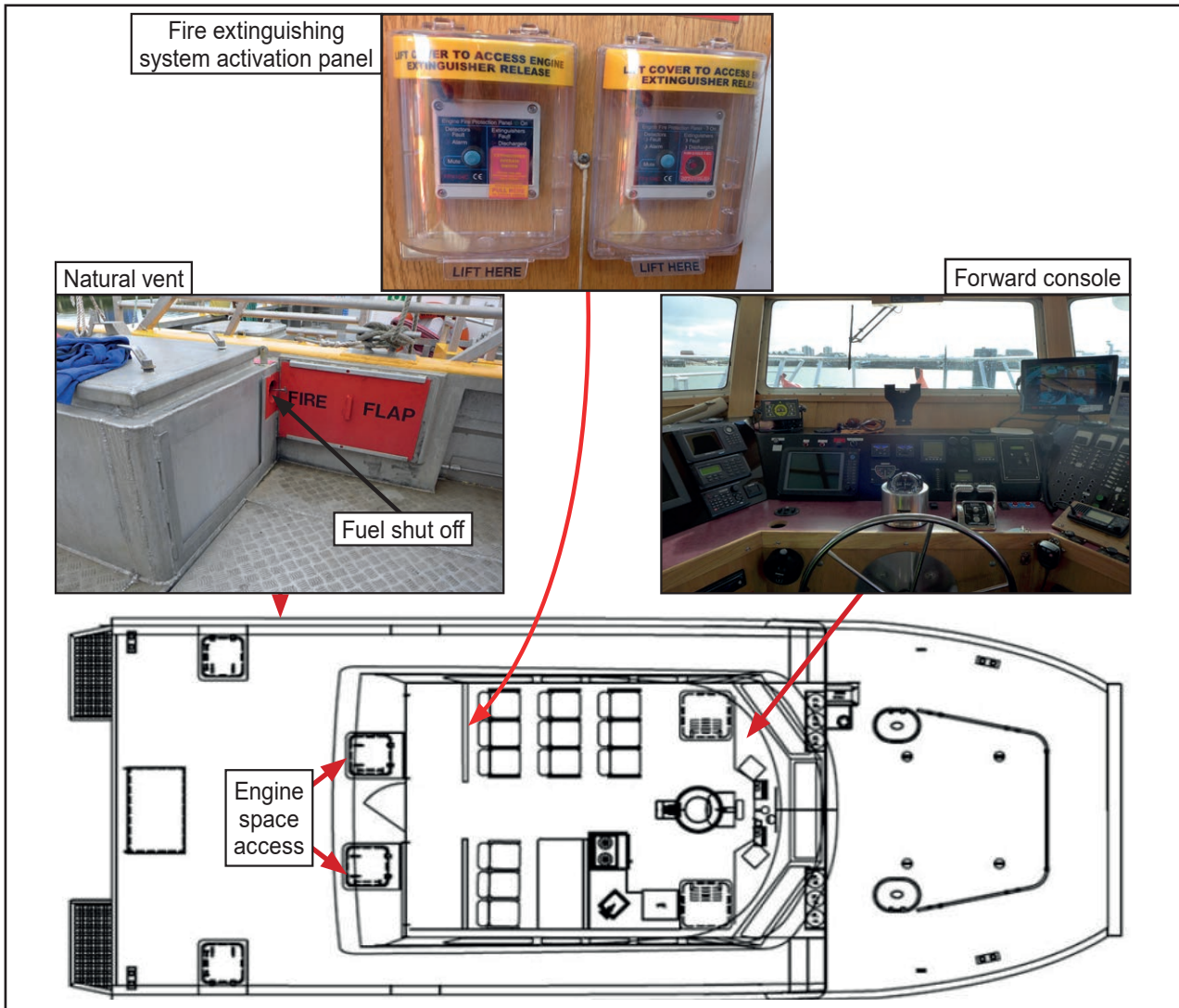


Figure 2: Deck plan and lay out



Figure 3: Aft deck

At 1646, there was a loud bang in the port engine space, the port engine stopped, and the port engine space fire alarm activated. The master saw from the closed-circuit television (CCTV) monitor that the port engine was alight (**Figure 4a**)³. In response, he stopped the starboard engine, shouted that there was a fire, instructed the deckhand to close down the port engine space and activate its fire extinguishing system. He also stopped the ventilation fans servicing the port engine space and told the eight technicians to prepare for evacuation.

The deckhand went onto the aft deck and closed the flap on the port engine space supply vent. He then activated the port engine space's fire extinguishing system using controls located on the cabin's aft bulkhead, behind the last row of seats (**Figure 2**). By 1648, the port engine space was filled with the extinguishing medium, which obscured the fire on the CCTV monitor (**Figure 4b**) and a white gaseous cloud billowed from the port engine space's natural air vent on the aft deck (**Figure 4c**) and into the cabin through its open door. The technicians left the cabin and mustered on the foredeck. At 1649, the master broadcast a "Mayday" using the fixed very high frequency radio on channel 16. *Windcat 30* and *Windcat 31*, also owned and operated by Windcat Workboats, were nearby and closed to assist.

At approximately 1650, the deckhand supervised the transfer of the technicians from *Windcat 8* to *Windcat 31*. He then returned to the aft deck, where plumes of dark smoke were now coming from the port engine space's natural vent and entering the cabin through its open door. He leaned through the smoke and operated the remote fuel shut-off for the port engine sited next to the vent (**Figure 4d**). The master then sealed the natural and exhaust vents.



Figure 4a: Initial fire



Figure 4b: Port engine space immediately following the operation of the fixed fire extinguishing system



Figure 4c: Fire extinguishing powder billowing from the natural air vent



Figure 4d: Deck hand shutting off fuel supply

³ The times shown on the CCTV recordings were 7 minutes slow

By 1653, the smoke had cleared from the port engine space and flames were observed burning along the top of the port engine (**Figure 5a**). Four minutes later the port engine was again obscured by smoke. Meanwhile, the master and the deckhand rigged a fire hose on the aft deck in readiness for boundary cooling. The remote fuel shut-off for the starboard engine was also operated.

At 1700, the fire appeared to be out and *Windcat 8* was taken in tow by *Windcat 30* for passage to Grimsby. The master referred to the vessel's emergency checklists and later re-started the starboard engine to expedite the transit. The vessels arrived at Grimsby Fish Dock at 2100 and were met by local fire and rescue services personnel, who confirmed that the fire in *Windcat's* port engine space had been extinguished.

Post-incident examination

Examinations of *Windcat 8's* port engine by Windcat Workboats' engineers and MAIB inspectors identified that the lower part of the piston, its connecting rod and the piston gudgeon pin from its No.6 cylinder had broken through the crankcase. As a result, the engine-mounted fuel pump had sheared off and the fuel pump casing was fractured.

Plastic shielding on the top of the engine had been completely consumed by the fire and the plastic coolant water header tank mounted on the top of the engine, along with conduit and wiring on the side of the engine, had also burned (**Figure 5b**). Secondary heat damage was limited to a fire detection head and a warning light immediately above the engine.

Windcat 8's port engine, a Volvo Penta D16C-A MH, was removed from the vessel and sent to Haisma Scheeps & Industriemotoren BV (Haisma Scheeps) in the Netherlands for thorough examination. The examination was completed on 21 September, and identified that the big end shell bearing on the No.6 piston connecting rod had been destroyed by heat (**Figures 6 and 7**). The level of the damage prevented analysis of the bearing to determine the precise cause of its failure.



Figure 5a: Fire on engine top



Figure 5b: Fire damage to port engine



Figure 6: Heat damage to No.6 piston connecting rod



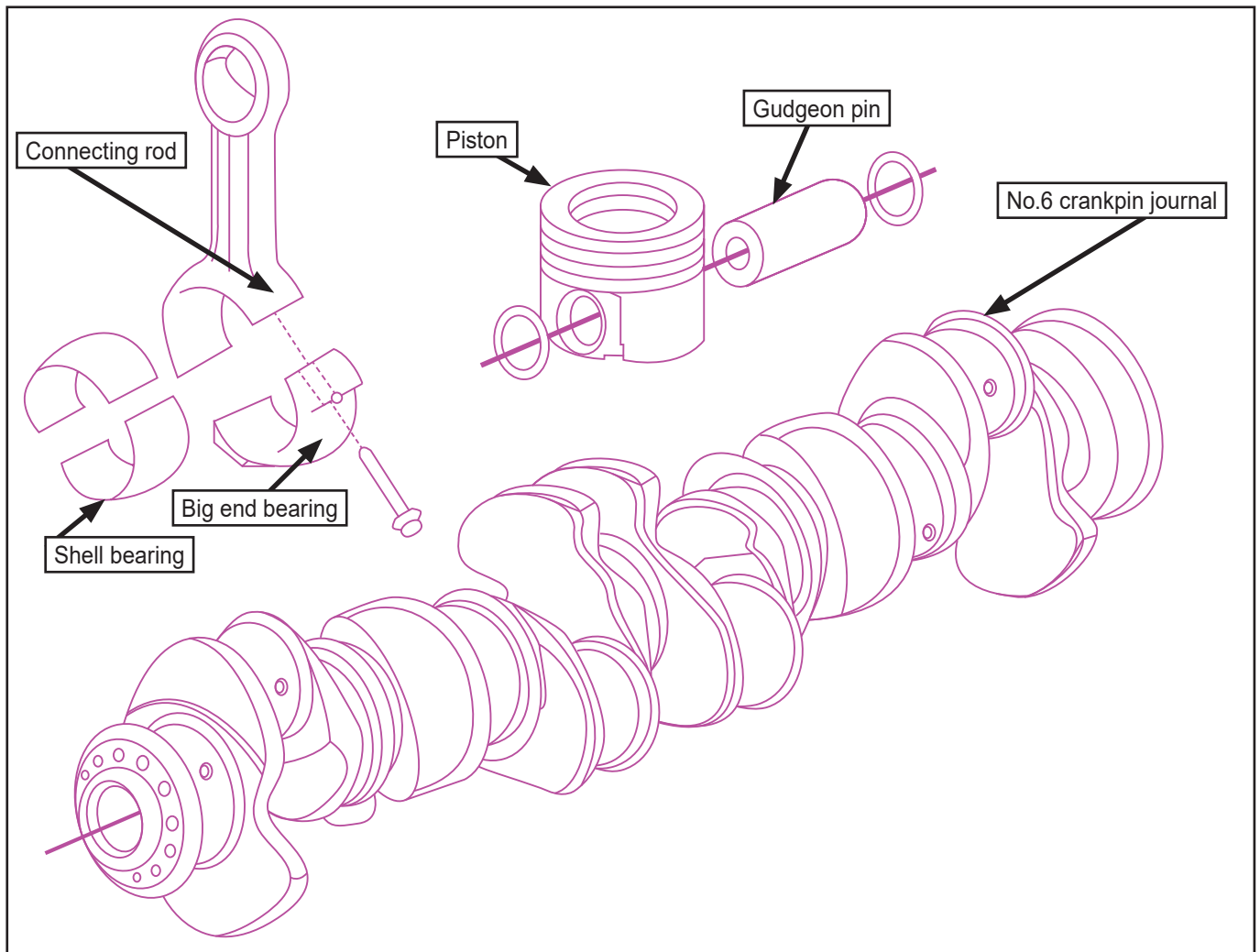


Figure 7: Schematic of crankshaft assembly

The thorough examination also identified that the camshaft, main bearings and the other connecting rod bearings were in pristine condition and that none of the pistons had seized. In addition, the lubricating oil system appeared to have functioned as expected. Components damaged by the heat generated by the failure of No.6 connecting rod big end bearing included the No.6 crankpin journal (plastic deformation) (**Figure 8**) and No.6 and No.7 main bearings. Physical damage included:

- The failure of the No.6 connecting rod bearing cap bolts.
- The separation of No.6 piston crown and skirt. The piston crown had struck the open exhaust valve, shattering the ceramic exhaust valve cam follower and damaging the running surface of the exhaust cam lobe.
- A hole in the engine crankcase in way of No.6 piston (**Figure 9**).

Operation

Windcat 8, a 15.87m aluminium catamaran, was one of 39 crew transfer vessels operated by Windcat Workboats, mainly in the European offshore wind power generation industry. The vessel was certified under the Brown Code 'A code of practice for the safety of small workboats and pilot boats under 24 metres' and was designed and built specifically for transporting up to 12 technicians and their equipment. The catamaran's square bow enabled the vessel to 'push on' to the wind turbines and create a stable platform for the technicians to safely disembark and embark. The vessel typically operated for 12 hours each day, of which 3 hours were spent on passage to and from the wind turbines and the remaining 9 hours were spent on site. It was usual for the vessel to remain 'pushing on' to the wind turbine on which the technicians were working.



Figure 8: Plastic deformation of crankpin

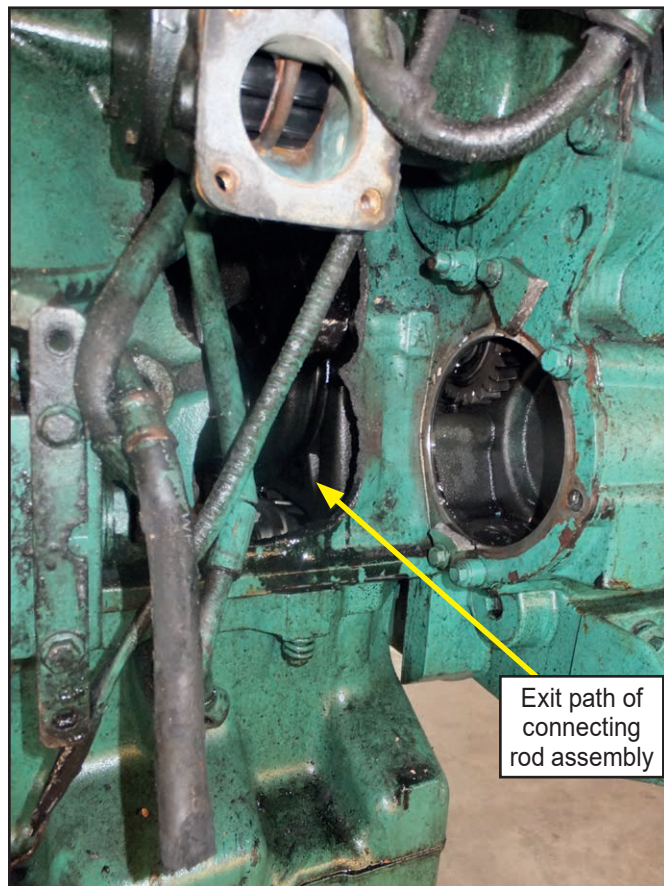


Figure 9: Hole in engine crankcase

Propulsion

Windcat 8's propulsion system consisted of twin shaft fixed pitch propellers powered by two Volvo Penta engines via reversing gearboxes. The engines were rated at 551kW at 1900rpm and were sited in separate spaces (port and starboard). Access to the spaces was via hatches on the aft deck (**Figures 2 and 3**). Remote fuel shut-off mechanisms were sited on the aft deck and were painted red.

The port engine was installed in *Windcat 8* in July 2015 as part of an engine service exchange contract with Haisma Scheeps, a Volvo Penta accredited service agent. Before installation, the engine had completed 10844 running hours and had been completely stripped down and rebuilt at Haisma Scheeps' workshops using new components supplied by Volvo Penta.

The engine's oil capacity was 55 litres and its normal operating temperature was 90°C. The high oil temperature alarm was set to activate at 125°C with an intended delay of 30 seconds. Other engine alarms included high exhaust and coolant temperatures and low oil pressure. The engine was not fitted with a protection device to automatically shut it down in the event of defined maximum operating parameters, which could include high oil temperature, being exceeded.

From its installation on board *Windcat 8*, the engine completed 2275 running hours during which the engine was maintained in accordance with Windcat Workboats' planned maintenance programme, and there had been no reported problems with its operation. In addition, neither the results of the analyses of regular oil sampling, nor the weekly records of the engine's pressures and temperatures taken when the vessel was either at 'full speed' or 'pushing on' indicated the presence of any defects or abnormalities. However, the records showed that when 'pushing on' at 1300rpm (50% engine speed), the turbocharger exhaust temperatures were higher than when the vessel was on passage and the engines were at their maximum speed of 1900rpm. The engine's idle speed was approximately 800rpm.

Engine space ventilation

Windcat 8's engine spaces each had a forced air supply vent, a forced air exhaust vent and a natural air vent. The fans for the supply and exhaust vents were operated by switches on the cabin's forward console. The supply vent was closed by the movement of a lever that operated an internal flap, and the exhaust and natural vents were closed by sliding plates over their external grills. The operating lever for the supply vent, and the sliding plates, were painted red. The sliding plates were also marked 'Fire Flap' (Figure 2). The integrity of the ventilation flaps and sliding plates was tested annually. It was also checked during fire drills.

Fixed fire extinguishing system

In common with all Windcat Workboats' vessels, the engine spaces on *Windcat 8* were protected by a manually-operated Stat-X fixed fire extinguishing system, supplied and fitted by Marine Fire Safety Limited. The system incorporated a combination of smoke and heat detectors linked to control boxes on the main cabin's aft bulkhead that also housed the activation mechanism and an audible alarm.

The system used a fine particulate agent, potassium carbonate, in aerosol form to extinguish the fire by acting on the chain reaction of the combustion process. To fully suppress flames, the potassium carbonate particles had to be maintained at sufficient density. The system's operating manual recommended that the engine space doors and hatches remained closed for at least 10 minutes after system activation. Instructions posted adjacent to the Stat-X system's control boxes advised that the affected space should not be re-entered for at least 15 minutes.

Emergency procedures

There was no guidance or instructions on board *Windcat 8* regarding action to be taken on the activation of engine alarms. Emergency checklists kept on the vessel's forward cabin console included actions to be taken in the event of abandonment, collision, grounding, man overboard and fire. Regarding an engine space fire, the checklist's actions included:

*Shutdown of engines, ventilation
Pull fuel shut offs and fit fire flaps and close louvres
Activate the engine room smothering system if appropriate*

Instructions posted adjacent to the Stat-X fire suppression control units stated:

*In the event of the engine room alarm sounding
Switch off engines and machinery
Evacuate all personnel from engine room
Close all engine room ventilation
Carry out fire procedures*

Crew

Windcat 8's master held an STCW⁴ accredited Maritime and Coastguard Agency Master's certificate for coded vessels less than 200 gross tonnes. He had worked for Windcat Workboats for 2 years and had successfully completed a seagoing performance assessment. He had also completed familiarisation training on board *Windcat 8* on 5 September 2017 before taking over as master the following day.

The deckhand held an STCW navigational watch rating certificate. He had worked for Windcat Workboats for 8 months and had successfully completed a performance assessment at sea. He had also completed familiarisation training on board *Windcat 8* when he joined the vessel on 24 May 2017.

⁴ STCW - International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended.

Drills

Windcat Workboats required the crews on board its vessels to follow a drills schedule that detailed the types of drill to be conducted and their frequency. It also prescribed the locations of the fire drills with engine room fire drills being scheduled for April and September. Windcat Workboats required the drills to be recorded in each vessel's deck logbooks on completion. The company also required crews to forward photographs taken during the drills to its UK office.

During 2017, the master had completed 16 emergency drills, including fire drills, on board other Windcat vessels and a manoverboard drill on board *Windcat 8* during the afternoon of 7 September. The deckhand had completed 23 emergency drills in 2017 including five fire drills. The fire drills did not include any engine space fire drills on board *Windcat 8*.

ANALYSIS

Failure mechanism

The initial inspection of *Windcat 8*'s port engine in Grimsby and the later thorough examination of the engine in the Netherlands, showed that the locus of the catastrophic failure was the big end bearing associated with the No.6 piston connecting rod. The condition of the bearing apparently quickly deteriorated soon after *Windcat 8* departed from the windfarm. Such a deterioration would have restricted or stopped the flow of oil that was necessary to lubricate the bearing's moving surfaces. At an engine speed of approximately 1840rpm, the resulting friction between the bearing and the crankpin journal would have generated high temperatures. Initially, the heat would have been conducted through the surrounding oil, but it is evident from the activation of the oil high temperature alarm that the oil temperature eventually exceeded the capacity of the oil cooler and reached 125°C.

Following the oil high temperature alarm, the master reduced the port engine's speed to approximately 800rpm. As a result, the heat generated from the friction between the bearing and the crankpin journal would have reduced. That the high temperature alarm automatically reset, indicates that the oil cooler again lowered the oil temperature to below 125°C.

However, as soon as the engine's speed was again increased to approximately 1840rpm, the big end bearing inevitably would have deteriorated further, heating the surfaces of the crankpin journal and the connecting rod bearing sufficiently to cause plastic deformation of the metal surfaces (**Figure 8**). Such heat would have also reduced the tensile strength of the bolts holding the connecting rod bearing cap in place. As a result, the bolts failed and the No.6 connecting rod assembly was released at high speed. That the oil high temperature alarm did not activate for a second time was possibly due to the time it would have taken the engine's 55 litres of oil to again reach 125°C, together with the 30-second delay set.

Engine loading

It was not possible to pinpoint the cause of the bearing's failure due to the extensive heat and mechanical damage sustained (**Figure 6**). However, the engine had been rebuilt in 2015 by an accredited Volvo Penta service agent using new components supplied by Volvo Penta. It had also run for 2270 hours over a period of 26 months, during which its performance had been routinely monitored and found to be within expected parameters. In addition, the thorough examination in the Netherlands did not find other defective parts or defects in the cooling and lubrication systems. Therefore, it is highly unlikely that the failure was the result of incorrect component assembly or a lack of oil. It is more likely that the failure was due to a weakness in the thin-walled shell bearing itself.

The likelihood of a relative weakness in the big end bearing leading to its failure was possibly increased by *Windcat 8* 'pushing on' to wind turbine towers for several hours each day. When 'pushing on' the recorded turbocharger exhaust temperatures indicate that the loading on the port engine was higher at 1300rpm than it was at 1900rpm with the vessel on passage. The higher loading when 'pushing on' would have resulted in more fuel being injected and an increase in the force acting on the pistons, bearings and crankpin journals. In such circumstances, any weakness or defect in the bearing's assembly would have been more vulnerable to failure than usual.

Engine alarms

Automatic engine shutdown arrangements are a technical means of preventing engine damage, but they are not required to be fitted to vessels certified under the Brown Code. However, no guidance or instructions were provided on board *Windcat 8* that specified the actions to be taken in response to the differing engine alarms. Therefore, the vessel's master had to rely on his experience and knowledge to decide on appropriate responses.

On this occasion, when the port engine high oil temperature alarm activated, the master immediately reduced the engine's speed to idle and instructed the deckhand to investigate. As the engine's cooling and lubrication systems appeared to be working normally and the alarm had reset, the master then resumed passage at 21 knots. At the time, this action was logical and well-intended. However, in hindsight, that the alarm remained unexplained and the engine was not protected by an automatic shutdown arrangement, a more cautious approach in the use of the engine would have been appropriate before it was again put under load.

Emergency response

The transfer of the eight windfarm technicians from *Windcat 8* to *Windcat 31* within 5 minutes of the fire in the port engine space being detected indicated that the master gave high priority to their safety. However, the closing down and isolation of the port engine space lacked co-ordination. Although the ventilation fans were stopped, all the ventilation flaps were closed, the Stat-X system was released and the fuel shut-offs were activated, the sequence in which the actions were taken rendered the release of the Stat-X fixed fire extinguishing system ineffective.

When the No.6 piston connecting rod assembly penetrated the engine crankcase, oil vapour and intense heat would have released simultaneously, and it is evident that the oil vapour ignited (**Figure 4a**). Within seconds, the deckhand had activated the Stat-X system in the port engine space and its effect was immediate (**Figure 4b**). However, it was also short-lived because much of the potassium carbonate quickly escaped through the space's natural and exhaust vents that remained open (**Figure 4c**).

Consequently, the density of the potassium carbonate was not maintained for sufficient time for it to act on the combustion process, and the fire continued to burn on the engine's side and top, consuming residual fuel from the fractured oil pump, wiring looms, plastic conduit and shielding, and the plastic coolant header tank (**Figures 5a** and **5b**). The fire extinguished at about 1700, largely because there was little else in its vicinity to burn and the air supply into the port engine space had been restricted by the eventual closure of all the ventilation flaps. Although all the vents were closed within about 2 minutes, this action was almost certainly prompted by the smoke being emitted and entering the cabin, rather than a recognition of the need to maintain the density of the Stat-X aerosol within the engine space.

Windcat 8's master and deckhand had worked on board Windcat Workboat vessels fitted with the Stat-X system for 2 years and 8 months respectively and both had participated in fire drills. In addition, the release procedure for the Stat-X system was straightforward and was posted adjacent to the system's control boxes and included in the onboard checklists. The vent flaps were also clearly marked. Therefore, notwithstanding the increased stress levels experienced by the master and the deckhand during the emergency, the sequence of their actions indicates that a greater focus on the Stat-X system release procedure is warranted during onboard training.

CONCLUSIONS

- The damage to the port engine was caused by the failure of a piston connecting rod big end shell bearing, which led to the connecting rod assembly releasing and penetrating through the engine crankcase.
- A high oil temperature alarm prior to the engine failure warranted a more cautious approach to the use of the engine until a deeper technical investigation could be conducted.
- The fire resulted from the ignition of oil vapour released from the damaged crankcase and did not spread beyond the port engine.
- The fixed fire-fighting system was rendered ineffective because not all the port engine space vents were closed prior to its release.
- The safety of the embarked technicians was given a high priority.

ACTION TAKEN

Windcat Workboats BV Ltd has:

- Instructed crews on board vessels fitted with Volvo Penta D16 engines to stop the affected engine when a high oil temperature alarm activates, and not to restart the engine until the reason for the alarm has been determined.
- Identified lessons to be learned from the accident and emergency response that will be highlighted in future crew training.
- Programmed additional fire drills on board its vessels.
- Ensured that signage on board its vessels reminds crew to close vent systems before activating engine space fire suppression systems.

RECOMMENDATIONS

Windcat Workboats BV Ltd is recommended to:

- 2018/101** Provide training and guidance on the action to be taken for all critical propulsion alarms, and to introduce measures to ensure its crews understand the principles of the installed fixed fire-fighting systems and are fully familiar with procedures for their operation.

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

SHIP PARTICULARS

Vessel's name	<i>Windcat 8</i>
Flag	United Kingdom
Classification society	Not applicable
IMO number/fishing numbers	913358
Type	Crew transfer vessel
Registered owner	Windcat Workboats BV Ltd
Manager(s)	Windcat Workboats BV Ltd
Year of build	2007
Construction	Aluminium
Length overall	15.87m
Registered length	15.87m
Gross tonnage	26.20
Minimum safe manning	2
Authorised cargo	12 passengers

VOYAGE PARTICULARS

Port of departure	Grimsby
Port of arrival	Grimsby
Type of voyage	Coastal
Cargo information	8 passengers
Manning	2

MARINE CASUALTY INFORMATION

Date and time	7 September 2017 16:39
Type of marine casualty or incident	Serious Marine Casualty
Location of incident	53° 16.5N 000° 23.1E 4.5nm north-north-west of the Inner Dowsing Wind Farm
Place on board	Port engine space
Injuries/fatalities	None
Damage/environmental impact	Significant damage to port engine
Ship operation	On passage
Voyage segment	Mid-water
External & internal environment	Daylight; Wind force 3; Sea state 3
Persons on board	10