

Extract from The United Kingdom Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 – Regulation 5:

“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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Fatal CO poisoning on board motor cruiser *Vasquez* while moored at Cardiff Yacht Club 12 November 2016

SUMMARY

At approximately 1200 (UTC¹) on 12 November 2016, the owner of the 7.75m motor cruiser *Vasquez* fell unconscious after being overcome by carbon monoxide (CO) that had emitted from his boat's inboard petrol engine. Although rescuers came to his aid and conducted cardio-pulmonary resuscitation, it was not possible to save his life. Two of the rescuers had to be treated for the effects of CO poisoning following the accident.

The CO was found to have originated from the rubber bellows of the wet-exhaust system of the engine, which was not only leaking gas but also water. The boat's engine had not been regularly serviced, and evidence revealed that the exhaust system of the engine had been modified during the boat's life.

Notwithstanding the initiatives already taken by various stakeholders from the recreational boating sector, there remains a significant task to raise boat owners' awareness about the dangers of CO. Due to the odourless nature of CO, the fitting of a detector/alarm remains the only effective warning that the poisonous gas is present.

Given the recommendations issued following the MAIB's recent *Love for Lydia* investigation, no further recommendations are made.



Figure 1: *Vasquez*

¹ UTC - Universal Co-ordinated Time.

FACTUAL INFORMATION

Narrative

During the morning of 12 November 2016, Ray Milton travelled to Cardiff Yacht Club to check on his motor cruiser *Vasquez* (**Figure 1**), which was moored in the marina. Ray regularly visited the club to socialise with other club members, usually on a weekly basis, but on this occasion had not visited for a couple of weeks. He had arranged to meet a friend at the club that morning.

At approximately 1120, Ray's friend walked down to where *Vasquez* was moored stern-to. He stepped onto the starboard bathing platform and leaned into the cockpit canopy, which was unzipped on the starboard side. Ray was sitting at the helm position and the aft floor area had been lifted to give access to the engine bay. There was water in the bilge and Ray was running the electric bilge pump to clear it. There was also water in the cabin, which was unusual.

Once the water level was below the starter motor of the engine, Ray wanted to see if the engine would start. He turned the ignition key and the engine started successfully. The friend suggested putting the engine in gear ahead while still moored so that the boat's bow would lift slightly and allow the water in the cabin to run aft into the engine bay bilge, where it could be pumped out easily. Ray followed this suggestion and water was seen to be running aft and being successfully pumped out by the electric bilge pump.

About 10-15 minutes after arriving, the friend left and he asked Ray to take the engine out of gear so that he could step back onto the pontoon. He expected to catch up with Ray later in the clubhouse. After the friend had stepped onto the pontoon, Ray re-engaged the engine and at some stage replaced the cockpit flooring above the engine bay.

At 1210, as he walked to the clubhouse, the friend called Ray on his mobile phone; there was no reply. He assumed Ray was busy and would ring back. He entered the clubhouse and ordered a drink at the bar. Approximately 30 minutes later, he tried calling Ray again, but still there was no reply. At 1242, he called another club member whom he knew was on a boat near *Vasquez* and asked him to check on Ray.

When the other club member reached *Vasquez* he found the engine still running ahead, but there was no sign of Ray. With the assistance of another club member, who was an off-duty firefighter and happened to be nearby, he managed to pull the stern lines in sufficiently so that they could step onto the aft bathing platforms. Initially there was no sign of Ray, but they then saw a foot next to the helm.

Emergency response

The firefighter undid the port aft zip of the cockpit canopy and entered the cockpit. He saw Ray lying head-down in a pool of water in the cabin, with his feet stretched aft as if he had fallen forward. The firefighter turned off the engine ignition and the other club member raised the alarm by firstly calling the clubhouse for assistance and then, at 1248, calling for an ambulance. Ray was rolled onto his back and cardio-pulmonary resuscitation (CPR) was commenced. Shortly afterwards a further club member arrived from the clubhouse and climbed on board to assist the firefighter. They took it in turns to administer chest compressions and rescue breaths.

After 10-15 minutes, the firefighter felt dizzy and developed a headache. The club member conducting CPR noticed the colour draining from the firefighter's face and asked him if he was okay. The firefighter said he was fine and continued with CPR. As the firefighter's condition appeared to worsen the other club member conducting CPR asked for the firefighter to be helped out of the boat, which was duly carried out by one of the small crowd of people now gathered on the pontoon.

The paramedics arrived shortly afterwards and were initially directed to attend to the firefighter. After examining him, the paramedics quickly removed the cockpit cover and then took over the CPR on Ray. With CPR continuing, Ray was lifted onto the aft seating area and *Vasquez* was towed round to another pontoon to allow better access ashore. Ray was then transferred to hospital by ambulance.

The two club members who had administered CPR were given oxygen and then taken to hospital for further tests and treatment. The firefighter had a carboxyhemoglobin level of 20% when first assessed, while the other club member had a reading of 9.5%; both indicating CO poisoning.

Ray did not recover consciousness and was declared deceased at hospital. The postmortem examination recorded that the cause of death was CO poisoning, noting a carboxyhemoglobin level of 51.8%.

Vessel owner

The owner of *Vasquez*, Ray Milton, was 72 years old and was a retired lorry driver. He had owned various motor boats throughout his life and had been a member at Cardiff Yacht Club for approximately 20 years. He bought *Vasquez* from a fellow club member 5-6 years prior to the accident. In common with many recreational boat owners, he neither held formal boating qualifications nor was he required to do so.

Vessel description

Vasquez was a Draco 2400ST motor cruiser constructed in 1985/86 in Norway. The design was certified by Det Norske Veritas in compliance with Nordic Requirements, a Norwegian boat construction standard. It was certified to carry up to 1400kg including a maximum of 10 persons.

The vessel had a forepeak cabin with seating area, dedicated sleeping berth and toilet compartment. The cockpit, which could be enclosed with a canopy, contained the helm position (**Figure 2**) as well as a small galley and further seating. The engine compartment was situated under the floor of the cockpit at the aft end.



Figure 2: Cockpit with view forward into the cabin

The boat was driven by an inboard V6 Volvo Penta AQ225F petrol engine that was naturally aspirated (**Figure 3**). The vessel was fitted with an OMC stern drive (**Figure 4**), which provided the boat's propulsion. It was not possible to determine if the stern drive was original or had been fitted later in the boat's life. The engine had a wet-exhaust system, whereby cooling water, which was sucked in via ports in the stern drive, was combined with the engine exhaust gas and expelled from the stern drive through the hub of the propeller.

Situated in the engine compartment were the boat's batteries as well as three bilge pumps. One bilge pump, which was positioned under the engine, was electrically driven and was operated by holding down a switch at the helm position, while the other two were hand pumps. There was a drain hole at the base of the engine compartment forward bulkhead that allowed water to flow freely through the bilge.

Although a switch on the helm console was labelled 'blower', no blower was found in the engine compartment. Whether it had been fitted in the past and removed or had never been fitted is unknown. The blower, if fitted, would have normally been used to clear the engine bay of any combustible fumes prior to starting the engine.



Figure 3: Volvo Penta AQ225F petrol engine



Figure 4: OMC stern drive

Use of Vasquez

Since buying *Vasquez* the owner had not used it frequently for trips, although he had visited the boat to check it and to start the engine periodically while at its mooring. During his ownership one major piece of work, costing over £1000, was undertaken on the engine by a local marine professional. However, it is believed that no regular servicing had been undertaken during the last 5-6 years.

The owner used the boat very little in the 2-3 years prior to the accident and had discussed selling the boat with friends. However, in the months before the accident, following a trip on a friend's boat to Portishead, the owner had taken a renewed interest in *Vasquez* and, a couple of months prior to the accident, had taken a trip around the bay.

During the trip, the engine temperature had run very high, so after returning to the yacht club the boat was lifted out of the water. The cooling water inlets on the stern drive were found blocked. The stern drive was cleaned off and re-antifouled, and the oil in the stern drive was changed.

Some 4-5 weeks before the accident *Vasquez* was taken on another test run and the over-heating problem had not re-occurred. However, the engine had not run smoothly at high revolutions and it was clear that it would need further attention before the boat could be used reliably outside Cardiff Bay.

Engine testing and inspection

Following the fatal accident, the MAIB conducted a reconstruction. The boat's engine was started with the cockpit floor in place and the canopy erected, but with the aft starboard zip open. Atmosphere monitors and a domestic CO detector were positioned inside the canopy and viewed through the clear plastic of the canopy. After 40 minutes with the engine running, a CO reading of 250ppm² was recorded on the atmosphere monitor at the helm position. The engine was then switched off, and over the next 5 minutes the CO level increased to 550ppm, before starting to slowly decrease.

The local Volvo agent was then contracted to conduct an inspection of the engine and to establish the source of the CO leak. With the engine stopped and the boat afloat, a small water leak was apparent emanating from the rubber bellows on the wet-exhaust system. With the engine running, a considerable amount of exhaust fumes and water were emitted from the port and starboard bellows (**Figure 5**).



Figure 5: Exhaust leak from rubber bellows

² ppm - parts per million: HSE workplace exposure limits for CO - long term exposure limit 30ppm (8hrs), short term exposure limit 200ppm (15 minutes).

On closer examination, it was apparent that the exhaust system was not in accordance with manufacturer's drawings and had been modified during the life of *Vasquez*. The following were observed:

- The exhaust manifolds were not original (**Figure 6**).
- The exhaust risers were not original (**Figure 7**).
- The cow horn castings had been cut down (**Figure 7**).
- The exhaust elbow had been connected on both sides of the engine with two unequal rubber bellows and a stepped aluminium tube retained by stainless steel hose clips (**Figure 7**).

Although it could not be confirmed, the lack of corrosion on the bolts attaching the risers to the exhaust manifold suggested that the exhaust system had been included in the work carried out in the last 3-4 years.

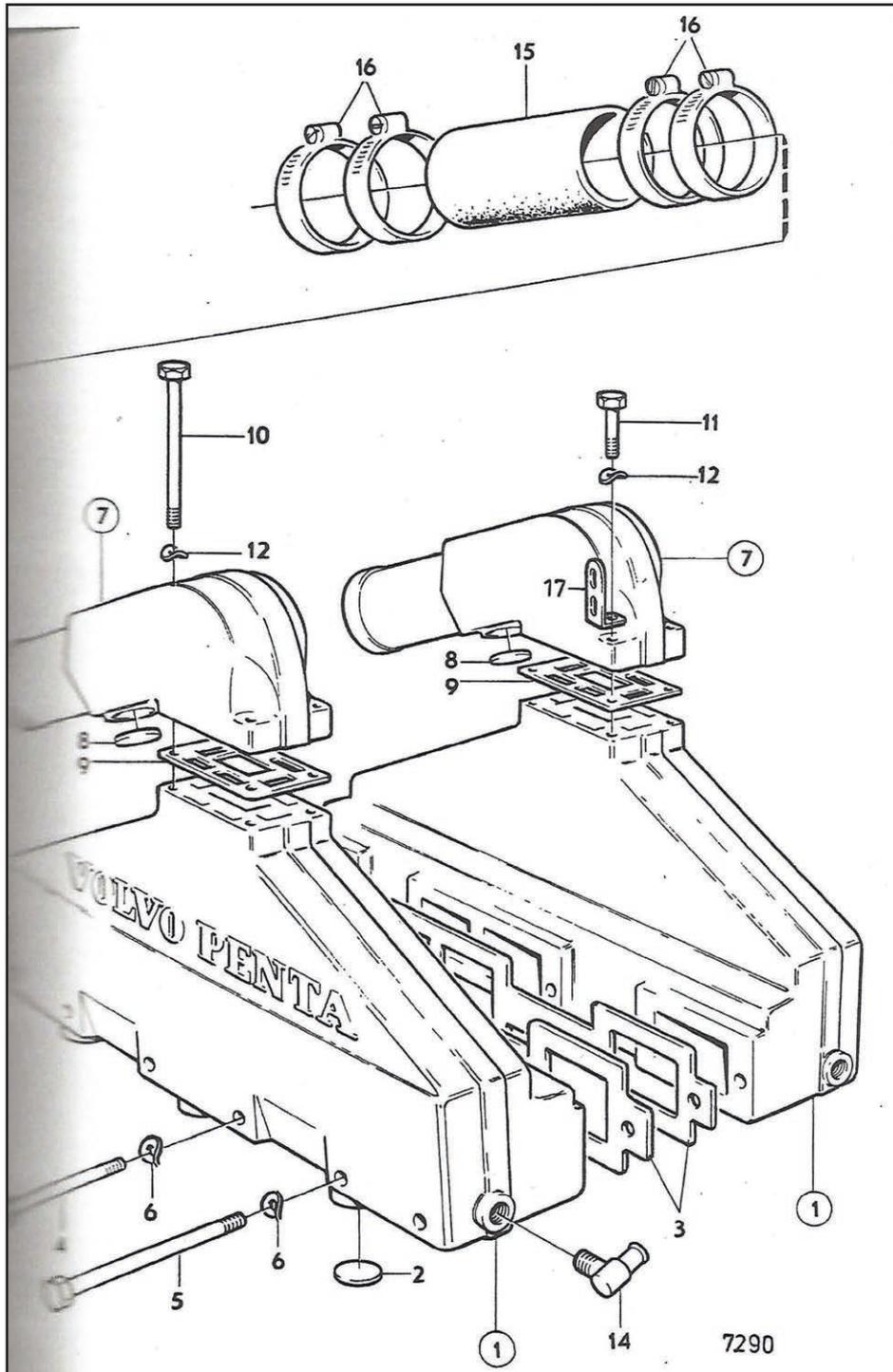


Figure 6: Drawing of original exhaust manifolds

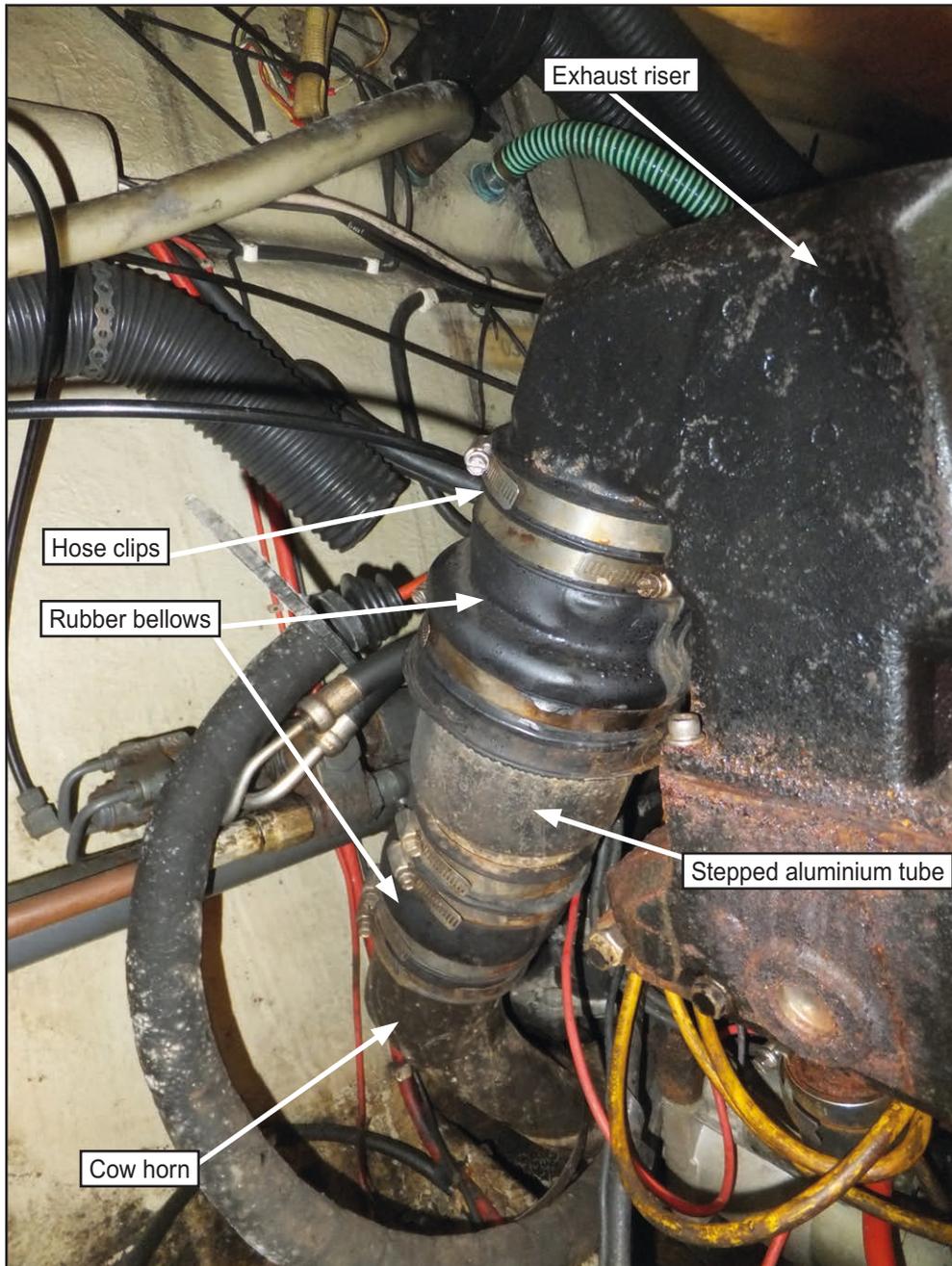


Figure 7: Exhaust riser and rubber bellows

Carbon monoxide hazard and legislation

CO is produced by incomplete combustion. Potential sources include propulsion engines, generators, paraffin and oil lamps, log burners and barbecues. CO is a highly poisonous gas that weighs the same as air. It cannot be seen, smelled, tasted or felt.

When breathed in, CO readily replaces oxygen in the human bloodstream by forming carboxyhemoglobin. This prevents oxygen from supplying the heart, brain and other vital organs. Common symptoms of low exposure to CO poisoning include headache, feeling sick, stomach pain, difficulty breathing, or feeling tired or confused. In greater concentrations a person will feel drowsy and lethargic, and may have difficulty walking and moving around.

CO poisoning is not a problem limited to recreational craft and can also be an issue in the home. CO detectors/alarms of varying types are widely available and will provide an early warning of the presence of the poisonous gas. Many detectors have an audible and visual alarm, which operate when a certain

level of exposure to CO has been reached. However, they are dependent on having a power supply, often in the form of a small battery. Legislation has been introduced requiring CO detectors/alarms to be fitted: since 2010 in some new dwellings; since 2011 in new caravans; and since 2015 in rented properties.

CO detectors/alarms, although widely recommended by organisations such as the Gas Safe Charity, CoGDEM³ and Boat Safety Scheme (BSS)⁴, are not required to be fitted under any UK regulations on board recreational craft. The Recreational Craft Directive (RCD), introduced in 1998, also has no provision for CO monitors, but does require inboard engines to be fitted in an enclosure separated from living quarters and installed to minimise the hazard from toxic fumes. However, these requirements would not have applied to *Vasquez* given that its construction predated the introduction of the RCD.

There is no specific legislation that applies to the maintenance of recreational craft that operate in coastal regions. However, those operating on inland waterways have to satisfy the requirements of the BSS.

Similar accidents

In April 2014 two fatalities occurred on the motor cruiser *Arniston*⁵. The owner had fitted a portable generator in the boat's engine compartment and rigged an exhaust system to discharge combustion gases overboard. The exhaust system failed during use while the vessel was moored, resulting in the exhaust fumes filling the motor cruiser's cabin and leading to the death of two of the occupants. They had not been alerted to the presence of CO because the alarms fitted on board were not working.

In June 2016 a further two fatalities resulted from CO poisoning on the motor cruiser *Love for Lydia*⁶. The petrol-driven inboard engine had been left running while alongside, probably to charge batteries. The exhaust from the engine filled the cockpit canopy and spread into the cabin. There was no CO detector/alarm fitted on board and the occupants were overcome by the fumes. The MAIB made recommendations to: the Maritime and Coastguard Agency regarding the co-ordination of raising CO awareness of the leisure boating community; British Marine to seek clarification on carbon monoxide requirements within the RCD; and the BSS regarding the compulsory installation of CO monitors in craft participating in the BSS scheme.

ANALYSIS

Accident scenario

Ray Milton died from CO poisoning because his boat's engine exhaust system was leaking the odourless gas into the cockpit and cabin area of his boat. With no CO detector/alarm fitted to his boat, he was unaware of the gas's increasing presence. Over a period of time, with little ventilation to disperse the gas, a sufficient concentration of CO built up, such that he was overcome by the gas and collapsed in the cabin.

The first responder on scene was also unaware of the presence of CO, and commenced CPR on Ray in the cabin not realising the danger he was placing himself in or that he would be breathing further CO into Ray's lungs during CPR.

The MAIB's reconstruction demonstrated that, although the first responder had switched off the engine, the CO levels increased significantly in the following few minutes, making the situation worse. This was probably because, with the engine running, it was drawing in some of the atmosphere from the cockpit. With the engine switched off this effect was removed.

³ CoGDEM - The Council of Gas Detection and Environmental Monitoring.

⁴ Boat Safety Scheme - This scheme's purpose is to help minimise the risk of boat fires, explosions, or pollution harming users of inland waterways.

⁵ www.gov.uk/maib-reports/carbon-monoxide-poisoning-on-motor-cruiser-arniston-with-loss-of-2-lives

⁶ www.gov.uk/maib-reports/carbon-monoxide-poisoning-on-board-the-motor-cruiser-love-for-lydia-with-the-loss-of-2-lives

CO awareness

Department of Health statistics from 2013 show that around 40 people in the UK are killed by accidental CO poisoning each year. At least a further 4,000 people are treated in hospital for non-fatal CO poisoning. The number of further individuals who might have suffered from CO poisoning and not visited hospital as they have assumed some other illness is responsible (given the common symptoms) is impossible to quantify. However, it is apparent that awareness of the dangers of CO is not widespread in the UK as a whole, and this equally applies to those involved with recreational craft.

In 2015, the All-Party Parliamentary Carbon Monoxide Group published a report, entitled '*Carbon Monoxide: From Awareness to Action*', which highlighted many issues regarding CO safety, including the difficulties of raising CO awareness. Within the context of recreational boaters, several organisations, notably the BSS, CoGDEM and the Royal Yachting Association (RYA), have been proactive in raising awareness of the dangers posed by CO, and the BSS 'Trusted Messenger' initiative, which started in April 2017, has the potential to significantly improve CO safety on inland waterways.

However, a significant task remains to raise CO awareness among the users of coastal recreational craft. It is welcome news that co-ordination of the task to raise awareness is underway following the MAIB's *Love for Lydia* report's recommendation.

CO detectors/alarms and ventilation

For those recreational craft not registered for use on inland waterways, such as *Vasquez* and numerous others operating around the UK coast, there is no requirement to fit a CO detector/alarm.

CO is often regarded as a product of poor combustion and, therefore, poorly maintained equipment. However, as demonstrated in the *Love for Lydia* accident, a properly maintained engine can still emit significant quantities of CO from its exhaust. Simply mooring near a motor boat with its engine running could expose the crew to CO. A suitable CO detector/alarm is the only effective way to be warned of the presence of the gas.

Once warned of the presence of the gas, steps can be taken to reduce its concentration by removing the source and by increasing ventilation. Unfortunately, when trying to keep warm while inside a recreational craft, the natural tendency is to try to limit draughts. This will only help with the build up of CO and is further justification for fitting a CO detector/alarm.

There is a common misconception that CO detectors/alarms used in the marine environment are prone to false alarms. This is rarely the case. If the alarm sounds it will be because CO is present. The alarm must sound at relatively low concentrations of CO to provide enough warning for effective remedial action to be taken. CO detectors/alarms intended for recreational craft are tested to a rigorous standard (EN 50291-2), which should reassure boat owners that when a CO alarm sounds, suitable action must be taken.

Recreational craft maintenance

Although new recreational craft have to meet the requirements of the RCD, once purchased there is no requirement for ongoing maintenance of a private leisure vessel. In addition, for private recreational craft operating around the UK coast, there is no requirement to regularly have the safety of the vessel checked. There is, therefore, a significant onus on a boat owner to ensure their boat is maintained properly and that it remains safe to operate.

Although the full maintenance history of *Vasquez's* engine could not be determined, it was apparent that the exhaust system had been modified and two rubber bellows added to the wet-exhaust pipework. Rubber bellows on a wet-exhaust system are vital in maintaining the watertight integrity of a boat and it is advisable to inspect them regularly and replace them every 2-3 years, as the rubber can harden and deteriorate. In this case, in addition to the rubber bellows being older than 3 years, the trial trip during which the engine overheated probably damaged the rubber. This ultimately led to a water/exhaust fumes leak, which caused *Vasquez's* cabin to slowly flood and CO gas to enter the engine compartment while the engine was running.

The RYA offers courses and provides guidance on various aspects of boating to educate boat owners on how to stay safe when afloat. It is important, however, to appreciate the extent of one's knowledge when it comes to self-maintenance of a boat, particularly with regard to its engine, and when professional advice should be sought. Regular engine servicing in accordance with the engine manufacturer's guidelines should ensure an engine remains reliable and safe to use.

CONCLUSIONS

- Ray Milton died from CO poisoning because, without a CO detector/alarm being fitted to his boat, he was unaware that CO from his boat's engine exhaust was emitting into the cockpit and cabin area.
- Given the recent fatal accidents from CO poisoning on recreational craft, there remains a significant task for the various stakeholders of the industry to assist in raising CO awareness.
- Given CO's odourless nature, the fitting of a CO detector/alarm remains the only effective warning against being poisoned by the gas.
- CO detectors/alarms intended for recreational craft are tested to a rigorous standard, which should reassure boat owners that when a CO alarm sounds, suitable action needs to be taken immediately.
- It is important to seek professional advice and regularly service a boat's engine, in accordance with the manufacturer's guidelines, to ensure it remains reliable and safe to use.

ACTION TAKEN

MAIB actions

The **Marine Accident Investigation Branch** has:

- Issued a Safety Bulletin⁷, in August 2016, following the two fatalities on the motor cruiser *Love for Lydia*, highlighting the dangers of CO poisoning and the need for detectors.

RECOMMENDATIONS

Given the recommendations issued following the MAIB's recent *Love for Lydia* investigation, no further recommendations are made.

⁷ www.gov.uk/maib-reports/safety-warning-after-carbon-monoxide-poisoning-on-motor-cruiser-results-in-loss-of-2-lives

SHIP PARTICULARS

Vessel's name	<i>Vasquez</i>
Flag	Not applicable
Classification society	Not applicable
IMO number/fishing numbers	Not applicable
Type	Draco 2400ST motor cruiser
Registered owner	Privately owned
Manager(s)	Not applicable
Construction	Glass reinforced plastic
Year of build	1985/86
Length overall	7.75m
Gross tonnage	Not applicable
Minimum safe manning	Not applicable
Authorised cargo	Not applicable

VOYAGE PARTICULARS

Port of departure	Cardiff
Port of arrival	Cardiff
Type of voyage	Moored
Cargo information	Not applicable
Manning	1

MARINE CASUALTY INFORMATION

Date and time	12 November 2016, approximately 1200
Type of marine casualty or incident	Very Serious Marine Casualty
Location of incident	Cardiff Yacht Club marina
Place on board	Cockpit
Injuries/fatalities	1 fatality
Damage/environmental impact	None
Ship operation	Moored
Voyage segment	In port
External & internal environment	No breeze, dry day
Persons on board	1