BSS Support Committee Risk Review and Assessment Paper

Carbon Monoxide (CO) alarms for boats

[Doc C1, BSSMC #95

Document compilation date 25 June 2018 -

as updated 12 August to support the public consultation]

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1. Introduction and Executive Summary

This paper was developed for members of the Boat Safety Scheme support committees and supports the decision of the Boat Safety Scheme Management Committee (BSSMC) to endorse the recommendation provided to them by the BSS support committees and BSS Office **to introduce a new mandatory BSS requirement for carbon monoxide (CO) alarms on all classes of boat with accommodation spaces.**

This paper presents the Risk Review and Assessment Paper (RRAP) as developed through Boat Safety Scheme Technical Committee (BSSTC) and as fully supported by Boat Safety Scheme Advisory Committee (BSSAC) and endorsed by BSSMC. This paper follows the process set out in the BSS Risk Management Process (BSSQA020).

Note that the outcome in support of a new BSS requirement updates the previous BSSTC RRAP on this same subject in April 2015, the position adopted at that time was not to introduce a mandatory BSS requirement (or advice check) for CO alarms. This paper emphasises what has changed since April 2015 and concludes that the introduction of new BSS requirement for CO alarms is a necessary and proportionate risk control.

The statements and recommendations below underpin the recommendation to introduce a mandatory BSS requirement for CO alarms on all classes of boat with accommodation spaces.

a. The recommendation for a mandatory BSS requirement for CO alarms takes full account of the Marine Accident Investigation Branch (MAIB) 'LOVE FOR LYDIA' recommendation[1] to *make the installation of carbon monoxide alarms a requirement for recreational craft participating in the Boat Safety Scheme*. In particular, the BSS support committees and BSS Office fully accept the *potential risk posed to other boat users by carbon monoxide-rich engine emissions*.

b. Taken together with a) above; it is becoming clear from some further initial studies and from some limited studies and anecdotal information[2], that the potential CO risk to boat owners presented by flue gas and petrol engine emissions from other boats, is not as low as reasonably practicable. This in particular when such emissions are exacerbated by weather, atmospheric or other environmental conditions. The protection of first responders and BSS Examiners is a consideration that must also be taken into account.

c. From a) and b) above, the conclusion is that the potential for the drawing in of CO from the outside is a newly identified potential risk that cannot be controlled by boat owners themselves and that CO is a hidden danger, with high levels of CO over a short period or low levels of CO over an extended period, representing a significant threat of harm to health. It is submitted that the circumstances fall within the remit of the Scheme to have in place measures that protect boat owners from the activity of others. The conclusion is that the introduction of a mandatory BSS requirement for CO alarms is a proportionate risk control in the circumstances.

d. It is considered that all CO fatalities are preventable. Albeit that introducing a mandatory requirement for CO alarms will help prevent harm from outside sources of CO, it is obvious that the key safety benefit will be the anticipated effectiveness of CO alarms in helping prevent death or injury to boat owners placed at risk in their own boats from running the boat's engines or appliances. It is contended that CO alarms represent an affordable and robust form of audible, potentially life-saving, protection and the Scheme is unaware of any boat CO fatality where a working CO alarm has been in place.

[1] MAIB report on LOVE FOR LYDIA 9 2017

[2] a) BRE study of boat emissions (5cii), b) BSS Examiner Environment Monitoring Project (see 5ciii), c) Case Study 1 - Lascar Data Logger evidence (see 5civ), d) Case Study 2 – Battlebridge Basin (see 5cv), e) Case Study 3 - First responders placed at risk (see 5cvi), Case Study 4 – a poorly maintained LPG water heater (see 5cvii)

e. Concerning the potential for boat owners to be placed at risk in their own boats from running the boat's engines or appliances, the above recommendation does not alter the BSS view that CO safety primarily concerns the proper installation, routine maintenance and safe use, of appliances and engines. The current BSS 'advice' checks covering the CO risk must remain and there remains an essential task to continue to educate boaters concerning this primary form of protection as well as on the nature of CO, how it is formed, how to recognise the symptoms and the last line of defence; the vital purpose of CO alarms in saving life (see 5f below). The BSS Examiner Trusted Messenger initiative continues to have an essential role to play. .

2. Pressures for change – (in particular, what has changed since the last RRAP in April 2015)

a. **MAIB Recommendation, LOVE FOR LYDIA** - Published in May 2017, the MAIB report concerning the LOVE FOR LYDIA double CO fatality incident in June 2016 included the following recommendation:

Recommendation - *the BSS make the installation of carbon monoxide alarms a requirement for recreational craft participating in the Boat Safety Scheme, taking into account, among other things, the:*

- *Potential risk posed to other boat users by carbon monoxide-rich engine emissions.*
- *Various sources of carbon monoxide on board recreational craft.*
- *Number of recent deaths of recreational boaters caused by carbon monoxide poisoning.*
- *Relatively low cost of carbon monoxide alarms.*

Some key features of the LOVE FOR LYDIA tragedy are that:

- The boat was moored and the boat was being used normally with engine running, probably to charge the boat's 12v batteries. The occupants did not recognise the danger from the exhaust fumes and did not have a CO alarm installed.
- The carbon monoxide from the under-water exhaust at the stern of the boat was drawn into the boat through a partially open cockpit cover and then onwards into the forepeak cabin where it quickly reached lethal concentrations. The impact of the 'station wagon' effect whilst moored had not previously been adequately appreciated. This indicates the need to take into account the prevailing conditions such as weather, wind direction and strength, atmospheric conditions, the presence of high-sided structures, etc.
- No CO alarm was present on LOVE FOR LYDIA.

b. **MAIB finding, LOVE FOR LYDIA** - In addition, the MAIB report concerning the LOVE FOR LYDIA tragedy highlighted that there is *the potential for a boat's exhaust emissions to poison the occupants of other boats moored nearby*. From the Annexes of the MAIB[3] report it is clear that five minutes in to Test 10, at the same time CO measurements of 2000ppm+ were being recorded at the helm of LOVE FOR LYDIA, outside of a boat moored astern, measurements of 450ppm+ were recorded and during Test 12, 140 ppm was recorded at the helm of the boat moored astern.

c. **The emerging trend of CO fatalities from the exhaust emissions from large capacity petrol engines** – MAIB tests employed to re-create the LOVE FOR LYDIA tragedy measured CO at the helm position at over 2000ppm within 39 seconds and similar levels were recorded in the forepeak cabin within 8 minutes.

Over the previous two boating seasons in the UK and Channel Islands, four boaters people have died[4] and another two have had emergency medical treatment after the cabins of their cruisers, with large inboard petrol engines, filled with a toxic cloud of CO as engine exhaust gases were drawn inside through the open flaps of cockpit awning covers. A recent BSS news release refers[5].

This new trend should be placed within the context of the MAIB recommendation which is specific to boats with large capacity petrol engines. The BSS assessment is that there are around 3000 boats of this type on UK inland waterways (see 5ci below). The conclusion is drawn that all of these boats have the potential to spread CO to adjacent boats.

[3] Annexes to MAIB report on LOVE FOR LYDIA

[4] Two persons aboard LOVE FOR LYDIA at Wroxham, one aboard VASQUEZ in Cardiff and one aboard MAIS OUI in Jersey.

[5] BSS New Release 18-002 Blunt CO warning for petrol-engine users

d. **The current level of widespread support for CO alarms**

Boat user groups - It is clear that the majority of boat User Group organisations are not only fully supportive of the introduction of a mandatory BSS requirement for CO alarms, they are becoming increasingly critical of a perceived delay in introducing it. For example, IWA policy is to work through its presence on BSSAC and BSSTC to have CO alarms added to mandatory equipment required on hire and private boats covered by BSS examinations *as a matter of urgency*.

It is estimated that a good proportion of boat owners already enjoy the protection of a CO alarm, possibly as high as 62% (see 5d below), especially narrowboat owners having solid fuel stove installations. This percentage is favourable in comparison to the 20% figure for domestic use**.**

Partner Organisations – CoGDEM is the Council of Gas Detection and Environmental Monitoring and is widely regarded as the authoritative body concerning CO alarms and is joint owner of the 'CO Safety on Boats' leaflet. Director Leigh Greenham provided this statement - *'CoGDEM definitely supports the call for a mandatory requirement for CO alarms on board all boats that have enclosed accommodation, not just those covered by the BSS scheme. We have seen evidence in MAIB reports of fatal incidents where no CO alarms were present, and this is very disturbing, whereas the reports of near-misses where a CO alarm has activated are encouraging. As well as the potential for CO ingress from outside, I think the BSS must 'protect' the visiting examiners, as proven by the number of instrument activations in the first 4 months of the current environment monitoring project (and also the off-duty firefighter in the [VASQUEZ] Cardiff incident).'*

The National Fire Chiefs Council (NFCC) is the professional voice of the UK fire and rescue service. Mark Hazelton, the CO-lead for the NFCC provided this statement. '*The NFCC support the call for mandatory carbon monoxide (CO) alarms in boats. The confined and often unventilated spaces within boats can provide the perfect environment for CO to build up in lethal concentrations. CO can be produced by burning carbon fuels such as the boats engine or a wood burner. Prolonged exposure even in low concentrations can be hazardous. When boats are moored together the fumes from one vessel can easily enter another. CO is colourless and odourless and only a CO alarm can provide the vital early warning that can save lives'*.

Examiner Bodies – Most Examiner Bodies, like the User Groups, advocate CO alarms as a mandatory BSS requirement.

Marine Trade - Three years ago there was a marine industry perception that CO alarms could not be recommended for use in boats as they were only intended for domestic use and now this perception has disappeared. The change in perception is partly because the BSS introduction of CO alarms for hire boats having solid fuel stoves led to trials that were entirely successful.

With the introduction of specific tests to the -2 version of CO alarm performance standard EN 50291, it has become clear the alarms are very robust and adaptable to leisure environments.

British Marine Inland Boatbuilding Code of Practice now contains the following; *it is good practice to fit carbon monoxide (CO) alarms certified to BS EN 50291-2 to all craft, and as recommended by the Boat Safety Scheme (BSS).*

There appears support from British Marine's executive interests for the move towards the acceptance of CO alarms on boats. It is likely that the recommendation for CO alarms to become a mandatory BSS requirement will be supported. It is also likely that British Marine will lobby through BSI committee GME/33, for CO alarms to feature within a clause of a relevant Recreational Craft Directive (RCD) harmonised standard and possibly even a longer-term goal for the RCD Essential Requirements to be amended to elevate the CO risk in some way.

Note that the ARNISTON MAIB recommendations[6] included one for the Government's Department for Business, Energy & Industrial Strategy to *explore, through the RCD framework, ways of ensuring that new vessels have a means of detecting toxic gases, particularly carbon monoxide, in habitable spaces, and alerting occupants to their presence*.

[6] MAIB report on ARNISTON Jan 2015

e. **APPCOG support for CO alarms to help protect tenants** - The All Party Parliamentary Carbon Monoxide Group (APPCOG) fully supports the work of the BSS concerning boat CO safety.

In other spheres APPCOG promoted the following into the recent consultation, *the Government should as a matter of urgency update the existing Smoke and Carbon Monoxide (CO) Alarm Regulations 2015 so that landlords are legally obliged to provide CO alarms in the rooms of private rented properties containing any fuel-burning appliance, not just solid fuel appliances.*

In 2015, the Smoke and Carbon Monoxide Alarm (England) regulations were introduced to protect private sector tenants from death or injury in the home caused by smoke and carbon monoxide poisoning. At the time of introduction, Ministers made a commitment to review them in 2017 and a formal consultation has recently ended. At the moment, the regulations require a CO alarm in any room of the tenanted premises which is used wholly or partly as living accommodation and contains a solid fuel burning combustion appliance; and checks are made that each alarm is in proper working order on the day the tenancy begins if it is a new tenancy.

Note that any proposed changes to the Smoke and Carbon Monoxide Alarm (England) Regulations would follow the Independent Review of Building Regulations and Fire Safety introduced following the Grenfell Tower fire tragedy.

BSS Support Committee/BSS office commentary – The relevance of this is that, even in the last three years, the perception is that the proportion of boat owners living aboard has increased and that a significant number of these will be tenanted boats.

Press articles talk of 10,000 people living on boats in London but the reality is provably nearer to 4000, and a Canal & River Trust survey[7] sent to 3675[8] boat owners in September 2016 indicated that:

- 69% of respondents are currently living on a boat on a London waterway;
- by inference, 20% rented the boat they were living on – albeit the actual proportion could well be higher, because not all boat owners divulge that their boat is rented.

The current Government focus on ensuring all tenants have a safe place to live, and the associated APPCOG call for tenants to be protected by CO alarms, acts as a pressure for change for the BSS to have in place equivalent measures to protect tenants. This is because the Smoke and CO Alarm Regulations 2015 do not apply to boats.

f. **APPCOG From Awareness to Action[9] Report 2015** – The report is extremely influential and is seen as authoritative. The report promotes behavioural change as the key to success in addressing the CO risk and, specific to boats, the report recognises that "….**campaigning to improve CO awareness ….. is extremely difficult, especially as people may only be in such an environment for a short time. In addition, there is evidence to suggest that behavioural norms may be temporarily abandoned in the 'holiday mind-set'. Building in safety measures, as has happened with some caravans and motor homes in recent years, may therefore be the most effective route to improving safety in this context, in conjunction with increasing detection and knowledge."**

BSS Support Committee/BSS office commentary – The BSS office position is that CO awareness campaigning needs external funding to be fully effective. Despite sometimes joint activities from organisations intended to reduce boat CO fatalities, the numbers of fatalities remain equal to boat fire fatalities at around 1.5 per year on average. It has become clear that preventing poisoning incidents through a behavioural approach requires truly focussed and co-ordinated efforts from a range of organisations. The range of organisations with an interest here is long; the BSS, navigation authorities, the marine trade, local fire and rescue authorities, training bodies such as the RYA, CoGDEM, charitable organisations such as the Waterways Chaplaincy, national user groups and boat clubs and local communities of boaters.

[7] Canal & River Trust - Who's on London's boats survey summary report
[8] 3675 made up of 1837 boaters with a home mooring and 1427 boaters without a home mooring
[9] APPCOG From Awareness to Action report 2015

Whereas in 2015 confidence was high, it transpired that the previous efforts to achieve charity funding for a part-time co-ordinator to drive through and lead initiatives such as data-gathering and campaigning efforts have stalled and so have efforts to achieve funding for research to help establish and improve the effectiveness of boat CO safety awareness, by way analysing the various sectors of boat ownership leading to effective and targeted communications, aimed at maintaining safe behaviour.

In order for the charity bids to be accepted, it is clear that there is a need to carry further studies to help identify the level of risk and especially the level of any risk to those persons considered to fit in the 'vulnerable' category.

One such study is the CO data logging initiative involving perhaps hundreds of liveaboard boats in London and to be run by London Fire Brigade and planned to start from early 2019. The bid to the Gas Safety Trust is imminent, but acceptance of the bid is by no means certain.

With funding for co-ordinated campaigning unlikely within the foreseeable future and without the benefit of knowledge of the different segments of the boating community and their attitudes to safety, it is concluded that it is not currently possible to ensure with any level of confidence that the safety messages fully hit home and that behaviour is influenced across all boat owning sectors. It is predicted that to 'do nothing' will see a continuation of CO incidents to boats even with the measures taken to extend awareness of CO risks. Concerns are amplified because of the perceived trend towards i) more boats in the tenanted and ii) more of those who live aboard in the 'hard to reach' or 'vulnerable' categories.

The conclusion is that the introduction of a mandatory BSS requirement for CO alarms is at present viewed as the most effective way to help keep people safe from CO poisoning; however see the potential minor dis-benefits at 5d below. The BSS office considers that it remains essential that awareness information continues to be delivered, updated and targeted, in order to help influence behaviour. The BSS Examiner 'Trusted Messenger' initiative offers an excellent opportunity in this respect.

g. **APPCOG Carbon Monoxide Poisoning: Saving Lives, Advancing Treatment 2017**[10] – This report was authored by members of COMed, the dedicated healthcare sub-group of the APPCOG Stakeholder Forum. COMed is made up of healthcare professionals. The report concludes that **"…high levels of CO exposure can be fatal within seconds, whilst low-level, repeated exposure may cause irreversible long-term damage, the extent of which is only beginning to be understood."**

The current published relevant workplace exposure limits (WELs) are set out below (as extracted from the APPCOG report); but without the further research called for, it is advocated that these can only act as current guidance. Current air quality limits for workplace exposures have been established as follows:

Workplace exposure levels to CO

8 hour time weighted average	15 minute time weighted average	
30ppm	200ppm	
35 mg/m3	232 mg/m3	Source: [Health & Safety Executive, 2011]

The World Health Organization guidelines for indoor exposure to CO

Averaging time	Concentration (mg/m3)	
15 minutes	100 (87.29ppm)	
1 hour	35 (30ppm)	
8 hours	10 (8.73ppm)	
24 hours	7 (5.24ppm)	Source: [WHO 2010]

[10] APPCOG Carbon monoxide poisoning saving lives advancing treatment report 2017

As reported by CoGDEM, the current WELs for CO are going to be reduced in August 2018 from 30 to 20 ppm (8-hour time weighted average long-term exposure limit) and from 200 to 100 ppm (15-minute time weighted average short-term exposure limit). The reduction for the CO WEL (as well as some other toxic gases) is to bring Britain into line with European workplace limits. In December 2017, the HSE announced a consultation which ran until 2 Feb 2018 for comments on the proposal to reintroduce these WELs. Subject to the consultation results, these WEL proposals will come into force from 21 August 2018.

BSS Support Committee/BSS office commentary – It follows that whereas it is known that high-level exposure is very dangerous, there is no answer to the questions; i) whether there is any low-level CO exposure limit that is considered 'safe', ii) whether there is a cumulative neurological impact concerning repeated low-level exposures to CO iii) the additional risk to sensitive groups such as the very young or pregnant women. The answer to the above questions will hopefully emerge following the research called for in the APPCOG report.

The pressure for change for the BSS is that i) without sure knowledge of any safe level of exposure to CO, coupled with ii) health professional concerns about chronic exposure to low levels of CO, and iii) downward pressure on CO WELs, the conclusion is CO alarms are necessary to help protect persons aboard boats.

The proposed reduction of the CO WEL is relevant to BSS Examiners, tradespeople, first responders etc, so the presence of a CO alarm will ensure that these workers have at least one level of protection.

h. **The outcome of initial studies and the collection of anecdotal information -** As referred to at 1b) above and as explored further at 5c) below, the concerns from initial and limited studies and from anecdotal information collected concerning the potential ingress of CO into boats from outside, act as a significant pressure for change.

i. **The introduction of CO alarms on fishing vessels subject to Merchant Shipping Regulations** - Three Merchant Shipping Notices (MSNs), containing Codes of Practice, came into force on 23 October 2017[11]. The Fishing Vessels (Codes of Practice) Regulations 2017 implements the three MSNs. Included is the requirement that *CO monitors are required on vessels with enclosed spaces with fired cooking or heating appliances*. The change to the code followed the deaths of two fishermen in January 2014, found dead in their bunks on board the scallop-dredger ESCOL in Whitby harbour. The men had died from carbon monoxide poisoning as a result of leaving the grill of a butane-fuelled gas cooker lit when they went to bed. The grill was being used to warm the wheelhouse and sleeping area. A subsequent recommendation from MAIB to the Maritime and Coastguard Agency was to *at the earliest opportunity, include in the Code of Practice for the Safety of Small Fishing Vessels a requirement for a carbon monoxide detector to be fitted in the accommodation on all vessels*.[12]

j. **The Govt review possibly leading to an amendment to the Building Regs[13] –** As announced on 30 April 2018, there is to be a government review into rules that require CO alarms to be fitted in homes across England. This will include whether there should be a blanket requirement to install alarms for all methods of heating, including gas and oil. Since 2010, the Building Regs have required CO alarms when solid fuel burning appliances are installed. The review will also consider whether the cost of alarms is affecting installation rates and will lokk at new research into the number of CO poisonings.

Any reform recommended in the review will be subject to ministers' agreement, further consultation and scrutiny.

[11] MSN 1871 The Code of Practice for Small Fishing Vessels under 15m LOA (replacing MSN 1813); MSN 1872 The Code of Practice for Fishing Vessels of 15m (LOA) to less than 24m (L); and MSN 1873 The Code of Practice for Fishing Vessels of 24m (L) and over.

[12] MAIB report on ESHCOL 6 14

[13] https://www.gov.uk/government/news/government-to-launch-review-into-carbon-monoxide-alarms

3. Existing risk controls – CO generally

a. The technical aspects of engines are within the scope of the BSS, Recreational Craft Directive (RCD), engines must be CE marked. RCDII includes slightly enhanced CO exhaust emission limits for engines including spark ignition engines. ISO 8178-4:2017 specifies the test cycles, the test procedures and the evaluation of gaseous and particulate exhaust emissions from reciprocating internal combustion engines coupled to a dynamometer.

b. The technical aspects of appliances are within the scope of the BSS, RCD, and (for boats in scope, such as boats used as the primary place of residence) the Gas Safety (Installation & Use) Regulations (GSIUR).

c. The primary proactive risk control is the appropriate selection (by the boat builder, service agent or boat owner), installation, maintenance and use of appliances and engines and ensuring appropriate behaviour concerning boaters not introducing other CO sources such as lit/cooling charcoal barbeques or space-heating using the LPG cooker.

d. Competent installation of appliances. For boats in scope GSIUR the use of boat-competent Gas Safe registered engineers to work on LPG systems is a legal requirement. The use of Gas Safe registered engineers on the LPG (and any natural gas) systems of boats outside of scope of GSIUR is recommended. For work on solid fuel and liquid fuel heating systems and engine fuel systems the use of suitably competent and qualified persons is strongly recommended.

e. Several existing private boat BSS 'Advice Checks' cover the risk of CO poisoning from appliance flues and poorly burning LPG flames and inadequate ventilation, listed below. The Advice Checks are mandatory for any commercial class of boat subject to the Scheme's requirements.

   - 8.8.1R Are all LPG appliance burners in good condition and delivering a proper flame? Fire + CO
   - 8.9.1A Is the vessel provided with adequate fixed ventilation?
   - 8.9.2A Are warning notices displayed on sea-going boats with closable ventilators?
   - 8.10.1A Are all appliances requiring a flue or exhaust, fitted with one?
   - 8.10.2A Are all appliance flues and exhausts complete and in good condition?
   - 8.10.3A Do all appliance flues and exhausts terminate directly to outside air?
   - 8.10.4A Are all open flues to LPG appliances operating effectively?
   - 8.10.5A Are all solid fuel appliances free of unintended gaps?

f. Since April 2017 hire boats have been subject to the mandatory BSS requirement for the provision of CO alarms on hire boats having solid fuel stoves.

g. The BSS/CoGDEM awareness leaflet 'Carbon Monoxide Safety on Boats' provides guidance on the characteristics of CO, how to recognise the symptoms of CO poisoning, how to prevent CO build-up, and makes a general recommendation that all boats with fuel burning appliances on board have suitable audible CO alarms fitted and guide boaters as to where to locate them.

h. The BSS 'Stay Safe' webpages provide comprehensive advice on CO safety[14].

i. Campaigning, alongside partner organisations, continues such as the partnership with the Fire Safety Unit at the Home Office concerning Boat Fire Safety Week. This has an equal focus on boat CO safety.

[14] https://www.boatsafetyscheme.org/stay-safe/carbon-monoxide-(co)/

4. Identification, characterisation and scale the risk

a. Summary - It is recognised that CO poisoning is a risk equal to fire and explosion in the number of boater fatalities over the past 20 years (30 fatalities). Note however that none of these fatalities concern CO entering the boat from outside. All the fatalities concern boat owners placing themselves at risk in their own boats from running the boat's engines or appliances.

   This area of risk falls under the remit of the BSS to help control (5a/b below). Figures published by the Gas Safety Trust for the 20-year period to 2015 show that 3.5% of all CO related deaths in the UK for all activities were related to boating. The Department of Health reports typically 50 CO-related deaths per annum for the whole population. Using the typical year's population of people boating on inland waters in the UK (800,000) and a UK total population of 60 million, the rate of CO death per head of inland boating population is approximately double that for the whole UK population) [15].

   Solid fuel stoves and the use of petrol generators present the bulk of the boat CO fatality causes during the past 20 years, however the last four fatalities recorded since the summer of 2016 all involve exhaust emissions from boats with large capacity petrol engines and concerning the LOVE FOR LYDIA incident, MAIB tests emissions were recorded in an adjacent boat moored astern.

   The risk of being poisoned by chronic low levels of CO from sources outside of the boat is a potential risk that has not yet manifested itself in known fatal incident or other known incidents of harm. It is this area of risk that is the main focus of this recommendation.

   There is an accepted need for more research regarding low-level carbon monoxide exposure generally (see 2g above) and until the outcome of the research is known it is not possible to grade the level of risk. It is known that the risk to those on board from sources on the boat is known and the potential risk level associated with CO exposure is high (significant likelihood of a fatality within five years).

b. Who is at risk? - All persons aboard boats with fossil fuel burning appliances and engines onboard or through mis-use of, or the use of faulty fuel-burning engines and appliances; and all boaters through stray CO gases entering the cabin from nearby boats.

   Persons sleeping on board are at heightened risk as symptoms of CO poisoning will not be apparent whilst asleep.

   Potentially, first responders can be placed at risk as can BSS Examiners at the time of carrying out BSS examinations.

   Critical groups include:

   - persons aboard large capacity petrol inboard cruisers and those near to such boats when the boat engines are operating and particularly in the event weather, atmospheric and other environmental conditions prevail. This is a newly identified group.
   - persons aboard boats vessels that have poorly installed, maintained or used appliances or portable engines. Note that the proportion of boats being used as affordable housing fit within this group because i) owners of such boats may have limited experience of boat dwelling and use of stoves and generators, ii) appliances onboard are less likely to be properly maintained, iii) inappropriate fuels are more likely to be used on solid fuel stoves, iv) generator use is more likely to be prevalent, v) indications are that this grouping are less likely to have CO alarms.

c. Personal acceptability of risk to those exposed to it - As CO cannot be detected through human senses, anything other than a low potential risk of CO is considered an unacceptable risk in a boat environment.

[15]Reference - Hire Safety Review Initial Recommendations, November 2013

CO poisoning is a preventable cause of death. The historic rate of occurrence of CO related fatalities on boats and the insidious nature of the hazard and its potential for multiple fatalities or chronic illnesses, defines it as a risk that requires proportionate control.

Currently the potential risk to boat occupants of CO poisoning through the boats own engines/appliances is considered high (significant likelihood of a fatality within five years). The potential risk presented to boat occupants from sources of CO drawn into the boat from external sources is considered to be a medium potential risk (fatalities possible but unlikely within 15 years)

The use of CO alarms combined with an effective influencing-behaviour campaign reduces risk to 'as low as reasonably practicable' (ALARP[16]).

The introduction of CO alarms would mean that the CO hazard would no longer be silent and that persons affected would be alerted before they became affected or even incapacitated. This would reduce the risk to a low potential risk (negligible potential for fatalities), the residual risk being due to such as alarm unserviceability, or tampering, and/or introduction of other CO sources such as barbeques to spaces not protected by alarms.

d. Risk benefit assessment - Any required use of CO alarms on boats would not detract from the overall health and well-being of boaters generally. No unintended consequences have been identified other that the predicted mis-use of CO alarms by small minority of people (see paragraph above and 5diii below).

   CO alarms have no bearing on whether or not dangerous levels of CO are present within a boat and as such represent a reactive risk control measure, having the potential to radically reduce the likelihood of injury or fatality in the event CO is present.

e. Future gazing – It is considered that the level of risk is unlikely to diminish over the next 5-10 years.

   - It is likely that there will be a slight drop in the numbers of boats with large-capacity petrol engines as boats built in the 1970/80s come to the end of their life.
   - It is likely that the trend toward more boats being used as a form of affordable housing will continue, bringing with it more burning of inappropriate stove fuels and generator use.
   - It is likely that new boats will be provided with CO alarms and therefore any BSS requirement for CO alarms will be seen as simply an in-service check of the boat's equipment.
   - It is likely that there will be a greater focus on boat emissions generally associated with an enhanced societal and navigation authority focus on health and wellbeing.
   - The solid fuel stove Eco Directive coming into force in 2022 will likely provide a good focus to improve behaviour related to fuel choice, the use of twin-walled insulated flues and stove use generally.
   - Maritime and Coastguard Agency commercial codes will likely include requirements for CO alarms at the time codes come up for review.

[16] http://www.hse.gov.uk/risk/theory/alarpglance.htm

5. Specific considerations

a. *The legal position of the navigation authorities* as provided within legal advice obtained. In general terms it is considered that the acts and byelaws of those navigation authorities that participate in the BSS allow for the prescription of standards for the construction and equipping of vessels and that the prescription could include CO alarms or any other type of equipment.

For example, for Canal & River Trust the relevant legislation is contained within Schedule 2, Part II of the British Waterways Act 1995 that confers a power as opposed to a statutory duty.

The question is whether the power should be exercised. The place to start is to employ the processes of the BSS to explore the subject, because all of the 14 participating navigation authorities choose to use the BSS requirements to help manage this area of risk. The Navigation Authority Agreement serves as the primary reference document for those navigation authorities that have adopted the BSS or are considering participating in the Scheme.

b. *Navigation Authority Agreement (NAA)* The NAA is the constitutional document that leads BSS operation and associated activities. Extracts:

- *The Boat Safety Scheme (BSS) is in place to help minimise the risks to people and property presented by boats that have been inadequately constructed, equipped or maintained, or through the inappropriate use of appliances, engines and associated boat systems and fuels*.
- *The BSS is in place to help minimise the risks to all visitors to the waterways and the waterways' workforce, and to help protect adjacent property, related to the condition, equipment and use of boats. The BSS is also used to minimise the risk of avoidable pollution from boats.*
- *The mandatory requirements of the BSS are kept to the minimum consistent with achieving the objectives and responsibilities of the Navigation Authorities to help prevent boat fires, explosions or boat pollution and environmental and other potential harm to people and property.*
- *The BSS employs education, persuasion and promotion of safety to address accepted risks linked to the use of the vessel and its appliances, engines and associated boat systems and fuels in order to assist owners and other craft occupants to identify and control the risks for which they have a responsibility*

BSS Support Committee/BSS office commentary – The protection of boat owners from external sources of CO is covered by the above extracts, in particular the third bullet point. Accordingly, to introduce a mandatory BSS requirement on the basis of the CO risk to the owners of craft, as introduced by their own mis-use of appliances or engines, would not fit with the NAA. Any proposal to introduce a mandatory requirement for CO alarms to protect boat owners from their own behaviour would first need a change to the NAA.

c. *Initial and limited studies and anecdotal evidence* The following initial and limited studies have informed this RRAP:

i. The numbers of large capacity petrol engines on inland waterways. The MAIB re-enactment study concerning the LOVE FOR LYDIA tragedy identified the potential for a boat's exhaust emissions to poison the occupants of other boats moored nearby (see 2b above). The engine on LOVE FOR LYDIA was a Mercruiser 300hp V8, 350 MAG petrol stern drive.

The engine details of the other two boats involved in the recent CO fatalities are as follows:

- VASQUEZ - V6 Volvo Penta AQ225F stern drive petrol engine
- MAIS OUI - Twin V6 Volvo Penta GL 4.3L stern drive petrol engines

The BSS database of BSS examinations has identified around 3000 boats having large capacity petrol engines (taken to be petrol engines with six cylinders and above).

Although the base data is not fully complete in terms of engine size, etc, it is taken that the following engine makes are a good indicator of petrol engine size: BMW, Chevrolet, Chrysler, Crusader, GM, Indmar, OMC, Mercruiser, Volvo Penta.

The figures can be further broken down as follows:

- Volvo Penta approx. 1500
- Mercruiser approx. 1300
- GM brands & Indmar approx. 100
- BMW approx 50

BSS Support Committee/BSS office commentary –

- Modern automotive exhaust systems incorporate a catalytic converter, which substantially reduces the amount of pollutants by converting harmful gases into water vapour and less harmful gases via a series of chemical reactions. Invariably, large capacity marine petrol engines are not fitted with catalytic converters.
- 3000 boats represent 4.3% of the estimated boat population subject to the BSS (70,000) and over 21% of the total number of boats with petrol engines on the BSS database (14200). Note that large-capacity petrol boats represent a significant proportion of the boats on the Lakes and Loch Lomond, and these are not included on the BSS database.
- The risk concerning large capacity petrol engines is specific to rivers, broads and lakes and is almost non-existent on narrow canals. However, it should be appreciated that perhaps boats with twin smaller petrol engines or perhaps a single engine boat having both the engine and petrol generator in use, may present an equivalent risk. According to the BSS database there are around 700 boats with smaller twin petrol engine arrangements.
- The risk associated with a single petrol generator use is identified as an area requiring its own study.

ii. BRE studies of boat emissions - Feb 2018

BRE were commissioned to undertake an initial and limited pilot study on the effects of combustion emissions, especially CO, on other third parties nearby, such as other adjacent boat users. Whilst undertaking this part of the study, other air pollutants such as nitrogen dioxide and particles were also measured.

Sources such as diesel engine, diesel heater, solid fuel stove and petrol generator were tested individually and combined on two boats moored at adjacent pontoons in a marina.

In advance of the testing the BRE scientists undertook an assessment of the ventilation rates on the boats used by measuring the decay rate of a tracer gas, with all doors and windows closed. The results indicated air change rates of around 2 air changes per hour which is favourable when houses and flats are typically in the range of 0.2 – 1 air change per hour.

The only testing that yielded CO measurements involved the petrol generator. The first test carried out with a petrol generator was suspended after 20 minutes because, as located on an upwind jetty 5-10 metres away, the generator had no noticeable effect. When positioned only 0.5m away and with the cabin doors open, the maximum reading recorded was 31.4ppm with a mean concentration over the 45-minute test of 19.4ppm.

BRE made recommendations that petrol generators should always be used downwind of the boat, but not upwind of any adjacent boat unless there is a minimum separation of 10 metres. BRE recommend more investigation of the use of petrol generators. In the US, comparable advice and warnings are already in place concerning generator use near the home[17]

iii. BSS Environment Monitoring Group

In November 2017 a group of 14BSS Examiners were given four-gas analysers to be used with each examination to monitor the environment presented to all Examiners to help assess whether it presents any exposure to gas hazards during site visits.

[17] CPSC portable generators 3 critical precautions so you don't die from CO poisoning CPSC = Consumer Product Safety Commission

So far 27 readings of CO at 20+ ppm have been recorded – exceeding the HSE 8-hour workplace exposure threshold and three recordings above 100 ppm – exceeding the 15-minute HSE limit.

These results were out of just under 1900 examinations. If this is extrapolated to all BSS examinations, 20,800 last year, we can expect around that around 300 boats will be found with concentrations of 20+ ppm and around 33 boats will have levels above 100 ppm each year.

BSS Support Committee/BSS office commentary - It's too early to draw conclusions from the two-year project, however initial results indicate a need to take an interest in the individual circumstances and to be mindful of boater safety and also examiner safety in the context of workplace exposure limits. Advice is being sought from a consultant health professional who is to interpret and comment on the initial results.

iv. Case study 1 – Vessel 'C', Lea Navigation

On Friday 3 November 2017 the owner of vessel C reported that his CO alarm had alarmed on consecutive days and at around the same time (12:00 noon - 13:00). On the days of the incidents the owner's partner complained of feeling unwell, her symptoms were similar to those of a migraine attack. She suffers from migraines occasionally. Persons were aboard the two boats ahead of vessel C, moored in line. The prevailing wind is from north to south so from the direction of the two boats.

One boat had stove operating and the other boat as it's diesel engine running. The boat with the stove was burning something the owner said he had acquired from work at a timber merchants, he said it was softwood but it smelt tanalised and had thick acrid black smoke.

At the time of the CO alarm activation incidents the doors of the narrowboat were closed but the high-level hopper windows were open. The owner had three CO alarms and all at various times activated.

As part of measures to assess and reduce any risk the owner agreed that the BSS could monitor for CO using Lascar Data Loggers. The testing took place around Christmas time, however unfortunately, one of the loggers suffered battery failure on day two.

However, the results for the afternoon of Friday 22 December are of interest. The Lascar Data Logger B4 situated very near to the ventilator at the stern doors started to record significant readings from 14:00 and continued in the 40ppm range for three hours before rising suddenly through the 50ppm threshold and up to 64ppm at 17:16, before the battery was depleted.

During that same afternoon period the B2 logger (located by the solid fuel stove) was collecting readings in the high-teens, but didn't show the same sudden increase at 17:00 as B4. The B3 logger (by the bow doors) only showed a slight 'hump' during that period.

It is certain that the occupants were not onboard vessel C at this time. The only explanation for the readings is the ingress of CO from the neighbouring boat operating its solid fuel stove and likely burning poor quality fuel. The owner reports that the offending boat is now no longer moored adjacent to vessel C but that on one occasion this year since the boat left, a CO alarm activation did occur when no appliances or engines were running on vessel C. The owner states that upwind was a boat again running a solid fuel stove and that the wind was strong when the CO alarm activated.

BSS Support Committee/BSS office commentary - The logging exercise is significant because it presents evidence of CO at significant levels entering a boat from another boat.

v. Case study 2 – Anecdote - Vessel 'D', Battlebridge Basin, Kings Cross, London

Anecdotes collected include where boat owners claim their CO alarms activated, or activate routinely when neighbouring craft run their engines or oil-fired heaters.

The BSS Examiner referred to below provided the report and it has not possible to verify the facts because the owner of vessel D has not been contactable to date. In late November 2017 a BSS Examiner who is also Gas Safe registered engineer attended a boat at Battlebridge Basin to carry out some gas work to an appliance. The following morning the owner of vessel D telephoned the gas engineer to ask what he had done wrong because since he carried out the work the CO alarm was going off now and again.

The gas fitter being worried attended the basin to investigate. Upon arrival he found that the basin was shrouded in a low-lying haze of solid fuel stove smoke about five metres above ground level and that of the 18 boats or so moored in the basin around 10 boats had their solid fuel stoves burning. The owner of vessel D reported to the engineer that since she telephoned she found out that two other boats had also had CO alarm activations. The owner of vessel D has not been contactable in recent months.

BSS Support Committee/BSS office commentary - The combination of multiple solid fuel stoves appliances operating coupled with weather, atmospheric and environmental conditions keeping the chimney smoke from dispersing led to the stove smoke entering the moored boats.

This is significant because it presents anecdotal evidence of CO at levels sufficient to activate CO alarms, entering a boat from outside and potentially from other boats.

vi. Case study 3 – First responders placed at risk In November 2016 the owner of VASQUEZ collapsed and died from CO poisoning whilst on his boat at Cardiff Boat Club mooring. He was running the boat's petrol engine in-gear, trying to warm it up prior to enjoying a day on the water. What he did not know was that engine exhaust gasses were leaking into the boat from a faulty hose connection.

An off-duty firefighter who owns his own boat at the boat club was nearby when the incident occurred. The off-duty firefighter made a desperate rescue attempt to save his friend, but who in doing so also collapsed and nearly became another boat CO fatality statistic. The boat was moored a couple of moorings away. The firefighter was concerned that the boat engine was running and in-gear but there was no sign of the owner. He looked through the window and could see the owner collapsed on the floor, he jumped on board and switched the engine off to allow another rescuer to jump on more easily. The casualty was motionless and on his side with his feet up the companionway steps. He was a big man, easily 20 stones and it took a lot of effort to roll him onto his back to start CPR. CPR continued for 15-20 minutes. but the firefighter was starting to feel sick and hot, he took off his chunky sweater and CPR continued. The firefighter felt more light-headed and he could feel his legs starting to go. The last thing he remembers before losing consciousness was a couple more club members jumping in to help. When the paramedics arrived they thought the firefighter was the casualty – in fact he was; but his friend of 15 years lay dead on his boat. The paramedics measured the oxygen levels and got the firefighter off to hospital by blue light. He was there for six hours on oxygen and was told that had he been on his own attempting the rescue he could also have died.

BSS Support Committee/BSS office commentary - The BSS does need to take account of the potential risk to its examiners and to those in the emergency services. There is more available evidence that first responders have been put at risk of CO poisoning.

vii. Case study 4 – a poorly maintained LPG boiler In late November 2017 Gas Safe registered engineer, who is also a BSS Examiner, attended a boat at a midlands marina to service the LPG boiler that was not heating the water or radiators effectively. Using his flue gas analyser he recorded 14,000ppm of CO in the flue which is 40 times greater than Gas Safe registers guidance for this type of appliance. Within a metre of the flue terminal, the engineer's CO measuring meter showed a reading of just under 1000ppm and 10ppm inside the boat at the opposite end from the boiler, despite the appliance being room sealed. Whilst standing on an adjacent boat a meter reading of 6ppm was recorded. the cause of this is lack of maintenance, with a sooted flue, a burner that required cleaning and a poorly fitted flue terminal.

The concern is that if the wind conditions changed, the dilution of the flue gases and the plume away from the flue terminal could be very different and might cause dangerously high readings to be seen aboard the boat itself and/or its neighbours.

d. *CO alarm uptake* There is no precise measurement of CO alarm uptake on boats or whether CO alarms are of a suitable type, correctly positioned and have been tested using the test function button

CO alarm uptake in the home is estimated to be quite low at around 15 – 20%, and from a survey of the experiences of the 14 BSS Examiners who have volunteered to take part in the

two-year BSS Environment Monitoring project it can be estimated that boater uptake is much higher at around 62%. The survey sample was 850 boats across the country.

BSS Support Committee/BSS office commentary - From the rough data gathered it can be concluded that:

i) campaigning to date has actually had a major positive impact on levels of CO alarm ownership. It follows that to introduce a mandatory requirement would not have an impact for the majority of boat owners.

ii) boats in narrowboat-dominated geographic areas are more likely to have a CO alarm than boats based in cruiser-dominated areas, and that from this we glean that there is strong relationship between solid fuel stove use and CO alarm ownership.

iii) boats used as affordable accommodation are less likely to have a CO alarm and that these will more likely to need that protection. For example, one BSS Examiner operating largely within the eastern half of London indicated on average only a 5% CO alarm uptake. This coincides with the APPCOG view about protecting tenants that those living in low income households are most at risk of CO poisoning.

Concerning iii) above it can be concluded that perhaps the biggest impact of introducing a mandatory CO alarm requirement would fall upon those who most need protection but that can least afford it. However, it is likely that a significant proportion of this population will be renting and as such the cost would/should fall upon the landlord boat owner.

Other efforts should be targeted towards those boaters considered to be at heighted risk, this could/should involve the free distribution of CO alarms through Fire and Rescue Service community fire safety initiatives, for example.

Alarms offer a secondary level of protection. A possible unintended consequence of the introduction of CO alarms could be that the presence of alarms may cause some boaters to relax primary safety standards increasing risks of dangerous conditions occurring.

There is a concern that for a small proportion of boaters, especially those not persuaded by any arguments in favour of introducing any mandatory requirement for CO alarms, may not use alarms appropriately, i.e. i) may seek only to use the alarm activation to engender appliance maintenance or as a warning of the need to change the way the appliances is being used, i.e. move the generator, ii) may not replace the alarm when the battery expires etc, or iii) may not react if the alarm activates. Boat owners in this category are those led by inertia and who prefer to bury heads in the sand, those who despite all of the information available remain ignorant of the risk and those who simply disagree with CO alarms or at the very least are dismissive or sceptical.

CoGDEM counter that there is also some anecdotal evidence from other sectors that the reverse situation can exist, i.e. when a person becomes knowledgeable enough about CO risks to take an action to fit a CO alarm, he/she becomes more knowledgeable about the need for (and benefits of) regular appliance servicing and is more likely to take the necessary action to organise this.

It is considered that mandating CO alarms may not be as good as achieving 90%+ voluntary uptake, but it will address those boaters in the categories described above and who have an attitude to safety that will be very difficult to otherwise influence.

The conclusion is that whilst it can be predicted that there will be a small proportion of inappropriately used, poorly maintained and battery-removed alarms, there will still be a far higher number of working alarms on boats.

e. *CO alarm cost and effectiveness* In support of the APPCOG push for a wider scope of the Smoke and Carbon Monoxide Alarm (England) Regulations, CoGDEM estimated that, since the original impact assessment, as well as the price of a CO alarm having reduced from over £23 to an average of £15, the life expectancy of an alarm has increased from five years to 7-10 years. The conclusion was that the cost-benefit analysis had changed to make the fitting of CO alarms a cost-effective measure to save lives in tenanted properties.

CoGDEM recently commented that the average price of £15 relates to basic CO alarms, not units with additional features such as displays or wireless links. The lowest price for an entry-level BS EN 50291-2 is currently £13.31 inc VAT (£11.09 for those traders who can claim back VAT).

To meet the suitability requirement, CO alarms must be to BS EN 50291-2 and 3rd party certified by an accredited certification body, as evidenced by a 'Kitemark' or LPCB mark.

The '-2' edition of the BS EN means that the units will have been tested to meet additional performance standards specifically relevant to boat installation - namely, shock, static orientation, dynamic orientation and steady-state acceleration. The BSS website has a list of alarms recommend by the makers as suitable for use in boats[18].

CoGDEM support the use of CO alarms in boats and advocate that many CO alarms are now tested for use in caravans and boats (to BS EN 50291-2), and some tent manufacturers have agreed that they will promote alarm use, partly through novel tent design features such as internal pockets for alarms. With alarms becoming more robust and adaptable to more environments, their ease and reliability of use increases.

The following information from CoGDEM provides full assurance of the robustness of testing CO alarms using the test button feature. The sensors in domestic CO alarms are two-electrode electrochemical amperometric fuel-cells, which only generate a small current flowing between the two electrodes when CO interacts with an acidic electrolyte which is in contact with the electrodes. Clause 4.5 of BS EN 50291-1 states: "*The apparatus shall provide a fault signal in the event of loss of continuity or short circuit to the sensor. The fault signal shall be clearly identified and different from a gas alarm*."

A compliant CO alarm will therefore have been tested by the UKAS-accredited Notified Body and test laboratory to ensure that these automatic tests will indeed identify a sensor failure. In fact, the CO alarm manufacturers go much further than this, and their products employ sophisticated self-test techniques to automatically and regularly pulse-test the alarm's internal sensor to determine the state of the acidic electrolyte and the electrodes to compare the results with that actual sensor's as-new characteristics. This enables the alarm's intelligent control algorithms to determine the health and efficacy of the sensor, reporting a fault condition if one should occur or if the sensor reaches the end of its working life.

The manufacturers have each published document's about how their particular alarms test sensors, such tests occur regularly at intervals such as every 60 minutes in the case of one manufacturer, 16 minutes with another and 3 minutes with another. These tests occur irrespective of whether the test-button is pressed.

However, a press of the test-button will manually invoke the pulsed sensor test, so when the user or test-engineer receives a positive result after the test-button is pushed, this confirms the sensor is fully active, the analogue and digital circuitry and software are operational, the battery is healthy and the alarm LEDs, display and audible sounder are functioning correctly. Obviously, a mechanical blockage of the gas path to the sensor could stop a CO alarm from correctly responding to ambient CO, but manufacturers have never seen a completely blocked gas inlet hole or sensor membrane from a returned CO alarm, and have never had a returned unit which passed the test-button test yet failed to respond to gas.

BSS Support Committee/BSS office commentary - CO alarms are robust and effective and pushing the test button provides a good level of assurance that the alarm would be effective, if called upon. CO alarms represent very good value for money and ought to be considered as a normal part of the boat's equipment.

f. *Campaigning to influence behaviour remains essential* The primary risk control measures must continue to concentrate on the prevention of dangerous levels of CO occurring within the confined spaces of a boat through the proper installation, maintenance and use of appliances and engines.

There needs to be an acceptance that alarms purely provide a 'last line of defence' protection. This relates to the importance of influencing behavioural change as set out in 2f above

[18] BSS Stay safe CO alarms save lives

Behavioural change is necessary to ensure the long-term protection of persons aboard boats, and understanding behavioural influences in order that CO safety messages are targeted and generally more effective at ensuring behavioural change is an essential step to achieving safe boaters. Emphasis will naturally include potential CO sources and how prevent CO build up, but will also include seasonal campaign messages, as per BSS summer message don't use charcoal BBQs on/in your boat. Also, ensuring knowledge of the symptoms of CO poisoning – to ensure appropriate medical care is achieved in a timely manner – is a key part of the safety messages.

g. *Proposed new BSS requirements for all boats subject to the BSS, having an accommodation space*

It is recommended that all boats having an accommodation space[19] be subject to a BSS requirement for the correct number of suitable CO alarms.

Note that the requirement is suggested not to cover day boats as in general those will be used with the accommodation open and will be used during the day when craft occupants are more likely to be alert to any symptoms of CO that could potentially develop. It is suggested that this position could be further reviewed as more research outcomes become known.

In general, one CO alarm will suffice to manage the risk and it is accepted that not each accommodation space should need an alarm. However, in circumstances where an enclosed cabin is located well away from the CO alarm, a second alarm may be necessary within the sleeping quarters to ensure any alert can be heard and the provide adequate protection.

The specific risk presented to the occupants of large petrol-engined boats requires further consideration. In the event the CO alarm was located in the living accommodation and the cabin door closed, those craft occupants in the cockpit may not be fully protected from the ingress of exhaust gases, in circumstances presented for example on LOVE FOR LYDIA. It was not suggested that an additional alarm somehow be located in the cockpit should be required. It was mentioned that maybe the guidance could be not to close off the door to the alarm whilst onboard. It was also suggested that this aspect could be covered in a targeted communications campaign.

A	**If the vessel has an accommodation space, are the correct number of carbon monoxide alarms provided?**	**Requirement**
Identify the presence of an accommodation space. If present, check for the presence and location of carbon monoxide alarm(s).	All boats having an accommodation space must be provided with at least one carbon monoxide alarm. Where the accommodation space is sub-divided by cabins with door(s), a CO alarm must be located within 10m of each cabin door.	
Applicability – where the accommodation space is not sub-divided by cabins with door(s) only one carbon monoxide alarm is required irrespective of the size of the space. Guidance for owners – follow the carbon monoxide alarm manufacturer's placement and other instructions.		

[19] From the BSS Examination Checking Procedures Glossary. *Accommodation space - Space surrounded by permanent boat structure in which there is provision for any of the following activities: sleeping, cooking, eating, washing/toilet, navigation, steering. Spaces intended exclusively for storage, open cockpits with or without canvas enclosures and engine rooms are not included*.

B	If the vessel has overnight accommodation and an installed solid fuel stove, is a carbon monoxide alarm provided within the same space as the solid fuel stove?	Advice
If the vessel has overnight accommodation and one or more solid fuel stove appliances are installed, check for the presence of a carbon monoxide alarm within the same space(s) as the stove(s).	All boats having overnight accommodation and an installed solid fuel stove appliance(s) must be provided with a carbon monoxide alarm within the same space(s) as the solid fuel stove(s). Within each overnight accommodation space separated from the space containing the solid fuel stove by a door(s), and being greater than 10m distance from the carbon monoxide alarm, an additional carbon monoxide alarm must be provided, located in the "breathing zone", i.e. near to a bed head.	
Applicability – the provision of a carbon monoxide alarm(s) in support of the requirement at Check B does not have to be in addition to the provision at Check A. Depending on configuration of the accommodation spaces (see 2nd requirement at Check A) one correctly located alarm might be all that is required to comply with Checks A and B. Guidance for owners – follow the manufacturer's placement instructions. Ideally, where a solid fuel stove appliance is installed, a CO alarm should be located between 1m and 3m (on plan view) from any stove and not directly above sources of heat or steam.		

C	Are carbon monoxide alarms correctly mounted and of a suitable type?	Requirement
Where one or more carbon monoxide alarms have been found to be necessary at Checks A and/or B, check the mounting position of each required alarm. Check the markings on each required carbon monoxide alarm. Identify the test function button.	Carbon monoxide alarms must be wall-mounted at high level, but must be at least 150mm below the ceiling height. Carbon monoxide alarms must be marked as being certified by an accredited third-party certification body to EN 50291 or equivalent. Carbon monoxide alarms must be provided with a test function button.	
Applicability – the main accredited third-party certification bodies in the UK are BSI and LPCB. For the following makes of carbon monoxide alarm accredited third-party certification can be assumed – Ei Electronics, Fire Hawk Alarms, Honeywell, Kidde, First Alert, Fire Angel, BRK and Dicon. For other makes, removing the alarm from its base may be necessary to view labels and approval marking on the base. Permission for removal should be sought from the owner/operator. Documentary evidence of accredited third-party certification is acceptable. Applicability – CO alarms may be mounted outside of the range specified in the requirement (…. *At high level, but must be at least 150mm below the ceiling height*) where any such alternative location is permitted by the alarm manufacturer and where appropriate supporting documentary evidence is available. In cases where alarms are mounted outside of the range specified in the requirement, examiners are recommended to make a note of the alarm make and model and the supporting documentation in their field notes. Guidance for owners – carbon monoxide alarms marked to the 'EN 50291-2' are the best choice for boats. They have been tested to meet the more onerous conditions found in recreational vehicles, including boats.		

D	Are carbon monoxide alarms in good condition?	Requirement
Where one or more carbon monoxide alarms have been found to be necessary at Checks A and/or B, visually check the condition of each required carbon monoxide alarm. Operate the test function button on each alarm.	Carbon monoxide alarms must be in good general condition, and must not show signs of any of the following indicators of poor condition: • damage or deterioration to the body of the alarm or the fixing mechanism; • having passed any manufacturer's express replacement date; • failing the test function test.	
Applicability – examiners are not required to open up alarms to check for internal damage or deterioration or for manufacturer's express replacement dates.		

6 Summary Impact Assessment

a. *The reason why a new BSS requirement is being considered - From the evidence collected, persons aboard boats are at medium risk of CO poisoning from sources of CO generated outside of the boat by others.*

b. *Objective and intended affect* - The objective of the proposed new BSS requirement is to help prevent CO poisoning fatalities and injuries to persons aboard boats from sources of CO generated by the activity of others and that can be drawn into the boat.

c. *Recognised beneficial affects*

   i. Implementing the recommendation will significantly help prevent CO poisoning fatalities and injuries to boat owners placed at risk in their own boats from running the boat's engines or appliances. This is a significant benefit in the context that to introduce a mandatory BSS requirement that addresses the self-harm risk could only be achieved if the BSS were to be re-constituted – see 5b.

   ii. Implementing the recommendation will help prevent CO poisoning fatalities and injuries to tenants on boats who may be at higher risk from CO poisoning.

d. *Policy options considered, including any alternatives to introducing a new BSS requirement*

   i. *Do nothing* – considered but rejected as the evidence supporting the new requirement is compelling enough to have emerged as the outcome of the thorough BSS Risk Review and Assessment Process as supported by BSS stakeholders.

   ii. *Reliance upon co-ordinated campaigns aimed at raising awareness*. The effectiveness of current campaigning remains unknown. Funding for a campaign co-ordinator is essential but not forthcoming. Funding for research to achieve data to accurately assess numbers of boaters most at risk or how to describe and measure numbers involved by way of the segmentation of boat users is not forthcoming at this time. It is heartening that CO alarm ownership is likely at +60% but complete coverage is not envisaged as possible, even with the necessary co-ordinated campaigning and research outlined at 2f above.

   iii. *Introduce a new BSS requirement* – is the proportionate risk control and has full stakeholder support and is the sole recommendation presented in this paper.

e. *Review plan* – Continuous monitoring and detail review within five years of implementation.

f. *Costs and benefits introducing a new BSS requirement* –

   Assumption a. 70,000 boats are subject to the BSS and 38% do not have a CO alarm = 26 600 boats affected.

   Assumption b. Each alarm costs £13.51 inc. VAT, being the minimum price of BS EN 50291-2 CO alarm at today's market prices.

   Assumption c. One alarm is generally sufficient, two may be required if separate accommodation spaces are separated by doors and are more than 10m from an alarm.

   Assumption d. Each alarm will have a life of seven years dependent upon battery health. Devices generally have a seven or ten-year life and a very few have five-year life.

   Assumption e. No installation costs are taken into account because, as an optional securing method, alarms can be secured in position using strong sticky pads.

   Assumption f. The estimated 62% of boats with existing CO alarms will mostly have alarms that will be compliant with the proposed new BSS requirement.

   Assumption g. The proposed new check will follow the relevant criteria of the existing hire boat requirement for CO alarms where solid fuel stoves are installed, namely:

- Carbon monoxide alarms must be marked as being certified by an accredited certification body to EN 50291 or equivalent.
- Carbon monoxide alarms must be wall-mounted at high level at least 150mm below the ceiling height.
- Alarms must be provided with a test function button.

1. Additional Costs

i. Additional costs to boat owners/operators - £354,046 (26,600 boats x £13.51 each boat), this could equate to an outlay of £1.93 per year over seven years.

ii. ii. Additional costs to the hire operators – it is estimated that there are currently around 2400 boats registered for weekly hire and 840 day-boats[20]. It is estimated that CO alarm uptake is already high at around 75-80%. For example, the two biggest hire companies (ABC Leisure Group and Richardsons Leisure Limited) are known to have successfully introduced CO alarms. The boats affected will be all of the weekly hire boats yet to have installed a CO alarm and a small proportion of the day boats, estimated at 700.

£9,457 (700 boats x £13.51 each boat), this could equate to an outlay of £1.93 per year over seven years.

iii. It is anticipated that operators of the non-private classes of boat will want a more robust form of attachment beyond the use of sticky tabs. Costs are estimated at a minimum charge of £8.50 and a maximum cost of £21. Hire boats - £5950 (700 boats at £8.50). Other classes of non-private boats – £2261 (266 x £8.50).

iv. Additional costs to the owners of other classes of non-private boats subject to the BSS. These are the workboats, hotel boats, floating cafes, etc, estimated at around 700 boats. It is estimated that CO alarm uptake will likely be already high at around the levels of private boat CO alarm ownership. £3,594 (266 x £13.51 each boat), this could equate to an outlay of £1.93 per year over seven years.

v. Additional BSS Examiner charges for their boat owners/operator customers? – it is possible that examiners will charge more for the added time taken to carry out the additional checks. Examiners operate in a free market regarding their charges.

vi. Additional costs to the BSS – no additional costs, only normal operating costs in support of consultation, implementation, promotion and review.

vii. Additional costs to BSS Examiners – it is intended that training to the proposed new checks will take place during the compulsory two-day LPG update course late year. As such there is regarded to be no additional cost to examiners.

viii. Additional cost to navigation authorities - Direct cost to the Navigation Authorities may arise from any need to further consult, amend of registration, licensing or other conditions and any information to reflect the change in requirements.

2. Benefits

i. The key intended benefit is the anticipated effectiveness of CO alarms in preventing death or injury from CO poisoning from sources of CO generated outside of the boat by others.

ii. The key recognised benefit is the anticipated effectiveness of CO alarms in preventing death or injury to boat owners placed at risk in their own boats from running the boat's engines or appliances

iii. The benefits apply to boat crews and could also potentially apply to third parties such as first-responders or BSS Examiners.

iv. The effectiveness is estimated at 90%. This figure takes account of the evidence that no CO fatalities are known to have occurred on a boat on which a working CO

[20] Based upon Hirer Safety Review data - Nov-13.pdf

alarm was fitted and concerning the high level of confidence about the quality and robustness meaning that CO alarms will be effective at detecting CO throughout their working life.

Factors that may lead to incidents occurring, include incidents arising distant from the location of a working alarm and boat crew/occupants' behavioural factors such as a failure to act upon an alarm activation, perhaps through incapacity through drugs or alcohol, or a failure to replace an alarm at life expiry or battery expiry.

v. Working on the previous 20-year history of 30 CO boat fatalities, it could be estimated that the next 20 years should see a reduction down to only one boat CO fatality every ten years. This estimate is entirely dependent upon the continued success with influencing boater behaviour.

7. Recommendations

a. To introduce mandatory BSS requirements for CO alarms on all classes of boat with accommodation spaces.

b. To continue to support initiatives aimed at influencing behaviour, in partnership. To prioritise CO safety awareness efforts targeted towards those boaters considered to be at heighted risk, i.e. 'hard to reach' vulnerable live-aboard boaters and those that are boaters new to boating who may or may not fall into the vulnerable category but who may not have a full understanding of the risks.

c. To promote through BSI committee GME/33, for CO alarms to feature within a clause of a relevant Recreational Craft Directive (RCD) harmonised standard.

d. To encourage further studies and research into inherent levels of CO encountered in the boating environment including:

i) continuing the BRE research already undertaken for BSS this time on a range of boats that are less well maintained than the ones tested;

ii) the 'station wagon' effect affecting boats with engines running whilst moored and underway;

iii) further assessing hazards associated with petrol generator exhaust emissions;

iv) impact on chimney emission characteristics of using poor quality fuels on solid fuel stoves;

v) test the exhaust emissions of diesel heaters;

vi) assessing any correlation between a boat's fixed ventilation provision and the dispersion characteristics of CO within the boat;

vii) the level of risk to occupants of boats without accommodation spaces.

8. Outline implementation plan

a. *Policy development* through the BSS Risk Management Process – February – July 2018;

i. Identification of pressures for change and collection of available evidence

ii. BSS Technical Committee consideration

iii. BSS Technical Committee recommendation

iv. BSS Advisory Committee assessment and onward recommendation

v. BSS Management Committee assessment and ratification

b. *Public consultation* – August - November 2018

i. Public consultation takes place from Friday 17 August to Friday 9 November 2018, providing a 12-week consultation period.

ii. All comments reviewed and table, of views expressed and responses to them, published by Friday 21 December 2018. This will be published on our website www.boatsafetyscheme.org

c. *Final version* of BSS requirements agreed at BSSMC – mid-December – Subject to the outcome of the consultation.

d. *BSS requirements implementation* – January – April 2019

i. A communications campaign will promote the final agreed changes in very early 2019 and include messages .

ii. The revised Boat Safety Scheme requirements are intended to come into effect from January 2019 and implemented as BSS checks on 1 April 2019 by which time, BSS examiners will have completed familiarisation training exercises.

e. *Monitoring* – Continuous monitoring, with reports reviewed quarterly and annually at the BSS support committees

f. *Review* – as decided by BSSMC or as recognised as necessary by BSSTC, or January 2024, whichever is the sooner.

Compiled by Graham Watts, BSS Manager/Secretariat

25 June 2018 [**Updated 12 August 2018**]