ISO 10239 v ER 5.5

Proposal to introduce a commissioning process for new gas systems on small craft

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Abstract

The Essential Requirements of the Recreational Craft Regulations 2017 require gas systems on small craft to be correctly installed, and many installers and boatbuilders use ISO 10239 to achieve this; in the EU, the Recreational Craft Directive supports this as a harmonised standard.

Essential Requirement 5.5 requires a domestic gas system to be tested after installation. Manufacturers may use the air tightness test in ISO 10239 as a means to achieve this, and declare compliance with the RCR as a result; most declarations of conformity list ISO 10239 as the standard used.

This short paper argues that air tightness testing is not an adequate test of a gas system, and that key elements vital to safe system operation can be overlooked. These omissions leave installers and boatbuilders exposed to litigation, while consumers receive a vessel without the guarantee of safety they are entitled to. Building to ISO 10239 does not necessarily mean a system has been adequately tested.

As a solution, recommendations are made to introduce mandatory commissioning to new boats sold in the UK, with a proposal to introduce a ‘combined standard commissioning test’. ISO 10239:2017 is currently undergoing international review, presenting an ideal opportunity to incorporate commissioning and improve boater safety.

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Acronyms

BSS	Boat Safety Scheme
ER	Essential Requirements, pertaining to the RCD or RCR
GSIUR	Gas Safety (Installation and Use) Regulations 1998
IS	In-scope of GSIUR, such as a hire or liveaboard vessel
OS	Out-of-scope of GSIUR, such as a private leisure vessel
RCD	Recreational Craft Directive, 2013/53/EU
RCR	Recreational Craft Regulations 2017

Glossary

Pipeline	Includes; piping (rigid metallic pipe); hoses (flexible gas carrying non-metallic tube); joints and all other gas carrying components such as isolator valves.

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Definitions used

For this paper it is essential to establish working definitions.

Test

The Oxford English Dictionary gives the following definitions of the word ‘test’:

- critical examination of a thing’s qualities

The Chambers Dictionary (2003) offers a more expansive definition, among the variants:

- Any critical trial; a standard for trial, judgement or comparison; to put to proof.

It is arguable that in testing a gas system, these definitions combined provide a clear aim. The test of a gas installation must be a critical appraisal, repeatable, and prove the installation safe.

Permanently installed gas system

A permanently installed gas system definition can be found in the terms and definitions of ISO 10239:2017 at 3.3 and 3.6, directly quoted as follows:

- Permanently installed: securely fastened so that tools need to be used for removal [SOURCE ISO 10088:2013 definition 3.3]

- LPG system: system consisting of an arrangement of cylinder(s), safety device(s), pressure regulation device(s), connection(s), valve(s), piping, tubing, hose, fitting(s) and devices intended to store, supply, monitor or control the flow of LPG up to and including the appliance

  Note 1 to entry: The cylinders are replaceable items and might or might not be supplied with the LPG system in the craft.

Introduction

Domestic gas systems on new boats subject to either EU Directive 2013/53/EU (known simply as the Recreational Craft Directive (RCD)), or the Recreational Craft Regulations 2017 (RCR) must comply with Essential Requirement (ER) 5.5; as shown below in Figure 1:

Gas system

Gas systems for domestic use shall be of the vapour-withdrawal type and shall be designed and installed so as to avoid leaks and the risk of explosion and be capable of being tested for leaks. Materials and components shall be suitable for the specific gas used to withstand the stresses and exposures found in the marine environment.

Each gas appliance intended by the manufacturer for the application for which it is used shall be so installed in accordance with the manufacturer's instructions. Each gas-consuming appliance must be supplied by a separate branch of the distribution system, and each appliance must be controlled by a separate closing device. Adequate ventilation must be provided to prevent hazards from leaks and products of combustion.

All watercraft with a permanently installed gas system shall be fitted with an enclosure to contain all gas cylinders. The enclosure shall be separated from the living quarters, accessible only from the outside and ventilated to the outside so that any escaping gas drains overboard.

In particular, any permanently installed gas system shall be tested after installation.

Figure 1 - Extract from Schedule 1, 5.5, RCR 2017

The highlighted text is clear:

> "any permanently installed gas system shall be tested after installation".

Boatbuilders typically use ISO 10239 to achieve compliance, itself harmonised to the RCD since 2014; the RCR may in time take the same stance. This short paper argues that using the test process identified in ISO 10239 does not satisfy the requirements of the RCR, and that to protect consumers an alternative process is required.

1 Comparing air and gas tightness testing

1.1 Air test process in ISO 10239

ISO 10239:2017 mandates an air tightness test, to establish the soundness of the gas system following installation; essentially intended to prove the system free of leaks. The air test is completed at three times the system operating pressure, and the system must be seen to be air-tight to pass. An installer typically connects a manometer and hand bellows to the piping and charges the system with the required amount of air. This is then monitored for an initial 5 minutes for stabilisation, and then for a further 5 minutes there must be no discernible loss of pressure. Completing this process satisfies the requirements for tightness testing according to ISO 10239:2017.

There is a recommendation in the note at Section 10 that a full gas test should completed by a competent person before first use.

1.2 Gas test process

The process of charging a gas system with gas and purging of air as a means of testing an installation is well known and the following documents detail a gas test procedure for boats:

- PD 54823:2016
- BSS checking procedures via Appendix C and D

In both cases the system must be purged of air, charged with gas and tested with a manometer for a defined test period, in a similar way to that outlined above for air tightness testing.

The BSS procedure uses zero pressure loss as a successful test requirement, and recent research within the industry has shown this is generally the accepted method for gas installers, with 93% of registered gas engineers agreeing (Keeling, 2022).

1.3 Omissions in the air-tightness test procedure

If air tightness testing is the only physical test completed, it means eight out of nine key elements of the system are not necessarily assessed, as highlighted in Figure 2:

Without gas in the system, eight key elements in red are omitted:

Testing

A. Air-tightness of the low pressure system

B. Gas-tightness of high pressure components upstream of the regulator

C. Gas-tightness of the low pressure system

D. Regulator lock up, working and standing pressures

E. Appliance operating pressures

Commissioning

F. Appliance burner operation

G. Appliance safety device operation

H. Appliance flue operation

I. Appliance control operation

Figure 2 - The eight key elements of gas system testing

Elements B-E can only be completed with gas in the system and a manometer connected, and can only be completed by a competent person which an installer or boatbuilder may or may not be.

Elements F-I can be completed without a manometer connected. Consumers expect a completed boat comes with appliances operating, and the gas system able to be charged with gas, and presume these items are tested before receipt. Any assessor of F-I is also required to be competent.

The problem with not completing elements B-E is, that without doing so, the installation has not been fully nor adequately tested. If B-E are not completed, F-I cannot be safely undertaken. It follows that on boats in-scope (IS) of the Gas Safety Installation and Use

Regulations 1998 (GSIUR) this also means that elements E-I cannot be then legally completed.

The air test process in ISO 10239:2017 confirms the low pressure pipeline is air-tight. It is a good indication, but not a guarantee, that the pipeline will also gas-tight, and it is not testing the system because items B-E are omitted.

2 Key elements of gas testing

The eight key elements of gas testing (B-I) listed in Figure 2 are discussed below.

2.1 B - High-pressure component gas tightness

High pressure components are found upstream of the regulator, and need to be assessed separately to a tightness test of the pipework for various practical reasons. When a system is charged with gas, the high pressure components are brushed or sprayed with leak detection fluid, which bubbles where leaks are present.

An air-tightness test will not charge the high-pressure components with air meaning the components cannot be verified until the system is charged with gas. ISO 10239:2017 makes an error at section 10 where it directs that any high-pressure components should be tested with leak detector fluid; during air tightness testing air will not have passed upstream of the regulator to have pressurised the components (there may be other components that prevent this too, such as changeovers / automatic pressure shut-offs / solenoid valves etc). There is no instruction to charge the system with gas; these important components can go untested.

2.2 C - Gas tightness test of the low-pressure system

In discussions with registered gas engineers in 2022, it was often said that it is important to prove the tightness of a system with gas because of the ‘searching’ nature of LPG. Engineers regularly say LPG will leak where other gases will not and it is a documented occurrence (Martyr and Rogers, 2021), despite there being no empirical evidence available at the time of writing to prove this so. On a molecular level, scientists point out that the dimensions of air molecules (O_2;N_2) are smaller than Propane (C_3H_8) and are differently shaped (Brookes, A. 2023). It’s possible air may not interact with jointing, seals and hoses in the same way as LPG, the difference being on a molecular level, perhaps due to shape. An air test alone, it seems, may not always guarantee gas tightness, but with smaller molecules, at 3 times the pressure the gas will be at it’s a solid preparatory proving test.

Once proved with air, it makes good engineering sense to test a system with gas, particularly when it's a volatile and explosive one, however, establishing pipeline air and gas tightness is only part of the process of what can be considered the test of a gas system.

2.3 D - Regulator, working and operating pressures

Air testing cannot assess regulator function, arguably the most significant safety device associated with the gas installation.

Until the installation has been charged with gas, and tested with a manometer by a competent person, the operating status of the regulator is not known. The parameters of regulator operation are important to know, because it ensures that safe, correct gas pressure is available in the system. The performance of any new regulator must be confirmed as satisfactory as a quality control before passing the system to a consumer. It is important lock up, standing and operating pressures are confirmed to meet the regulator design parameters declared by manufacturers.

2.4 E - Appliance operating pressures

Until the installation has been charged with gas, and tested with a manometer by a competent person, the operating pressures of appliances are not known. It is essential to verify appliance operating pressures meet manufacturer's requirements as stated in the appliance manual or data plate. Correct operating pressure at a gas appliance is a well-documented necessity for safe operation (Brown et al., 2004; Aymes, 2021; IGEM, 2021). Significantly, correct gas pressure is required for complete combustion. If incomplete combustion occurs, then CO and other unwelcome products of combustion such as formaldehydes are created and released (Brown et al., 2004).

It is worth noting ISO 10239:2017 states appliances should be installed to manufacturer's instructions, and manufacturer's often include commissioning processes. However the prescribed air-tightness only test, and lack of gas testing in ISO 10239:2017, might lead boatbuilders to consider the system is adequately tested at air-tightness stage.

Furthermore an installer might not be aware that an installation process goes beyond the dimensions page in the handbook.

To ensure user safety the below key gas pressures should be obtained at the time of a test:

NB: the below definitions are taken from the author's initial gas training and some might use variances.

- Lock up pressure: the maximum pressure the regulator gets to when charged with gas at cylinder pressure, to verify the regulator is working within its service requirements.

- Working pressure: the pressure at the appliance with one burner lit, to establish that the regulator lowers pressure from lock up, and that the nominal system pressure is established e.g. 37mbar for Propane.

- Standing or static pressure: the pressure with the system returned to static condition, with no burners lit, to ensure the regulator holds constant pressure against the cylinder, and to verify the regulator is working within its service requirements.

- Operating pressure: the pressure at the appliance with all appliance burners operating. This is two-fold: 1) to ascertain the system pressure drop is not less than 2mbar from the working pressure figure (as system design requirements in ISO 10239:2017), and to ascertain an appliance is operating at the manufacturer's required pressure.

Any air-test only procedure precludes these being completed.

2.5 F to I - Commissioning factors assessed with gas testing

In addition to ascertaining the key gas pressures detailed above, other important checks can be completed during gas testing:

- Burner flames pictures can be visually assessed to ensure the appliance delivers clean blue even flames, and that burner assemblies are fitted correctly.

- Safety devices within the appliance, such as flame supervision devices can be verified as operational.

- Flue testing can be completed as necessary, with a Flue Gas Analyser or smoke test dependent on flue type.

- User controls can be confirmed as working correctly, and in the case of cookers low flames can be adjusted to right level.

Following satisfactory completion of these factors, the system has been subjected to a full test and proven safe.

3 Other test considerations

3.1 Bubble leak detectors

Bubble leak detectors are a device fitted in the low-pressure pipeline that allow users to periodically test for gas tightness with a simple push-button device.

The most common bubble leak detector is the ‘Alde’ branded one. The BSS permits use of the device as a means of meeting examination compliance at the gas tightness check 7.12.2. Bubble leak detectors are of limited use as a test device as they only assess gas-tightness, giving no assurance of regulator or appliance performance or condition. However, they give a fair indication that a system (when correctly configured and the bubble tester is functioning correctly) is gas-tight.

The Navigation Authorities, through the BSS, for the extent of their risk and liability, are content to accept a gas tightness test with either a bubble tester or a manometer. In this regard the procedure with a manometer and bubble tester have parity for BSS purposes; both processes test for system gas tightness. However, a test completed with a bubble tester omits any check of regulator operation (key elements D-E), something Navigation Authority risk assessments presumably consider acceptable.

Gas Safe Registered engineers will not use a bubble leak detector when completing landlord’s certification, as they are required to ensure the safe operating conditions of appliances. In this regard a bubble leak detector is not a device suitable for professional testing of a gas installation.

The bubble tester therefore has limitations when considering the test of a system after installation. There is no way of testing regulator or appliance pressures, key elements D-E above. Any low-pressure piping upstream of the device is not incorporated into the tightness test, making it a less thorough examination. A bubble leak detector test cannot be considered suitable as a way of testing a system after installation, due to its inherent limitations meaning that important elements of a full test cannot be completed.

3.2 Combined air tightness testing and bubble leak detector

If an air test is completed in line with ISO 10239:2017, followed by a gas test with a bubble leak detector, there has at least been a more determined effort to establish gas tightness). The factors listed that have been assessed increase but key elements C-D (regulator and operating pressure of appliances) are still not assessed. This combination test is still omitting key elements of testing requirements, and is therefore not fulfilling the need of testing a system after installation.

3.3 When an air tightness test is effective

There are useful purposes to an air tightness test. It enables installers to verify that there are no significant leaks in the pipeline, prior to charging with LPG and therefore it prevents uncontrolled release of gas into an accommodation space; particularly important in the confined space of a small craft where LPG can accumulate in bilges.

The air tightness test may also be useful where a part-completed system is installed, for example where appliances might be installed at a later date and the system completed by others. The installer can use an air test to verify their installation to the point of completion meets ISO 10239. The onus for the safe completion of the system then depends on the person who completes the system, and rightly the unfinished system should be capped off and the vessel supplied without LPG at that point. This procedure also ensures the manufacturer meets their legal obligations in GSIUR if the vessel is in-scope of that legislation.

4 Understanding GSIUR legal requirements

4.1 When new boats are in-scope of GSIUR

A further complication of an air-test only is that it in no way meets the requirements for testing of boats subject to GSIUR. Boats in the UK are generally described as being 'in-scope' (IS) or 'out of scope' (OS) of GSIUR. IS boats are generally hire or liveaboard boats. OS are private leisure vessels.

GSIUR requires boatbuilders to establish the intended use of the vessel as shown in the highlighted text in Figure 3 below:

> 97 Regulation 3(8) requires manufacturers of caravans, holiday homes or inland waterway boats for use in situations where GSIUR will apply to ensure employees who install gas fittings (or who do subsequent maintenance or repair work) are competent, and to take reasonable steps to secure the safety of these gas fittings once their products are taken/retaken into use. Manufacturers should take reasonable steps, eg by arrangements with their supply outlets and dealers, to establish, as best they can, the intended use of their products and whether the requirements in regulation 3(8) will therefore apply.

Figure 3 - Extract from GSIUR, Reg 3(8)

GSIUR has very clear and direct requirements for a gas system to be fully tested with gas before passing to a consumer. Regulation 22(2) states:

> *The person finally connecting the supply to the installation is responsible for testing and purging the pipe system in accordance with regulation 22(2).*

And if appliances are installed but no gas is present, the requirement is also clear at Regulation 33(3):

> *no person shall subsequently permit gas to pass into the appliance unless he has caused such testing, examination and adjustment as is specified in paragraphs (1) and (2) above to be carried out;*

It is clear then that if the vessel is intended to be liveaboard or hire, the installer has a requirement that exceeds an air tightness test, because there must be a full gas test completed. GSIUR goes further of course, with various requirements mandated for safe appliance operation and testing following inspection, similar to the key elements B-I above.

It is also worth noting that where a system is amended, and the boat is IS of GSIUR, that the same obligations apply to the installer as detailed above.

4.2 Obligations for full gas testing of OS boats

Private leisure vessels are outside the scope of GSIUR, but if GSIUR has such detailed requirements intended to safeguard consumers, it seems disproportionate that users might at best get an air tightness test only. Notwithstanding any IS or OS legality, there is still a requirement for the finished product to be fit for purpose and safe, under various UK legislation such as the Consumer Rights Act 2015 (Which, 2022).

British Marine (2022), in their boatbuilding guide do make reference to PD 54823 and using gas registered engineers, but it is also made clear there is no legal obligation unless the vessel is liveaboard or hire. The advice is there though, but only if an installer is a member and has read the guide.

A scenario will also exist where a boat sold by an agent or intermediatory, away from the boatbuilder, may have been air tested but never charged with gas. The boatbuilder believes that relevant requirements have been met with an air test, and the agent receives a new boat that they believe ready to go. It could be that the first person charging the system with gas is the new owner, with the first gas test completed 4 years later at BSS examination time. Even then it could be with a bubble leak detector, so no commissioning aspect ever gets appraised.

Furthermore, the ‘out-of-scope’ new boat might be sold on in 6 months to a new owner, who lives aboard bringing the vessel in-scope of GSIUR, yet it has never been tested with gas or commissioned properly.

From an engineering standpoint, the IS / OS definition is a distraction and a competent engineer should install and test the system the same thorough way irrespective of the end use of the vessel. The problem is that installers of gas systems are not always competent.

5 Evidence for change

It would not be surprising for an argument to be made against change based on the fact ISO 10239 and the air test procedure has been extant since 2000. Some might say that irrespective of any air tightness test procedure, boatbuilders do carry out commissioning and are or are themselves registered gas engineers or use a qualified contractor.

However, unique research throughout 2022 by the author as part of a MSc[1] showed there are longstanding issues regarding gas installations on small craft. In brief, part of the work involved:

- 55 boat gas system owner interviews
- 30 registered boat gas engineer interviews
- 59 boat gas systems measured for design accuracy
- 55 boat gas systems tested for operational success

The relevant results showed:

- 54% of boats had a design error resulting in undersized piping being installed, with 69% of those being post-1998 built.
- That a contributing factor to the design errors is the existence of erroneous data in standards and training materials, with errors present in at least one of the three commonly used sources dating back to 2005.
- 83% of registered gas engineers believed new boat gas systems are not adequately installed, with only 3% declaring they attend new boats to complete testing, indicating a lack of uptake of professional services.
- 74% of boaters do not complete appliance servicing, with 54% never having commissioned or undertaken any form of gas service or repair work whatsoever, showing that once the system is in service it is more often than not ignored.

[1] MSc undertaken via MLA College / Plymouth University, with a research project focussing on gas safety on inland waterways vessels. The project included unique research using data from 89,000 BSS examinations, interviews of consumers and gas engineers, and testing of gas systems. MSc degree awarded February 2023.

There is a need to ensure responsibility for safe system operation that is being overlooked at the installation stage; if the system was required to be fully tested and commissioned, the design can be tested prior to consumer interaction. Even if they fail to complete routine maintenance down the line, the system was at least configured correctly from the start.

There is also a need to consider demographic change in the UK. The proportion of liveaboard boaters has risen from 15% in 2011 to 27% in 2020 (CRT, 2021a), and the reality is it is probably much higher than that. The inland waterways liveaboard population is now a reasonably sized town. There are an estimated 5000 liveaboards in London alone (CRT, 2021b).

An air tightness test with no commissioning is simply not adequate for a gas system. The fact that it might be in a multi-appliance installation, with complex supply requirements in a high-intensity domicile environment only adds to the significance.

6 Proposal

6.1 Outline proposal

It’s clear that in some circumstances an air tightness test has useful purpose as a pipeline test, or as a preliminary proving test prior to charging with gas, but not as a test of a gas system after installation.

It is also clear that incorporating a full gas test and a commissioning process into ISO 10239 would be advantageous in the UK, with other countries also able to benefit; for some it may be the first formal commissioning process introduced.

There is a full gas test process available in PD 54823:2016, but there is no reference to this in ISO 10239:2017, and unless an installer is particularly diligent they may not know to look, nor can it be assumed that they have access. They may think they don’t need to look, because they believe ISO 10239:2017 has adequately despatched their liability. Gas engineers know about PD 54823, but installers of gas systems on new boats are not always gas engineers.

However it is achieved, there are undeniable benefits to introducing a mandatory commissioning process that ensures an installer tests a gas system as the RCR requires, meets the test requirements of ISO 10239:2017 as required, and ensures the system is safe for the consumer. The only way to do that is with full gas testing and a record of it.

A further benefit of a commissioning process would be where a system is amended once in-service, and ISO 10239 is used to complete the amendment; full testing following changes is essential to user safety.

6.2 Suggested format

The following could be a mechanism of ensuring full gas testing is achieved:

- A full gas test and commissioning process for completed gas systems could be added to ISO 10239, following on from the initial air tightness test. The procedure could be adopted from other existing sources such as PD 54823:2016.

- The text of ISO 10239 could be amended to state a gas test is ‘necessary’ as opposed to ‘recommended’; it is hard to see how this has a negative impact.

In the definitions section on p5 of this paper, the test of a gas installation was defined as being a critical appraisal, repeatable, to prove the installation safe. However there is presently no harmonised form or place to state or record what level of test has been completed to a gas installation. In this respect a simple single page appendix could be created and inserted into the UK release of ISO 10239 or made available otherwise. This should be a free issue sheet that installers can freely access.

6.3 Commissioning form mock-up

Combined Standard Commissioning Test Record for Small Craft LPG Systems

VESSEL NAME _____ VESSEL ID NUMBER _____

SECTION 1 – AIR TEST FOR NEW INSTALLATIONS

Date Tester

A For new installations, complete installation air-test according to ISO 10239:2017, record the results below and proceed to step B.

For existing in-use gas systems skip this step and proceed to step C.

Air tightness test: 1)_____ 2)_____ 3)_____

B If the installation is being left for others to complete and not being charged with gas, nor is a gas cylinder being supplied, the system must be capped off to prevent use before full testing has been completed. Fix label Z in gas enclosure and sign below.

CSCT terminated at this point and system capped off: Signed _____

SECTION 2 – GAS TEST FOR INSTALLATIONS

Date Tester

C Complete gas tightness testing in line with PD 54823:2016, and record the following information:

Lock up pressure: _____mbar

Let-by test: 1)_____ 2)_____ 3)_____

Gas tightness test: 1)_____ 2)_____ 3)_____

D Complete working pressure tests, and record results:

System standing or static pressure _____ mbar

Record working pressure:

Appliance 1 name _____ operating pressure 1 burner _____ mbar

Appliance 2 name _____ operating pressure 1 burner _____ mbar

Appliance 3 name _____ operating pressure 1 burner _____ mbar

E Complete full operating pressure test: all burners lit _____ mbar

CSCT completed signature _____

Figure 4 - Commissioning form mock-up

7 Conclusions

This paper has shown that there are clear arguments that agree:

1. The existing air tightness test process in ISO 10239:2017 is not an adequate test of a gas installation, but does have some merit as an initial pipework proving tool.

2. The existing air tightness test process in ISO 10239:2017 omits eight key elements of testing a gas system. On this basis it seems impossible to consider that the gas system has been tested at all if no test is completed with the system charged with gas.

3. If the aim of RCR ER 5.5 is to ensure a gas system is tested after installation, the existing air tightness test process in ISO 10239:2017 is not adequate to ensure compliance as it is not a full test.

4. The limitations of the existing air tightness test process in ISO 10239 means ER 5.5 of the RCD is not being met as the system is not being tested after installation, despite the harmonised status.

5. As the existing test process is not adequate, a revised, alternative or complementary process is required to satisfy the requirements of the RCR, and GSIUR where applicable, to safeguard consumers and protect installers.

6. Irrespective of the IS / OS status, the consumer has a right to expect a fully tested, correctly installed gas system.

The ongoing current review of ISO 10239 provides a timely juncture to get a thorough process in place, and there are seemingly no reasonable arguments against.

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