

A guide to the pressure testing of in-service pressurised equipment

PUBLICATION 168

Edition 2

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THE ENGINEERING EQUIPMENT AND MATERIALS USERS' ASSOCIATION

A guide to the pressure testing of in-service pressurised equipment

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ISBN 978 0 85931 181 6

Imprint reference 07-2010

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ENGINEERING EQUIPMENT AND MATERIALS USERS' ASSOCIATION

The Engineering Equipment and Materials Users' Association, more commonly known as EEMUA, is a European non-profit membership Association helping companies that own or operate industrial facilities - the *users* of engineering equipment and materials.

EEMUA aims to improve the safety, environmental and operating performance of industrial facilities in the most cost-effective way, thereby demonstrating and pursuing leadership in asset management.

EEMUA Members pursue these aims through collaboration for mutual benefit, sharing engineering experiences and expertise and by promoting their distinct interests as the users of engineering products.

Specifically, the aims of EEMUA Member companies are achieved by:

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- influencing the way written regulations are interpreted and applied in practice;
- presenting and promoting Members' views, and encouraging the application of good, sound engineering practices;
- developing user guides, specifications, training and competency schemes;
- facilitating Members' participation in national and international standards making;
- influencing relevant national and European legislation and regulations.

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Comments are considered by the relevant EEMUA Technical Committees and may be incorporated in future editions of this Publication. New editions are publicised on the EEMUA website.

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Scope

EEMUA Publication 168 provides guidance on if, when and how pressure testing can be carried out on used pressure equipment and systems, based on a risk assessment and a safe system of work, before returning it to service. It gives a formal and clearly identifiable process which can be followed to manage and minimize the risks associated with in-service pressure testing. Some alternatives to pressure testing are also considered, and when it may be appropriate to employ them.

The Guide gives practical advice on the testing and inspection which may be carried out once the service life of pressure equipment has begun, but excluding the initial installation and commissioning. It is applicable to all types of non-transportable industrial pressure equipment and systems, including pressure vessels and pipework.

This Publication is aimed primarily at employees, managers and supervisors of pressure testing teams of both plant operators and owners. Engineers in other disciplines or with other responsibilities may also find the information useful.

Exclusions from Scope

The following topics are either excluded from the scope of this Publication or not dealt with in any great detail:

- *Initial installation and commissioning* of unused equipment is excluded.
- *The pressure testing of atmospheric storage tanks* is considered a special case, and therefore not included in the scope. The subject is dealt with in EEMUA Publication 159⁽¹⁾.
- *Equipment that is subjected to heat* for long periods, and/or that has been designed originally to operate in the 'creep' region is not normally pressure tested. For such equipment, alternative non-destructive testing (NDT) and inspection techniques are available. This Publication introduces the subject of testing and inspecting pressure equipment designed to operate in the 'creep' region before it is returned to service. However, it does not – at least in the current Edition – go into any great detail.
- *Proof testing* is excluded. This is a special kind of pressure test used to establish the maximum allowable working pressure of a system where this has not been calculated.
- *Test waivers*. Occasionally, it might be justifiable for equipment which would normally be pressure tested before returning to service – to have the pressure test waived. The pressure test waiver is considered a special case, and excluded from the scope. For guidance on the pressure test waiver, readers are referred to EEMUA Publication 223⁽²⁾.
- *Subsea equipment*: special circumstances may apply to subsea installations.

Purpose of this Publication

Pressure equipment and systems, including pipework, are ubiquitous throughout industry. Europe's pressure equipment market alone has an annual turnover of many tens of billions of Euros. Once new pressure equipment is placed on the market, it will often remain in service for decades. During its long service life, the equipment may be subjected to many repairs, modifications and re-rating – requiring significant inspection and testing.

Pressure equipment in service presents hazards from stored energy, escape of harmful fluids, or both, and may result in significant loss of plant and harm to people – as, regrettably, some high profile accidents have shown.

If such disasters are to be avoided in the future, then every opportunity should be taken to learn from others. This Publication aims to contribute to the learning by capturing the combined knowledge and expertise of pressure equipment users across a range of industrial segments.

Revision from the First Edition

The First Edition of this Publication was produced in 1991. Since then there has been a significant rise in the understanding of the technology surrounding pressure testing. The variety and reliability of non-destructive testing techniques has increased and the application of fracture mechanics has provided a more quantitative approach. This new Second Edition reflects these developments.

The Standards for pressure vessels – at least, those where 'proof stress' is of primary concern – have also changed since the First Edition was published. BSI's PD 5500⁽³⁾ (formerly BS 5500) is a Standard for unfired pressure vessels. It is still used for the design of some new vessels and was used for many older vessels. EN 13445⁽⁴⁻⁷⁾, the European standard for unfired pressure vessels, is now in place. In-service equipment might therefore be found which was designed to any of these standards. In this Second Edition both the BSI and the EN standards are referenced, as well as the US (ASME) design code⁽⁸⁾.

Consequently, for this new Second Edition, the original Chapters 1, 5, 6 and 7 have been substantially re-written. Indeed, Chapter 1 has been changed so much it is essentially a new chapter. By contrast, Chapters 2, 3, 4, and 8 have been updated, but remain largely unchanged from the First Edition. Appendices I and II are entirely new, as are Figure 1 and Table 1.

Acknowledgement

The work of B. J. Darlaston in helping the EEMUA Committee/authors to draft the Second Edition of this Publication is acknowledged.

Definitions

**Creep designed
pressure equipment**

Equipment designed to operate at elevated temperatures where creep and rupture are a design consideration.

**Proof stress designed
pressure equipment**

Equipment designed to operate at temperatures where proof stress is a design consideration.

1. Introduction

In some countries it is a statutory obligation to carry out a pressure test on certain equipment at prescribed intervals. The requirements vary across the European Union (EU) Member States as well as elsewhere. In the United Kingdom, for example, there is no statutory requirement to conduct pressure tests at prescribed intervals. As a result of the different requirements and historical traditions from country to country, the practices applied by EEMUA Member companies vary considerably.

It should also be recognised that pressure testing of pressure equipment operating for long periods at elevated temperatures and/or designed to operate in the 'creep' region, is not usually appropriate, and alternative strategies may be employed.

This Publication does not seek to impose policy, but rather to set out the various factors and aspects to consider when determining if, when and how a pressure test should be carried out. A process flow diagram – to assist with decision making about testing and inspection before returning pressure equipment and systems to service – is suggested in Figure 1 on page 4.

When undertaking a pressure test on used equipment, there are a number of issues that must be addressed in order to ensure the safety of personnel and the continuing integrity of the equipment. A pressure test involves using an incompressible fluid (usually water, when it can variably be called a hydraulic test, hydrostatic test or hydrotest) or a compressible fluid (air, steam, etc., when it is called a pneumatic test), under high pressure. In either case there is the potential for the sudden release of high levels of stored energy with the risk to both safety of personnel and plant damage. It is important that those considering undertaking a pressure test should carry out a suitable hazard assessment and conduct safe, effective testing.

When new and before being placed into service, pressure equipment (in particular fabricated vessels and pipework) would have been assured through a combination of good design and selection of appropriate materials, quality fabrication, inspection and testing. For equipment or systems designed on a proof stress basis it is standard practice to test newly fabricated vessels and pipework to a pressure higher than that at which it will be used. This acceptance test is generally an integral part of the design code used, and is intended to give assurance that the equipment has been designed, fabricated and constructed to the required standards.

The inspection and testing elements continue in-service after repair, maintenance, re-rating, re-qualification or for statutory reasons. The extent to which the various elements are implemented relates to the risk associated with the equipment.

The pressure test is no longer used solely as an acceptance test but may also be considered as part of the fabrication process. It can provide certain advantages in that it can help to redistribute the stress in regions of high stress concentration (Levasseur, 2007⁽⁹⁾) and also can blunt crack-like defects thus increasing the fatigue life (Baylac, 2002⁽¹⁰⁾).

In some circumstances in-service pressure testing often plays an important role in the demonstration of the continuing integrity of the equipment.

The in-service pressure test is required in several countries for the periodic re-qualification of pressure vessels. This can have a negative economic impact as a production unit needs to be taken out of service for a period of time to undertake the test.

A pressure test should generally not be considered as a substitute for the appropriate inspection or non destructive examination. There are cases where the pressure test is justified, for example following significant repairs. However there are also cases where the pressure test is impractical, impossible or would subject the plant to excessive risks.

The use of the pressure test has been abandoned in many countries and replaced by alternative methods that give an equivalent or better safety level. This has been due to progress in: non-destructive testing methods; knowledge of metallurgy; risk-based inspection and fitness for service analysis. A summary comparison of the advantages and disadvantages of various inspection techniques is provided in Appendix I, Table 1.

The potential hazard posed by a pressure test is a combination of the stored energy and any ignorance of the suitability or compatibility of the equipment to contain the pressure. It is important that consideration should be given to the need for a risk assessment to be carried out before performing a pressure test. It is recommended in the UK that the HSE Guidance Note *Safety in Pressure Testing*⁽¹¹⁾ and associated HSE material⁽¹²⁾ should be studied by those concerned with decisions about pressure testing, whether hydraulic or pneumatic.