

Risk management of legacy systems with potential for excess overpressure

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Preface

All relief systems should be designed, maintained and managed in accordance with relevant good practice (RGP), i.e. to keep equipment within code allowable overpressure limits.

However, the EEMUA PRS Technical Committee were made aware of instances where, during the course of regulatory inspections, concerns related to the adequacy of overpressure protection and the management of the identified risk were identified. Specifically, cases were cited where the overpressure protection was undersized / inadequate and where a risk management approach for managing the identified concern had been adopted which did not demonstrate relevant good practice (RGP), or recognise the need for code compliance and did not demonstrate an adequate ALARP ("As Low As Reasonably Practicable") position. Consequently, it was considered that there is a need for improved industry guidance in this area of "Management of Legacy Systems".

This publication (EEMUA 236) is borne out of the identified need for a guidance framework for the management of practical realities on legacy systems, recognising that code compliance through the application of relevant good practice – where lacking – is not something that can always be addressed straight away. It provides a platform for the development of a risk-based approach that can be used to aid prioritisation of effort towards code compliance (as a basis of ALARP) and help focus action where it will reduce / eliminate risk fastest (and most effectively). The absence of such guidance (or equivalent internal company procedures and expertise) increases the risk of a major accident and / or the potential for a legal non-compliance which may result in regulatory enforcement action.

ALARP (As Low as Reasonably Practicable) is an important concept and requirement for compliance with UK health and safety law. The guiding principles of ALARP are covered in detail on the Health & Safety Executive website. The HSE ALARP expectations on duty holders are explained by the HSE website references provided in the Reference section of this document and it is recommended that the reader refer to these. Demonstrating ALARP for risk reduction is "about weighing the risk against the sacrifice needed to further reduce it. To avoid having to make this sacrifice, the duty-holder must be able to show that it would be grossly disproportionate to the benefits of risk reduction that would be achieved. Thus, the process is not one of balancing the costs and benefits of measures but, rather, of adopting measures except where they are ruled out because they involve grossly disproportionate sacrifices".

During the development of this guidance described by this document, some important aspects of ALARP were emphasised by the regulator. These are also described by the references stated above however, the following important points should be noted:

- i) There is a clear expectation that the application of Relevant Good Practice (RGP) should be considered as a minimum requirement for ALARP demonstration.
- ii) In certain circumstances – depending on the nature of the hazard and risk – ALARP demonstration may require more than the application of RGP.

- iii) Over time there is an underpinning regulatory expectation of the advancement of the application of RGP rather than acceptance of current, or legacy, status quo.

In the context of this document, it is a clear regulatory expectation that “equipment with potential for overpressure beyond code allowable limits” will need to be made code compliant and demonstrate RGP.

Acknowledgements

This Publication is the product of a working group of the EEMUA Pressure Relieving Systems (PRS) technical committee, focused on a recurring issue that was highlighted to EEMUA by the relevant UK regulatory authority. During the development of this publication, initial consultation was made with individuals from the UK Health and Safety Executive (HSE) who at the outset of this work, highlighted some cases of poor overpressure management for situations where there was potential for excess accumulation above code allowable limits in legacy systems. This work would not have been possible without the co-operation of the participants, their companies and stakeholders. Their help with, and enthusiasm for, the project is gratefully acknowledged.

Contents

Preface	IV
Acknowledgements	V
1. Introduction	1
2. Glossary of terms	2
3. Legacy systems	4
3.1 How do systems become legacy systems?	4
4. Impact of exceeding code allowable overpressures	6
4.1 Background relating to likelihood of failure	6
4.2 Vessel degradation	7
4.3 Significance of the hydrostatic test (P_T)	8
4.4 Pressures above hydrostatic test pressure	8
4.5 Data requirements for the assessment	9
4.6 Calculation of maximum pressure expected during overpressure scenario (P_{max})	9
4.7 Likelihood of the overpressure scenario	10
5. Qualitative prioritisation method	11
5.1 Hazardous event likelihood prioritisation method	11
5.2 Hazardous event consequence	13
5.3 Qualitative prioritisation outcome	14
5.4 Vessel specific assessment	14
5.5 Risk associated with making site modifications	15
6. Risk management of overpressure beyond code allowable limits – workflow	16
7. Examples using the workflow	19
7.1 EXEMPLAR CASE 1 – Distillation column	19
7.2 EXEMPLAR CASE 2 – Shell and tube heat exchanger	20
7.3 EXEMPLAR CASE 3 – Produced water skimmer vessel	22
References and Bibliography	24
Appendix 1 – Dealing with degradation	25

List of Figures

Figure 1: Exemplar Case 1 – Distillation column 19

Figure 2: Exemplar Case 2 – Shell and tube heat exchanger 21

Figure 3: Exemplar Case 3 – Produced water skimmer vessel 22

List of Tables

Table 1: Definitions of qualitative classifications 11

Table 2: Scenario overpressure vs Likelihood of Failure 12

Table 3: Hazardous event likelihood 13

Table 4: Action required 14

1. Introduction

Throughout the life of a plant, additional process safety hazards or concerns can be identified or uncovered. This might for example be as part of a periodic formal process safety review; it could be related to changes in equipment use or operating mode or as a result of deterioration and damage due to ageing. It might also be due to changes in industry practice resulting from lessons learned or step changes in technology.

In some cases, these additional process safety hazards may result in situations where there is the potential to exceed the code allowable overpressure for the equipment concerned. It is important to understand the impact of any identified hazard on the installed equipment and whether new operational risks are introduced, including risks to personnel, the surrounding environment and licence to operate.

This document aims to give a basis for understanding the risk associated with exceeding code allowable overpressures and ultimately in assisting and providing an equipment operator with a basis for decision making and prioritisation in order to manage and maintain safe operations and move towards a code compliant position.

It is recognised that performing physical plant modifications to ageing plant is not always without risk and that often it also involves significant cost and disruption. It may be the case therefore that other solutions are identified (permanent or temporary) to manage towards code compliance without necessarily committing to major physical changes. Such alternative solutions may include: equipment de-rating, capacity downgrading, changing operating conditions or the addition of instrumented protection systems (such as HIPS).

The approaches outlined in this publication are applicable to legacy systems. Legacy systems are described in more detail later in this document and there is also a separate EEMUA publication on this topic (to be issued as EEMUA 216^[6]). The expectation for any new facility or equipment item is that it shall be designed from the outset to be fully code compliant, using relevant good practice and that all overpressure scenarios and associated hazards are documented and addressed (protected against) by design.

This guidance document has been developed by EEMUA Working Group 94, under the authority of the EEMUA Pressure Relieving Safety Systems (PRS) Committee.

2. Glossary of terms

As Low as Reasonably Practicable (ALARP).

This involves weighing a risk against the trouble, time, resources and money needed to control it. Recommended further reading references on ALARP are provided in the References section of this document; it is also discussed in the Preface.

COMAH

Control of Major Accident Hazard Regulations.

Corrosion Allowance (CA)

The amount of wall thickness added to the pipe or component to allow for corrosion / erosion / wear (Ref: API RP 17G)

The extra wall thickness added during design to compensate for any anticipated reduction in thickness during the operation. (Ref: Offshore Standard DNV-OS-C101 & ASME BPVC standards)

Critical Crack Size (CCS)

The length, at a given stress / pressure level, at which a crack becomes unstable and crack propagation continues spontaneously leading to rapid failure. A critical crack at pressures above design pressure will be smaller than the critical crack defined at design pressure. Structures must be inspected periodically to ensure actual crack size is smaller than critical crack size, otherwise the structure is certain to fail.

Design Pressure (DP)

The design pressure is the maximum pressure the vessel can be exposed to, and is typically between 10 and 25 percent above the maximum operating pressure, and is equal to, or slightly lower than, the MAWP.

The design pressure of each component in a piping system shall not be less than the pressure at the most severe condition of coincident internal or external pressure and temperature (minimum or maximum) expected during service, except as provided in para. 302.2.4. (Ref: ASME B31.3).

The design pressure can also be the pressure at the top of each chamber of the pressure equipment chosen for the derivation of the calculation pressure of each component (Ref: BS EN 13445-3).

Fitness For Service (FFS)

A detailed assessment to show that, although a vessel may not meet all code requirements, it is suitable for continued operation in the service that it is operating.

Operating Pressure (OP)

The operating pressure is the pressure that a vessel is subjected to when in service.

HAZOP

Hazard and Operability study. Typically carried-out as a qualitative hazard assessment as distinct from PHA/LOPA described below.

Hydrostatic test pressure (P_t) and corrected hydrostatic test pressure

The pressure at the top of a vessel when subjected to a hydrostatic test. The pressure typically varies between 130-150% of design pressure depending on the applicable design standard. In some cases a higher hydrostatic test pressure may be specified for specific services.

In some cases, the hydrostatic test pressure requires correction to include the effects of differences between design temperature and the temperature during the hydrostatic test, and also for changes in corrosion allowance during service.

Prior to using the hydrostatic test pressure in any risk assessment, it is important to understand whether the pressure has been corrected for temperature and / or corrosion allowance, and make the appropriate adjustments.

Where other testing methods are used (e.g. pneumatic pressure test), this test pressure should be used in place of hydrostatic test pressure for any risk assessment.

HIPS

High Integrity Protection System – in reference to instrumented overpressure protection in lieu of a physical relieving device. These are typically high reliability SIL rated trip systems which isolate or remove the source of overpressure.

LOPC

Loss of Primary Containment.

LOPA

Layers of Protection Analysis.

MAWP

The Maximum Allowable Working Pressure (where stated) is the maximum pressure which the weakest point of the equipment, system or vessel can handle at a specific temperature when in normal operation. MAWP may be stamped on ASME VIII vessels, but it is not a term used in all design codes.

PHA

Process Hazard Analysis. Typically, a quantitative process risk analysis focussed on scenario identification and quantitative risk / layers of protection analysis for those scenarios.

RGP

Relevant Good Practice.

Note other similar, equivalent terms may sometimes be used e.g. RAGAGEP (Recommended and Generally Accepted Good Engineering Practice).

WSE

Written Scheme of Examination – completed by the 'Competent Person' with associated thorough examination reports. The WSE needs to be in place before a pressure system or equipment is launched for operation, ensuring that any mandatory examinations within the scheme are completed safely on time; this is a legal requirement in the UK under The Pressure Systems Safety Regulations 2000 (PSSR).

3. Legacy systems

There is an expectation that all systems adhere to relevant good practice, and overpressure protection systems are designed and maintained to ensure equipment remains within code allowable overpressure.

For the purposes of this document, legacy systems are defined as those systems where the available documentation or records fail to fully define the system being protected, the system design pressure(s), the materials being handled, the causes of over or under-pressure, the philosophy and design basis of overpressure protection (e.g. relief valve, bursting discs, high integrity instrumented systems) and the performance of the system in practice, etc.

Those systems involving relief devices should be regarded as legacy systems if the following items are not fully documented and applicable to the current operation of the protected system:

- Required relief rate for each identified cause of over (or under) pressure;
- The sizing basis for the selected devices; and
- Confirmation that the selected device(s) provide adequate relief capacity.

This could also be extended more generally to “overpressure protection” as relief devices are not the only means of protecting against overpressure. In some cases, instrumented protection may be provided (often referred to a “HIPS”), which may also be regarded as being legacy systems if they are not fully defined as described above.

3.1 How do systems become legacy systems?

A number of issues can contribute to an over (or under) pressure protection system becoming a legacy system. These can include but are not limited to:

- Loss of original design documentation (particularly an issue for mature plant);
- Oversight or omissions in the original design;
- Ineffective Management of Change;
- Changes to process operating conditions or reactants (including impurity levels), the effects of which were not fully considered and documented at the time;
- Cumulative effect of numerous changes over the life cycle of the plant;
- Process capacity uprating leading to changes in, for example, control valve capacity, where the impact on the over pressure protection system has not been fully and adequately considered;
- Changes to equipment due to, for example, replacement of existing equipment, such as heat exchangers, by equipment with different physical characteristics (e.g. larger tube diameter which could impact on the relief rate associated with tube failure);
- In-service fouling reducing heat transfer rates and increasing rates of reaction runaway;
- Identification of safety issues, e.g. from HAZOP, PHA etc. or safety incident;

- Increase in frequency of occurrence for any initiating cause taken into consideration for the SIL assessment of instrumented systems, such as increased frequency of start-ups or shut downs, increased maintenance frequencies, etc.;
- Removal of independent layers of protection or changes to them making them less reliable, which may increase the SIL requirement of instrumented protective systems;
- Developments in industry recommended practice, e.g. RGP or similar;
- Changes to legislative environmental practices;
- Obsolescence due to ageing or degradation of equipment;
- Corporate changes leading to loss of knowledge.

The following sections of this document outline an approach that can assist decision making for the management of issues where there is potential to exceed code allowable overpressure on legacy systems.

An important point of note: the responsibilities around management of legacy systems towards ALARP / code compliance are not diminished in any way by a change of ownership and an “inheritance” of such systems.