COMAH Control of Major Accident Hazards

COMAH Competent Authorities

Mechanical Integrity Intervention Tool

HSE Environment Agency SEPA Cyfoeth Naturiol Cymru Natural Resources Wales ONR Office for Nuclear Regulation

Mechanical Integrity Intervention Tool (MIIT)

This MIIT should be read alongside the CA Mechanical Integrity Delivery Guide (DG). It defines four key topics to be addressed during CA mechanical integrity inspections in order to secure a consistent and thorough approach to regulation at COMAH sites. Use of the MIIT will also provide evidence to assign performance ratings against the four Mechanical Integrity scoring topics.

Inspectors should form a view of the adequacy of management and leadership relating to Mechanical Integrity after evaluating the robustness of at least one of the other topics described in this MIIT. For this reason, the topics are listed with Integrity Management and Leadership last.

An overview of each topic is given below, with an outline benchmark, success criteria and some sample challenge questions.

The success criteria listed under each topic describe arrangements that, if relevant to risk control at that establishment, would all need to be in place for an exemplary performance rating to be awarded. The extent to which relevant success criteria are met will determine the performance score assigned after an inspection (see the mechanical integrity DG for more details on performance rating).

Under the Profiling, Targeting and Strategy (PTS) framework, interventions should appropriately target those risks that are most important at the specific establishment being inspected. As part of the planning for mechanical integrity inspections, inspectors should develop focussed and specific question sets based on operational intelligence obtained from the establishment and/or operator in question. It is not sufficient to use the sample questions in this tool as a ‘one size fits all’ approach.

Mechanical Integrity Topic 1:
Initial Integrity and Design

The initial design of plant should be to recognised standards wherever possible, and always be constructed to a standard commensurate with the risk.

Rationale: Initial integrity is plainly relevant to newly built plant, but also for modified plant, or where the operating conditions or use have changed. For established installations, the design basis remains relevant, as ongoing integrity is reliant on the adequacy of the original design, materials of construction and quality of the initial build. It is therefore important that:

- Operators can demonstrate that the plant they run is built to an accepted design code or standard and the design is suitable for fluid they handle and the process they undertake;
- Where design codes are not available, operators should be able to demonstrate an equivalent level of design and construction integrity, delivering the same level of safety assurance as plant built to a code or standard and commensurate with the risks their process poses;
- Where “in-house” or corporate standards and guidance have been applied, they can be validated against accepted industry benchmarks;
- Plant has been subject to suitable and sufficient examination and testing during the construction and commissioning stages, proving that it can operate safely;
- New plant is built with an appropriate margin of safety, materials of construction, quality control etc., and this can be evidenced;
- Plant is operated within an envelope commensurate with the design;
- The impact on integrity is understood so correct action can be taken in the event that operational limits are breached;
- Operators understand the impact of change and the importance of maintaining the design intent. This should extend to changes in plant, process, procedure and personnel. For all change that impacts on the process plant, mechanical integrity should be considered.
- In the event of a change in ownership, operators should incorporate integrity as part of the due diligence exercise, and ensure that information relating to integrity, such as design documentation and operating history, are retained.
- Where creeping change could have occurred, there is provision to revisit the design and reinstate an appropriate level of design integrity.

Benchmark / Success Criteria

The operator can demonstrate, at any time during a site's operating life, that key items of plant and equipment (e.g., structures, pressure vessels, storage tanks and pipework etc.) have been designed, constructed and installed in accordance with appropriate codes, standards and other relevant good practice (RGP). Where that is not the case, there will be demonstration that items of plant and equipment achieve an equivalent level of initial integrity to accepted codes, standards or RGP. Note that the mixing of standards should be avoided.

The plant design will adopt a clear hierarchy and, where hazards cannot be eliminated, prevention, control and mitigation measures are in place to minimise the risk. For example, fully welded pipework is generally preferable to flanged joints, which in turn are more secure than screwed connections.

The plant design will also incorporate features to reduce the risk during maintenance activities, such as ready access, secure isolation and drain down, lifting points etc.

There will be a well-defined design case with the design assumptions and design basis retained and life limiting parameters, such as corrosion limits, fatigue life, creep life etc. clearly stipulated. Operational constraints (such as temperature, pressure etc.) are clearly defined and understood by those who operate the plant, and excursions beyond safe operating limits are reported to those responsible for mechanical integrity. Adversely affected equipment will be assessed by a competent person with fitness for service evaluation applied where necessary.

Legacy equipment items with limited design basis or operating history are subject to design code gap analysis with fitness for service assessment applied where required. The operational history of assets is known and maintained.

There will be demonstration of applicable control and protection systems, e.g., suitable safety valve provision and sizing etc.

Quality control and assurance records relating to the original manufacture are retained and kept up to date, as ongoing integrity is based on having adequate initial integrity. For the highest hazard plant, records are in accordance with quality plans that are endorsed with a suitable level of authority. Records should include materials certificates, competence demonstrations, baseline examination records and testing records from the post-construction phase, including NDT and hydro-static testing. Such documents are retained for the life of the plant and added to where the plant is modified.

Where the plant or process is modified, full consideration is given to the design and the impact of the changes is understood, including implications for protective devices, inspection regime etc. Repairs to plant are in accordance with the original design, or where appropriate, improved standards. Temporary repairs (such as over-plating, composite wraps etc.) are to an accepted standard and the operating life and inspection requirements clearly stipulated.

Where existing facilities are sold on, wherever possible the design, examination and operational records are retained as part of a due diligence exercise. The purchaser should establish a baseline level of integrity, satisfying themselves that the assets are of appropriate design and integrity. Modifications should be in accordance with an appropriate design code or standard, compatible and complimentary to the original design.

Note: QA/QC information may become crucial later in life, for example where questions regarding material supply arise after some years in service or proving the location and size of embedded defects. Declarations of Conformity and Technical Files should be accessible where supply regulations apply.

There are clear commissioning and hand over procedures with project management of change and punch list management systems in place. There is a form of project safety review process that includes commissioning activities. The organisation’s management of change procedure is integrated with a project safety review process.

Note: Commissioning records go some way to proving the operational envelope, particularly for start/stop conditions which may be the most arduous.

The organisation has corporate knowledge and application of suitable design and construction codes and an awareness of emerging issues, and for best practice, is engaged with design code development with in-house design competence.

Note:

To be applied as is proportionate to the risk profile of an organisation and taking account of specific accepted industry practice within certain industries.

Legal Basis

- Control of Major Accident Hazards Regulations 2015 (COMAH):
  Regulation 5(1), 7(8) and Schedule 2
- Pressure Equipment (Safety) Regulations 2016
- Provision and Use of Work Equipment Regulations 1998 (PUWER):
  Regulations 4, 7 & 10
- Pressure Systems Safety Regulations 2000 (PSSR):
  Regulations 4, 5, 7 & 13
- Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR):
  Regulation 6

Mechanical Integrity Topic 2: Inspection

The primary containment boundary cannot be allowed to fail where there is major accident potential through unintended release. Retaining flammable, toxic and ecotoxic fluids, or biological agents, in the vessels, pipework and other containment systems should be the main goal of an integrity management system, and examination of the primary containment boundary is crucial where ageing can compromise integrity. Equally, structures that have a retaining or supporting function need to be examined to ensure that they remain in good condition.

The examination regime for vessels, pipework and structures should be based on the guidance given in EEMUA 231/SAFed IMG1, which includes recommendations on:

- The systematic identification of potential deterioration and the impact, with a multi-disciplinary approach;
- The derivation of an approved Written Scheme of Examination (WSE) capturing the scope, methods used and frequency of inspection;
- The reporting of the examination process, including: adverse and/or unexpected findings; remedial work arising from it, and declaring fitness for service, as well as repairing, re-rating or retiring equipment.
- The review of examination effectiveness and revisiting the WSE, based upon inspection findings, internal/external learning (such as incidents) and advancing technology;
- The setting of roles and responsibilities;
- A postponement process, authorised at a suitably high level within the organisation when applied to high hazard plant;
- Preventing overdue examinations;
- Keeping of records, and
- Auditing the entire process.

For other equipment, such as items identified as Safety Critical, or rotating equipment, they should be subject to an inspection regime that prevents failure in service.

Rationale: Retention of dangerous fluids within the plant, and avoidance of unintentional release is key to safe operation. Prevention by integrity assurance is preferable to mitigation following a release and is a fundamental principle of major accident regulation. In addition, the primary containment boundary is often the only preventative physical barrier to a major accident, so its integrity is of key importance. Degradation of this boundary, as well as relevant supporting structures, needs to be identified so that it can be monitored and assessed to check whether plant and equipment remains fit for purpose. If deterioration is significant, then the equipment may have to be down-rated, removed from service, or other measures introduced so it can safely continue in operation. For items that are required to function to prevent, control or mitigate a loss of containment (e.g., pressure relief valves, bursting discs, remotely operated shut off valves etc.) there should be arrangements in place to provide assurance that they will work as intended.

Benchmark / Success Criteria

For containment plant, details are contained within EEMUA231/SAFed IMG1, but briefly:

The operator has identified key equipment, in particular the primary containment boundary for hazardous fluids, but also machines, equipment and structures where integrity failure could result in a major accident. This plant and equipment is captured within an appropriate database and identified within operational documentation such as site piping and instrumentation diagrams (P&IDs) and operational procedures etc.

For each individual asset, there is a rigorous approach to risk identification which is multi-disciplinary, involving technical and operational staff, and subject to regular periodic review as well as re-evaluation following significant change. All possible degradation threats are understood and relate to the actual process conditions. The likelihood of occurrence and the consequences of failure are used to derive an inspection regime to counter each credible threat, i.e., is risk based.

Suitable WSEs are derived in-house or via third party input with good technical justification, linked to the mature Risk Based Inspection regime outlined above. The inspection scope and frequency are defined within the WSE, based upon the anticipated degradation, and the scheme outlines how and where each deterioration mechanism is to be detected. In all but the most simple of cases, WSEs are specific to each asset and contain sufficient instruction to accurately assess condition, illustrative drawings and photographs are good practice, e.g., pipework isometrics. The schemes are reviewed for suitability by a competent person following each examination, including consideration of unexpected deterioration. In addition to the formal inspection requirements, observational and/or operational inspections should be in place.

Consideration is given to other instances where examination may be necessary – e.g. following a process or plant change or in the event of an excursion beyond safe operational limits. In addition, the operator takes advantage of opportunistic examination whenever possible.

Inspection results and notifications are reviewed and assessed by an inspection / integrity engineer or competent person and ultimately result in a fitness for service declaration. Leading up to that, adverse findings are prioritised and captured within a suitable data base or management system to ensure follow-up and reporting. Any repairs are approved by the competent person on completion. Actions are reviewed to ensure completion in a timely fashion.

If the integrity management regime is resourced internally it would be expected to follow the requirements of ISO/IEC 17020 and be UKAS accredited typically as a type C inspection body, or subject to external or group audit. If external resource is utilised the inspection organisation is subject to similar accreditation or audit procedures and in addition subject to audit or oversight by the duty holder. Whether the integrity management regime uses in-house or external resource, there is a clearly defined inspection process and clear lines of responsibility.

There is sufficient competent resource in house to adequately manage all aspects of the inspection regime. Inspection staff are demonstrably competent to undertake their work – those undertaking examinations have valid qualifications in the techniques being applied, and those interpreting the results are qualified to make judgements on the integrity of the related equipment.

The asset integrity management strategy ensures the testing and validation prior to deployment of novel emerging examination techniques. Wherever possible, new techniques and approaches are applied to enhance the examination regime.

The organisation does not typically postpone or defer critical inspection activity. Where deemed necessary, postponements and deferrals are well planned and managed with a thorough assessment of risk with independent oversight. Any deferment would be time bound, remain visible to management, subject to regular review and be approved in advance by the integrity assessor or competent person.

The entire examination regime is subject to thorough and regular independent audit.

Where items have a safety critical function, they should be inspected and tested at regular intervals so that their integrity can be assured and their performance can be relied upon. For operational equipment the Original Equipment Manufacturer (OEM) recommendations are adopted in the first instance.

Note: Criteria to be applied as is proportionate to the risk profile of an organisation and taking account of specific accepted industry practice within certain industries.

Legal Basis

- Control Of Major Accident Hazzard Regulations, Regulations 5 & 7 (including Schedule 2)
- Provision and Use of Work Equipment Regulations Regulation 6
- Pressure Systems Safety Regulations Regulation 8 & 9

Mechanical Integrity Topic 3: Maintenance

The maintenance of plant in a 'safe and suitable condition' and in 'good order' is required so that the fabric of the containment envelope, supporting structures and the function of devices and machinery that are critical to safety are not impaired. The maintenance of the primary containment boundary, reacting to examination findings to limit or repair deterioration, is plainly crucial in preventing failure. Equally, maintaining the performance of devices and machines, such as safety critical isolation valves or relief devices, can prevent major accidents from initiating or escalating.

A key to this is understanding the number and nature of assets, which means the adoption and upkeep of an asset register. Proactive or preventative maintenance should be adopted wherever possible, either based on a schedule or as a result of monitoring equipment condition. The need for reactive and uncontrolled interventions should be minimised by an effective proactive or planned maintenance regime.

There should be a clear understanding of the relative importance of certain items of plant. Equipment that is relied upon to prevent the occurrence or limit the consequences of a major accident should be readily identifiable so that maintenance and examination can be prioritised and reported on.

Rationale: Failure of the equipment on site is prevented by having a suitable maintenance regime, and this needs to focus on the most important equipment so that major accidents are avoided. Repairs should be of suitable quality and undertaken in good time, so as to maintain equipment in good working order.

Benchmark / Success Criteria

The organisation has a maintenance management system (MMS) that clearly identifies all primary containment equipment (tanks, vessels, pumps, piping, critical flanges etc.) which, if it fails, could give rise to major accident.

Maintenance management should be built around a searchable database, which for all but the most rudimentary plant will be computer based. The asset database discriminates equipment categories with associated safety significance, such as tanks, vessels and safety critical devices (SCD) that are relied upon to prevent, control or mitigate against a major accident hazard. The operator should be able to demonstrate which equipment is associated with a major accident and show that it is being maintained in accordance with relevant good practice. Success in this respect should be outcome driven - minimal reactive work and backlog of planned tasks, and with key plant, equipment and infrastructure kept in good working order.

The MMS contains asset maintenance and operational history with key information to assist the maintenance function, such as baseline data, maintenance history, planned or reactive and scheduling of regular tasks etc. The MMS will reference or maintain critical documentation such as drawings (such as P&IDs), OEM maintenance and operation manuals etc. and exercise adequate management and control of document status and availability. Those documents referenced or held within the MMS may mirror similar information held on other systems, such as Engineering Line Diagrams, Isometrics, P&IDs etc. but have a robust control procedure.

Note: Information provision and records can be kept in a number of formats – original construction files and drawings may well still be on paper for example. The format is less important, as long as the system provides or references the necessary level of information and is readily accessible by *those who need it.*

The maintenance regime is largely proactive with adequate look ahead enabling effective maintenance planning and preparation. The maintenance system includes a means of prioritising work so that tasks associated with key equipment are addressed ahead of less important work. In addition, overdue work is readily apparent and managed, so that there are no long-standing or repeat overdue tasks, and that such work on the primary containment boundary or SCD is kept to a minimum and well controlled. The postponement or deferment of maintenance on SCDs, the primary containment boundary and other critical assets is suitably assessed and approved in advance and not subject to undue production or operational influence. Any deferment is risk assessed, with approval at an appropriate level of seniority, and time bound, as per section 2 - inspection.

Maintenance procedures, intervals and other recommendations by manufacturers should be adopted in the first instance. Breakdowns and history of reactive intervention on key plant are reviewed, so that the identification of trends and problematic equipment can be undertaken. Substantive reactive work is formally investigated to inform the adequacy of the maintenance strategy.

The MMS is used to generate asset and maintenance performance data. Plant with major accident implications can be discriminated within the MMS reporting. There is an audit and review process in place covering the overall maintenance function, so that failings are identified and measures taken to address shortcomings in the way the system is managed.

Major items of critical rotating equipment are subject to condition monitoring with approach based upon criticality ranging from continuous on-line monitoring to local data capture. Such a regime can give early indication of pending failure and allow for controlled intervention. Trends are identified to schedule maintenance; for example oil sampling, vibration etc with action levels defined.

There will be a logical approach to the level of spare part provision so that the safe operation of the plant is not compromised for lack of parts. Equally, the quality, technical and functional equivalence of the spare parts will be considered, so that the function and life of the plant is not compromised and any certification invalidated. The procurement of such spares is controlled to ensure correct specification. The holding of critical spares is controlled within suitable conditions with a defined shelf life where they are prone to deterioration.

Where maintenance work could subject personnel to risk, there is a suitably structured risk-based Permit to Work system covering hot work control, confined space entry, working at height amongst others, that includes robust risk based procedures and certification for process isolation (mechanical, electrical, radiation etc.), in accordance with HSG253 or equivalent. There are also robust controls in place to manage de-isolation and re-energisation / pressurisation of equipment.

Notes:

There should be recognition that where the integrity management system is fragmented, for example where inspection services are provided by a third party and aren't part of the site maintenance function, then additional effort is necessary to ensure that related maintenance work is still captured and adequately managed. Recommendations on suitability for continued operation, repair or the need for follow-up visits are often missed in such circumstances.

The key outcome is to maintain the integrity and function of the plant, and ensure that the risk of failure, most especially of the primary containment boundary and SCD, is kept as low as reasonably practicable (ALARP).

To be applied as is proportionate to the risk profile of an organisation and taking account of specific accepted industry practice within certain industries.

Legal Basis

- Control Of Major Accident Hazard Regulations 2015 Regulation 5(1), 7 (including Schedule 2)
- Provision and Use of Work Equipment Regulations Regulation 5
- Pressure Systems Safety Regulations Regulation 12
- Pressure Equipment (Safety) 13

Mechanical Integrity Topic 4:
Integrity management and leadership

Site Leadership and Management should be aware of the performance of the parts of the Safety Management System that seek to maintain the integrity of their plant and demonstrate a commitment to ensuring that site assets remain fit for service.

Rationale: It is important that the site's Senior Leadership Team (SLT) have clear visibility of the performance of the various systems that deliver continuing mechanical integrity in order that they have confidence that the site remains in a fit state to operate safely. In addition, it is important that those in ultimate authority demonstrate a commitment to asset integrity by:

- *Understanding the relative importance of integrity and the impact failure can have – mechanical integrity failure is the biggest single cause of loss in the major hazards sector;*
- *Taking ownership of their plant, and being responsible for its condition and any residual risk arising from its condition;*
- *Providing independence to those who are charged with making key integrity decisions;*
- *Providing sufficient resources in all aspects of integrity, including appropriate commitment to inspection and maintenance;*
- *Ensuring that the competence requirements for each role are adequately described and fulfilled, and*
- *Monitoring performance by measuring the right things and ensuring compliance with accepted standards.*

The above may be encompassed within a mechanical integrity management policy that is communicated within the organisation, providing a clear vision of the intent of the leadership that is communicated and shared and defines how knowledge and resources are to be managed to realise that leadership vision.

Benchmark / Success Criteria

The SLT are fully informed of the status of their plant, and able to describe its condition, with demonstrable technical competence at a senior level. Where ageing threatens plant integrity, there is a clear understanding of the impact in terms of the MAH potential.

The organisation has a suitable Integrity Management policy incorporated in to their Safety Management System.

Where plant is approaching end of life, there is a commitment or policy to retirement and / or replacement in a timely fashion, with risks clearly managed to the principles of ALARP. Where new or replacement plant is required, the SLT ensures that a hierarchal approach is adopted and commits to design and installation to a demonstrable standard, adopting relevant good practice and developing opportunities to improve wherever possible. Where significant repair work or fitness for service assessments are required to enable equipment to stay in service in the interim, this should be clearly visible to the SLT.

The SLT ensures that all aspects of the Management of Health and Safety at Work Regulations are applied to Mechanical Integrity, including a documented audit and review process.

There are clear procedures for audit and review of the mechanical integrity processes, including effectiveness of inspection and maintenance. The SLT has an understanding of the barriers to major accidents, and in particular the significance of mechanical integrity. Complementing the audit and review process there is a suite of Key Performance Indicators (KPIs) related to integrity management reported regularly to the SLT with threshold targets imposed and reviewed. Inspection and maintenance performance related to critical assets and SCDs are reported separately and prioritised. The KPIs highlight overdue maintenance and inspection tasks, levels of temporary repair, Fitness For Service (FFS) assessments etc. There is evidence that poor performance is subject to challenge with appropriate remedial measures taken to address root causes, rather than superficial 'quick fixes' put in place. Senior Leaders take an active role in overseeing the integrity function, including visits and audits.

The organisation has a reporting and investigation process to incorporate improvements from near misses, incidents and major accidents, on a site basis, company-wide and from relevant industries. It is important that the systematic failings from a near miss are identified and corrected, and that the culture doesn't see such close calls as vindication of the management system ('disaster averted').

All critical changes are subject to an effective management of change process with oversight and approval at appropriate level of seniority. There is a clear definition of what constitutes an engineering or process change. Mechanical integrity considerations are specifically identified within the management of change process, including the derating of equipment due to adverse inspection findings or FFS reviews etc.

Where difficult integrity decisions have been necessary, there is evidence that the SLT have supported the independence of those charged with making such decisions, ensuring that mechanical integrity is not compromised by operational or production demands and the risks kept ALARP.

The SLT ensures sufficient competent resource is employed at all levels where personnel may impact on plant integrity. Such competence extends to design, inspection, maintenance and operation, to ensure initial and on-going integrity. Resource and competence requirements are clearly understood defined and recorded for specific roles. Competencies are monitored and developed as required with demonstration. Critical personnel have the competence to act in the role of the intelligent customer. The organisation demonstrates that assurance of required competence is extended to third party contractors and service providers where such activities may impact upon the integrity or safe operation of the plant.

The provision of adequate resource extends to other areas, including the provision of sufficient spare parts so that the integrity and function of the plant can be adequately maintained. There is a spares holding policy in place that is commensurate with the criticality of the plant.

Senior Leaders ensure that information relating to integrity, such as design data and inspection history, is considered during mergers and acquisitions.

Notes:

Leadership should not only have visibility of the MAH risks, but also be engaged in the risk management process and lead by example.

Where there is a change in ownership, leadership should ensure that there is no adverse effect on integrity – for example, the impending sale of a site can lead to reduced maintenance spend, and equally, integrity is not always considered as part of a 'due diligence' package.

Criteria is to be applied as is proportionate to the risk profile of an organisation.

<u>Legal Basis</u>

- Health & Safety at Work Etc Act 1974
- Management of Health and Safety at Work regulations 1999
- Control Of Major Accident Hazard regulations 5 and 7 (including Schedule 2)

Appendix 1 – Benchmarks – Supporting Guidance and Standards

Notes.

1. The listings are indicative only and should not be regarded as a complete register of applicable guidance and standards. Effort should be made to research which publications apply to any given installation, and there may be more which are pertinent.
2. The listing is valid only at the time of writing – the validity of any standard should be checked prior to using as a benchmark.
3. There may be elements of one criteria in another, e.g., there may be advice on inspection contained within design standards.

Appendix 1.1 – Design

- Mechanical Engineering Aspects of Safety Report Assessment – Control Of Major Accident Hazzard Regulations 2015 safety report assessment manual (SRAM) – Mechanical Engineering Criteria

4. Safety Report Assessment Manual – Criterion 5.2.1 - Design

- Lifting Operations and Lifting Equipment Regulations
- Control Of Major Accident Hazard Regulations Guidance (e.g., Regulation 23, Schedule 2 etc.)
- Provision and Use of Work Equipment Regulations Guidance (e.g., Regulation 4(1) etc.)
- Pressure Systems Safety Regulations ACoP & Guidance (e.g., Regulation 4, Regulation 5, Regulation 7, Regulation 13 etc.), EEMUA Publication 168
- Dangerous Substances and Explosive Atmospheres Regulations ACoP & Guidance (e.g., 200 etc.)
- SAFed PEDG 1/EEMUA Publication 237– 'Pressure Equipment Directive – Global Conformity Assessment A Guide to Site Installed Assemblies', EEMUA 211
- HS(G) Series, various
- Liquid Gas UK Codes of Practice (various)
- National Fire Protection Association (NFPA) 30 Flammable & combustible liquids code
- Pressure Vessels (including cryogenic and various materials):
  - BS EN 13445, PD 5500, ASME VIII, BS EN 13923, BS EN 13458, BS EN 21009, EEMUA Publications 149, 211 etc.
- GRP / Thermoplastic Vessels and Tanks:
  - BS EN 13121, BS EN 13923, BS EN 13575, EEMUA 225 etc.
- Atmospheric & Refrigerated Storage Tanks:
  - BS EN 14015, API 620, API 650, API RP 652, BS EN 12285, BS EN 12573, BS EN 14620, BS EN 1993-4-2 (Eurocode 3), EEMUA Publications 147, 159, 180, 183, 207 etc.
- Silos:
  - Eurocode 3 Section 4 Part 1 (BS EN 1993-4-1), Eurocode 1 Section 4 (BS EN 1991-4), plus National Annexes.
- Pipework:

    - Piping - BS ISO 15649, BS EN 13480, ASME B31.3, BS EN 16125, Liquid Gas UK CoP 22, EEMUA Publication 200, Energy Institute 'Guidelines for the avoidance of vibration induced fatigue in process pipework', 'Guidelines for the design, installation and management of small-bore tubing assemblies' etc.
    - GRP – BS EN ISO 14692
    - Flanges – BS EN 1591, BS EN 1759, Energy Institute 'Guidelines for the Management of integrity of bolted joints in pressurised systems' etc.
    - Bolting – BS EN ISO 898, BS EN 10269, BS EN ISO 3506 etc.
    - Gaskets – BS EN 12560
- Heat Exchangers:
    - PD 6550-4, BS EN ISO 13706, BS EN ISO 16812, TEMA etc.
- Pumps:
    - Machinery – BS EN ISO 14847, BS EN 13709, BS EN ISO 13710, BS EN ISO 9905, BS EN ISO 9908, BS EN 22858, BS EN ISO 5199, BS EN 14847, API 610, API 674, EEMUA Publication 151, etc.
    - Shaft Sealing - BS EN ISO 21049, API 682, etc.
- Compressors:
    - BS EN ISO 13631, BS EN ISO 10439, BS EN ISO 10440, BS EN 1012, API 617/618, etc.
- Other Structures:
    - Eurocode series – BS EN 1991 to BS EN 1999 inclusive, plus National Annexes.
- Installation specific:
    - Hydrogen systems - PD ISO/TR 15916:2015, NFPA 2 etc.
    - LNG Systems - BS EN 1473, BS EN 13645, NFPA 59a etc.
    - LPG systems – EEMUA 190, Liquid Gas UK Codes of Practice (various), Energy Institute 'Model code of safe practice Part 9: Liquefied petroleum gas', NFPA 58 etc.
    - Chlorine – HSG 28, HSG 40. Eurochlor guidance (GEST series & various)
    - Plant Fire precautions - BS 5908, Energy Institute Code of Safe Practice Part 19 etc.
    - Cathodic Protection – BS EN 12954, BS EN 13636, BS EN 16299, API 651 etc.
    - Explosive Atmospheres – BS EN ISO 80079, BS EN 13463, BS EN 15198 etc.
    - Alkylation Units – API RP 751
    - HTHA – API RP 941
    - Operational – API RP 584, Energy Institute Model Code of Practice Part 15,
    - Materials – EEMUA Publication 211
    - Welding – SAFed WG1, WMC series
    - Composite repairs – BS EN ISO 24817
    - Gas caverns – BS EN 1918
    - Jetty operations – ISGOTT 5th Edition,
- Equipment:

- Relief - BS EN 4126, BS EN 14129, BS EN 14071, BS EN ISO 23251, BS EN ISO 28300 NFPA 68 & 69, etc.
- Bellows - BS 6129, BS EN 14917 etc.
- Insulation - BS 5970, Energy Institute 'Guidelines for the design, installation and management of thermal insulation systems', etc.
- Passive Fire Protection – Energy Institute 'Guidance on Passive Fire Protection for Process and Storage Plant and Equipment'.
- Coatings – BS EN ISO 12944, Energy Institute 'Guidelines for the management of coatings for external corrosion protection',
- LPG Equipment - BS EN 13175 etc.
- Hoses – BS 6501, BS EN 12434, BS EN ISO 10380, BS EN 13765, BS EN 13766, BS EN 12115, BS ISO 27126, BS EN ISO 21012, Energy Institute 'Guidelines for the management of flexible hose assemblies' etc.
- Valves & Actuators – HS(G) 244, BS EN ISO 17292, BS EN 15761, BS 1873, BS EN 5210, BS EN 5211 etc.
- Hazardous Area eqt. – BS EN 80079, BS EN 13463

Appendix 1.2 – Inspection

- Control Of Major Accident Hazard Regulations Guidance L111, including Regulation Schedule 2 etc.
- Provision and Use of Work Equipment Regulations ACoP & Guidance L22, including Regulations 6 etc.
- Pressure Systems Safety Regulations ACoP & Guidance L122, including Regulations 8, Regulation 9 etc.
- HSE COMAH Guidance, Technical Measures – Inspection/Non-Destructive Testing.
- General:
  EEMUA Publication 231, & SAFed IMG1, EEMUA Publication 232, BS EN ISO 17020, SAFed TC6 01, CAC Series
- Risk Based Inspection:
  HSE SPC 'Risk Based Inspection' (SPC/TECH/GEN/46), API RP 580, API RP 581, HSL RR363, BS EN 16991, EEMUA Publication 193 & 206, etc.
- Pressure Vessels:
  SAFed PSG series, SAFed PEC series, API 510, API RP 572, API RP 585, EEMUA Publications 168, 223, BS EN ISO 16753 etc.
- Tank storage:
  - General - HS(G)176, EEMUA 159, , API 653, API RP 575, SAFed IMG02 series, SAFed IMG07, Energy Institute Model Code of Practice Part 16,
  - Plastics – HSE PM75 & PM86, EEMUA 225, SAFed IMG 02b & c, etc.
  - Ammonia – EFMA 'Recommendations for inspection of atmospheric, refrigerated Ammonia storage tanks'
- Pipework:
  API 570, API RP 574, API RP 2611, BS EN ISO 24817
- Equipment:
  - Materials – EEMUA Publication 149
  - Relief – EEMUA Publications 184, 188 & 208, API RP 576, SAFed PEC09 & PEC13
  - Valves – API Std 598, EEMUA Publication 205
  - Fired Heaters – API RP 573
  - Condition Monitoring – BS ISO 13372, BS ISO 13373, BS ISO 13379, BS ISO 17359 etc.
- Structures
  - Bunds – SAFed IMG07
- Degradation:
  - General – API 571, Energy Institute 'Guidelines for the Management of Corrosion Under Pipe Supports', 'Guidance for Corrosion Management in oil and gas production and processing' etc.
  - Corrosion under insulation – HSE SPC 'Corrosion Under Insulation of plant and pipework' (SPC/TECH/GEN/18), API RP 583, European Federation of Corrosion 'Corrosion Under Insulation',
  - Fitness for Service – BS EN 7910, API 579 etc.

- Non Destructive Testing (examples only)
  - Personnel – BS EN ISO 9712, PD CEN/TR 15589, SAFed TC5 01, NDTC series, UKAS RG series, EEMAU 193, etc.
  - Visual – BS EN 13018, BS EN 13927, BS EN 1330-10, BS EN ISO 17637, BS EN ISO 4628 etc.
  - Replication – BS ISO 3057
  - Penetrant - BS EN ISO 3452, BS EN ISO 3059 etc.
  - Magnetic Particle – BS EN ISO 9934, BS EN ISO 3059 etc.
  - Ultrasonic - BS EN 14127, BS EN 15317, BS EN ISO 16810, BS EN ISO 17640 etc.
  - Radiography – BS EN ISO 5579, BS EN ISO 17636, BS EN ISO 20769 etc.
  - Eddy Current – BS EN ISO 15549 etc.
  - Etc.

Appendix 1.3 – Maintenance

- Control Of Major Accident Hazard Regulations ACoP & Guidance L111, Regulation 5, Schedule 2.
- Provision and Use of Work Equipment Regulations ACoP Guidance Regulation 5.
- HSE COMAH Guidance, Technical Measures – Maintenance, Permit to Work Systems.
- British Standards Institute: BS ISO 55000 series - Asset management
- Energy Institute: *'Guidance on meeting the expectations of EI Process Safety Management Framework – Element 15: Inspection and Maintenance', 'Guidance on meeting the expectations of EI Process Safety Management Framework – Element 16 Management of Safety Critical Devices', 'Framework for monitoring the management of ageing effects on safety critical elements'.*
- General:
    - BS EN 13460, BS EN 16646, BS EN 17007, BS EN 15341, BS EN 15628
    - EEMUA 231 / SAFed IMG01 – The mechanical integrity of plant containing hazardous substances – Section 8.6 etc.
- Storage:
    - BS EN 13121-4
    - API Std 653 Tank Inspection, Repair, Alteration and Reconstruction
- Pressure Vessels and Pipework:
    - API 510 Pressure Vessel Inspection Code: In-service Inspection, Rating, Repair and Alteration
    - ASME PCC-1 Guidelines for Pressure Boundary Bolted Flange Joint Assembly
    - Energy Institute: Guidelines for the management of integrity of bolted joints for pressurised systems
    - Repair – ASME PCC-2 Repair of Pressure Equipment and Piping, EEMUA Publication 199, 200, BS 6990
    - Composites – BS EN ISO 14692, BS EN ISO 24817
    - Pressure testing – HSE GS4
- Machines:
    - Condition Monitoring – BS ISO 17359, BS ISO 13373, BS EN 18436 etc.
    - Rotating equipment – EEMUA Publication 230
- Permits, Isolation
    - HSG 250, HSG 253
    - L101 Safe Work in confined spaces
    - Energy Institute Model Code of Safe practice part 16 - Guidance on tank cleaning.
    - NFPA 326, 350
- Corrosion Protection:
    - BS EN ISO 12944
    - BS EN 4628-3
- Relief & other Safety Critical Devices:
    - API RP 576 Inspection of Pressure-relieving devices
    - EEMUA 188, 205, 208

Appendix 1.4 – Integrity Management & Leadership

- Control Of Major Accident Hazard Regulations ACoP & Guidance L111, Regulation 5 Schedule 2.
- Control Of Major Accident Hazard Regulations Competent Authorities (CA) - Operational Delivery Guide - Inspecting Major Hazard Leadership and Investigating Leadership Failures in Major Accidents
- Control Of Major Accident Hazard Regulations CA – Major Hazard Leadership Intervention Tool
- HSE - Leadership for major hazard industries – INDG277
- HSE - Leading health and safety at work INDG417
- HSE - HS(G) 65 'Managing for health and safety'.
- COMAH Strategic Forum: '*Managing Risk: The hazards that can destroy your business. A guide to leadership in process safety.*'
- HSE Research Reports: RR509 'Plant Ageing: Management of equipment containing hazardous fluids or pressure', RR823 'Managing Ageing Plant'.
- Energy Institute: '*Guidance on meeting the expectations of EI Process Safety Management Framework - Element 1: Leadership, commitment and responsibility', Guidelines for the management of Safety Critical Elements', 'Framework for monitoring the management of ageing effects on safety critical elements'.*
- International Association of Oil & Gas Producers Report 415: *'Asset integrity – the key to managing major incident risks'* December 2018
- British Standards Institute: *BS ISO 55000 series - Asset management*
- HS(G)254 Developing Process Safety Indicators
- API RP 754

Reference sources

- Health and Safety Executive
  https://www.hse.gov.uk
- www.safed.co.uk
- Engineering Equipment and Material Users Association
  https://www.eemua.org
- Liquid Gas Uk (was UKLPG)
  https://www.liquidgasuk.org
- National Fire Protection Association
  https://www.nfpa.org
- British Standards Institution
  https://www.bsigroup.com
- American Society of Mechanical Engineers
  https://www.asme.org
- American Petroleum Institute
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- Euro Chlor
  https://www.eurochlor.org
- International Safety Guide for Oil Tankers
  www.isgott.co.uk
- The European Fertilizer Manufacturers Association
  www.ecetoc.org
- Energy Institute
  https://www.energyinst.org