Loss of Containment Manual

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Introduction

Reducing Offshore Hydrocarbon Releases

This document, originally designed to give guidance to inspectors under the Key Programme 1 - 'Reducing offshore hydrocarbon releases' initiative, indicates ten important elements relating to the management of the integrity of the process containment envelope and provides advice on topics for inspection within each of the elements. The maintenance of high standards of operation in these areas should help to minimise the frequency of occurrence of offshore hydrocarbon leaks.

Asset Integrity Programme

This programme, known as KP3 ran from 2004 to 2007. It focused on the effective management and maintenance of safety critical elements. Inspectors using a template, which covered a number of key topics, obtained an overall picture of industry performance. One topic, relevant to loss of containment prevention, where performance was poor was Topic C – Maintenance of safety critical elements.

Offshore Hydrocarbon Releases

HSL was asked to identify the main causes of major and significant releases between 2001 and 2007 using the Hydrocarbon Releases Database. Information was obtained on systems, equipment types, equipment causes, operational causes, procedural cause and operational mode. The key issues and underlying causes relating to hydrocarbon releases are summarised below.

- Evidence suggests that piping systems, including flanges and valves collectively continue to be a major source of Hydro Carbon Releases (HCRs), with piping being the single largest contributor. Instruments (i.e. Small Bore Tubings (SBTs)) contribute the second largest single source of HCRs. Gas Compression is the operating system having the highest number of HCRs.

- Incorrectly fitted equipment is the most widespread operational cause followed by improper operation (i.e. human factor issues) where operational failures are reported.

- Non-compliance with procedure (i.e. human factors issue) is the most common procedural cause where procedural failures are reported.

- Reported experience of inspection and survey on SBT systems suggests that 26% of fittings examined are found to contain faults, e.g. under-tightness, incorrect or mismatched components, leaks, incorrect or poor installation, etc., and that this failure rate has remained constant from 2001 to 2007.

Part 1 - Management of process integrity

This part involves onshore inspection. It reviews the way in which process integrity is managed, and is intended to examine and reinforce the role of onshore management.

Item	Inspection Topics	Guidance Notes
1.1	**Policy / Record of Arrangements**	
1.1.1	Is there a policy statement, and / or any other record of the arrangements for managing process safety, or is it rolled into the overall SMS? If so, is it adequately defined, communicated, and put into practice? Is process integrity adequately included in an SMS improvement programme?	A good policy statement, or record of arrangements, would include principles such as: • inherent safety • hierarchy of prevention, detection, control, mitigation • role of risk assessment and ALARP principles • maintaining up to date documentation • competence, and adequacy of resources • working within a safe operating envelope • control of changes that impact on process safety • maintenance / verification of safety critical systems • line management monitoring • independent management and technical audits • establishing basic causes of accidents / incidents • reviewing process safety performance • continuous improvement, with improvement plans • Principles of quality management e.g. ISO 9000.
Legal Basis	An employer has a legal duty under s.2 (3) of HSWA to have a written policy statement with respect to health and safety. This statement of his general policy should include the organisation and arrangements for carrying out that policy, including those applicable to process safety. MHSWR, Reg. 5 requires a record of arrangements for planning, organisation, control, monitoring and review of preventive and protective measures. A policy statement addressing process safety management will help define the management requirements. Senior management should endorse the policy, which should be adequately communicated; commitment to it should be visibly demonstrated.	
1.2	**Accountabilities / Responsibilities / Resources**	
1.2.1	**Accountabilities etc.** Are responsibilities / accountabilities for process integrity adequately defined and allocated (e.g. between operational and technical functions)?	Responsibilities for process integrity should be assigned, and accountability reinforced through job descriptions. There should be a senior figure in the organisation to co-ordinate general safety policy implementation, and a safety management programme with objectives and performance criteria. Process safety may have a separate programme, or it may be integrated into the general programme. Responsibilities should generally be allocated to line managers, with specialists acting as advisers. Responsibilities and accountabilities should be clearly assigned (e.g. responsibilities should be allocated between operational and technical functions, with a nominated technical custodian for process integrity) and appropriately reinforced (e.g. through performance reviews). Line management should be actively involved in monitoring performance, and evaluating the achievement of performance criteria.
1.2.2	**Technical Support**	There should be sufficient resources and expertise for

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	How is technical support provided, and how is the adequacy of this support assessed?	process safety requirements. There is no legal requirement for technical support to be provided in house. However, some of OSD's process safety audits have noted a lack of expertise where there has been outsourcing of engineering requirements.
Legal Basis	MHSWR Reg. 5 requires an "organisational structure" to provide for progressive improvement in health and safety, and adequate "control" to ensure that decisions are implemented as planned. Otherwise, the requirements specified in the guidance notes above should be treated as good practice rather than legal requirements.	
1.3	**Communication**	
1.3.1	**Do managers demonstrate their commitment to process integrity through effective and appropriate communication?**	HSG65 notes that communication is often the single most important area that requires improvement. It is important for management to demonstrate commitment through written/verbal communications, installation visits etc. Communications of particular relevance to process integrity are: • The meaning and purpose of the policy for process integrity • Objectives, standards, and procedures relating to policy implementation • Communications to secure involvement and commitment of employees • Responses to comments and ideas for improvement • Meetings where teams discuss process related safety matters • Discussion of lessons from accidents and incidents • Communication of plant status at shift and crew change handovers
Legal Basis	HSWA s.2(2)(c) requires "the provision of such information, instruction and supervision as is necessary...", and s.2(6) requires employers to consult representatives over arrangements which will enable the employer and employees to co-operate effectively. MHSWR Reg. 10 requires employers to provide employees with comprehensible and relevant information on risks to their health and safety, preventive and protective measures, and emergency procedures. Reg. 11 requires co-operation and co-ordination of measures between different employers in the same workplace; it is not applicable to co-operation between employers and employees.	
1.4	**Training / Competence**	
1.4.1	**Training content for process personnel** What safety-related process-specific training requirements have been defined for process personnel?	The design of a training programme for process personnel should include the general training that everyone on the installation receives, and process-specific training. Training should include Management of Change procedures, and techniques for process Hazards Analysis and Risk Assessments. Duty holders should define: • How (safety related) process training objectives are set; • What subjects are to be included in the training programme; • Responsibility for developing and validating training material; • How primary responsibility for the training is assigned; • How competence is established.

Item	Inspection Topics	Guidance Notes
		Process specific training should deal with: • the basic process • the design of plant • critical factors which affect productivity and safety • important process safety considerations relating to flammability, explosivity, and toxicity **Task specific training** generally starts with basic principles of common unit operations, such as separation, heat transfer, pump and compressor operation, and concepts of process control. Specific unit training would then concentrate on details of the units that comprise the process. **Operations procedures** would be covered, including; • safe operating limits • actions to keep within safe limits, and consequences of failing to do so • procedures for start up, normal operation and shutdown • contingency procedures for upsets and / or emergencies Training should be given as appropriate in **Management of Change** procedures and in techniques for **Hazards Analysis and Risk Assessment**. Training should be frequent enough to maintain skills; frequencies should be specified. It may be that for some infrequent operations, training should be given each time the operation is undertaken. **Training records** should be kept for comparison with the schedule.
1.4.2	**Training content for other relevant personnel** What safety-related process-specific training requirements have been defined for maintenance personnel, and others such as contractor organisations?	Training for **maintenance personnel** in process areas should include general process safety training, and relevant aspects of process specific training. The training should then focus on standard maintenance operations, such as working in specific hazardous locations. **Contractor organisations** should be provided with sufficient process hazard information, and site-specific information necessary for them to train their employees.
1.4.3	**Training responsibilities / programme evaluation** Who is responsible for developing / validating training material, carrying out training, reviewing needs?	Training effectiveness, and competence, may be determined by a variety of means, including written / oral testing, demonstrations in the field, random spot-checking, and incident reviews.

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1.4.4	**Competence** How is competence established / assured?	Competence includes knowledge, skills, experience, and personal qualities. Offshore industry guidance (E&P Forum Guidelines), states that systems of competence assurance should apply, to initial recruitment and selection for new activities, and to both staff and contractors. Competence assessment schemes are available for process operators and maintenance technicians, and many companies have formal in-house schemes. Training does not guarantee competence, but it contributes towards it; it can be categorised into "general" and "specific" training. General training includes those subjects with which everyone at the facility should be familiar. Specific training covers core or trade skills. Competence assessment of core / trade skills is probably the most widely developed, and lead bodies, such as OPITO, set competence criteria on which qualifications can be based. NVQ / SVQ competence assessment schemes are available for process operators and maintenance technicians, and many companies have formal in-house schemes.
Legal Basis	Competence assurance programmes are recognised good practice (e.g. Oil and Gas UK and E&P Forum Guidelines). PUWER Reg. 9 requires employers to ensure that all persons who use work equipment have received adequate training, including training in methods of use, risks such use may entail, and precautions to be taken. PUWER Reg 3(3) extends this duty to others who have control, to any extent, of work equipment, including duty holders. MHSWR places specific requirements on employers to provide information for employees (Reg. 8), and to take their employees capabilities into account, and ensure they are provided with adequate health and safety training (Reg. 13).	
1.5	**Identification of basic / underlying causes in process incidents**	
	Methodology Is there a defined methodology for establishing basic causes? How has this been applied for recent process-related incidents? Has potential human failure and its impact on the process-related incident been considered? Have the underlying causes of the process incidents been identified?	As technical systems have become more reliable, the focus has turned to human causes of accidents. HSG48 states that up to 80% of accidents may be attributed, at least in part, to the actions or omissions of people. The reasons for the errors of individuals are usually rooted deeper in the organisation's design, decision-making, and management functions. HSG48 gives several examples of major accidents where failures of people at many levels (i.e. organisational failures) contributed substantially towards the accidents. Human factors topics of particular relevance to process integrity include: • ergonomic design of plant, control and alarm systems • style and content of operating procedures • management of fatigue and shift work • shift / crew change communications, and • actions intended to establish a positive safety culture, including active monitoring. Human factors cover a broad field. In the past, duty holders may have viewed it as being too complex or difficult to do anything about, but a range of measures is now available. There should be a systematic analysis of the causes of human failure, and appropriate measures should be implemented. For example the Human Factors Roadmap is a practical approach to the management of major accident hazards (MAHs), developed by HSE, it is a framework whereby MAHs are linked to the assured

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		performance of humans engaged on safety critical tasks associated with those hazards. It includes as key milestones identification of safety critical tasks, task analysis and human error analysis (together with consideration of performance influencing factors). Investigation procedures should address both immediate and underlying causes, including human factors. HSG65 Appendix 5 describes one approach that may be used as a guide for analysing the immediate and underlying causes of effects. There are several other methodologies available in the industry.
Legal Basis	MHSWR Reg 5 requires employers to make arrangements for the effective planning, organisation, control, monitoring and review of the preventive and protective measures defined in Reg 1 Paragraph 36 of the ACOP to the regulations indicates that monitoring includes investigating the immediate and underlying causes of incidents, to ensure that remedial action is taken, lessons are learnt and longer term objectives are introduced..	
1.6	**Monitoring of process systems and procedures**	
1.6.1	**Arrangements** What monitoring arrangements are in place for key risk control procedures?	Active monitoring gives an organisation feedback on its performance before an incident occurs. It should be seen as a means of reinforcing positive achievement, rather than penalising failure after the event. It includes monitoring the achievement of specific plans and objectives, the operation of the SMS, and compliance with performance standards. This provides a firm basis for decisions about improvements in risk control and the SMS. Leading indicators are the outcome of active monitoring, for example the number or percentage of specific audits of work activity conducted against the plan. Reactive monitoring is, by definition, triggered after an event, and includes identifying, reporting and measuring injuries, dangerous occurrences (including near misses), other losses, observation of hazards etc. The requirements for reactive monitoring are not specific to process integrity. Lagging indicators are the outcome of reactive monitoring, for example the number of incidents that have occurred as a result of human error. HSG254 describes a six step approach to developing process safety indicators, in brief these are: 1. establish the organisational arrangements to implement the indicators 2. decide on the scope of the measurement system 3. identify the risk control systems, decide on the outcomes and set lagging indicators 4. identify critical elements of each risk control system and set leading indicators 5. establish data collection and reporting system 6. review data and take action. Step 3 should include the identification of underlying causes in process incidents as well as identifying risk control systems that are in place to prevent or mitigate the effects of the incidents identified.

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		Understanding of risk control systems is facilitated by, for instance, the 'bow-tie' diagram and barrier diagrams (e.g. Reason's 'Swiss Cheese' Model). Consideration should be given to each risk control measure identified on the diagram as a relevant measure in order to effectively manage process integrity.
1.6.2	**Allocation of responsibilities** How have responsibilities been allocated between onshore and offshore staff?	Organisations need to decide how to allocate responsibilities for monitoring at different levels in the management chain, and what level of detail is appropriate. In general, managers should monitor the achievement of objectives and compliance with standards for which their subordinates are responsible. Managers and supervisors responsible for direct implementation of standards should monitor compliance in detail. Above this immediate level of control, monitoring needs to be more selective, but provide assurance that adequate first line monitoring is taking place.
1.6.3	**Process Safety Leadership** Do the most senior managers within the organisation routinely receive information on process safety performance? How is the information used? What impact does it have on the management of process safety risks? What changes have been made within the organisation as a result of the information provided? Are the process safety indicators set at: plant/installation; site; organisational level; or a combination of the above? How was the scope of the indicators set? Are they based on: process safety and major hazard risk profile, where greater business assurance is needed, or improvement programmes?	Directors and senior managers should be actively involved in the control of business risks (corporate governance). (HSG254 page 7 Step 1.3). Senior managers should understand fully the business benefits of performance measurement and clearly see how managing process safety contributes to the success and sustainability of their company. Performance indicators should be used to show the status of the process safety management system. Direct and tangible action should be taken to make improvements where necessary based on the information gained from performance indicators. (HSG254 page 14, Step 3.4 & page 17, Step 4.4). The indicators should be chosen to provide the management team with the right scope and level of information they need to be satisfied that process safety risks are under control The management should: actively participate in the development of indicators and the setting of tolerances; routinely see and act upon the information provided from the process safety measurement system. (HSG254 page 7 Step 1.3). Both leading and lagging indicators should be used to monitor specific process safety risks (HSG254 page 2 Figure1: Dual Assurance). Information from the measurement system should have a clear and tangible impact on the management of process safety risks.

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1.6.4	**Content of monitoring programmes** Do the formal monitoring arrangements include: • change control • isolation practices • control of locked valves • control of overrides on process protection systems • adequacy of local risk assessments etc.?	Various forms and levels of active monitoring include: • examination of work and behaviour • systematic examination of premises, plant and equipment by managers, supervisors, safety representatives, or other employees to ensure continued operation of workplace risk precautions • the operation of audit systems • routine monitoring of progress towards specific objectives e.g. training / competence assurance objectives. Many of these topics are not specific to process integrity, but are equally applicable to all areas. Topics which are of particular relevance to process integrity, however, include: Permit to Work Systems, isolation standards, change control, HAZOP close out, procedural controls for process plant protection systems, controls at HP / LP interfaces, operating procedures, workplace risk assessments etc.
1.6.5	**Records** What records are kept, how are the results reviewed, and actions implemented?	Verification that suitable records are accurate, complete and being maintained (e.g. a record of risk assessments). Safety case regulations covering offshore installations require duty holders to keep more detailed records of process hazards, risks and precautions.
Legal Basis	MHSWR Reg. 5 places a general obligation on employers to monitor preventive and protective measures. SCR Reg. 13 management of health and safety and control of major accident hazards. The measurement of process safety indicators is recognised good practice (ref. HSG254).	
1.7	**Audit and review of process plant and management systems**	
1.7.1	**Audit scope** How is process integrity catered for in the audit programme?	HSG 65 refers to auditing as the structured process of collecting **independent** information on the efficiency, effectiveness, and reliability of the **total** health and safety management system, and drawing up plans for corrective action.
1.7.2	**Audit description**	**Auditing** is not a substitute for active monitoring. Auditing supports monitoring by providing managers with information on how effectively the SMS is being implemented. The aims of auditing should be to ensure that appropriate management arrangements are in place, adequate risk control systems are implemented, and workplace precautions are in place. Various methods can achieve this, and some parts of the system do not need to be audited as often as others. AIChE Guidelines draw a distinction between process safety auditing, and Process Safety Management System (PSMS) auditing. Both types are important. Process safety auditing focuses on specific hazards (e.g. hardware systems). PSMS auditing, involves assessment and verification of the management systems that ensure ongoing control (e.g. the management systems in place to ensure that pressure relief devices have been designed, installed, operated, and maintained in accordance with company standards).

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1.7.3	**Audit implementation** What process management audits have been carried out in the past 3 years, and how have they been organised? (Aim to form a judgement on the adequacy of these audits)	The auditing process should involve the collection of information about the offshore installations and management system providing the duty holder with an impression of how effectively the process safety management system is controlling risk, so that judgements can be made about the adequacy and performance of the system.
1.7.4	**Review of audits** How are process-related audits and monitoring activities reviewed, and improvement programmes developed?	**Reviewing** should be based on information from measuring (i.e. active and reactive monitoring) and auditing activities. Organisations should clarify how process integrity is to be included in the review process. In all reviewing activity, the result should be specific remedial actions which establish who is responsible for implementation, and set deadlines for completion.
1.7.5	**Reviews of process plant** What reviews have been carried out of process plant against current standards?	Standards change, and it is good practice to review the adequacy of existing plant against current standards from time to time (say every 5 years).
Legal Basis	SCR Reg. 12 require an audit system which is adequate for ensuring that relevant statutory legal provisions, including the provisions relating to process integrity in PFEER and DCR, are complied with. Process integrity safety management systems audits are recognised good practice. MHSWR Reg. 5 require effective arrangements for monitoring and “review” of preventive and protective measures.	

Part 2 - Small bore tubing and piping systems

This part reviews the way in which small bore tubing and piping systems are managed, together with small bore flexible hoses which may be used for hydrocarbon duties. The guidance notes are largely based on Institute of Petroleum / Oil and Gas UK "Guidelines for the Management, Design, Installation and Maintenance of Small Bore Tubing Systems".

Item	Inspection Topic	Guidance Notes
2.1	**Management Systems for Small Bore Tubing**	
2.1.1	**Overview** Have the management arrangements been reviewed against IP / Oil and Gas UK Guidelines, or has the duty holder (DH) got other appropriate guidelines to work to?	The DH should ensure that the integrity of small bore tubing system over the whole life of the plant is addressed within the management system. This should be achieved as a matter of management policy by specifically identifying small bore tubing systems within the engineering design, construction, maintenance and operations standards and procedures, with special emphasis being placed on personnel competency.
2.1.2	**Responsibilities** Are responsibilities / accountabilities adequately defined for management of small bore tubing?	IP Guidelines state that responsibility for carrying out management policy should be allocated to technical authorities within the management system. The monitoring of the implementation of the policy should be specifically included within the Technical Audit programme.
2.1.3	**Training and Competence** How is competence established / assured?	IP guidelines states that the duty holder should have a formal competence assurance scheme which ensures that all the personnel (company and contractor) required to work on small bore tubing systems are formally assessed as being competent to work with small bore tubing and fittings. Such a scheme should cover the range of knowledge and task skills appropriate to small-bore tubing and fittings on the installation.
	Is there a register of competent persons?	The DH should ensure the long-term retention of competence by periodic reassessment of personnel. Personnel assessed as being competent should be registered as being 'Authorised' to carry out the range of tasks in which they have been assessed as being competent.
	How is the competence of vendors addressed?	Management procedures should ensure that Vendor personnel employed on short term construction or maintenance work are competent to carry out such work and it is recommended that their competence is also recorded in the register of authorised personnel.
2.1.4	**Standardisation Policy and Procedures** Do the DH procedures address the issue of standardisation for small bore tubing and fittings?	A control and standardisation policy for the technical management and minimisation of small-bore tubing and fittings types should be developed, documented and implemented for each new and existing installation. On installations where several makes and types of tubing and fittings are already present, it may not be reasonably practicable to change all systems. In this case it should be demonstrated that the range of fittings and tubes have been minimised to a manageable level, and that personnel competencies are consistent with the residual inventory. Policy and Procedures should address the following:

Item	Inspection Topic	Guidance Notes
		• preferred fitting and tube types per plant • the fitting and tube type per system or sub system • the planned fitting and tube type migration per system or sub-system • the strategy to minimise the inventory by design-out, refurbishment and ad-hoc maintenance activities • a company or installation directive for new and replacement systems to comply with the preferred equipment requirement • vendor compliance with the policy.
2.1.5	**Maintenance and Operational Procedures** Does the DH have specific maintenance and operational procedures for small bore tubing? Have these been reviewed against the IP / Oil and Gas UK Guidelines?	Procedures should include: • the overall integrity of the system • visual inspection of compression fittings for correct component selection and correct make-up (with use of manufacturer's gauge as applicable) • process leakage or seepage from compression joints and pipe thread connections • sample disassembly of compression fittings to check for correct make-up, tube penetration and internal corrosion of tube and clamp • examination of support and mounting for vibration control • check to identify possible problems with maintainability, i.e. access, corrosion, ease of removal etc. • minimum of full three threads engagement on fully assembled joints.
2.1.6	**Reinstatement Procedures** Do the maintenance and operational procedures cover reinstatement of small bore tubing and fittings?	Procedures for pressure testing and leak testing should be available for: • reinstatement of systems which have been subject to extensive disconnection or involves the installation of untested fabricated equipment, and for • reinstatement of individual impulse lines which have been subject to minor disconnection. Adjustment and rework should not be permitted on systems whilst pressurised or not adequately isolated.
Legal Basis	PUWER Regs 3,4,5,6,8 and 9 require employers, and duty holders (Reg. 3), to ensure: Work equipment is constructed or adapted so as to be suitable for the purpose for which it is provided (Reg. 4); work equipment is maintained in an efficient state, efficient working order, and good repair (Reg. 5); where work equipment is of a type where safe operation is critically dependent on it being properly installed, (or reinstalled) the equipment is inspected before being put into service, and at suitable intervals (Reg. 6); people who use work equipment have adequate health and safety information, and written instructions (Reg. 8); all persons who use work equipment have received adequate training (Reg. 9). PFEER Reg. 5 and 9, and MHSWR Reg. 5 are also relevant.	
2.2	**Control of Risks from Vibration**	

Item	Inspection Topic	Guidance Notes
2.2.1	**Identification of Vibration Problems** Has the DH identified any piping vibration problem, or given consideration to the potential existence of such a problem?	Process piping systems have traditionally been designed on the basis of static analysis with little attention paid to vibration-induced fatigue. Significant contributory factors to vibration related fatigue failures have been: • increased flowrates as a result of debottlenecking and relaxation of erosion velocity limits, resulting in greater level of turbulent energy in process systems • greater use of thin walled pipework made possible by the use of new higher strength materials (i.e duplex stainless steel), resulting in more flexible pipework and higher stress concentration at small bore connections.
2.2.2	**Assessment of Vibration** Does the DH have a structured assessment methodology to identify potential problem areas? Has the duty holder addressed the issue of excitation mechanism in the methodology? (Stage 1) What further analysis of the vibration sensitive system has been undertaken? (Stages 2 and 3)	The DH should have a structured assessment methodology in place. A suitable assessment may include the following three stages, or similar process: **Stage 1:** Divide the plant into manageable systems and identify whether there is a potential problem for each system. The possible excitation mechanisms for each system are: • flow induced turbulence • high frequency excitation • mechanical excitation • pulsation **Stage 2:** A system that has been identified to have a problem should be further analysed to determine the extent to which the potential excitation mechanism will cause vibration problems in pipework. If the likelihood of failure is high or medium, then a stage 3 assessment should be undertaken. **Stage 3**: In this stage, the features of the small bore pipe and its connection to the main pipe should be reviewed. The contribution of each feature to the likelihood of failure of the small-bore connection (SBC) should be identified. Important features are type of fitting (i.e. weldolet, contoured body, short contoured body etc.), length of branch, number and sizes of valves, main and small bore pipe wall thickness (schedule), small bore connection diameter, location of small bore pipe on the main pipe.

Item	Inspection Topic	Guidance Notes
2.2.3	**Remedial Actions following Stages 2 and 3** Has the duty holder identified remedial actions following a structured assessment? Have these actions been implemented?	If likelihood of failure is assessed as high in Stage 2, then where possible the main pipe should be redesigned, re-supported, or a detailed analysis conducted. In addition, the small-bore pipe connection should be assessed as in Stage 3. The following design solutions could be applied to reduce failure of a SBC due to vibration: • the fitting and overall unsupported length should be as short as possible • mass of unsupported valves / instruments should be minimised • mass at the free end of a cantilever pipe assembly should be supported in both directions perpendicular to axis of the small bore • supports should be from the main pipe, to ensure that the small bore connection moves with the parent pipe • diam. of small bore connections should be maximised
Legal Basis	See Legal Basis in Section 2.1 for details	
2.3	**Small Bore Tubing Systems in Practice**	
2.3.1	**Field Installation practice** How is interchange of sub-components prevented? How are fittings inspected prior to installation and on completion? What training / competence assessment has been carried out, and how is work on small bore tubing restricted to competent persons?	The DH should make procedures available to installation personnel who deal with the selection, assembly and inspection of the range of tubing and fittings that they will encounter. The following instructions should be part of these procedures: • it is not permissible to interchange sub-components of different designs or types of fittings • the installation and assembly of particular types of small bore tubing and fittings must be made in accordance with the manufacturer's instructions. (Note: these can be different between manufacturers and between fitting sizes of the same manufacturer) • it is essential that fitting is inspected on completion using gauges where available or by other methods recommended by the manufacturers • appropriate tools should be defined and used and special tools, such as hydraulic swaging machine should be considered for fittings of larger sizes of fittings and tubing.
2.3.2	**Integrity of supporting arrangements** Are the supporting arrangements in accordance with specified arrangements? (To be examined for selected systems)	Tube support should be provided as per manufacturer's instructions to prevent unacceptable stresses on fittings e.g. eliminate sagging and vibration. Valves, gauges etc. should be independently mounted. Expansion loops should be provided as per design. Tube support material should be as per design specification. Tube systems should be adequately supported as necessary when connections are being tightened or uncoupled.
2.3.3	**Isolation practices and standards** Does the DH's isolation	Guidance on isolation for instrumentation is provided in HSG253 "The safe isolation of plant and equipment" Appendix 9.

Item	Inspection Topic	Guidance Notes
	procedure address the particular requirements for small bore tubing? How do isolation standards on site compare with recommended practice? Are ends that are open to atmosphere plugged or blanked?	A primary isolation valve (piping standard) should be located close to the pipe or vessel, and be to the same standard of pressure integrity. Instrument connections beyond the primary isolation facility are sometimes less robust than the primary connection e.g. compression fitting may be used in the impulse tubing and the instrument may use components such as flexible hoses or sight glasses. Instruments will generally be provided with local isolation facilities that, together with the primary isolation, can provide a double block and bleed isolation. Drain, vent and test points should be provided with valves to close them off when not in use.
2.3.4	Is there any evidence of vibration problems on site, or of remedial actions from vibration assessment not implemented? How does the DH assure the integrity of plant against vibration-induced fatigue? [Gascet section 4.3.3]	Guidance can be found in the EI/HSE publication "Guidelines for the Avoidance of Vibration Induced Fatigue in Process Pipework" 2nd Edition, 2008. There are various signs and indicators of possible vibration issues including: • Fatigue failure or damage to plant on items such as small bore connections, instrumentation, connections or braces; • Damage to supports, connections, or braces; • Fretting of pipework and/or associated structures; • Weeping/leaking from instrument tubing; and • Perceived high levels of noise and vibration.
Legal Basis	See Legal Basis in Section 2.1 for details	
2.4	**Control of Small Bore Flexible Hoses for Hydrocarbon Duty**	
2.4.1	**Management of flexible hoses** Awareness of published EI/Oil & Gas UK/HSE guidance (Feb 2011) 'Guidance for the management of flexible hose assemblies'. What systems / procedures are in place for selection and use of small bore flexible hoses in hydrocarbon or other hazardous service? Competence and awareness.	The EI/Oil & Gas UK/HSE guidelines provide advice on the whole lifecycle of flexible hose management. Duty holders should ensure that integrity of small bore flexible hoses used on hydrocarbon/hazardous processing plant is addressed within their management system. Elements should include consideration of design, risk assessment, construction, installation, commissioning, operation, maintenance, testing, modification and decommissioning. Persons responsible for hose selection, maintenance or use should be suitably competent and aware of safety critical factors affecting hose integrity through an understanding of hose constructional elements and their function in maintaining integrity, failure modes, failure criteria, etc. More detail is given in Annex A of the EI/Oil & Gas UK/HSE guidelines.

Item	Inspection Topic	Guidance Notes
2.4.2	**Risk Assessment, Selection, Installation and Performance** Are hose assemblies being used in suitable applications? Have hose assemblies been subjected to a suitable risk assessment and classification process? Are hoses installed to recognised good practice?	Hose assemblies should only be used in hazardous duties where permanent piped solutions are not suitable or do not offer a safer alternative solution. Hoses should be classified according to the consequence of failure. The EI/Oil & Gas UK/HSE guidelines offer one approach for risk assessment and classification of hoses. When deciding upon the performance and safe operational requirement of a hose, parameters for consideration include (see Annex F of EI/Oil & Gas UK/HSE guidelines): • compatibility of inner liner material with the media to be carried • compatibility of outer cover with working environment • flow requirements • pressure and temperature range • the operational environment - length, flexibility and bend radius • weight, compactness and support requirements • volumetric expansion, movement under loading • compatibility of hose with end fittings, and fitting compatibility with media and operational environment.
2.4.3	What maintenance, inspection and monitoring procedures are in place for small bore flexible hoses?	All hoses in critical service applications should be examined on a regular basis, to assess their suitability for continued service. Inspection frequency and criteria should be developed from the risk assessment derived from the classification process as per clause 2.4.2 (above). Hoses and their fittings should be visually examined for physical damage against defined criteria including: (a) blisters or bulges (b) looseness of the outer cover (c) excessive softening or hardening of the hose (any of these three points may indicate fractured or displaced reinforcement or a leaking liner) (d) kinks, twists (poor installation) (e) abrasion, cuts, excessive elongation under load or test (f) end coupling integrity. Inspection and rejection criteria are given in the EI/Oil & Gas UK/HSE guidelines section 8.5.3. Any hose exhibiting cover cracks, cuts or bulges should be removed from service, examined and retested as necessary. Any hose with reinforcement exposed should be removed from service and replaced if extent of damage exceeds manufacturer recommended limits. If in doubt, hoses displaying visible faults should be replaced.
2.4.4	**Testing / records / tagging** Check the DH's test records, inspection records and tagging arrangements.	Pressure testing should be carried out in compliance with relevant vendor's procedure. Records of visual examination should be kept, recording the condition of the hose on a particular date and the date of next inspection. The hose should be tagged with the latest inspection date and the date of next inspection.
Legal Basis	See Legal Basis in section 2.1 for details	

Item	Inspection Topic	Guidance Notes
	SCR requires safety critical elements to be verified by independent competent persons. This may include flexible hose assemblies. Pressure Equipment Regulations 1999 (PER) applies to fixed installations between well and pipeline, for equipment installed by the manufacturer, which may include flexible hose assemblies. PER does not apply to mobile offshore drilling units (MODUs) and equipment assembled under the responsibility of the user, including well control equipment and pipelines.	

Part 3 - Information, instructions and training

This part reviews the way in which documentation for process integrity is maintained, key communications managed, and competence assured. It involves a mix of onshore and offshore inspection; inspectors will need to decide on the best place to obtain the relevant information.

Item	Inspection Topics	Guidance Notes
3.1	**Design data / as built status**	
3.1.1	**Document control procedures** What procedures are in place for retaining design data and updating to built status as changes take place?	The SMS should ensure that information is kept current throughout process changes, equipment maintenance, and other normal activities. Responsibility should be assigned, and resources allocated to this.
3.1.2	**Data for process equipment** Select a few examples of process plant to verify that a system exists to ensure data sources are reliable, up to date, and available to people who need to have access to them. How is documentation updated after changes to process or equipment specifications?	Specification sheets should be provided for each piece of process equipment such as pumps, compressors, vessels, heat exchangers, pressure relief / safety valves etc. These sheets should typically show the design codes and standards used, the expected process conditions, the design conditions, the materials of construction, and other mechanical details. Much of the process design information is normally shown on Process Flow Diagrams, which can show information in varying levels of detail. During the life of a plant, modifications are made to process and equipment. Each change should be evaluated to assure that the process safety design is not compromised, and equipment data sheets should be appropriately updated.
3.1.3	**Data for instruments** Check that up to date data sheets are available for a few key examples of protective instrumentation.	Instruments which may be important to maintaining process safety include sensors, transmitters, controllers, control valves, pressure reducers etc. Each of the instruments should have a specification sheet, with design conditions, required materials of construction for the portions in contact with process fluids, as well as the range it must cover, and its protective function.
3.1.4	**Data for piping systems** Check what documentation is available on specifications for piping systems.	Piping specifications include, for each line, the type of pipe used along with data on the types of fittings, valves, and gasket materials that are acceptable for the expected process materials and conditions, and the acceptable standards and conditions that the piping components must meet.
3.1.5	**Vendor data** Check the availability of relevant documentation.	Since there are usually only a limited number of copies of technical data for these units, at least one set of the vendor documents should be maintained on a central file with controlled access. Other copies may be utilised where most required for reference or troubleshooting.
3.1.6	**P&IDs** Check the status of P&IDs. When were they last updated, and how have recent modifications been incorporated?	P&IDs show all process and utility piping, instrumentation and protective systems. These drawings also typically show design temperature and pressure ratings for vessels, piping specifications, relief valve settings, capacities of vessels etc. Vendor packages within a process should be identified

Item	Inspection Topics	Guidance Notes
	Do P&IDs identify vendor package boundaries? Are locked valve positions identified on P&IDs?	on P&IDs. Where control of process safety is dependent on procedural arrangements for control of valve positions (e.g. locked valve controls on shutdown valve bypasses, at HP / LP interfaces, or on pressure relief systems).
3.1.8	**Cause and Effects Diagrams** Check that an up to date C&E chart is available.	API RP 14C states that a safety analysis function evaluation (SAFE) chart (similar in format to a cause and effect chart) should relate all sensing devices, SDVs and emergency support systems to their functions. (No other specific guidance has been found on cause and effect diagrams, although they are established practice offshore).
Legal Basis	PUWER Reg. 8 requires employers to ensure that all persons who use work equipment have …adequate health and safety information and, where appropriate, written instructions. HSWA s2(2)(c) requires the provision of such information, as is necessary.	
3.2	**Safe Operating Limits and Process Plant Protection Settings**	
3.2.1	**Identification of Safe Operating Limits** Check how safe operating limits are recorded.	Safe operating limits should be specified for pressure, temperature, level and flow, and other parameters that may be applicable, such as process composition or material additions.
3.2.2	**Protection settings** Check that there is an unambiguous, up to date register of trip and alarm settings, and that actual settings correspond with the register. (Check a few examples, including devices that may have been subject to application of overrides, or systems that have been changed recently).	A register of trip and alarm settings should be readily available for each installation.
Legal Basis	DCR Reg. 7 requires the duty holder to ensure that the installation is not operated unless appropriate limits within which it is to be operated have been recorded. PUWER Reg. 8 requires employers to ensure that all persons who use work equipment have … adequate health and safety information and, where appropriate, written instructions.	
3.3	**Identification of Plant and Equipment**	
3.3.1	**Identification of plant and equipment on site** Check a few examples of vessels, valves and instruments on site to verify the adequacy of identification.	Process vessels, valves and instruments should be clearly marked to facilitate identification. Accurate identification of lines, valves, and equipment is important to promoting safe isolations. There have been several examples of incidents where the wrong item of equipment has been operated or maintained. Process theme audits have revealed installations where not all relevant items have been marked.
Legal Basis	PUWER Reg. 8 requires employers to ensure that all persons who use work equipment have … adequate health and safety information and, where appropriate, written instructions. PUWER Reg. 23 places duties on employers to ensure that work equipment is marked in a clearly visible manner with any marking appropriate for reasons of health and safety.	

<table>
<tr><th>Item</th><th>Inspection Topics</th><th>Guidance Notes</th></tr>
<tr><td>3.4</td><td colspan="2">Operating Procedures</td></tr>
<tr><td>3.4.1</td><td>Availability of procedures

Are up to date procedures available for each section of the process plant?</td><td>Operating procedures should be kept up to date, and there should be systems in place to ensure that process changes are incorporated. The procedures should be periodically reviewed for accuracy and completeness. (Problems with operating procedures being inadequate, or out of date, have been noted in Theme Audits conducted by OSD).</td></tr>
<tr><td>3.4.2</td><td>Scope of procedures

Do the procedures address each phase of operation? (Select a section of plant and examine the procedures in detail)</td><td>Operating procedures should contain clear instructions for each phase of operation, including initial start up, normal operation, emergency operations (including emergency shutdown), normal shutdown, and startup following emergency shutdown or a turnaround.

In addition, operating procedures should be developed whenever a temporary operation is to be conducted.</td></tr>
<tr><td>3.4.3</td><td>Safety Information

Do the procedures include reference to safe operating limits, and actions to take in response to alarms as the limits are being approached?</td><td>In addition to describing the sequence of actions to be taken, the procedures should describe safe operating limits, and other safety information related to the process.</td></tr>
<tr><td>3.4.4</td><td>Style / language

Are the procedures in a form that the operators find suitable?</td><td>The procedures should be written in language and terminology clearly understandable to the operators.</td></tr>
<tr><td>Legal Basis</td><td colspan="2">PUWER Reg. 8 requires employers to ensure that all persons who use work equipment have … adequate health and safety information and, where appropriate, written instructions.</td></tr>
<tr><td>3.5</td><td colspan="2">Shift / Crew Change Handovers</td></tr>
<tr><td>3.5.1</td><td>Has a standard procedure been developed for handovers?

Does the procedure recognise and make provision for the high risk situations indicated?

Does the procedure specify simple steps to improve communications?

Are crew change handover notes written in a structured log format?</td><td>Effective communication is particularly important when responsibility for a task is handed over to another person or work team. This can occur at shift changeover, between shift and day workers, or between different functions within a shift (e.g. operations and maintenance). High risk situations include:

• maintenance carried out across a shift change
• deviations from normal working
• crew change situations, and
• handovers between experienced and inexperienced staff.

Organisations should have procedures which specify simple steps to improve communications at shift / crew change. These include:

• carefully specifying what information needs to be communicated, cutting out the transmission of unnecessary information
• using structured logs or computer displays
• ensuring that key information is transmitted both verbally and in writing, encouraging two way communication etc.</td></tr>
</table>

Item	Inspection Topics	Guidance Notes
Legal Basis	MHSWR, Reg. 5 requires arrangements for planning and control ... of preventive and protective measures. HSWA, s2(2)(c) requires the provision of such information ... as is necessary. PFEER Reg. 9 requires duty holders to take appropriate measures with a view to preventing fire and explosion....	
3.6	**Monitoring of Documentation**	
3.6.1	What arrangements are there in place for monitoring (or auditing) the status of documentation? including: • documentation relating to as built status • definition of safe operating limits • protection settings • operating procedures • handover arrangements • plant condition records, and • control room records.	MHSWR Reg. 5 requires arrangements for monitoring of preventive and protective measures.
Legal Basis	MHSW Regs 1999, Reg. 5 requires arrangements for planning and control and monitoring of preventive and protective measures.	
3.7	**Training / Competence**	
3.7.1	**Training for process personnel** What safety related process specific training has been provided for production personnel? What training has been given in control of change procedures, and hazard analysis / risk assessment?	Process specific training should deal with: The basic process, design of plant, critical factors which affect safety, and process safety considerations relating to flammability, explosivity, toxicity. Operating procedures, including safe operating limits, actions to keep within those limits, procedures for start up, normal operation and shutdown, and contingency procedures for upsets / emergencies. Training should also be given as appropriate in management of change procedures and in techniques for hazards analysis and risk assessment.
3.7.2	**Competence assurance** How has competence been established / assured for production personnel?	Quality assurance processes, procedures and methods should be developed which are designed to ensure the competence management system consistently achieves the intended results. Lead bodies such as OPITO set competence criteria on which qualifications can be based. The Qualifications and Credit Framework (QCF) is available for process operators and maintenance technicians, and many companies have in-house schemes.
Legal Basis	MHSWR places specific requirements on employers to provide information for employees (Reg. 8), take their employees capabilities into account, and ensure they are provided with adequate health and safety training (Reg. 10). There is no legal requirement for a specific competence assurance programme, but such programmes are recognised good practice (e.g. Oil and Gas UK and E&P Forum Guidelines).	

Part 4 - Isolations and permits to work

This section covers isolation standards, locked valve controls, extended term isolations, isolations for relief and vent systems, permit systems and monitoring arrangements. It is largely based on HSG 253 "The safe isolation of plant and equipment" and HSG250 "Guidance on permit-to-work systems".

Item	Inspection Topics	Guidance Notes
4.1	**Isolation Standards and Procedures**	
4.1.1	Have standards and procedures for isolations been reviewed / revised against HSG 253, for safeguarding against releases from pressurised systems? Are offshore responsibilities clear and adequate planning arrangements in place? Are human factors adequately considered? Is the isolation selection procedure based on risk assessment? Does implementation offshore match HSG 253?	HSG253 addresses the need for: • clear identification of plant and equipment • isolation standards to reflect foreseeable risks and consequences • initial testing of isolations • security of isolation throughout the activity • documentation of the isolation • personnel competent regarding hazards, plant, procedures and skills. [paras. 49-57]. The guidance describes how roles and responsibilities are defined, what planning is required, and the importance of co-operation and communication [47-48]. Incident analysis confirms that human failures cause, or are involved in, a large proportion of isolation failures. The performance of isolations depends not only on the integrity of the isolation hardware, but also on the adequacy of the arrangements for identifying each isolation point, securing the isolation, proving/monitoring and maintaining overall control of work. Examples of human failures relevant to isolation include: • failure to complete or reverse isolations fully before starting work or restarting plant; • failure to prove and monitor isolated valves; • poor communication (eg at shift handover); and • failure to check P&IDs/schematic diagrams against the actual installed plant and equipment. Appendix 6 of HSG253 describes a risk-based way of selecting an appropriate method of isolation, based on situation, substance, pressure, line size, frequency and duration. Implementation will normally include: • a local or company-wide procedure [107-108] • isolation for generic operations • a means to assess non-standard and short-term isolations [128-140] • clear hand-over/renewal procedures • isolation certificates and risk assessments, usually linked to the permit system [69-86] • a competence assurance programme for users [49-57] • monitoring, audit and review procedures [58-66].

Item	Inspection Topics	Guidance Notes
Legal Basis	HSWA s.2 requires the provision of safe systems of work… MHSWR Reg. 3 requires assessment of risks to health and safety PFEER Reg. 9 requires safe production, processing, etc. of flammable and explosive substances, and prevention of their uncontrolled release. PUWER Reg. 8 requires employers to ensure that all persons who use work equipment have adequate health and safety information and, where appropriate, written instructions.	
4.2	**Locked Valve Controls**	
4.2.1	Are locked valves marked on diagrams?	Some process valves are specified as locked open or locked shut, and are marked "LO" or "LC" on diagrams. e.g. open valves on vent and drain lines, and closed valves on bypasses around ESD or control valves. It is important that such valves are kept in the correct position, as they may be a primary means of preventing high pressure from entering low-pressure plant.
	Are valves identified, marked and locked? (small sample to be checked)	The reason for designating a valve as locked-open or locked-closed should be known to personnel. Often the need for locking stems from a HAZOP study or a more specialised HP/LP interface study. Any changes should be subject to a formal change procedure.
	Are keys adequately controlled?	Valves should be clearly identified by name or number, on or near the valve, and on diagrams. Valves should be positively secured so that significant movement is prevented, for example by mechanical interlock, key switch or padlock and chain. If keys are used, access to them should be controlled.
	Is a register available, and is a checking procedure being properly used?	Valve status should be periodically checked, with the frequency taking into account the potential consequences of the valve being in the wrong position. More critical valves, such as any in ESDV vent lines, should be checked at least monthly. Valves should be identified on a readily available register, with details of each valve, its location and status, and the checks carried out, including the date, the person doing the checking and the results.
Legal Basis	See 4.1 above	
4.3	**Extended term isolations**	
4.3.1	Is a register used? Is there a procedure for checking long-term isolations? Are there arrangements for periodic review?	Process equipment may be isolated for extended periods of time (sometimes permanently) because it is not commissioned, redundant, only used infrequently or awaiting repair or modification. Such items can be hazardous if personnel try to make use of them without proper re-commissioning procedures. [HSG 253 paras. 203-205] The reason for isolation may be forgotten, allowing an undesirable situation, tolerated on a temporary basis, to become permanent. Typical precautions are:

Item	Inspection Topics	Guidance Notes
		• A register, readily available to personnel, identifying all long-term isolations and the reasons for isolation • A procedure for checking the status and integrity of each isolation • A system for periodic review of the status of each item, to decide if the isolation is still appropriate, if the plant should be removed, or if other action should be taken.
Legal Basis	See 4.1 above	
4.4	**Isolations for relief and vent systems**	
4.4.1	Are all valves locked or interlocked? Are locks / interlock keys controlled? Are operating instructions available? Are specification breaks marked? Do interlocks cater for specification breaks?	Relief systems are required to be operational at all times when the plant being protected is, or is liable to become, pressurised. Similarly vent lines need to be kept open to allow a safe path to atmosphere from process equipment. Isolation valves are undesirable because they can be left in other than completely open positions. Often however valves are installed to allow maintenance to be done on a live system, for example when two relief valves are used in parallel, one on-line and one off-line. A system is then required to ensure one valve is always on line, preferably in the form of mechanical interlocks on the isolation valves on each relief valve branch. Locking is also an acceptable standard provided there are effective procedures to monitor the isolations. The use of interlock keys should be controlled, particularly if spare or master keys exist for maintenance purposes. Authorisation of the use of spare/master keys by a supervisor's signature in a register is recommended, with a procedure that requires alternative precautions (such as depressuring the plant) to be identified and implemented. Operating instructions for interlock systems should be available, with personnel trained in their use. Maintenance of the system is required, as keys and lock mechanisms can wear and keys can become misplaced. The pipework downstream of a relief valve may be rated for a much lower pressure than that upstream, because it only sees the relatively low back-pressure generated during blowdown to the open vent or flare. The specification break is normally at a flange, and should be marked on a P&I diagram. If the downstream isolation valve of a relief valve system is to the lower rating, the interlock should also ensure this valve cannot be closed when the upstream isolation valve is open. This is because if the relief valve is passing, full line pressure can build up on the downstream valve, with a risk of catastrophic failure.
Legal Basis	See 4.1 above	
4.5	**Permit to Work Systems**	
4.5.1	Is the guidance followed?	Although permit systems are generally effective in

Item	Inspection Topics	Guidance Notes
	Are tasks and limits clearly identified? Are precautions clearly specified? Are job-specific factors considered? Are risk assessment outputs used in conjunction with permits? Are end-of-shift actions clear? Is guidance given on interruptions, or unusual events?	controlling risks, weaknesses can occur: This guidance is based on HSG250, "Guidance on permit-to-work systems". Task definition HSG250 [paras. 52-56]. The work required should be clearly identified, if necessary with specific limitations on what is to be done or not done. Relevant procedures should be referenced. Precautions should likewise be specific, and either listed in detail or reference made to procedures containing the precautions, which should be readily available and known to those involved. Phrases such as "Take the usual precautions" are not suitable, even for familiar tasks. Each job should be considered afresh, to identify any factors that make it different from previous occasions. Work planning is described in paras. 52-56 of HSG250, which includes a flow diagram to illustrate the process. Risk assessment should be closely linked to permit systems. This means that a risk assessment should either be performed at the time the permit is issued, or available from previous. In either case the output from the assessment, in terms of the precautions required, should be transferred to the permit form as actions to be carried out before the work is started. A list of tick-boxes on the permit form for the issuing authority to consider may not be adequate. Handovers [paras. 23-24]: the permit procedure should be clear about end-of-shift actions. Permits are cancelled and re-issued, if required, for the new shift, or reviewed and endorsed by the new shift supervisor to allow the work to continue. In either case the procedure should specify an effective handover from one shift to the other. Work interruptions/suspension [paras.19-21]: the permit procedure should give guidance on the actions to take if the work is interrupted, such as for a gas alarm. Likewise the actions to be taken if something unusual crops up during the work should be described.
Legal Basis	See 4.1 above	
4.6	**Monitoring of PTW and isolation procedures**	
4.6.1	Is formal monitoring of the PTW and isolation arrangements undertaken? Is the content of monitoring programmes adequate to ensure satisfactory isolation standards in practice?	Monitoring is an important part of line management duties, but may be overlooked because personnel are considered competent. However, management needs to know if personnel are working to procedures and instructions. This type of monitoring should be described in the SMS. See paras. 58-68 of HSG253 Monitoring arrangements should include: • Compliance with the company PTW procedure

Item	Inspection Topics	Guidance Notes
		• Compliance with the company isolation procedure • Adequacy of assessment of non-standard isolations • Locked valve control procedures • Extended term isolations • Relief system isolations, including locks and interlocks
Legal basis	MHSWR, Reg. 5 places an obligation on employers to monitor preventive and protective measures.	

Part 5 - Process plant protection systems

This part examines the way in which process excursions are prevented from violating the safe operating envelope of the process equipment. It includes both instrumented protection systems, and relief and blowdown systems. It is intended for offshore inspection, although in some cases reference onshore may be required to expand on the initial offshore responses e.g. aspects of the documentation system.

Item	Inspection Topics	Guidance Notes
5.1	**Instrumented protection and ESD systems**	
5.1.1	**Safety Criticality** Are protective functions identified as safety critical elements? Has the safety criticality of instrumented protective functions being established using suitable guidance?	The safety criticality of each instrumented protective function should be established. EEMUA 'Guideline to the Application of IEC 61511 to Safety Instrumented Systems in the UK Process Industries' should be consulted along with the various parts of EN 61511 Functional safety —Safety instrumented systems for the process industry sector. Another useful document is ISO 10418 Petroleum and natural gas industries — Offshore production installations —Basic surface process safety systems. Application of IEC 61511 to safety instrumented systems makes use of Safety Integrity Levels (SILs). The higher the SIL level the more critical the safety function. Functions designated as 'safety critical elements', must be identified and verified in accordance with SCR 19 These typically include trip systems, fire and gas, HIPS, relief and blowdown systems. EN 61508 (Functional safety of electrical / electronic / programmable electronic safety related systems) Part 5 and EN 61511 Part 3 both discuss the various methods used to determine SILs. The methods described include risk graphs, LOPA methods, risk matrices and QRA. Shutdown systems provide an instrumented means of protecting plant and equipment from conditions outside the design basis. By isolating inventories and effecting blowdown they also provide means for mitigating some of the hazards arising following loss of containment. Trip systems provide an instrumented means of protecting plant and equipment from conditions that could lead to circumstances outside the design basis. Trip systems shutdown items of plant when significant deviations from normal occur.
5.1.2	**Documentation** Is there documentation available that identifies protective functions as SCEs? Is there further information on e.g. performance standards, cause and effects analysis, trip settings, proof test procedures, test intervals and test results?	Documentation should indicate: • which instrumented protective functions have been designated safety critical elements (SCEs) • the requirements of each protective function (usually in the form of 'cause and effect charts') • the criticality rating (e.g. SIL) • trip settings (e.g. in a 'trip register') • procedures for proof testing • the required test intervals and results of test activity. Experience suggests that all relevant information

Item	Inspection Topics	Guidance Notes
		including details of the requisite performance standards may not always be available.
5.1.3	**High integrity functions** Have high integrity functions been identified? If so, what arrangements are in place to ensure that process safety intent is achieved?	Where no independent mechanical protection (e.g. pressure relief protection) is provided, an instrument based protective trip function (e.g. a HIPS system) is an alternative but requires particularly high integrity. Such trips are not the preferred protective arrangement, and need to be engineered with detailed attention to failure-to-safety, fault tolerant multiple redundant architecture, speed of response etc. Note that the use of pressure switches rather than pressure transmitters is undesirable on HIPS. The concept of Safety Integrity Levels (SILs) is now commonly used for instrumented protective functions, and has largely overtaken the concept of HIPS. Examples of such systems have been found where no detailed response analysis had been carried out, and the response characteristics were such that the required performance standards could not be achieved.
5.1.4	**Testing** What arrangements are in place for testing safety critical instrumented protection functions and are they being followed?	All safety critical instrumented protective functions should be tested at suitable intervals to ensure that their performance standards continue to be met. Higher integrity functions require a more stringent test programme than lower integrity functions. HIPS systems require regular proof testing, and monitoring of the demand rate and performance in service. Typically, testing may be broken down into separate processes on the sensors, logic and final end elements. Sensors may be tested quite easily with the logic inhibited, so are usually tested at intervals of a few months to 1 year. Testing the logic and end elements may involve a real plant trip, and is often undertaken less frequently, typically at two or three times that interval. It may be possible to take credit for real or spurious trip demands, if all the appropriate data are gathered. In any event, failures in service should be investigated. Trip testing should check all redundant paths through the function, including all of the solenoid valves controlling ESD valves. Experience suggests that whilst problems with trip testing regimes are fairly uncommon, failure to execute associated testing regimes such as valve closure time, valve leakage rate etc are more frequent.
5.1.5	**Separation of control and protection functions** Is there separation of these functions? Are separate valves used for control and shutdown	Production control functions should be separate from protective functions in order to avoid common cause failures e.g. trip tappings should always be independent of those used for the primary controller to avoid common cause failure if the tapping line should be blocked or mechanically isolated. Several examples have been identified where this was not the case.

Item	Inspection Topics	Guidance Notes
	purposes?	Control valves should not be used for dual control/shutdown purposes because of the potential for common cause failure and that the fact that control valves are not designed for tight shut-off.
5.1.6	**Actions on utility failure** Do shutdown and blowdown valves fail-safe on utility failure?	The action of shutdown and blowdown valves should preferably be fail-safe. In general, isolation valves should fail closed and blowdown valves should fail open on loss of power or control signal. Where valves are not fail-safe detailed justification should be provided.
5.1.7	**Isolation issues** Are bypasses around shutdown valves locked closed? How are hydraulic systems checked and monitored?	Maintenance bypasses around shutdown valves should be locked closed and shutdown valves should not be fitted with handwheels. Valves on hydraulic control system return lines can cause system failure; these should be locked open.
Legal Basis	PFEER Regs. 5, 9 and 12 contain several references to 'measures' being 'appropriate'. A measure may not be appropriate if its performance capabilities fall short of normal industry standards. 'Appropriateness' therefore implies some assessment of criticality, and this is supported by the PFEER concept of a 'written scheme of examination'. SCR 19 establishes the concept of 'safety critical elements' and their verification.	
5.2	**Control of inhibits / overrides**	
5.2.1	**Inhibit requirements** Have requirements for the application of inhibits been adequately defined? Do inhibits apply to only one function, or groups of functions?	Inhibits may be required to allow plant to be started or maintained. However, protective functions of SIL 3 should not generally be capable of being inhibited, as the loss of safety functionality is intolerable on live plant. Facilities such as keyswitches or VDU displays should be designed into systems to allow controlled application of inhibits to SIL 1 and SIL 2 functions, and to allow the operator to check all inhibits in place (and to ensure that uncontrolled activities on hardwired links within marshalling cabinets are not used). Ideally, inhibits should apply to only one function, and should certainly not apply to large groups of functions. Where VDU screens are used to apply inhibits the control room operator should be easily able to locate and interpret all inhibits that are present. Also where overrides are applied through VDUs there should be a keyswitch or password system to prevent inadvertent / unauthorised application of overrides. If inhibit keys are used they should be consistent between different panels (e.g. if right rotation applies on inhibition one panel, the same should apply on all panels). Where an installation may be controlled from two different locations (e.g. NUIs) it should be possible at both locations to check what overrides are in place.
5.2.2	**Risk assessment** Are inhibits assessed before being applied?	Inhibits should be applied only as part of an established control procedure. Risk assessment should be included as part of this process.

Item	Inspection Topics	Guidance Notes
5.2.3	**Control and monitoring** Is there a comprehensive record of all inhibits that have been applied? Are they removed when no longer needed? Are adequate monitoring arrangements in place? If there are two control locations, is there a proper protocol in place?	Inhibits should be applied for the shortest possible times, and their continued application should be monitored and controlled, for example each shift handover. Inhibits should be removed as part of the process of finishing the relevant work activity. An 'inhibit log' should be kept recording the function inhibited, time and date applied, a cross reference to the relevant permit to work (where applicable), time and date of each re-assessment, time and date removed. The total number of inhibits in place should not be allowed to grow beyond some manageable limit (perhaps ~ 10). Monitoring arrangements should verify the quality of risk assessments, to ensure that when inhibits are applied they are properly justified. Where there ares two control locations there should be a proper handover protocol when control moves from one location to another.
Legal Basis	PFEER Reg. 9 requires the DH to take appropriate measures with a view to preventing fire and explosion. PFEER Reg. 19 requires that plant provided is maintained in an “efficient” state; a protective function that is inhibited may not be “efficient”.	
5.3	**Control of programmable systems**	
5.3.1	**Application of programmable systems** Are high SIL functions separated out into non-programmable hardware?	Programmable systems may have less predictable failure modes than non-programmable systems. They are therefore not necessarily suitable for high SIL protective functions. It is good practice to separate out high SIL functions into separate non-programmable hardware. Programmable systems used in safety related applications should be specifically conceived, designed, tested and verified for safety applications.
5.3.2	**Software change control** Are software changes adequately controlled?	Apparently benign changes to software can have unpredictable effects, so software configuration control and change control are vital to prevent loss of safety functionality (even at the lower SILs where programmable systems find most of their applications). When safety software is being modified onshore, checks should be made for any changes made offshore which onshore personnel may not be aware of.
5.3.3	**Documentation** Are adequate records available for software?	A record should be kept of current software versions and their means of identification, the functional differences between versions, and interoperability between different versions of programmable sub-systems. This record should include all circuit boards and programmable electronic field devices. The version number records should include all items held on the installation as spares.
Legal Basis	The PFEER concepts of 'appropriate measures' and 'efficient state' are applicable to the availability in service programmable systems.	
5.4	**Alarm system integrity**	
5.4.1	**Design standard** Have alarm systems been designed or reviewed in accord with a recognised	Process control equipment usually provides alarm functions that allow operator intervention; this provides a useful layer of protection by reducing the demand rate on formal protective systems. However, the generation of alarms requires reasonable reliability for the claim of

Item	Inspection Topics	Guidance Notes
	standard?	reduced demand rate on formal protective systems to be credible. Alarm systems should therefore be engineered in line with an appropriate standard, so that all appropriate initiating events are identified, and appropriate equipment is provided to generate those alarms. Alarm systems provide a means of warning operators that plant conditions are deviating significantly from normal or for alerting operators to take mitigating action after an incident. If there are situations on plant where an operator response to an alarm condition is required to prevent conditions exceeding the design basis of the plant then the plant design does not follow the principles of inherently safer design. In such cases the duty holder should be required to justify in detail why none of the inherently safer options is reasonably practicable
5.4.2	**Human factors** Are there circumstances where alarms come too fast for operators to take them in? Are there alarms that operators find are of little value, and which could be eliminated? Are alarms displayed in logical groupings? Is it clear from VDU displays which items are in alarm? Are the most important alarms clearly identified? Is there a facility to identify first up alarms? Is the number of standing alarms monitored, and adequately controlled? If alarm lamps are in use on a panel is there a lamp test and do the lamps work? Are there any activated alarms that have not triggered appropriate action?	Human factors need to be taken into account before any claim of safety improvements based on response to alarms can be credible. In particular, alarm floods during process upsets can be so difficult to interpret that the control room operator can make mistakes or may deliberately violate the official operational procedures. Process plant is usually fully protected by automatic trips and mechanical devices, so the effect of an alarm flood may be to mask critical fire and gas system alarms. Two EEMUA guides could be consulted which deal with ergonomic issues relating to alarm presentation / information overload and the interface with the process operator - 191 Alarm Systems - A Guide to Design, Management and Procurement (2007) and 201 Process plant control desks utilising human-computer interfaces: a guide to design, operational and human-computer interface issues (2010).
Legal Basis	PFEER Reg. 9 requires the duty holder to take appropriate measures with a view to preventing fire and explosion	

Item	Inspection Topics	Guidance Notes
5.5	**Relief / blowdown / flare system integrity**	
5.5.1	**Relief and Blowdown Philosophy** Has the philosophy been adequately documented? How is the integrity of phased blowdown assured? Is there battery back-up for phased blowdown logic (i.e. loss of power should not interfere with the correct blowdown phasing). Have the design of the relief and blowdown systems been re-evaluated in the light of any additions of new equipment or changed operating conditions?	Many of the problems that have occurred on relief and blowdown systems result from lack of a clear design philosophy. The philosophy should be adequately documented. Incompatible fluids should be segregated (e.g. cold streams / wet streams, or hot streams / condensate). Piping should be designed to prevent slugs of liquid accumulating. A special case occurs when the blowdown system or flare cannot handle the simultaneous flow from all plant items being blown down. In this case, a choice is made (either automatically or by remote manual selection) as to which plant item is at greatest threat and requires to be blown down first, with 'phased blowdown' of other plant some minutes later when the inventory of the first item has diminished. The control system for phased blowdown requires suitable integrity; a hazard exists if the sequence fails and allows too high a blowdown rate. Relief and blowdown valves/systems are sized for specific design conditions. If these conditions change they may not be adequate for the new duty. Conditions may change either because of plant modifications or changed operating parameters (e.g. increased water cut). Several instances have been identified where relief valve capacity had not been reviewed although the required duty had changed. A review of lessons learned from past incidents is given in Section 6 of Institute of Petroleum Guidelines for the Safe and Optimum Design of Hydrocarbon Pressure Relief and Blowdown Systems. This guide includes ‘checklists for assessment of relief and blowdown systems’ [pp 100-102] for both designers and operators. The guide should be included as part of the inspection process.
5.5.2	**Relief and Blowdown System Operations** Are operating procedures adequately in place for the relief and blowdown system? Are purge rates specified, and applied as specified? Is this subject to routine monitoring by operators?	Operators should fully understand how the relief and blowdown system works, and the key features for diagnostics. Operating procedures should contain guidance on whether to shut down, or continue operating, in all the circumstances that are likely to be encountered. A plan of action should be in place for high flare drum level. Arrangements should be in place to prevent air ingress; purges on headers should be monitored. On a routine basis, header drains should be checked to ensure they are clear and not choked with debris.

Item	Inspection Topics	Guidance Notes
5.5.3	**HP/LP interface studies** Have risks of overpressurisation at HP/LP interfaces been adequately assessed, and are they adequately controlled?	All HP/LP interfaces should be clearly identified and adequately protected. Protection may be by mechanical relief or instrumented trips of adequate integrity. In some situations it may be by procedural or other means to prevent overpressurisation, using locked valves, blinds, restrictor orifices etc. It is generally best to carry out a specific HP/LP interface study, separate from the more routine HAZOP procedure.
Legal Basis	PFEER Reg. 9 requires appropriate measures with a view to preventing fire and explosion. PFEER Reg. 12 requires appropriate measures to limit an emergency, including remote operation of plant.	

Part 6 - Change control

Many of the catastrophic events that have occurred on process facilities are attributable to changes. There have also been numerous deficiencies in offshore process systems arising from the failure to control change.

A typical change control problem concerns a failure to re-evaluate relief requirements adequately when process fluids or operating conditions are changed, or when mechanical changes are made. Another example involves change from dry gas to wet gas operations. Key safety issues include different corrosion/erosion rates, liquid slugging effects, increased pigging frequency, hydrate formation/inhibition, and effects on blowdown, flare and vent systems.

Duty holders need to have systems to ensure that changes to the process and its equipment, or to the management system, are properly evaluated before their introduction. This part reviews the way in which change is initiated, communicated, analysed, implemented, and reviewed. It involves a mix of onshore and offshore inspection; inspectors will need to decide on the best place to obtain the relevant information.

It is intended that the guidance should be used flexibly; if it is sufficient to open a meaningful dialogue then the inspection topics/action will have served its purpose.

Item	Inspection Topics	Guidance Notes
6.1	**Change Control Procedure**	
6.1	**Change control procedures** What procedures are in place for the identification and control of changes to process systems? Do the procedures include the various aspects required for effective management of change?	A formal written procedure should ensure that all changes are assessed for impact on safe process operation. Some changes will require formal change control, but others will already have been evaluated for increased risk but will have been incorporated into the design basis and reflected in the normal operating procedures. The procedure should identify: Scope of application; Roles and responsibilities; Risk analysis requirements; Communication (including notifications); Training; Implementation; Monitoring and review.
Legal Basis	HSWA s2(1) provision and maintenance of plant and safe systems of work that are, …. safe and without risks to health, and s3(1) ensure, … that persons not in his employment ....are not ... exposed to risks to their health and safety.	
6.2	**Scope of Application**	
6.2.1	**Hardware / software modifications** Does the change control procedure include: • major plant addition or modification? • change in process operating parameter (control, alarm, or trip setting)? • change in mode of operation?	A change outwith the design intention should be subject to change control. Examination of relevant documentation should reveal the plant design limits, allowable modes of operation, control and safety system settings etc. Relevant documentation includes the Basis for Design, Process Flow Diagram, P&ID, Cause and Effect Diagrams, and Instrument Information Schedule (list of control, alarm and trip settings), Process and Mechanical Equipment Specifications, Hazardous area classification drawings, and Line List.

Item	Inspection Topics	Guidance Notes
6.2.2	**Temporary changes** Does the change control procedure apply for temporary changes? Is there an appropriate procedure for control of overrides / inhibits of trip or other safety-related systems?	An example of a temporary change is the use of an override or inhibit on a safety related system. Control of such changes is normally effected through a separate procedure for control of overrides / inhibits. However, use of overrides / inhibits needs to be kept under review, and any changes e.g. to modify or design out a trip function, should be handled through the change control procedure.
6.2.3	**Replacement equipment** Does the change control procedure apply for replacement of equipment?	Replacement of equipment with non-identical parts or addition of new equipment (whether for safety-related purposes or not) will require change control.
6.2.4	**Operating procedures** Does it apply for changes to operating procedures or other formal operating instructions?	Changes to operating procedures should be subject to change control, unless such changes are within the established design basis and safe operating envelope.
6.2.5	**Organisational changes** How are changes to organisational structures managed e.g. contractorisation, downsizing, multi-skilling, change in shift patterns?	Mapping of transfer of line management and functional responsibilities is necessary to prevent gaps e.g. contractor-based production operator fulfilling the new role of Control Room operator may require further emergency response training. Matching of personnel and their skills to the requirements of the task is necessary for selection, and to identify outstanding training requirements. Phasing of change may be necessary for safe transfer from the old to the new regime. Training needs should be scheduled, resourced and tracked over a period of time culminating in an assessment process to assure competence of production operators.
Legal Basis	HSWA ss2(1), 2(2)(a) and s3(1). (See above).	
6.3	**Roles and Responsibilities**	
6.3.1	**Change initiation** Who can initiate change? How is it done?	The opportunity for initiating changes should be widely available to people associated with process systems. A description of the proposed change, the date of the proposal, and the reasons to support it, including health, safety and welfare issues, are normally recorded on a purpose-designed document. Before changes are made, the workforce should be consulted. This will usually be via the safety representatives (see guidance document L110 "A guide to the Offshore Installations (Safety Representatives and Safety Committees) Regulations 1989").
6.3.2	**Change approvals** Who approves change?	Post-holders who can authorize different types of change should be clearly identified. The process should involve personnel with the background and experience to ensure that changes will not result in operations outside established

Item	Inspection Topics	Guidance Notes
	Who else is involved?	safe limits. Problems have been experienced where offshore personnel thought they knew more than they did i.e. there is a need to involve onshore support for the more significant changes.
6.3.3	**Communication** How is feedback provided to initiators of change proposals?	Good practice includes provision for feedback on the reasons why each proposal has or has not been approved.
6.3.4	**Monitoring, Audit and Review** Who is responsible for monitoring and reviewing the application of change control procedures? What provision is there for audit of the application of change control procedures?	There should be clear mechanisms for monitoring application of the procedure to ensure that it is not short-circuited or missed out altogether. Auditing of the SMS, including change control, should be by independent competent persons (outside the line-management chain).
Legal Basis	HSWA ss2(1) and s3(1). (See above).	
6.4	**Hazard Identification and Risk Assessment**	
6.4.1	**Hazard Identification** What hazard identification tools are used?	HAZID is a term that is often used to refer to safety studies of a brainstorming nature, sometimes driven by consideration of keywords selected appropriately to the scope of the study. It is particularly useful for considering changes to plant layout, and is sometimes used in conjunction with "walk-through" methods through existing plant, or computer-aided virtual plant layout. The aim is to identify as many potential hazards as possible, for later assessment. HAZOP is a systematic method of hazard identification for the assessment of process systems. If conducted against well-established guidelines the method brings the benefits of a multi-discipline team approach prompted by consideration of deviations from normal process operating parameters and their consequences. As the name implies the method is suitable for identifying hazards and also operability problems. FMEA, failure modes and effects (criticality) analysis is a useful method for determining functional redundancy of protective system elements. It can be used to consider the effects of removal of layers of protection on process system integrity. Fault tree analysis is a technique used to illustrate graphically the characteristics of protective and other systems, and may be used to quantitatively model failures of such systems. Cause-consequence diagrams are used to graphically illustrate the range of outcomes that may arise from the success or failure of a system or its components.

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6.4.2	**Risk assessment** How are risks arising from change assessed? Are practicable measures to reduce the risks to a tolerable level considered?	Risk assessment must be suitable and sufficient. Where hazards are identified, the risks may be assessed qualitatively or quantitatively. For most change control applications risk will be evaluated qualitatively using some sort of risk matrix. Where risks are computed numerically it is necessary to have a performance standard by which suitable comparisons of benefit vs. risk may be made. This may take the form of an implied cost of avoiding a fatality. If the risks are found to be intolerable and can not be reduced, then the change must not be implemented. Risk assessments can sometimes become mechanistic and superficial. Line management should monitor the quality of risk assessment, and the implementation of prescribed control measures.
Legal Basis	MHSWR Reg. 3, suitable and sufficient assessment of the risk ... and that any such assessment shall be reviewed … if there is a reason to suspect that it is no longer valid or there has been a significant change in the matter to which it relates.	
6.5	**Implementation and Follow-Up**	
6.5.1	**Actions from Risk Assessment etc.** How does the procedure ensure that actions identified during risk assessment are implemented?	Actions from HAZID, HAZOP etc. should be summarized for tracking implementation in the as-built modification.
6.5.2	**Documentation** How is document updating managed following change?	The document control system should ensure that updated documents are available to personnel and that outdated documents are withdrawn from circulation.
Legal Basis	MHSWR Reg. 5, planning, organisation, control, monitoring and review of preventive and protective measures	
6.6	**Safety Case / Verification**	
6.6.1	**Safety Case change notification** How is a change to the safety case identified and initiated?	Even apparently minor changes to the safety case (SC) should be assessed and logged, and all relevant documentation updated. The SC should be revised periodically to incorporate relevant changes. Material changes to the SC require submission to HSE 3 months prior to implementation. Material changes may include: • modifications or repairs to the structure of any plant where the changes may have a major impact on safety • new activities on the installation or in connection with it • changes of operator or ownership or other circumstances involving changes in the management arrangements • remedial measures resulting from an accident or incident investigation, or safety management system audit • implementation of novel technology.

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6.6.2	Implications for PFEER / DCR / verification How are potential changes to the PFEER assessment considered? How is the ICP notified of changes to SCEs, and how are these examined / verified by the ICP?	The duty holder is required to repeat PFEER risk assessments as appropriate. The DH is required to operate a suitable written scheme of examination (PFEER Reg. 19) and verification scheme (SCR Reg. 21)
Legal Basis	SCR Reg. 14 require the revision of the contents of the SC as often as may be appropriate and/or where revision will render the SC materially different. SCR Regs. 20 & 21 review, revision, and continuing effect of verification scheme PFEER Reg. 5(1) assessment to be performed and repeated as often as may be appropriate PFEER Reg. 19(2) & (3) operation of a suitable written scheme of examination	
6.7	**Operational Risk Management and Assessment**	
6.7.1	**Introduction to Operational Risk Assessment** Is the duty holder using Operational Risk Assessment on the installation?	Operational Risk Management (ORM) is concerned with the determination and management of the measures necessary for continued operations where failure of a process, plant, equipment or procedure has the potential to adversely affect the risk profile of the installation at any level of operation. Operational risk assessment (ORA) is an integral part of ORM. ORA's are considered to be a deviation from an installation's design intent and as such provide an indication of where the design and/or design intent may be flawed, plant is not adequately maintained or is used outside of its normal operating envelope or design parameters. It is essential that ORA's are produced, verified, controlled, applied, monitored, audited and liquidated to the highest standards.
6.7.2	**Operational Risk Assessment Process** Is the duty holder using a suitable Operational Risk Assessment Process?	The following seven steps comprise a typical operational risk assessment process. 1. Recognise the need 2. Identify the Hazard 3. Assess the Risk 4. Analyze Risk Control Measures 5. Make Control Decisions 6. Implement Risk Control Measures 7. Monitor and Review
6.7.3	**Operational Risk Management** Is the duty holder getting the desired outputs from the Operational Risk Assessment?	There are many desired outputs from the ORA: 1) a decision as to whether the offshore team is suitably qualified to conduct the ORA in all of the circumstances, and if not to supplement the team; 2) identification of cumulative effects which have a bearing on the situation e.g. number of impaired barriers to prevent or mitigate a major accident; 3) identification of practicable interim additional barriers to supplement those of the design; 4) identification of suitable interim/special emergency response arrangements;

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		5) an estimate of time scale for the barrier/barriers to be restored; 6) an assessment of the residual risk; 7) according to the residual risk, consideration of the level of authority required to proceed; 8) a decision that the residual risk is tolerable or not for the proposed timescale, and taking the appropriate action i.e. continue production with the additional measures or shut down all or part of the process plant; 9) audit and review periodically to ensure no further degraded situations have arisen, and that the time for restoration of the barrier/barriers has not slipped.
6.7.4	**Good Practice** Does the duty holder show good operational risk management practice?	The number of live operational risk assessments should be low, as their presence indicates that the installation is not well maintained and is used outside its operating envelope or design parameters. The time at risk should be as short as reasonably practicable. The duty holder should review operational risk assessments periodically to ensure that lessons are learned.

Part 7 - Maintenance and verification of process safety-critical elements

This part examines the way in which process safety critical elements are managed. OSD's analysis of incidents indicates that particular attention needs to be given to systems for managing corrosion & erosion, and leaks at flanges. It involves a mix of onshore and offshore inspection. Guidance is available which sets out various recommendations for industry to follow: e.g. HS007 Guidelines for the management of safety critical elements, EI / Oil and Gas UK (2007), Fire and Explosion Hazard Management, part of HS025 Fire and Explosion Guidance, Oil and Gas UK / HSE (2007) and HS015 Guidelines for the management of integrity of bolted joints in pressurised systems, EI / Oil and Gas UK (2007).

Item	Inspection Topics	Guidance Notes
7.1	**Process safety critical elements (SCEs)**	
7.1.1	**Identification of SCEs** Have industry guidelines on identification of SCEs been followed, and do they include those referenced opposite? Are there any unexpected omissions from the SCE list?	SCEs relevant to preventing hydrocarbon releases include the following systems: • Hydrocarbon containment envelope: e.g. vessels & pipework, rotating machinery, risers, pipelines, corrosion protection systems, etc. • ESD system including HIPS: e.g. initiating devices, cabling, logic systems and software, control room panels and displays, emergency power supplies, process and riser ESDVs, SSIVs, and associated equipment, HIP systems, etc. • Relief, blowdown, flare and vent: e.g. relief valves, blowdown systems, pipework and supports, knock out vessels and supports, flare or vent tower / boom etc. • SCEs that are sometimes overlooked include, for example, temporary equipment, and software controlling compressor and turbine overspeed protection.
7.1.2	**Performance standards** Are performance standards measurable / auditable? Has an independent competent person reviewed them? How have the comments of the ICP been addressed?	Except for PFEER SCEs, performance standards are not an explicit requirement of the regulations. However, the requirement to verify the suitability of elements means that there must be some recognised criteria by which suitability may be judged. Such criteria include both functional requirements and the integrity level needed to control risks adequately. Performance standards should: • record the essential features of SCEs • set measurable goals that each SCE is to achieve • specify the nature / frequency of examination / testing • address the initial and continuing suitability of SCEs.
7.1.3	**Integrity assurance for SCEs** Is there an adequate testing regime in support of SCE performance standards?	Planned maintenance routines should provide appropriate checks on the specified performance standards.
7.1.4	**Verification of SCE performance standards** How is verification of performance standards	The verification scheme needs to examine and test the effectiveness of safety-critical elements. The DH should have arrangements to deal with failure of a SCE to meet its performance standard. These might include:

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	undertaken?
	
	How are failures in performance addressed?
	
	Are the relevant verification documents available at the nominated UK address?
	
	Are changes to SCEs subject to formal change control, and ICP involvement?
		• identifying responsible person to be notified
		• undertaking an assessment of significance of non-conformity with safety case risk assessment
		• record assessment and tracking actions to close-out.
		• Documentation should be held at a nominated UK address, and should include:
		  ▪ verification schedules
		  ▪ written schemes of verification
		  ▪ ICP record sheets
		  ▪ ICP reservations
		
		Changes to SCEs require use of the duty holder's change control procedure and referral to the ICP for comment.

Legal Basis	SCR Regs.19, 20 & 21 require a verification scheme to be put into effect to verify that SCEs are suitable, and that they remain in good repair and condition. These requirements are also partly covered by PFEER Reg. 9 (2). The ACOP (L65) states that setting performance standards for measures is a crucial aspect of the assessment process.	
7.2	**Control of corrosion and erosion**	
7.2.1	**Corrosion policy** What corrosion management policies are in place?	A corrosion management policy should: • be clear and understandable • demonstrate management commitment • lay down performance targets • address pipelines and topsides in an integrated approach
7.2.2	**Organisation** Have roles / responsibilities for corrosion and line managers been adequately defined?	The roles and responsibilities of Operator, engineering contractor and inspection company staff in connection with corrosion management should be clearly defined.
7.2.3	**Planning and implementing** What is the status of corrosion control plans / strategies, and performance standards? How are the various corrosion control measures implemented on site?	Evaluation of both the corrosion control and corrosion monitoring / inspection aspects is required. The following are key elements of a good corrosion management plan: • Identification of corrosion mechanisms and the affected equipment under normal and abnormal operating conditions • Risk assessment to establish equipment criticality, and to guide corrosion control / monitoring arrangements • Corrosion control systems to prevent or reduce material degradation i.e. corrosion inhibition, protective coatings, extra wall thickness (corrosion allowance) • Corrosion monitoring, consisting of data gathering, data analysis and data assessment • Corrosion acceptance standards • Feedback mechanism.
7.2.4	**Performance monitoring** How is performance monitored against predetermined criteria?	Some of the proactive monitoring measures include: • checking amount of inhibitor used • regular checks on data gathering activities • opportunistic inspection • monitoring of corrosion rates and incident rates • checks on quality of inspection reports • examination of the status of corrosion probes

Item	Inspection Topics	Guidance Notes
		• coupons and data storage equipment • checks on data from on-line monitoring probes • supervision of non destructive inspection activities • checks on protective coatings. (Note: Performance monitoring of corrosion management systems has often tended to be limited)
7.2.5	**Audit and Review** What arrangements are in place to review the corrosion management system? What audits of the corrosion / erosion management system have been undertaken? Have recommendations arising from audits and reviews been implemented?	Review should include evaluation of the effectiveness of existing equipment and techniques, and an evaluation of the benefits to be gained by adopting newer equipment and improved techniques. Periodic audits should be carried out.
7.2.6	**Offshore Implementation** Is the corrosion management strategy effectively enacted offshore?	Aspects for consideration during offshore inspection include: • the potential for under lagging corrosion, and how this is managed • extent of undesirable corrosion initiating design features such as dead legs, masked areas etc. • the distribution of small bore pipe work and the condition monitoring regime • condition of flange bolts • location of monitoring probes and wall thickness monitoring areas • maintenance of corrosion inhibitor injection equipment, and its availability • corrosion knowledge and responsibilities of offshore staff • actions to raise awareness of corrosion amongst the offshore operations staff • corrosion incidents and remedial actions • actions to achieve continuous improvement and a reduction in leak rates.
Legal Basis	PFEER Reg. 9 requires duty holders to take appropriate measures for preventing the uncontrolled release of flammable etc substances. PUWER Reg. 5 requires the maintenance of work equipment in an efficient state. MHSWR Reg. 5 requires arrangements for planning and control ... of preventive and protective measures.	
7.3	**Pump and compressor seal integrity**	
7.3.1	Have there been any significant deviations in the process fluids, or operating conditions, compared with those specified? Are adequate monitoring arrangements in place for seal systems, including flow rates,	Many seal system failure incidents in compressors and pumps can be attributed to deviations from the process fluid specification, or deviation from design operating conditions, or the after effects of maintenance intervention Maintenance arrangements should address the required training and competency of personnel refitting seals.

Item	Inspection Topics	Guidance Notes
	pressures and temperatures? Is competence of maintenance personnel adequately assured? Have actions from any seal failure incidents been implemented?	
Legal Basis	PUWER Reg. 5 requires the maintenance of work equipment in an efficient state. PFEER Reg. 9 requires duty holders to take appropriate measures for preventing the uncontrolled release of flammable etc substances.	
7.4	**Management Systems for Flange Joints**	
7.4.1	**Overview** Have the management arrangements been reviewed against the latest bolted joint guidelines or has the DH other guidelines to work to?	The duty holder should ensure that the integrity of Bolted Pipe joints over the whole life of the plant is addressed within the management system. This should be achieved as a matter of management policy by specifically identifying management of bolted pipe joints within the engineering design, construction, maintenance and operation standards and procedures. An inspection of this topic should include reference to the latest industry bolted joint guidelines; inspectors should therefore take a copy with them offshore. The integrity of joints and seals is important as failure could lead to a release of hydrocarbons. Flanges and other joints should be adequately designed and properly made to avoid flammable and toxic hazards.
7.4.2	**Responsibilities** Are responsibilities / accountabilities adequately defined for management of bolted pipe joints?	The guidelines state that there should be an identified owner of the management system, responsible not only for its implementation and ongoing maintenance, but also for communicating its aims and objectives throughout the organisation. The owner should state the expectation for the system and monitor its effectiveness.
7.4.3	**Training and Competence** How is competence established/assured? Is there a register of competent persons? How is the competence of vendors addressed?	According to the guidelines training and competence is one of the key elements of joint integrity management. The duty holder should have a formal competence assurance scheme, which ensures that all personnel (company and contractor) who are required to work on bolted pipe joints are formally assessed as being competent to work with such connections. The scheme should cover the range and task skills appropriate for bolted pipe joints. The DH should ensure long-term retention of competence by periodic reassessment of personnel. Personnel assessed as being competent should be registered as being 'Authorized' to carry out the range of tasks in which they have been assessed as being competent. A register of competent personnel should be kept. Management procedures should ensure that Vendor personnel employed on short term construction or maintenance work are competent to carry out such work and it is recommended that their competence is recorded

Item	Inspection Topics	Guidance Notes
		in the register of authorized personnel.
7.4.4	**Verification of bolted pipe joints** Is the integrity of critical flange joints adequately verified?	The verification scheme should provide assurance that the integrity of critical bolted pipe joints is maintained to very high level. This should include the competence of fitters, checking/testing the joint after make-up, and inspection and maintenance routines.
Legal Basis	PFEER Reg. 9 requires duty holders to take appropriate measures for preventing the uncontrolled release of flammable etc substances. PUWER Reg. 5 requires the maintenance of work equipment in an efficient state. PUWER Reg. 8 requires … ensure that persons who use work equipment have … adequate health and safety information and, where appropriate, written instructions.	
7.5	**Review of ageing plant against current standards**	
7.5.1	**Review of older installations** Has the installation been reviewed against current standards (if applicable)? Have improvements to mechanical system integrity been implemented as a result of reviews?	Older installations were often designed to standards that have since been superseded. For example, a number of older offshore installations have threaded pipe connections on hydrocarbon systems. Piping codes such as ANSI B31.3 would now only allow their usage under very restricted circumstances. Duty holders should have arrangements to review older facilities against current standards, to determine whether upgrades would be reasonably practicable. A cost-benefit analysis may be used to determine if potential improvements are reasonably practicable.
Legal Basis	HSWA s2(2)(c) requires the provision of such information, ...as is necessary to ensure, so far as is reasonably practicable, the health and safety of employees. PUWER Reg. 5 requires the maintenance of work equipment in an efficient state. MHSWR Reg. 5 requires an “organisational structure” to provide for progressive improvement in health and safety.	

Part 8 - Control of miscellaneous process hazards

This part reviews the way in which some miscellaneous process hazards are managed. Not all the hazards are relevant to every installation, and the notes concentrate on preventive controls rather than loss of containment etc.

8.1 Control of H_2S and CO_2

Gas streams associated with some reservoirs have to be treated to reduce the Carbon Dioxide (CO_2) or Hydrogen Sulphide (H_2S) to levels to meet export pipeline gas specifications. Two main methods are used, these are a) counter-current contact in which the gas stream rises through a column against a downward flowing stream of amine or proprietary solvent, and b) absorption, where the gas stream may be passed through a column packed with zinc oxide in powder or granular form

8.2 Sand management

Production of sand with well fluids presents several potential hazards for topsides pipework and equipment, for example:

- Sand plugging causes valves to seize, potentially compromising ESD action.
- Accumulated sand requires operator intervention to remove it, by sand-washing, digging out, or dismantling of plate exchangers.
- Sand accumulation can prevent corrosion inhibitor reaching the material surface leading to increased corrosion.
- Sand accumulation in level instruments and bridles can lead to false readings and poor control, and may compromise shutdown initiation.

8.3 Control of hydrates

Hydrates are ice-like solids that can form when wet gas and light condensate at high pressures cools to lower temperatures. Hydrates are formed by gas cooling to below its water dew point, or when free water is present. Cooling may be due to operational pressure drop, or during start-up when hydrocarbon is introduced into cold pipework or equipment. Once formed hydrates are difficult to remove; prevention is better than cure. Hydrate inhibitor, such as glycol, methanol or industrial methylated spirits, is used to inhibit the formation of hydrates, by removal of free water. Hazards caused by hydrates include:

- Blockage of pipework, and instrument tappings, causing false readings.
- Plugging of valves, giving operational problems, and potentially compromising ESD action.
- Hydrate particles travelling at high gas velocities can cause large forces at elbows and tees.
- Removal of hydrates may require physical intervention, with associated risks. Sand particles can erode piping and fittings, particularly chokes and flowlines,

8.4 Sampling arrangements

Sampling involves directly breaking into the hydrocarbon containment envelope. Hazards associated with potential loss of containment, and static electricity, should be recognised.

8.5 Protection against air ingress and flammable mixtures in process plant

Flammable mixtures can form in piping, plant and equipment when air enters systems that normally contain hydrocarbon, as a result of operational or maintenance activities. Correct purging and operational procedures will ensure that the risks are minimised.

8.6 Segregation of hazardous drains

Open drain systems are typically classified as hazardous and non-hazardous. It is important that segregation of the drain systems is maintained at all times to prevent migration of hydrocarbons into safe areas where they may present an ignition risk.

Item	Inspection Topics	Guidance Notes
8.1	**Control of H_2S and CO_2** Note: Hydrogen Sulphide is a highly toxic gas, and adequate precautions have to be in place to deal with toxic hazards. However, this inspection project focuses primarily on prevention of loss of containment, not on dealing with the consequences.	
8.1.1	**Risk Assessment / Incidents** Are risks, arising from the presence of H_2S or CO_2 in process fluids, significant? Have there been any incidents arising from presence of H_2S or CO_2?	Risks arising from presence of H_2S and / or CO_2 should have been assessed, and appropriate controls put in place.
8.1.2	**Operating Procedures** Are duty holder procedures and systems for the control of H_2S based on recognised codes and standards?	API RP 55 - 'Conducting Oil and Gas Producing and Gas Processing Plant Operations Involving Hydrogen Sulphide' covers recommendations for protection of employees as well as conducting oil and gas processing plant operations where hydrogen sulphide is present in the fluids. The recommended practices should be reflected in the duty holder's procedures and systems. Procedures should explicitly mention the hazards of H_2S and how the plant is managed to address these hazards. Operating procedures should include: • Actions to keep within safe operating limits, and the consequences of failing to do so • Start up, normal operation and shutdown • Contingencies for upsets / emergencies.
8.1.3	**Integrity monitoring** Is the integrity of the H_2S & CO_2 plant adequately maintained? Was the plant designed, and is it inspected, to ANSI 'M fluid service' code requirements?	H_2S & CO_2 form corrosive acidic solutions in the presence of water. In view of the hazardous and toxic nature of these gases maintaining the integrity of the plant is essential. An effective system should be in place to monitor the condition of pipework and equipment. Repairs and replacement of plant must be to a suitable standard (e.g. the NACE standard for equipment containing H_2S) If a process fluid contains H_2S, according to ANSI B 31.3 it might be categorised as 'M fluid service'. The definition of 'M fluid service' is "A fluid service in which the potential for personnel exposure is judged to be significant and in which a single exposure to a very small quantity of a toxic fluid, caused by leakage, can produce serious irreversible harm to person on breathing or bodily contact, even when prompt restorative measure are taken." The Code puts extra requirement for the system design, fabrication and inspection etc. for systems containing 'M' fluid.

Item	Inspection Topics	Guidance Notes
Legal Basis	MHSWR Reg. 5 requires arrangements for planning and control ... of preventive and protective measures. PUWER Reg. 8 requires … adequate health and safety information and, where appropriate, written instructions. PFEER Reg. 9 requires … appropriate measures for preventing the uncontrolled release of flammable etc substances.	
8.2	**Sand management**	
8.2.1	**Risk Assessment / Incidents** Are there significant risks arising from sand production? Have there been any incidents arising from presence of sand?	Risks arising from presence of sand should have been assessed, and appropriate controls put in place.
8.2.2	**Sand management strategy** Is there an adequate sand management strategy in place?	Sand management strategies may aim to prevent sand production, or may rely on monitoring to avoid loss of containment. The following elements should be included: • A policy or strategy statement • Arrangements for assessment of sand-related hazards • A reservoir management strategy for sand control • Sharing of experience of sand problems with others.
8.2.3	**Sand management organisation** Are there systems in place for management of sand production? Is integrity monitoring of vulnerable pipework and systems undertaken?	Effective systems should be in place, onshore and offshore, for the management of sand production, e.g. • If the sand management strategy allows some sand production, limits on sand production should be set • Lesson learned from flowline inspection programmes should be captured • Operating conditions, particularly fluid velocity, should be optimised to minimise erosion • Wall thickness checks, of critical areas of pipework, should be undertaken • The verification body should verify the effectiveness of the sand management strategy.
8.2.4	**Sand monitoring** Are adequate arrangements for sand monitoring in place? Are the results from sand monitoring properly used?	If sand monitoring systems are provided: • The philosophy for sand monitoring should be clear, i.e. is it alarms only, periodic measurement, or continuous monitoring? • Sand monitoring instruments should be calibrated. • 'Trending' the results should facilitate deterioration over time to be measured • If results from one instrument are used to infer conditions in other places, (e.g. monitoring on one flowline used to infer conditions in other flowlines), the validity of the assumptions used should be robust • Appropriate actions should be taken if alarm limits are exceeded.

Item	Inspection Topics	Guidance Notes
8.2.5	**Operating procedures** Are there adequate operating procedures for control of sand production? Are operators aware of the limitations imposed by sand production?	Operators should be aware of the hazards associated with sand production and the limits of individual wells and operating plant. Operating procedures may include: • Restrictions on the operation of individual wells or systems • Control of the operation of chokes to avoid settings where erosion may occur • Procedures for removal of sand from vessels, etc.
Legal Basis	DCR Reg. 14 requires the well-operator to assess the well conditions, and any hazards… PFEER Reg. 9 requires duty holders to take appropriate measures for preventing the uncontrolled release of flammable etc substances. PUWER Reg. 5 requires the maintenance of work equipment in an efficient state.	
8.3	**Control of Hydrates**	
8.3.1	**Risk assessment / incidents** Is there a proper awareness of the hazards associated with hydrates and hydrate inhibition systems? Have there been any hydrate-related incidents?	If hydrates form there may be large slug forces at bends and tees in piping systems. There are also hazards associated with methanol injection into wells and flowlines, where pressures may be >100 bar. The potential for hydrate formation under non-routine activities should be addressed.
8.3.2	**Procedures** Do procedures cover hydrate hazards, and the arrangements for prevention and control?	Hazards associated with hydrate formation should be specifically addressed in operating procedures. Procedures should include: • Actions to keep within safe limits by preventing hydrate formation, and the consequences of failing to do so • Procedures for start up, normal operation and shutdown • Contingency procedures e.g. for situations where hydrate formation is suspected, or where the supply of inhibitor is interrupted.
8.3.3	**Provision of inhibitor** Are operators aware of the requirement for inhibitor during all operating modes? Is hydrate inhibitor injection provided at all necessary points on the installation?	Once formed hydrates are difficult to get rid of, it is therefore essential for inhibitor injection to be started before hydrocarbon flows are started. Inhibitors are frequently injected temporarily on start up, when high-pressure drops occur and pipework and equipment may be cold. Depending on the conditions the injection may be discontinued when the process reaches steady state conditions. Hydrate inhibitor may be injected at a rate proportional to the hydrocarbon flowrate. Tables or charts of well flowrate versus inhibitor injection rate will enable operators to set appropriate rates. It is essential that the hydrate inhibitor is present at the point where gas / condensate is cooled to its hydrate formation temperature. Therefore injection is upstream of control valves, choke valves or any place where pressure reduction takes place.

Item	Inspection Topics	Guidance Notes
Legal Basis	MHSWR Reg. 5 requires arrangements for planning and control ... of preventive and protective measures. DCR Reg. 7 require the duty holder to ensure that the installation is not operated unless appropriate limits within which it is to be operated have been recorded. PUWER Reg. 8 requires employers to ensure that all persons who use work equipment have available to them adequate health and safety information and, where appropriate, written instructions.	
8.4	**Sampling arrangements**	
8.4.1	**Risk assessment / procedures / incidents** Has risk assessment of sampling activities been undertaken? Are sampling activities covered by operating procedures? Are precautions adequately specified and implemented? Have there been any examples of loss of containment from sampling activities? Are only designated sample points used for taking samples? Are sample points designed to minimise the possibility of hydrocarbon release? Has the plant been critically reviewed to remove redundant sample points? Are suitable vessels used for collecting samples?	The hazards associated with breaking into the hydrocarbon containment envelope should be specifically addressed in procedures for interventions into the process plant. Operating procedures should include: • Techniques for sampling all the likely fluids • All the types of sample connection in use • Precautions to be taken during sampling • Contingency procedures for upsets / emergencies. Only properly designed and designated sample points should be used for taking samples. Serious incidents, involving loss of containment, have occurred where unofficial connections have been used for sampling. Closed bomb sample loops may be used in preference to open sample vessels. Specifications should be available for pressure ratings, etc. for sample bombs. There should be a system in place to assure the integrity of the pressure containing sampling equipment.
8.4.2	**Static electricity hazards** Is the plant designed to minimise effects of static electricity during sampling, and is this reflected in sampling procedures? Are precautions based on recognised practices (NFPA, BS 5958), and are they applied in practice?	For open sample connections the design of the system should prevent the accumulation of any static electrical charge, for example, by the avoidance of non-conducting surfaces and the bonding of metal parts. Efficient static bonding connectors should be provided. NFPA Recommended Practices Manual Vol 9 Section 77 recommends that containers of more than 5 gal (19 litre) capacity made of non-conducting materials should not be used without special precautions. BS 5958 Part 2, para 12.4.4 notes that when a liquid of low conductivity is being handled, and various other specified precautions are applied, a small electrostatic charge may remain, but it is common practice to use high resistivity containers with capacities up to 5 litres. Other precautions referred to in BS 5958 Part 2 include

Item	Inspection Topics	Guidance Notes
		earthing of conducting components and adjacent objects, limitations on filling rate, avoiding rubbing the external surface of the container, and ensuring that personnel in the vicinity of the container do not present an ignition risk.
Legal Basis	PUWER Reg. 5 requires the maintenance of work equipment in an efficient state. PUWER Reg. 8 requires …adequate health and safety information and, where appropriate, written instructions.	
8.5	**Air ingress / flammable mixtures in process plant**	
8.5.1	**Flare and vent purging** Are adequate precautions taken to prevent air ingress into the flare and vent systems? Have recognised methods been used to determine the required purge rates? Are alternative supplies available?	Purging of flare and vent headers is required to prevent air ingress, which could lead to a flammable mixture forming in the system. Purge rates may vary depending on the operating mode. If there are sufficient continuous and incidental discharges from the process into the flare system a minimum purge rate may be acceptable. Purge points should be located at the upstream end of headers to ensure that there are no dead ends. Several methods are available to calculate required purge rates, e.g. Husa (1964 updated 1977) - based on achieving a max 6% O_2 25ft from an open vent stack, Tan (1967) or Cochrane & Paterson (1995). Alternative supplies of purge gas (e.g. nitrogen, fuel gas or propane) should be available, and used when the normal supply is not available.
8.5.2	**Vessel purging** Are adequate purge rates maintained at all times to prevent air being drawn into process vessels?	Fuel gas or nitrogen may be provided to some tanks and vessels to maintain system pressurisation, allow for expansion/contraction or to exclude air to prevent formation of an explosive atmosphere or to prevent chemical degradation. Vessels may include: • methanol or glycol storage tanks • cooling / heating medium expansion vessels • open / closed drains tanks etc. (Note: inert gas blanketing of FPSO cargo tanks is covered in Part 9 of this project).
8.5.3	**Maintenance purging** Do procedures cover the precautions taken to minimise the formation of flammable atmospheres within systems following maintenance or routine operations? How is the adequacy of purging determined?	Procedures for maintenance intervention, and for restoring equipment back into service, should address the control of any flammable atmosphere that may be formed. Purging with nitrogen, or other inert gas, prior to intervention, or restoring equipment back into service, will minimise the flammable atmosphere. Following maintenance, sampling of the ‘inert’ atmosphere should be undertaken to ensure that the oxygen content is less than a specified amount (typically $<5\% O_2$). For interventions that are carried out routinely, e.g. pig traps, dedicated arrangements for purging and venting should be provided.

Item	Inspection Topics	Guidance Notes
		If tanks or caissons are opened for maintenance from which hydrocarbon cannot be fully removed special precautions may be necessary (e.g. continuous purging or foam blanketing).
8.5.4	**Other hazards**	If nitrogen is produced on the installation using a nitrogen generation plant the quality of the nitrogen should be assured. Of particular concern would be high levels of oxygen in the 'inert' product gas.
Legal Basis	MHSWR Reg. 5 requires arrangements for planning and control ... of preventive and protective measures. PFEER Reg. 9 requires duty holders to take appropriate measures with a view to preventing fire and explosion....	
8.6	**Segregation of hazardous drains**	
8.6.1	**Integrity of segregation** Are seal pots and loop seals maintained liquid full? Are routine inspections carried out? Is the integrity of lute seals adequately maintained?	Seal pots and seal loops in the drain headers are used to provide segregation between drain systems. Seal pots and loop seals can either rely on a continuous or a dedicated water supply, which should maintain **all** seals liquid full. Routine plant inspections should include checking that seals are intact and that no debris has collected to block drains or gullies. Vents or siphon breakers should be provided at vertical falls to prevent liquid being siphoned out of the seal. Segregation of the drains systems is also necessary at the drains caisson. Dip pipes for the non-hazardous drains should be lower than those for the hazardous drains, to prevent migration of gas. The integrity of the dip pipes should be assured. (The dip pipes may have corroded off or perforated at or above the water line). Lute seals (U bends) may also be provided on drains tanks, bulk storage tanks, tanks in columns and crane pedestals. These provide a liquid seal to prevent migration of gas between systems. The integrity of these seals should be maintained.
8.6.2	**Other considerations** Has winterisation been considered? Have effects of modifications been considered?	Winterisation of drain lines (particularly across bridges) and seal loops may be provided to prevent blockage. Winterisation should be maintained in good condition, and its effectiveness assured. The implications on the drain systems of any changes to the area classification of the installation should have been addressed, e.g. an area with new equipment redesignated as Zone 1 or 2 yet still drained by a non-hazardous drain.
Legal Basis	PFEER Reg. 9 requires duty holders to take appropriate measures for preventing the uncontrolled release of flammable etc substances. PUWER Reg. 5 requires the maintenance of work equipment in an efficient state.	

Part 9 - FPSO specific systems

This part reviews factors that are specific to FPSOs and, in some cases, floating production platforms, i.e. semi-subs. and tension leg platforms (TLPs).

Item	Inspection Topics	Guidance Notes
9.1	**Effects of Motion on Process Plant Systems**	
9.1.1	**Operating Envelope** Is the operating envelope clearly defined?	Wave-induced vessel movement can significantly affect the performance of process equipment. The equipment will normally be designed to cope with a specified amount of movement, but beyond that there can be severe reductions in performance with potentially serious safety implications, e.g. liquid carry over into gas streams to compressors (particularly reciprocating compressors). Some mechanical equipment, e.g. turbines & compressors, may also be adversely affected (shaft axial alignment) by vessel flexing / motion. The operating envelope, in terms of vessel movement, for the process equipment on the installation should be clearly specified and understood by the operational crew.
9.1.2	**Flare & Relief System Design** Is the flare and relief system designed, and the vessel operated, to avoid accumulation of liquids downstream of relief devices?	Flare & relief system pipework should be constructed such that liquids flow away from relief devices towards the flare knockout drum. API RP 521 recommends a slope of ¼ in. in 10 ft. (i.e. 1 in 480). Whilst this may be satisfactory for land based process plant; it is often inadequate for floating production units. Floating installations, particularly semi-subs., may be permanently trimmed to 0.5º to 1.0º (i.e. 1 in 115 to 1 in 57) to assist with deck run-off. If this trim opposes the slope in the flare system, condensed liquids will accumulate on the downstream side of relief devices, limiting their capacity.
9.1.3	**Procedures / Instructions** Are there instructions on action to take when operating limits are reached? Are instructions adhered to? Have inhibits / overrides been applied to avoid tripping due to vessel motion?	There should be clear instructions on action to be taken when the limits of the operating envelope are reached, and the parameters to be used to decide when this is the case. Indications are that some installations are continuing to operate even in the most adverse of weather conditions and resultant vessel movement. Inhibits / overrides should not be applied to shutdown functions to counteract the effects of vessel movement on the process plant. (It should be possible to determine when periods of adverse weather have occurred and check, from operator logs etc., whether there was compliance with the required actions with respect to process operations).
Legal Basis	DCR Reg. 7 requires limits within which the installation is to be operated have been recorded. PUWER Reg. 4 requires work equipment to be suitable for the purpose for which it is used or provided. PUWER Reg. 8 requires instructions to include conditions and methods by which work equipment may be used, foreseeable abnormal situations and the action to be taken...	

<table>
<tr><th>Item</th><th>Inspection Topics</th><th>Guidance Notes</th></tr>
<tr><td>9.2</td><td colspan="2">Turret Arrangements / Swivel Joints & Seals, Leakage & Recovery</td></tr>
<tr><td>9.2.1</td><td>Design limits

Are the operating limits for the system clearly specified?

Are recuperation facilities designed to withstand maximum foreseeable pressure?</td><td>FPSOs have turret / swivel arrangements to allow rotation of the vessel without damaging the risers / moorings.

GASCET Section 5.1.HS18 gives information on the mechanical integrity of FPSO turrets.

Some FPSOs have the drag chain type of turret / riser arrangement with long flexible hoses connecting the risers to the topsides plant. Drag chain turret arrangements allow rotation of the vessel of up to 270º, and no rotational seals are required.

Other FPSOs have a swivel connected to the topsides by shorter flexible hoses; each tier of the swivel can move independently of the others. Some swivels have rotation limiting devices to minimise the wear on the seals and bearings. Where swivels are used, the operating envelope, and allowable seal leakage rates, should be clearly specified and understood.

Recuperation facilities must be capable of withstanding the maximum foreseeable fluid pressure, or be fitted with relief devices to prevent overpressure, and be of sufficient capacity to contain recovered fluids.</td></tr>
<tr><td>9.2.2</td><td>Operations

Are there instructions on action to take when the limits of vessel rotation, or swivel seal leakage, are reached?

Are swivel seals being regularly flushed / greased to minimise wear and reduce leakage?

Is there any evidence of leakage of process fluids to atmosphere?</td><td>Whatever type of turret arrangement is used, the limits for vessel rotation about the turret / swivel should be understood and adhered to.

Special seal arrangements are fitted to the swivel to prevent leakage to atmosphere or cross contamination of fluids. The seals and their faces have to be kept clean (i.e. free of sand or scale etc.); a seal flushing / greasing facility is normally installed for this purpose.

Some leakage across the seals may occur. This should be recovered in the recuperation system; leakage to atmosphere may indicate damage to seals or an inadequate recuperation system.</td></tr>
<tr><td>Legal Basis</td><td colspan="2">PUWER Reg. 4, work equipment has to be constructed or adapted as to be suitable for the purpose for which it is used or provided.

PUWER Reg. 6, inspection.

PUWER Reg. 8, provision of information and instructions

SCR Reg. 12

PFEER Regs. 4, 5, 9 & 19

DCR Regs. 4-8</td></tr>
<tr><td>9.3</td><td colspan="2">Integrity of Flexible Hoses</td></tr>
<tr><td>9.3.1</td><td>Inspection / Testing

Are inspection / testing arrangements adequately in place?</td><td>There should be a plan and records of the inspection / testing of the flexible hoses, their connectors and supports. For Coflexip type hoses, which are provided with carcass leakage vents, there should be a system in place for monitoring leakage.</td></tr>
</table>

Item	Inspection Topics	Guidance Notes
Legal Basis	PUWER Reg. 6, inspection. PUWER Reg. 8, provision of information and instructions.	
9.4	**Inert Gas Controls / Cargo Tank Blanketing**	
9.4.1	**Design** Is the system adequately protected against overpressure / underpressure?	Cargo tanks on FPSOs are blanketed with inert gas to prevent the ingress of air when cargo is being off-loaded which may, when mixed with the hydrocarbon vapours in the tanks, form flammable or explosive mixtures. The inert gas generation system should be fitted with shutdown and relief facilities, to prevent overpressurisation of the cargo tanks. During the transfer of crude oil from the cargo tanks, or as the tank contents cool and contract, it is also possible to pull a vacuum on the tanks if the inert gas system fails to deliver the required quantity of gas. There should be provision on the cargo tanks for vacuum relief
9.4.2	**Operations** Are isolations controlled and monitored using a locked open / locked closed valve register?	The inert gas is normally produced by treating engine / generator exhaust gas. The limits for oxygen concentration in the inert gas and cargo tank vapour space should be clearly specified, understood and monitored by the operational crew. There should be clear instructions to the operational crew covering both the inert gas system and the isolation / de-isolation of cargo storage tanks. The presence of closed isolation valves & spades in the cargo tank vent lines to the vent headers has led to tanks being overpressurised. Vent isolation valves should normally be locked open, and recorded in a locked open / locked closed valve register.
Legal Basis	PUWER Reg. 4, work equipment has to be constructed or adapted as to be suitable for the purpose for which it is used or provided. PUWER Reg. 8, provision of information and instructions.	
9.5	**Marine & Process Systems Interfaces**	
9.5.1	**Design** Are P&IDs adequate for process requirements? Are there any indications of incompatibility between marine and process systems?	Many FPSOs are converted oil tankers, and use is often made of existing marine facilities for process operations. Marine-based documentation, e.g. piping and instrument diagrams, may not be to the standard normally expected of the oil & gas industry. Marine cooling system pipework may have been designed to a different code from that of the process topsides equipment. Where operators try to achieve production targets with poorly designed or restricted capacity plant, this may, in some cases, result in higher than design crude oil rundown temperature to the cargo tanks.
9.5.2	**Operations** Is there clear demarcation between marine and process systems?	Procedures and instructions should clearly define where there are marine / process interfaces, and highlight potential problem areas. Where there are interfaces, appropriate training should have been provided, so that marine and process crews are both aware of the consequences of their actions on the other’s systems.

Item	Inspection Topics	Guidance Notes
Legal Basis	PUWER Reg. 4, work equipment has to be constructed or adapted as to be suitable for the purpose for which it is used or provided. PUWER Reg. 8, provision of information and instructions.	
9.6	**HP Fuel Gas**	
9.6.1	**Design** Is the design of the fuel supply system of adequate integrity? Does the annular space, or pressure protection, vent to a safe location?	Some FPSOs have dual fuel diesel engines, which can run on high-pressure fuel gas, compressed to a pressure of around 350 barg. The fuel gas is routed to the engines via double walled pipework. The outer pipe should be designed to full system pressure, or adequately protected against overpressure. The weak link in the system is the flexible hose, or expansion joint from the double walled pipework to the engine. The double walled pipework should have its annular space (or overpressure relief device) vented to a safe location.
9.6.2	**Operations / maintenance** Are adequate arrangements in place for monitoring of the annular space, and inspection of pipework?	Continuous, or regular, monitoring of the double walled pipework annular space should be undertaken to detect leaks. The connections from the hard pipework to the engines should be regularly inspected for signs of deterioration.
Legal Basis	PUWER Reg. 4, work equipment has to be constructed or adapted as to be suitable for the purpose for which it is used or provided. PUWER Reg. 6, inspection.	
9.7	**Gas Compression**	
9.7.1	**Design** Have any design problems been noted for use of compressors in a marine environment?	Gas will normally be compressed using either centrifugal or reciprocating compressors. Because FPSOs flex, due to wave action, there have been problems with driver / centrifugal compressor alignment on some installations. The compressor package should have been designed to maintain alignment as the vessel flexes but there may be limits on vessel movement. Axial displacement instrumentation for compressor shafts should have appropriate alarm and trip settings. Reciprocating compressors should have provision (flexible mountings) to reduce transmission of vibration to the vessel structure.
9.7.2	**Operations** Are operations crew aware of operating / sea state limitations for compressor operations?	Procedures and instructions should clearly define the operating and sea state envelopes for gas compressors.
Legal Basis	PUWER Reg. 4, requires employers to ensure that work equipment is only used for operations for which, and under conditions for which, it is suitable. Reg. 3(3) extends this duty to others, including duty holders. PUWER Reg. 8, requires instructions to include conditions and methods by which work equipment may be used, foreseeable abnormal situations and the action to be taken, conclusions to be drawn from experience of use, and for the information and instructions to be readily comprehensible to those concerned.	

Part 10 - Process plant construction & commissioning

This part reviews the way in which commissioning is managed; it is intended to examine the roles of both onshore and offshore management. This may involve both onshore and offshore inspection, depending on the scope of the work.

Item	Inspection Topics	Guidance Notes
10.1	**Management System**	
10.1.1	**Project Control** Is there a project safety plan? Has the plan been adequately communicated?	All personnel, including third parties, should have been made aware of the overall aims of the project and how health and safety aspects are integrated into the plan.
10.1.2	**SMS Interfaces** Have SMS interfaces been clarified?	If more than one SMS applies, measures should be in place to ensure that there are no conflicts and that all relevant information has been effectively communicated to all parties.
10.1.3	**Responsibilities** Have responsibilities been clearly defined?	Responsibilities should be clearly assigned. Where projects involve the installation and commissioning of vendor packages there can be a breakdown of responsibilities if this is not adequately controlled. E.g. where vendor packages are assembled and pressure tested onshore then partially disassembled for shipment, the parties involved may include vendor package, project, hook-up contractor, and maintenance and operations personnel.
10.1.4	**Change Control** Is there a procedure for controlling changes arising from construction and commissioning?	Change control is an area where problems have been found during OSD's inspection / audit of operating companies / design houses.
10.1.5	**Risk Assessment** Is there a structured mechanism for risk assessment? Does risk assessment adequately reflect potential consequences?	Risk assessment procedures, relating to construction & commissioning activities, should have been made available to all relevant parties. Previous HSE inspection / audit experience has shown that risk assessments have often not adequately reflected the potential consequences.
Legal Basis	MHSWR Reg. 3, requirement for suitable and sufficient risk assessment. MHSWR Reg. 4, requirement to apply principles of prevention. MHSWR Reg. 5, requires a record of arrangements for planning, organisation, control, monitoring and review of preventive and protective measures. MHSWR Reg. 10, requires provision of comprehensible and relevant information. MHSWR Reg. 11, requires cooperation and coordination between employers.	
10.2	**Post Design**	
10.2.1	**HAZOP** Have HAZOP and / or other safety studies (e.g. API RP 14C review of HP / LP interfaces) been carried out at the design stage?	HAZOP studies should be formally recorded with lists of resulting actions (where necessary). Carrying out specific HP / LP interface studies in addition to HAZOP, such as an API RP 14C review, is accepted good practice.

Item	Inspection Topics	Guidance Notes
	Has an action list been produced and an action tracking system set up? Have all actions been closed out (i.e. completed & signed off)?	There should be a system in place to follow up and close out HAZOP actions. Actions should be closed out in a timely manner (i.e. relative to the priorities assigned to them).
10.2.2	**Changes / Modifications** Have new HP / LP interfaces, created as a result of changes, been reviewed and actioned as above?	For additions to existing process plant, it is important that all factors affecting the existing plant have been addressed.
10.2.3	**Operating Procedures** Have relevant operating procedures (new & revised), resulting from the project, been prepared?	Procedures should have been developed, reviewed, approved and formally issued in advance of commissioning. Where there have been additions, or modifications, to existing process plant, procedures should be updated to reflect the changes.
10.2.4	**Training** Are adequate arrangements in place for the training of operators & technicians?	Operator / technician training can commence when the design has been fixed (i.e. approved for construction) and operating procedures become available.
Legal Basis	MHSWR Reg. 3, requirement for suitable and sufficient risk assessment. PUWER Reg. 4, work equipment has to be constructed or adapted as to be suitable for the purpose for which it is used or provided. PUWER Reg. 8, provision of information and instructions. PUWER Reg. 9, provision of adequate training.	
10.3	**Pre-construction**	
10.3.1	**Hazard analysis** Has a study of all potential hazards, arising out of the construction phase, been carried out (e.g. analysis of activities such as lifting adjacent to or over, live process plant)?	Procedures should have been developed to cover these activities. An action tracking system should have been set up, and actions should be closed out (i.e. completed & signed off).
10.3.2	**Procedures** Are procedures available detailing methods of work and precautions to be taken? Is there compatibility of procedures for the control of construction work?	Procedures should have been developed covering precautions required for construction activities such as equipment lifts adjacent to, or over, live process plant etc. If more than one SMS applies, effective measures should be in place to ensure that there are no conflicts and that relevant information has be effectively communicated to all parties.
Legal Basis	MHSWR Reg. 3, Requirement for suitable and sufficient risk assessment. PUWER Reg. 8, Provision of information and instructions. LOLER Reg. 8, Organisation of lifting operations.	

Item	Inspection Topics	Guidance Notes
10.4	**Construction**	
10.4.1	**Piping, Flange Joints, & Small Bore Pipework / Tubing** Is there a system of competence assurance for piping / tubing work? Is there a system in place for identifying critical flange joints, and recording torque / tension settings?	Problems have been experienced with incorrectly assembled piping flange joints and small bore fittings. The problems include the use of incorrect or incompatible materials and fittings, incorrectly tensioned bolts in flanged joints, over or under tightened compression fittings and insufficient tubing / piping length inserted into compression fittings. To reduce the probability of leaking joints, there should be systems in place for competence assurance of the personnel carrying out and inspecting such work. The system(s) may include the retraining / testing of personnel. Joints identified as 'safety critical' should require bolts to be torqued or tensioned to specified values and the work to be witnessed by independent parties. **These values should be formally recorded and tagged as per the latest industry guidelines.** Note: For management of small bore pipework and bolted flange joints, please see part 2 and part 7 respectively.
10.4.2	**Control of change** Is there a system in place to assess safety implications of modifications carried out during construction?	Modifications such as re-routing pipework around obstructions, or tie-ins into existing plant at different locations from the design, or altering the elevation/location of a PSV (which could affect draining of the discharge line into the flare header) would be typical of those, which may bypass procedures.
Legal Basis	PUWER Reg. 4, work equipment has to be constructed or adapted as to be suitable for the purpose for which it is used or provided. PUWER Reg. 8, provision of information and instructions. PUWER Reg. 9, provision of adequate training.	
10.5	**Commissioning**	
10.5.1	**Procedures** Have procedures been developed and approved? Is there a system for controlling distribution, changes and status? Have all parties, including contractors' personnel, received relevant documentation?	Commissioning activities include cleaning / flushing, drying, pressure / leak testing, and function testing. Commissioning procedures should have been produced and made available to all relevant parties. The project document control system should cover the distribution and checking of project documentation across all parties

Item	Inspection Topics	Guidance Notes
10.5.2	**Cleaning / Flushing / Drying** Have process pipework and vessels been cleaned / flushed to remove debris (scale, slag etc.)?	The flushing process would normally be carried out using a high volume flow of compatible fluid, i.e. normally fresh water but special fluid or hydraulic oil for a hydraulic system so as not to contaminate the system with water. For some systems seawater may be used for flushing but it should be inhibited as required. Some systems, e.g. stainless steel, may require fresh water flush, following seawater, to remove chlorides. Following water flushing, the system is drained at low points; residual water may be blown out of the system using dry air. Where the system is to be left empty for more than a few days, it should be blanketed with dry air or nitrogen to prevent internal corrosion. For prolonged periods in this state, the system may need to be treated with corrosion inhibitor.
10.5.3	**Pressure Testing / Leak Testing** Are adequate arrangements in place for pressure / leak testing?	Pressure testing includes proof / strength testing, and leak testing. Pressure testing can be carried out either hydraulically or pneumatically. Wherever practicable hydraulic testing should be employed to reduce the risks to personnel. Guidance is available in "Safety in Pressure Testing", HSE Guidance Note GS4 (3rd ed. 1998). Strength testing is carried out to prove the quality of materials and the construction of the equipment / system before it enters service. Test pressure is typically 1.25 - 1.5 x system design pressure. All temporary connections must be adequately rated for the test. Relevant standards are: • EN 13445 (replacing BS 5500) - 1.25 x design • ASME VIII Div.1 - 1.5 x design • ANSI B31.3 (topsides pipework) - 1.5 x design Pneumatic leak testing is normally carried out at relatively low pressure (not exceeding 10% design pressure; normally ~2 barg) to identify leaks prior to hydrostatic testing or reinstatement testing at higher pressures. Testing with soap (or proprietary) solution, or inert gas with tracer (usually helium) is commonly carried out.
10.5.4	**Function Testing** Has function testing been carried out, and signed off?	Function testing is carried out using a suitable test medium at design pressure, or working pressure if this is lower, to check the function of components including the actuation of moveable parts. (Inspection on one installation showed that not all shutdown trips were function tested because the project was behind schedule).
10.5.5	**Documentation / Records** Is there a system for recording activities, test results, rectification work, re-testing etc.?	Each of the commissioning activities should have documented records.

Item	Inspection Topics	Guidance Notes
10.5.6	**Training** Does the training programme include involvement in the commissioning of vendor packages?	For vendor packages, it is beneficial for operators and technicians to gain familiarity with the equipment by becoming actively involved in the commissioning, working alongside the vendor's personnel. Evidence from audits indicates that whilst installation personnel were meant to become involved in the commissioning of vendor packages they were sometimes seen as slowing down progress and were discouraged from detailed involvement. Packages were handed over to installation personnel who had only limited knowledge of how to maintain and operate them.
Legal Basis	PUWER Reg. 8, provision of information and instructions. PUWER Reg. 6, requirement to inspect work equipment after it has been installed and put into service for the first time, or after assembly at a new site or location. Requirement to keep records of inspection. PUWER Reg. 12, protection against specific hazards. Cleaning, flushing and pressure testing contribute to the overall scheme of taking measures to prevent the unintended discharge of fluids from the work equipment.	
10.6	**Post Commissioning**	
10.6.1	**Punch Lists** Is there an adequate system in place to identify punch list items, and track them to completion?	Punch lists are normally used to collate problems that come to light during commissioning, and to prioritize actions. Typical items, which may not be progressed in a timely manner, are valve tagging, repairs to damaged or missing insulation, plugging or blanking off open ends of small bore pipework.
Legal Basis	PUWER Reg. 4, work equipment has to be constructed or adapted as to be suitable for the purpose for which it is used or provided. PUWER Reg. 8, provision of information and instructions.	

Part 10 – Glossary

ACOP	Approved Code of Practice
DCR	Offshore Installations and Wells (Design and Construction, etc) Regulations 1996
DH	Duty holder
ESD	Emergency shutdown
ESDV	Emergency Shutdown Valve
FMEA	Failure modes and Effects Analysis
FPOSO	Floating Production, Storage and Offloading Vessel
HAZID	Hazard Identification Study
HAZOP	Hazard and Operability Study
HCR	Hydrocarbon Release
HIPS	High Integrity Protection System
HSWA	Health and Safety at Work etc. Act 1974
ICP	Independent Competent Person
LOPA	Level of Protection Analysis
MAH	Major Accident Hazard
MHSWR	Management of Health and Safety at Work Regulations 1999
NUI	Normally Unattended Installation
ORA	Operational risk assessment
OSD	Offshore Division
PFEER	Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations 1995
PTW	Permit to work
PUWER	Provision and Use of Work Equipment Regulations 1998
QRA	Quantified risk assessment
SBT	Small bore tubing
SC	Safety Case
SCE	Safety critical element
SCR	Offshore Installations (Safety Case) Regulations 2005
SIL	Safety integrity level
SMS	Safety management system
SSIV	Sub Sea Isolation Valve