



Exploration & Production

GENERAL SPECIFICATION

Field Operations

GS EP EXP 407

Identification of Safety Critical Elements

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Contents

1. Scope	3
2. Reference documents.....	3
3. Introduction	4
3.1 Purpose	4
3.2 Definitions	4
3.3 General process for managing SCE.....	6
4. Workpack 1- Identification of SCE.....	7
4.1 Step 1- Collect Risk Assessments outcomes	7
4.2 Step 2 – Identify SCEs.....	7
4.3 Step 3 – Establish SCE sponsors.....	8
4.4 Step 4 – Establish the specific list of SCE	9
5. Workpack 2 – Establish Performance Standards for SCE.....	12
5.1 Definition.....	12
5.2 Step 1 - Establish Performance Standards.....	13
5.3 Step 2 – Validation.....	13
5.4 Step 3 – Loading and management of SCEs in the CMMS	13
Bibliography.....	14
Glossary of terms	15
Appendix 1 Generic List of SCE.....	18
Appendix 2 Example Major Risk Register (from PRA).....	25
Appendix 3 Example of Bow Tie Representation.....	27
Appendix 4 Example format of SCE registers	29
Appendix 5 Example format of Performance Standards	34



1. Scope

This document intends to provide Maintenance and Inspection Engineering Contractors with the methodology for identifying Safety Critical Elements (SCE) and preparing the baseframe requirements for managing SCEs.

This document applies to all Total E&P projects and operated installations.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Standards

Reference	Title
Not applicable	

Professional Documents

Reference	Title
Not applicable	

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	



Total General Specifications

Reference	Title
GS EP SAF 041	Technological Risk Assessment Methodology
GS EP EXP 311	Plant Integrity, Minimum Inspection Requirements

3. Introduction

3.1 Purpose

Total E&P have defined the requirements to manage Asset Integrity. The objective is to ensure that the people, systems, processes & resources, which deliver integrity, are in place, in use and fit for purpose over the whole lifecycle of the assets.

To achieve this while considering the vast inventory of assets and activities the general principle is to concentrate management efforts on those elements being the most critical to safety, the objective being to minimize the risk of major accidents. These elements are designated as Safety Critical Elements (SCE).

Total's Integrity Management (IM) expectations are also to take benefit from improved safe operation practices to maximize production performance. The improvement is expected to result from increased facilities availability and more robust operational processes. Elements having a major impact on production performance or financial aspects are designated as Business Critical Elements (BCE).

This document defines how SCEs should be identified and how their minimum performance requirements should be formalised. Requirements for identifying and managing BCEs are not described in this document.

Present General Specification is intended to be used by Contractors mandated by Total Project Groups. It can be included as part of Maintenance & Inspection Engineering Contracts (MIEC) or separately.

3.2 Definitions

Definitions adopted by Total E&P are as follows:

An element can designate a physical piece of equipment, an activity, a work process, a person or an organisation.

Safety Critical Elements (SCE) are any element (as defined above) whose failure will either cause or contribute to a major accident, the purpose of which is to prevent or limit the effect of a major accident (UKOOA). SCE are equivalent to Safety Critical Measures (SCM) introduced in [GS EP SAF 041](#).

Business Critical Elements (BCE) include elements whose failure would have a major impact on production or asset value.

Major Accident Hazard Scenarios (MAH) are defined as "The scenarios with potential damage severity of "catastrophic" or above to people, environment or asset". According to Total rules (re. [GS EP SAF 041](#)) such situations correspond to the red squared zone of the risk matrix shown in fig. 1 below. These scenarios are also referred as Major Scenarios in this document. It should be noted that this definition implies that the severity of consequences is the leading

criteria and elements falling into the “green area” of the matrix may be SCEs even though the probability of occurrence of concerned scenario is very low.

From the above definitions, it should be understood that SCEs form the barriers protecting the personnel and assets from a major hazardous event. Operators shall then focus efforts on identifying credible major accident hazards and then identifying SCEs which will prevent, control, mitigate and facilitate the safe evacuation from the identified hazards.

Because of the essential role of SCEs, assurance activities (maintenance, inspection and testing) must be put in place to continuously demonstrate that they remain fit for purpose during the whole life of the installations.

Other equipment having a similar role but which would not be active or operated in the occurrence of major accident hazards will not be considered as SCEs. This does not mean they should not be submitted to appropriate maintenance, inspection or testing as they may be important to field operations activities.

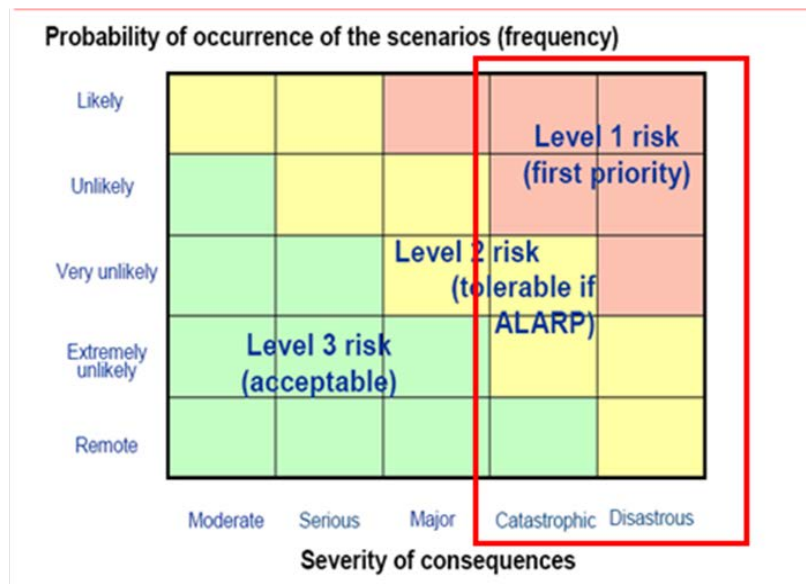
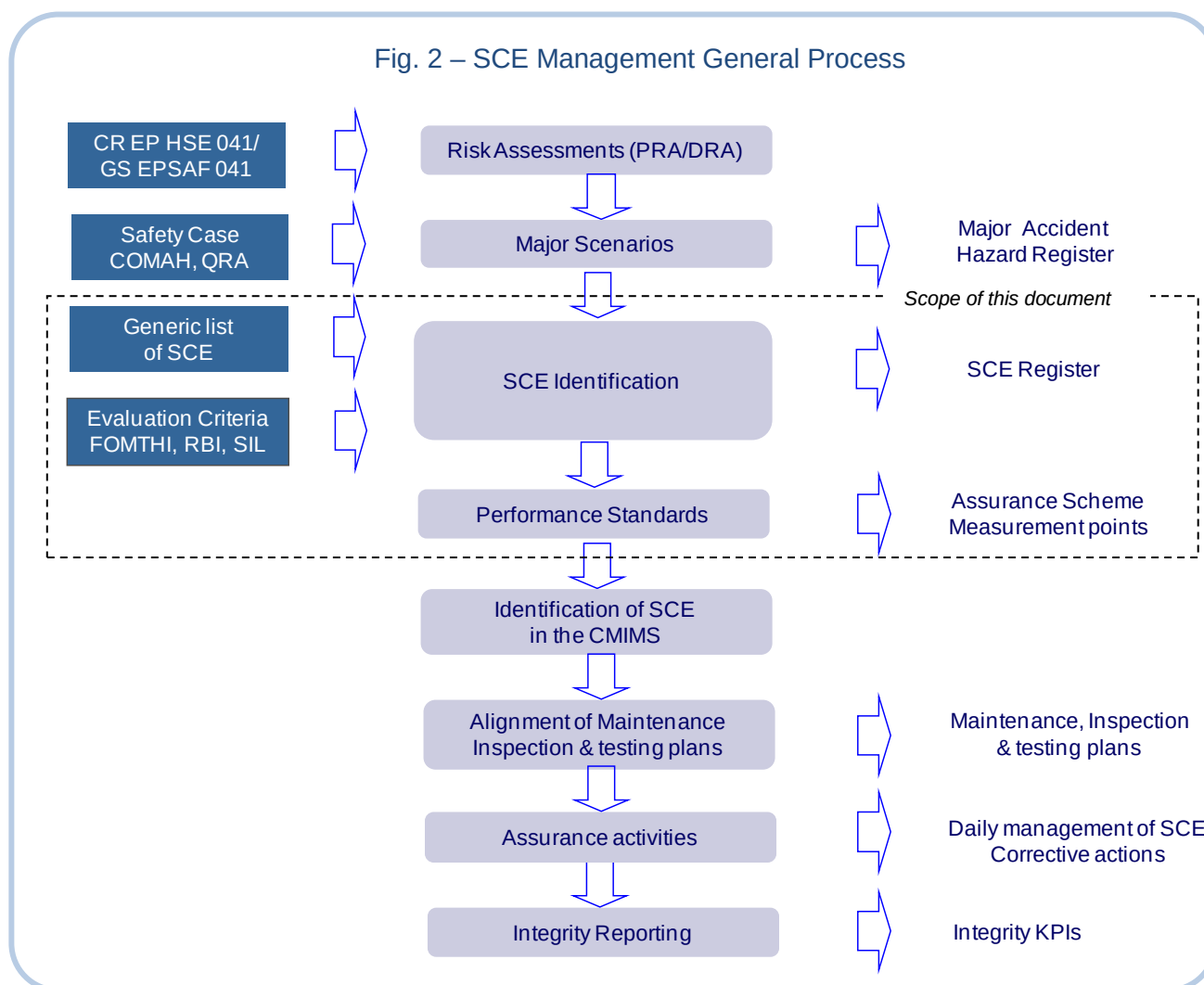


Fig. 1 – Scenarios generated or controlled by SCEs

3.3 General process for managing SCE

The overall process can be illustrated by the following diagram:

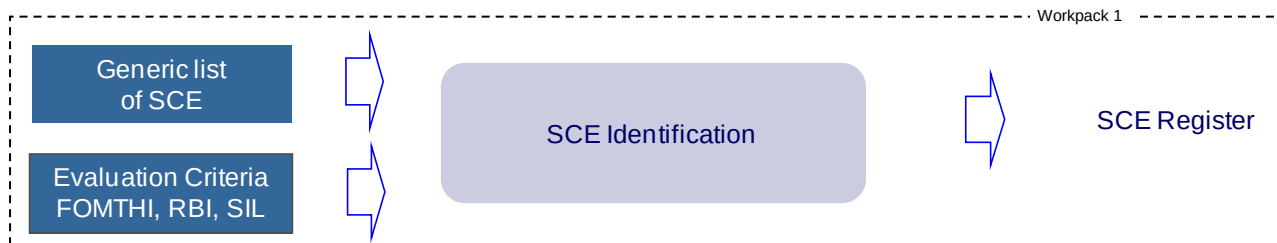


The process is based on a step by step approach, each step requiring separate work packs and dedicated competences.

The dotted line in the above diagram shows the scope of this document

The following sections segregate the process in successive workpacks, each workpack being split into several steps that are to be conducted in sequence. Workpacks may be left to different contractors as the nature of the work varies significantly from one to the other. The given split and scope of workpacks is indicative only, and can be adjusted to project needs or to the organization of the affiliate, especially when the work is partially done using internal resources.

4. Workpack 1- Identification of SCE



4.1 Step 1- Collect Risk Assessments outcomes

In Total E&P risk assessment (RA) is a mandatory requirement being part of the control of major Technological Risks. **GS EP SAF 041** defines dedicated methodologies and responsibilities for conducting preliminary and detailed risk assessments (PRA/DRA), during the project phase and during the operation phase. RA studies are generally performed by specialist contractors.

The outcome of these studies is the creation of a Risk Register and action plan. The Risk Register describes the major risks and provides clear links between the identified risks and control measures, systems, processes and procedures implemented to manage/mitigate the risk.

For some projects, conducting these assessments is already subject to local regulatory requirements. They are sanctioned by e.g. COMAH/HSEIA processes (UK, NL, UAE). Reports are available and can be used, although assessments may not fully comply with **GS EP SAF 041**.

In other cases Quantitative Risk Assessments (QRA) may have been conducted as part of project requirements.

All available RA realized by the project or the affiliate shall be collected and gathered within a dedicated "Risk Assessment Dossier" for future reference.

4.2 Step 2 – Identify SCEs

By principle, and in compliance with **GS EP SAF 041**, the identification of SCEs shall be directly derived from the major scenarios that have been analysed during the Detailed Risk Assessment (DRA) stage of the risk assessment process. Comprehensive assessment is needed to identify SCE on the basis of their quantified influence on risks, considering especially the impact when they fail on demand.

In order to simplify the evaluation, an acceptable approach will be to identify SCE from a generic list instead of considering the whole inventory of facilities and activities. With the growing experience gained over the recent years, especially in the North Sea, such an approach is becoming a standard practice for operators. At this stage, it is considered that SCEs are identified at the function level, not at the single equipment TAG level. In other words, a detailed identification of all the components constituting SCEs is not required. The objective of the task is to identify individual SCE functions effectively present within the installations.

The list of SCE functions specific to concerned facilities shall be based on the generic list provided in appendix 1.



The generic list shall be screened in detail and tailored to comply with actual facilities asset register, by removing assets that do not exist in the concerned installations e.g. offshore related assets if concerned development is onshore. Additions may be done as deemed necessary for project specific items.

SCE classification given in attached generic list shall be respected so as to ensure system coherence throughout affiliates.

- Level 1: Protective role
 - P Hazard Prevention*
 - C Hazard Control*
 - M Hazard Mitigation*
 - E Evacuation, Escape & Rescue*
 - S Staff competency*
- Level 2 : Critical Function
 - P1 to P18**
 - C1 to C14**
 - M1 to M10**
 - E1 to E12**
 - S1**
- Level 3: SCE
 - P1.1 to P1.n**
 - C1.1 to C1.n**
 - Etc.*

The classification shall be used in all aspects of SCE management, especially for identifying SCE in the CIMMS and reporting on Asset Integrity.

4.3 Step 3 – Establish SCE sponsors

Once the generic list is established, it is important to clearly define who shall be the lead discipline in charge of the establishment of the requirements attached to each SCE. In general, the proposed SCE classification allows one key discipline per class to be easily identified, a single discipline quite often being in charge of several classes of SCEs. For example Instruments are usually in charge of Process Control SCEs (P7) and Hazard Control (C1, C2, C3, etc.).

During the project phase, Key SCE sponsors shall be identified within project organisation. Their role is to establish the detailed list of SCEs being within their area of work, verify/establish generic performance standards, ensure adequacy of design solutions and supplies, validate assurance activities, etc.

It is important that a Task leader is formally nominated in order to ensure the coordination, the consistency and timely delivery of the task. The Project Lead Integrity Engineer or the Integrity Manager of the affiliate (as relevant) are the natural candidates.



4.4 Step 4 – Establish the specific list of SCE

Identifying individual SCE by simply screening and tailoring the asset inventory as per the elements of the generic list of SCE does not identify those elements that are potentially involved in major scenarios nor those which control or mitigate the risks associated with major scenarios. Many items from the generic list may be involved in non-major scenarios outside the squared “major risk area” shown in fig. 1 section 1.2.

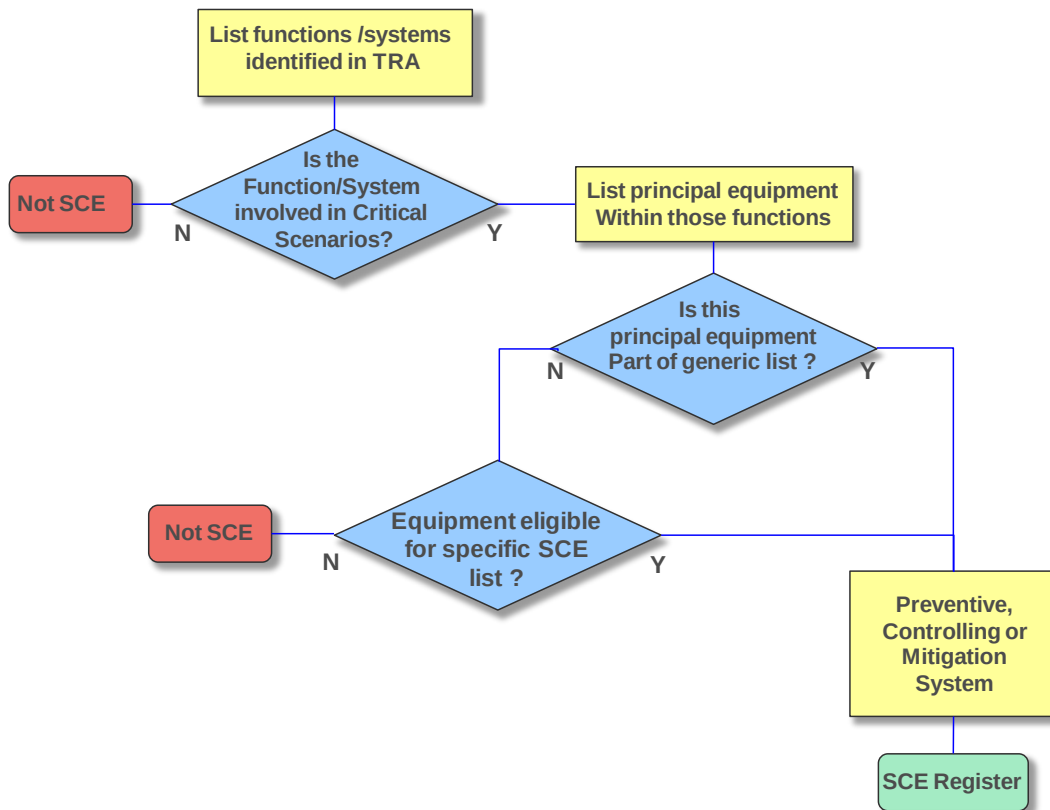
Step 4 consists in selecting for each SCE class of the generic list, those individual SCEs involved in scenarios belonging to the categories “disastrous” or “catastrophic” as per the definitions of Total E&P risk matrix.

The reference basis shall be the “Risk Assessment Dossier” established during step 1, which should include the “Major Risk Register” required by **GS EP SAF 041**. The Major Risk Register is the collection of major scenarios. A typical example is given in Appendix 2, showing the main elements of the Register i.e.

- The critical Scenarios,
- The main causes of the event,
- The associated preventive measures,
- The associated mitigation measures.

The key sources of data from which SCE shall be identified will be the PIDs for process equipment and construction files for other equipment, e.g. structures.

The general process can be illustrated by the following simplified chart.



Pending on the time at which the identification of SCE is conducted within the project overall schedule, the asset register may not be fully available at the time of implementation of present work scope. In this case the list of SCE will have to be established directly from the review of PID for process systems or from construction files for other assets (structures, wells, lifting appliances, subsea equipment, etc.).

SCE shall be identified as elements being in the same time:-

- 1- Hardware or activity belonging to the generic list of SCEs
- 2- An identified barrier in the “Disastrous” or “Catastrophic” major scenarios.

The Bow Tie format representation of scenarios shall be used to identify the barriers and SCEs involved and to verify they belong to a major scenario. An example is given in Appendix 3 extracted from same study as above.

There is a large part of qualitative judgment in this assessment. Many secondary pieces of equipment can theoretically be found belonging physically to a SCE and then become SCE themselves. Common sense and pragmatic judgment shall be used to define the contour of an SCE without unnecessary complication. As a general guideline, reference to Maintenance practice will generally help to define the appropriate extent of the SCE.

For example, an ESDV is composed of many elements including the valve, the actuator, the instrumented control loops, the detectors, etc. All could be individually considered as SCE as their failure could compromise the response of the protective system. However a good way to define the contour of SCEs is to consider how the system is maintained and how it is tested. In this case the valve and its actuator can hardly be segregated as they will be tested and



maintained in the same time. Detectors should be separated as they are submitted to specific testing regime, depending on their reliability and SIL. Same would apply to the control system.

In the proposed SCE Register format (see below) the lowest SCE level that reflects the above principle is designated "Principal Equipment Item Concerned"

Overall, the objective should be also to ensure that SCEs are selected with a sufficient degree of discrimination, so as to ensure that the reporting of their condition reflects a true control of the risks. This task requires sound engineering judgment. Should it be conducted by a Contractor's Team or by an affiliate task group, it is important that those teams gather all required competences, basically:

- A Field Operations representative: to identify equipment belonging to a scenario, to help understand logic controls and safety systems
- A safety engineering specialist: To help understand and analyse TRA outputs
- A Maintenance/Inspection representative: to define measuring points, routes and associated tasks
- The Asset Integrity manager (as relevant): To coordinate the task and maintain coherence over time
- Discipline specialists on demand (instruments, structures, marine, subsea, logistics, etc.) : to incorporate discipline technical input

The determination of the criticality of an SCE is not a required step of the process. However this parameter may be available as a result of specific assessments such as RBI or SIL assessments. It can therefore be used for possible more detailed evaluations.

Reporting format: The SCE Register

The minimum information to be provided in the SCE Register is:

1. The SCE Reference
2. The SCE Function
3. The General SCE Designation
4. The Principal Equipment Items
5. The Major Scenario(s) the SCE is contributing to
6. The type of contribution of the SCE (Protection, Mitigation, Escape)
7. The Sponsor of the SCE
8. Reference of associated Performance Standard

All major "Catastrophic" and "Disastrous" scenarios identified during the TRA must be referenced in the SCE Register.

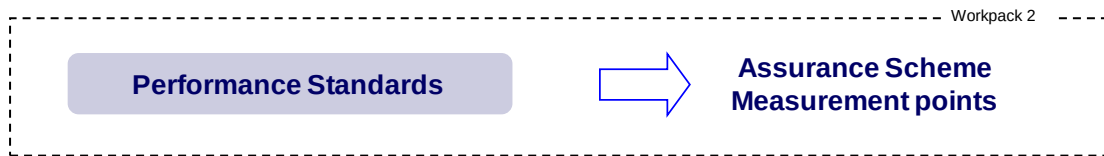
The tabulated format given in Appendix 3 is provided for guidance only., Please note that only three scenarios are mentioned for the sake of clarity. In reality, several tenths of critical scenarios can be identified.

Finally, it can be noted that the proposed format will allow the easy identification of SCEs being involved in several critical scenarios.

Workpack 1 Deliverables

- 1- The Risk Assessment dossier
- 2- The SCE Register.

5. Workpack 2 – Establish Performance Standards for SCE



5.1 Definition

Performance standards are the key technical requirements to be met by SCEs in order to ensure they are effectively operable on demand, they perform as expected and they have some capacity to survive incidents.

Performance standards describe the goal of an SCE in its safety critical role and the performance requirements/thresholds (acceptance criteria) the SCE must meet during design and operational life.

As introduced earlier, assurance activities (maintenance, inspection and testing) must be put in place to continuously demonstrate that SCEs remain fit for purpose during their whole service life. It should be noted that most of assurance activities required for SCEs are usually already in place through preventive maintenance (PM) programmes and Inspection programmes. However SCEs may deserve “special treatment” i.e. specific inspection frequency, more thorough maintenance regime or possibly stricter tolerances in their management.

It is not directly implied that an SCE should be given the highest level of urgency when scheduling inspection, testing or maintenance activities. The scheduling of assurance activities should be also based on reliability aspects, so as to avoid unnecessary checks or to avoid too frequent checks that have limited added value in demonstrating fitness for purpose.

Performance standards (PS) include all the controls that are needed to verify SCE integrity together with the minimum performance that should be maintained for each control point. It is important to note that the requirements set in PS may not coincide with original design specifications of the equipment. PS should rather correspond to operational needs. Typical example is the output of a firepump that should satisfy the actual firewater worst case demand, which could be lower than the OEM specified max output.

Performance Standards should cover at least three main areas of control:

1. **Functionality** – What to control to ensure the equipment fulfils its functions

Example: for an ESD Valve - pressure containment, mechanical activation, system activation (control loop), closure time

2. **Availability, reliability** – At what frequency should it be controlled and maintained to meet performance/integrity minimum requirements

Example for an ESD Valve: testing frequency for partial and full stroke, instrument loop testing, based on SIL assessments

3. **Survivability** – Does the equipment need to keep its functions during an incident and how to maintain this capacity

Example for an ESD Valve: fail safe philosophy, fire proofing



More detailed considerations on Performance Standard design can be found in [GS EP SAF 041](#).

Performance Standards shall include the requirements associated to the design phase AND those associated to the operational phase of the facilities.

5.2 Step 1 - Establish Performance Standards

Controls required to ensure fitness for purpose of the various types of asset are usually well established. For example the controls for a pressure vessel are quite generic, including the conformity to Design & Construction Standards (project phase), the validation of material selection (project phase), the verification of wall thicknesses (project phase and operational phase), the internal and external examinations (operational phase), the verification of coatings and linings, etc. There are few pressure vessels that would require specific controls.

Performance Standards shall then be the collection of specific assurance activity requirements attached to each SCE, as they appear in the SCE Register. They are generic by nature as similar requirements should apply to all individual items belonging to the same type of equipment.

Performance Standards shall be established on the basis of the Performance Standard Format given in Appendix 5.. The contractor shall use this as a guidance to develop Project Specific Performance Standards.

Other examples of Performance Standards covering most types of SCEs can be obtained from Total E&P on demand.

Individual and detailed maintenance, inspection and testing requirements for each SCE (TAG item) shall be governed by the general requirements set in Project Performance Standards. They will be established according to Total E&P policies, such as [GS EP EXP 311](#) for plant inspection. Of course the number of controls, their frequency, the expected performance and possible specific techniques to be used may differ significantly from one SCE to the other.

The establishment and management of individual assurance requirements (per TAG item) and the corresponding measurement points in the CIMMS do not form part of the scope of this document.

Workpack 2 deliverables

- 1- The Integrity Assurance Scheme Dossier, collecting all Performance Standards associated to SCEs that have been identified after completion of Workpack 1.

5.3 Step 2 – Validation

The Project Group or the affiliate Task Leader shall ensure that the SCE Register and Performance Standards delivered by the contractor(s) in charge are formally validated by the appropriate Total Technical Authorities. The objective is to verify that the requirements set in the study comply with Total E&P Field Operations rules and practices. As far as principal concerned activities relate to Risks, Maintenance and Inspection, concerned Technical Authorities are currently located in EXP/MIN and EXP/SRI.

5.4 Step 3 – Loading and management of SCEs in the CMMS

As indicated earlier, the establishment in the CMMS of measuring points, routes and workpacks corresponding to Performance Standards requirements is not covered by this document.



Bibliography

GS EP SAF 371	Emergency Control Facilities
GS EP SAF 261	Emergency Shut-Down and Emergency De-Pressurisation (ESD & EDP)
GS EP SAF 312	Guidelines for selecting and installing fire and gas detection systems

Glossary of terms

Asset	Resource owned by an organisation. In current context: An engineered piece of equipment (i.e. excludes reservoirs and people). An asset can be categorised at various levels of detail: Platform, processing unit, equipment type or tag item).
Assurance Activities	Designates maintenance, inspection and testing tasks used to demonstrate that equipment or activities are operated/conducted as per initial specifications. These tasks and their results must be traced, measured and followed-up to provide the positive assurance that equipment or activities remain fit for purpose over their whole life cycle.
BCE	Business Critical Elements. Part of the installation or plant whose failure would have a major impact on production or asset value.
Business Risk	Threats or opportunities concerning the survival or prosperity of the business. In current context covers threats to production or revenue.
CIMMS	Computerised Inspection & Maintenance Management System. A computerised system that allows detailed management of activities and data related to the maintenance and inspection of assets. In this document CIMMS designates UNISUP or lighter version SALSA PM, developed within the SAP environment.
COMAH	Control Of Major Accident Hazard. UK HSE Regulatory requirements aiming at preventing and mitigating the effects on people and the environment of those major incidents involving dangerous substances.COMAH applies mainly to the chemical industry, but also to some storage activities. Used to implement Seveso 2 requirements.
Compliance	Fulfilment of specified requirements (regulations, specifications, company rules, etc.)
Deviation	Permanent exception or excursion from standards, specifications or design conditions
Discipline	In present document a Discipline refers to an organisation entity or individual having a specific technical specialty (e.g. production, inspection, corrosion control, instruments, rotating machinery, etc.)
DRA	Detailed Risk Assessment. Second step of the risk assessment process required by GS EP SAF 041 to select and quantify the risks in a comprehensive manner, using scenario based approach and QRA.
EPC	Engineering, Procurement & Construction contract for new projects
Follow-up	The activity which ensures that agreed action items resulting from an audit or an investigation is traced and implemented
FOMTHI	Field Operations Major Technological Hazards Indicator
Hazard	Condition or practice with the potential to cause harm to people, the environment, property or Total's reputation



HSEIA	HSE Impact Assessment. Process used for assessing environmental impact of new projects, generally before development decision.
IM related Incident	Incident involving the failure of an engineered system including mechanical, electrical, structural, process or lifting equipment or the loss of containment , for any reason other than operational human errors.
Integrity	Unimpaired state of fitness. See Asset Integrity definition in document
Integrity threats	Any IM related incident, deficiency in business processes or activity having the potential to compromise asset integrity.
KPI	Key Performance Indicator. A quantifiable/recordable measure of the performance of an activity or state of condition to meet specified targets. KPIs are generally established at various levels in the organisation to drive business improvement from work level to senior management.
Life cycle (asset)	The total period during which a facility or an asset within a facility, exists. It covers the time from initial design and construction through to decommissioning and abandonment
MIEC	Maintenance & Inspection Engineering Contract. Contracts put in place during the project phase. The main scope is to specify M&I requirements
MRT Plan	French Acronym (Maîtrise de Risques Technologiques) designating the plan set at the Holding level to improve the control of major technological risks
OEM	Original Equipment Manufacturer
PRA	Preliminary Risk Assessment. First step of the risk assessment process required by GS EP SAF 041 to screen major risk scenarios
PS (Performance Standards)	Performance Standards are documents stating the requirements for maintaining and testing critical equipment throughout their life cycle (ongoing suitability). PS also include asset functionality, availability, reliability and survivability elements. PS are used to materialise the operating envelope of critical elements (CE) and to measure integrity compliance. They refer to asset design specifications (original suitability) or operational requirements (desired performance).
QRA	Quantitative Risk Assessment. Established methodology to quantify levels of risk an installation (or part of) can be exposed under various normal or exceptional operating situations.
RBI	Risk Based Inspection. The process and system established to base inspection techniques and frequencies on the perceived risk of degradation
Responsibility	Organisational empowerment assigned to an individual or entity to realise a specific task or function



Risk	Chance of loss. Often calculated as the product of the probability of occurrence of an event and the potential severity of the loss, should the event occur
Risk Assessment	The process of estimating the likelihood of an incident, estimating the magnitude of the consequential loss, and make a judgement as to the significance of the risk
Safety Critical Elements (SCE)	(see document) "Safety Critical Elements (SCE) are any part of the installation or plant whose failure will either cause or contribute to a major accident, the purpose of which is to prevent or limit the effect of a major accident" (UKOOA).
Safety Critical Measures (SCM)	Equivalent to SCE
SIL	Safety Integrity Level
Technical Authority	The entity or person in the organisation mandated to establish policies, strategies or technical expert advice related to a specific area of work or technical discipline. Their primary role is to ensure the safe and consistent application of Total's referential documents, codes, standards and good engineering practice.

Appendix 1 Generic List of SCE

HAZARD PREVENTION			
Elements which failure could result in a Major Accident			
PRIMARY DEFENCE BARRIER			
SCE No.	SCE FUNCTION	SCE No.	SCE Sub-System
P1	Structural Integrity	P1.1	Jacket
		P1.2	Piles
		P1.3	Foundations
		P1.4	Topsides/Surface Structures
		P1.5	Flare Structure
		P1.6	Crane Structure
		P1.7	Derrick and Sub Structure
		P1.8	Appurtenances and supports
		P1.10	Bridge
		P1.11	Hull Structure
P2	Legs Jacking & Locking System	P2.1	Legs
		P2.2	Jacking Mechanism
		P2.3	Locking Mechanism
P3	Collision Avoidance System	P3.1	Navigational Aids
		P3.2	Vessel Warning Lights
		P3.3	Fog Horn
		P3.4	UK specific DO NOT USE
		P3.5	UK specific DO NOT USE
		P3.6	UK specific DO NOT USE
		P3.7	UK specific DO NOT USE
		P3.8	Radar
		P3.9	Tanker Tugs
		P3.10	Marker Buoys
P4	Process Containment Integrity	P4.1	HC Pressure Vessels
		P4.2	HC Pipework
		P4.3	HC Exchangers
		P4.4	Machinery
P5	Pipelines and Riser Integrity	P5.1	Imp/Exp Pipelines & Risers
		P5.2	UK specific DO NOT USE
		P5.3	UK specific DO NOT USE
		P5.4	Corrosion/Cathodic Protection

HAZARD PREVENTION			
Elements which failure could result in a Major Accident			
PRIMARY DEFENCE BARRIER			
SCE No.	SCE FUNCTION	SCE No.	SCE Sub-System
P5	Pipelines and Riser Integrity	P5.5	Exp FPSO to BUOY-below water
		P5.6	Exp FPSO to BUOY-above water
		P5.7	Imp Flex Risers-below water
		P5.8	Dynamic Umbilical-below water
		P5.9	Floating Hoses-Oil & Methanol
P6	Inter-Field Pipelines, Manifolds & Equipment	P6.1	Inter-Field HC Pipelines
		P6.2	UK specific DO NOT USE
		P6.3	UK specific DO NOT USE
		P6.4	UK specific DO NOT USE
		P6.5	Manifolds, Jumpers & Xmas Trees
		P6.6	Riser Tower
P7	Prevention and Containment of Rotating Equipment Failures	P7.1	Prev/Cont of Rotating Equipment Failures
P8	Process Area Ventilation	P8.1	Natural/Forced Vent of HC Area
P9	UK specific DO NOT USE		UK specific DO NOT USE
P10	Relief Systems	P10.1	Relief Valves/PSVs
		P10.2	Bursting Discs
		P10.4	Venting Devices
P11	HVAC Systems	P11.1	HVAC Systems and Fire Dampers
P12	Ignition Prevention Systems	P12.1	ATEX / Ex Ignition Prevention
		P12.2	UK specific DO NOT USE
		P12.3	Flame Arrestors
		P12.4	UK specific DO NOT USE
		P12.5	Exh Insulation on Fixed/Mobile Eqt
		P12.6	Blanket & Inert Gas Systems
		P12.7	UK specific DO NOT USE
P13	UK specific DO NOT USE		UK specific DO NOT USE
P14	Drilling System	P14.1	Drill Line
		P14.2	Disk Brake System
		P14.3	Crown/Travelling Block
		P14.4	Deadline Anchor
		P14.5	Top Drive Load Path
		P14.6	TBM, KEMS, Ultimate Stop

HAZARD PREVENTION Elements which failure could result in a Major Accident PRIMARY DEFENCE BARRIER			
SCE No.	SCE FUNCTION	SCE No.	SCE Sub-System
P14	Drilling System	P14.7	Crown Saver
		P14.8	Wellhead
		P14.9	Christmas tree
P15	Ballast System and Stability Management	P15.1	Ballast Control System
		P15.2	Ballast Pumps
		P15.3	Ballast Piping
		P15.4	Load Management Computer System
P16	Anchoring & Mooring System	P16.1	FPSO Mooring Lines, Anchors/Piles
		P16.2	Buoy Mooring Lines, Anchors/Piles
		P16.3	FPSO Mooring Winch & Tension Monitor
P17	Crane and Lifting Equipment	P17.1	Powered Cranes
		P17.2	Lifting Equip-Fixed and Loose
P18	Corrosion Prevention and Corrosion Monitoring	P18.1	Cathodic Protection and System
		P18.2	Corrosion Monitoring
		P18.3	Corrosion Inhibitor Injection System

HAZARD CONTROL Elements required to control initial losses of integrity to prevent or minimise escalation SECONDARY DEFENCE BARRIER			
SCE No.	SCE FUNCTION	SCE No.	SCE Sub-System
C1	Flammable Gas Detection	C1.1	Gas Detection Systems
		C1.2	UK specific DO NOT USE
C2	Fire Detection	C2.1	Fire Detection Systems
C3	Fire & Gas Control System	C3.1	Fire & Gas Control System
C4	Emergency Isolation	C4.1	ESD System
		C4.2	ESD Valves
C5	Riser / Pipeline ESDV's	C5.1	Riser & Pipeline ESDV's
C6	Reservoir Isolation & Containment	C6.1	Well control facilities
		C6.2	SCSSV (DHSV)
C7	SSIV SSBV	C7.1	Subsea Isolation Valves
C8	UK specific DO NOT USE		UK specific DO NOT USE
		C9.1	Emergency Depressurisation Sys

HAZARD CONTROL Elements required to control initial losses of integrity to prevent or minimise escalation SECONDARY DEFENCE BARRIER			
SCE No.	SCE FUNCTION	SCE No.	SCE Sub-System
C9	Emergency Depressurisation	C9.2	Blowdown Valves
		C9.3	Flare systems
		C9.4	UK specific DO NOT USE
		C9.5	UK specific DO NOT USE
		C9.6	UK specific DO NOT USE
C10	Toxic Gas Detection	C10.1	Gas Detection Equipment
C11	UK specific DO NOT USE	-	UK specific DO NOT USE
C12	Drainage and Containment	C12.1	Haz Area Open Drains Sys
		C12.2	Disposal Systems
		C12.3	UK specific DO NOT USE
		C12.4	UK specific DO NOT USE
		C12.5	UK specific DO NOT USE
		C12.6	UK specific DO NOT USE
		C12.7	UK specific DO NOT USE
C13	Drilling Well Control System	C13.1	BOP-CHOKE
		C13.2	Choke & Kill Manifold/System
		C13.3	Mud Pits
		C13.4	Mud Gas Separator
		C13.5	Mud Monitoring System
		C13.6	Mud pumps and motors
		C13.7	UK specific DO NOT USE
		C13.8	UK specific DO NOT USE
C14	HIPS Systems	C14.1	HIPS Piping Valves & Actuators

HAZARD MITIGATION			
Elements required to mitigate to consequences of a major incident			
THIRD DEFENCE BARRIER			
SCE No.	SCE FUNCTION	SCE No.	SCE Sub-System
M1	Dropped Object Protection	M1.4	Dropped Object Protection
M2	Blast Resistant Construction	M2.1	Blast Walls
		M2.2	UK specific DO NOT USE
		M2.3	UK specific DO NOT USE
M3	Fire Mitigation	M3.1	Passive Fire Protection
M4	Temporary Refuge	M4.1	Temporary Refuge, Muster Drill
M5	Fire Pumps	M5.1	Firewater Pumps and Drives
		M5.2	Firewater Pumps Enclosures
		M5.3	Diesel Day Tanks
M6	Firewater Main	M6.1	Firewater Ring Main & Supports
M7	Firewater Systems	M7.1	Deluge System
		M7.2	Fixed/Oscil Firewater Monitors
		M7.3	Sprinkler Systems
		M7.4	Hydrants
		M7.5	Hose Reel Cabinets
		M7.6	Water Mist Systems
		M7.7	Water Fog System
		M7.8	High Capacity Hose Reels
		M7.9	UK specific DO NOT USE
		M7.10	UK specific DO NOT USE
M8	Foam Systems	M8.1	Heli-deck Foam Monitors
		M8.2	UK specific DO NOT USE
		M8.3	Foam Storage Tanks
		M8.4	UK specific DO NOT USE
		M8.5	Process deluge/foam systems
		M8.6	Mobile Foam Units
		M8.7	UK specific DO NOT USE
		M8.8	UK specific DO NOT USE
		M8.9	Foam Piping Network
		M8.10	Foam Injection Pump
	Liquid & Gaseous	M9.1	Enclosure Extinguisher System (CO2...)
		M9.2	Tech Room Extinguisher System (FM200)

HAZARD MITIGATION			
Elements required to mitigate to consequences of a major incident			
THIRD DEFENCE BARRIER			
SCE No.	SCE FUNCTION	SCE No.	SCE Sub-System
M9	Extinguishing Systems	M9.3	Galley Hood Suppression System
M10	Portable/Trolley Mounted Extinguishers	M10.1	Portable Fire Extinguishers
		M10.2	Large Capacity Wheeled Extinguisher
		M10.3	Trolley Mounted Extinguishers

EE&R			
Elements required to provide the means of Evacuation, Escape and Rescue			
FINAL DEFENCE BARRIER			
SCE No.	SCE FUNCTION	SCE No.	SCE Sub-System
E1	Alarm & PA Systems	E1.1	PAGA Control Sys & Field Equip
E2	Egress & Access Routes	E2.1	Escape Routes and Access Ways
		E2.2	Safety Signs and Notices
E3	Emergency Lighting	E3.1	Emergency Lighting,EDG Backed
		E3.2	Escape Lights,Battery Backed
E4	Helideck	E4.1	Helideck Structure
		E4.2	Helideck Drainage
		E4.3	Wind Direction Indicator
		E4.4	Access Routes
		E4.5	Emergency Equipment
		E4.6	UK specific DO NOT USE
E5	Internal Communications	E5.1	Internal & Inter Complex Comm
E6	External Communications	E6.1	External communications
E7	Lifeboats (TEMPSC)	E7.1	TEMPSC (free fall type)
		E7.2	TEMPSC (davit launch type)
E8	Liferafts	E8.1	Liferafts (Roll-over type)
		E8.2	Liferafts (Selantic Skyscape)
E9	Maintained Power Supplies	E9.1	Emergency Diesel Gen, Emergency Load
		E9.2	Uninterruptible Power, Essential Load
E10	Means of Escape to Sea	E10.1	Ladders & Boat Landings
		E10.2	Selantic Skyscape System
		E10.3	Descent to Sea (Scramble Nets)
		E11.1	Life Jackets



EE&R Elements required to provide the means of Evacuation, Escape and Rescue FINAL DEFENCE BARRIER			
SCE No.	SCE FUNCTION	SCE No.	SCE Sub-System
E11	Personnel Protective Equipment	E11.2	Immersion Suits
		E11.3	Smoke Hoods
		E11.4	Gloves
		E11.5	Portable Lights
		E11.6	Fireman's Equipment
		E11.7	Breathing Apparatus (Escape Sets)
E12	Rescue & Recovery Facilities	E12.1	Emergency Response & Rescue Vessel
		E12.2	UK specific DO NOT USE

STAFF COMPETENCE			
SCE No.	SCE FUNCTION	SCE No.	SCE Sub-System
S1	Resources and Competence	S1.1	Operations
		S1.2	Maintenance
		S1.3	Inspection
		S1.4	Safety & Emergency Training



Exploration & Production

General Specification

Date : 01/2012

GS EP EXP 407

Rev : 01

Appendix 2

Appendix 2 Example Major Risk Register (from PRA)

Functional Blocks	Operating or environment parameter	Critical events	Causes	Preventive measures	Incident outcomes	Mitigation measures	Damages category						
							SI No.	Human severity	Human frequency	R	Asset severity	Asset frequency	R
Halul Inventory 1 - T2 20" Import from DP2	Normal operation	Generic medium process release from the import line from DP2 to beach valve. Operating pressure 7 barg. Generic release Frequency = 1.2-03 per year	Release of Flammable due to: External Corrosion Internal Corrosion Failure of Gaskets, Valves, Stem packings Over pressure Design Errors, Improper Material Selection during design, construction & fabrication errors) Natural & Seismic hazards - exposure by costal erosion or changes to island level Natural & Seismic hazards - covering of above ground pipeline by unstabilised soil Excavation Excess top loading on buried pipe e.g. by vehicles passing over	Coating, Cathodic Protection, Anodes, Inspection Corrosion Allowance, Inhibitors, Material Selection, Inspection, Intelligent Pigging Material Selection, Planned Inspection and Maintenance procedures Material Selection & Design Specification, Pressure Protection System (HIPPS at source platform - 70Bar, ESD, PSH), QA / QC, TOTAL Material Specification, International Standards, Third Party Inspection during EPIC phases Routine inspection of pipe routing Excavation permits, PTW, detailed knowledge of pipeline routing Defined vehicle routes and knowledge of pipeline routing PTW and SIMOPs procedures (TEPQ/QP)	Isolated jet fire Flowrate:57.31 kg/s Jet fire distance to 9.5kw/m2 130.00m Frequency of event =5.75E-6 per year.	ESD systems, Oil Spill Response Plans, Fire fighting facilities, Emergency Response Plans, Fire Fighting Training, Spill Containment PT0211 gives actuation of ESD2 to stop import on High or low pressure (14 and 3barg) PT0414 gives ESD4 on high pressure	HAL-01-L-M-I-J	Catastrophic	2.40E-07	2	Serious	5.75E-06	1



Exploration & Production

General Specification

Date : 01/2012

GS EP EXP 407

Rev : 01

Appendix 2

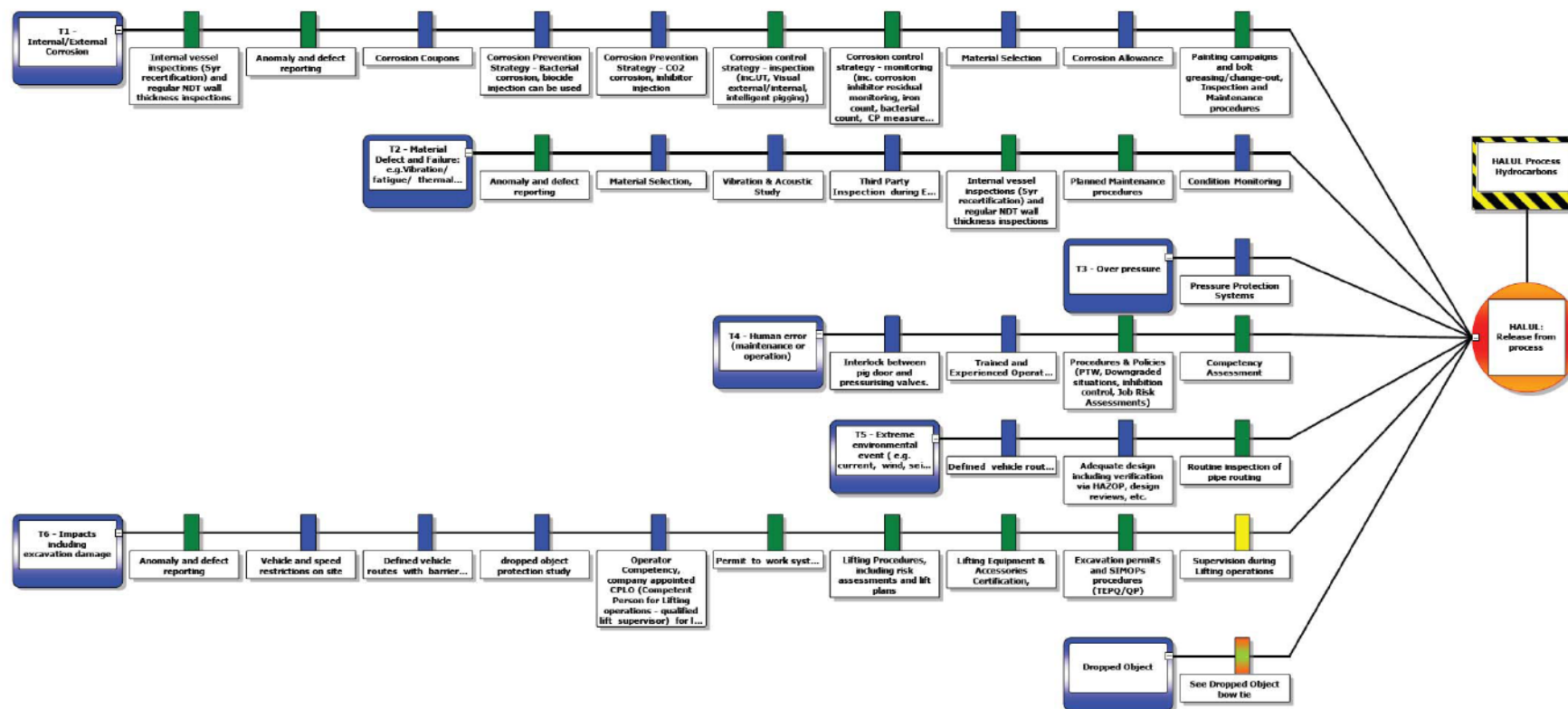
Halul Inventory 1 - T2 20" Import from DP2	Normal operation	Generic medium process release from the import line from DP2 to beach valve. Operating pressure 7 barg. Generic release Frequency = 1.2-03 per year	Release of Flammable due to: External Corrosion Internal Corrosion Failure of Gaskets, Valves, Stem packings Over pressure Design Errors, Improper Material Selection during design, construction & fabrication errors) Natural & Seismic hazards - exposure by costal erosion or changes to island level Natural & Seismic hazards - covering of above ground pipeline by un stabilised soil Excavation Excess top loading on buried pipe e.g. by vehicles passing over	Coating, Cathodic Protection, Anodes, Inspection Corrosion Allowance, Inhibitors, Material Selection, Inspection, Intelligent Pigging Material Selection, Planned Inspection and Maintenance procedures Material Selection & Design Specification, Pressure Protection System (HIPPS at source platform - 70Bar, ESD, PSH),QA / QC, TOTAL Material Specification, International Standards, Third Party Inspection during EPIC phases Routine inspection of pipe routing Excavation permits, PTW, detailed knowledge of pipeline routing Defined vehicle routes and knowledge of pipeline routing PTW and SIMOPs procedures (TEPQ/QP)	Unisolated jet fire Flowrate:57.31 kg/s Jet fire distance to 9.5kw/m2 130.00m Frequency of event =5.00E-7 per year.	ESD systems, Oil Spill Response Plans, Fire fighting facilities, Emergency Response Plans, Fire Fighting Training, Spill Containment PT0211 gives actuation of ESD2 to stop import on High or low pressure (14 and 3barg) PT0414 gives ESD4 on high pressure	HAL-01-L-M-U-J	Catastrophic	2.08E-08	2	Serious	5.00E-07	1
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Appendix 3 Example of Bow Tie Representation

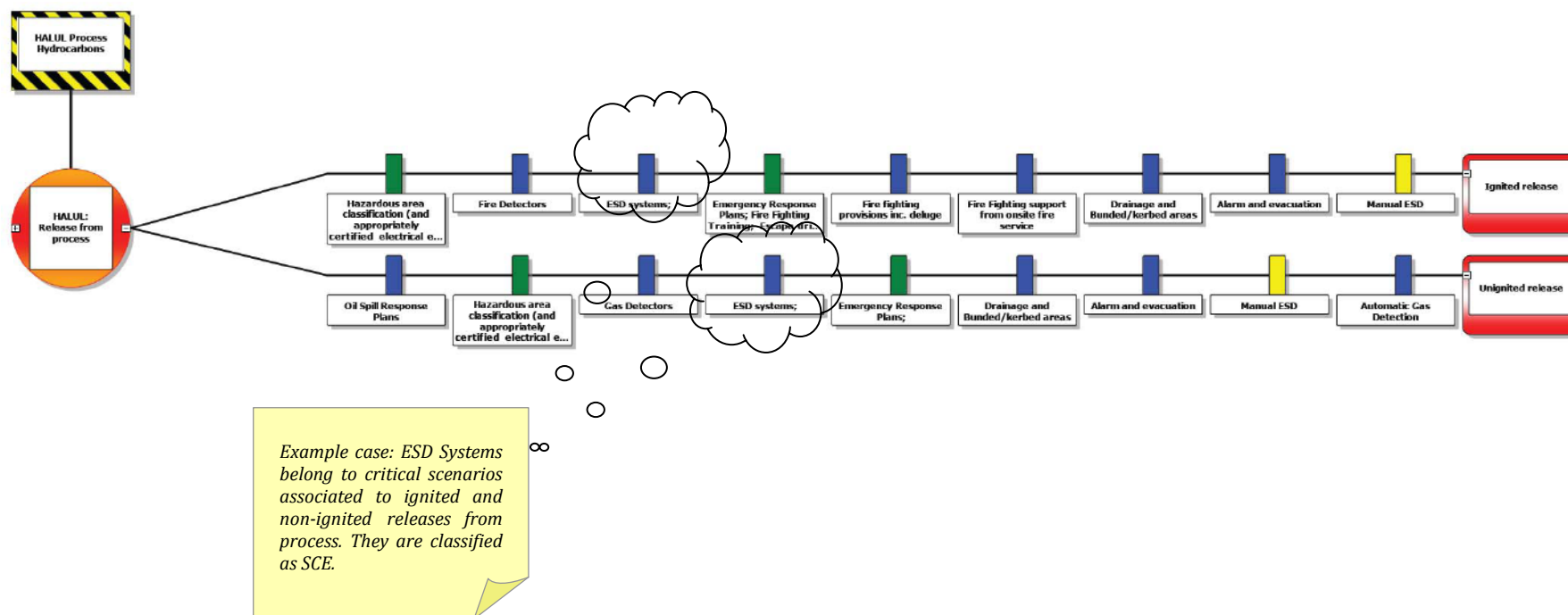
Colour code for Controls:

- Design Hardware
- Procedural
- Direct Human Intervention

1 – PREVENTION BARRIERS



2- MITIGATION BARRIERS





Appendix 4 Example format of SCE registers

SCE REGISTER					Major Accident Hazard Scenarios			
SCE Class	SCE FUNCTION	SCE DESCRIPTION	Principal Equipment Item Concerned	SCE Guardian/Sponsor	HAL-01-LM-I-J	HAL-01-LM-U-J	HAL-06-LM-U-J	Other Scenarios from PRA
					Generic medium process release from the import line from DP2 to beach valve. Isolated jet fire	Generic medium process release from the import line from DP2 to beach valve. Un isolated jet fire	Generic medium process release from process pipework. Unisolated jet fire	.../...
					Catastrophic	Catastrophic	Disastrous	.../...
HAZARD PREVENTION								
P1	Structural and stability integrity	Hull Structure						
		Jacket						
		Mooring system						
		Well completion						
		Loading/Offloading facilities						
P2	Process Containment Integrity	Vessels/Tanks						
		Pipework	T2 Oil to atmospheric separator V5613				P	
		Pipeline	20" Import DP2 - HALUL		P	P		
		Risers			P	P		
		Fired heater/Boilers					P	
		Compressor and pumps						
		Gas turbines						



Exploration & Production

General Specification

Date : 01/2012

GS EP EXP 407

Rev : 01

Appendix 4

SCE REGISTER					Major Accident Hazard Scenarios			
					HAL-01-LM-I-J	HAL-01-LM-U-J	HAL-06-LM-U-J	Other Scenarios from PRA
P3	Prevention of mechanical failure	Inspection of equipment			P	P	P	
		Maintenance of equipment			P	P	P	
		Corrosion-prevention systems	Coatings				P	
			Inhibitor injection		P	P		
			Material selection		P	P	P	
			Cathodic protection		P	P		
P4	Prevention of dropped/swinging object damage	Inspection of lifting equipment						
		Maintenance of lifting equipment						
		Crane						
		Lifting procedures						
		Dropped object/Impact protection						
P5	Prevention of collisions/impacts	Collision Avoidance System						
		Navais						
		Collision protection						
		Anchor dragging protection						
		Traffic control procedures			P	P		
P6	Prevention of well control failure	Well safety barriers						
		Well operation/intervention procedures						



Exploration & Production

General Specification

Date : 01/2012

GS EP EXP 407

Rev : 01

Appendix 4

SCE REGISTER					Major Accident Hazard Scenarios			
					HAL-01-LM-I-J	HAL-01-LM-U-J	HAL-06-LM-U-J	Other Scenarios from PRA
P7	Prevention of process hazards	Process Control System			P	P		
		High Integrity Protection Systems HIPS			P	P		
		Relief systems	Pressure Safety devices (PSV, TSV, bursting discs, venting and purging devices, etc.)				P	
			Interlocks					
			Isolation procedures					
		Flare systems						
		Disposal systems						
P8	Operational Safety Procedures	Hazardous operations procedures	Loading/offloading procedures					
			SIMOPS		P	P		
		Non-routine operations procedures	Start-up/restart/shutdown procedures					
		Safety procedures	Inhibition procedures					
			Interlocking procedures					
			Work permit procedures					



Exploration & Production

General Specification

Date : 01/2012

GS EP EXP 407

Rev : 01

Appendix 4

SCE REGISTER					Major Accident Hazard Scenarios			
					HAL-01-LM-I-J	HAL-01-LM-U-J	HAL-06-LM-U-J	Other Scenarios from PRA
P9	Prevention of ignition	Pressurisation	Heating, Ventilation and Air Conditioning (HVAC)					
		ATEX	Certification of Electrical Equipment					
			Earth bonding and continuity					
			Electrical isolation					
		Lightning Protection						
		Anti ignition devices	Flame arrestors					
		Traffic control procedures						
		Hot work permit procedure						
HAZARD CONTROL								
C1	Fire & Gas detection	Gas detection systems	Toxic gas detectors				C	
			Flammable gas detectors				C	
			Test procedures				C	
			Alarm (local, control room, etc.)				C	
		Fire detection systems	Smoke detectors				C	
			Flame detectors				C	
			Heat detectors					
			Fusible plugs					
			Test procedures					
			Alarm (local, control room, etc.)					



Exploration & Production

General Specification

Date : 01/2012

GS EP EXP 407

Rev : 01

Appendix 4

SCE REGISTER					Major Accident Hazard Scenarios			
					HAL-01-LM-I-J	HAL-01-LM-U-J	HAL-06-LM-U-J	Other Scenarios from PRA
C2	Emergency Isolation	Emergency Shutdown Systems ESD	Alarm (local, control room, etc.)		C	C	C	
			Test procedures		C	C	C	
			Actuators		C	C	C	
			ESDV valves (all types)		C	C	C	
			Circuit breaker		C	C	C	
			Push Buttons		C	C	C	
C3	Emergency Depressurisation	Emergency Depressurisation systems EDP	Test procedures					
			BDV timer					
			BDV valves (all types)					
			Restriction orifice					
			Isolation valves					
			Isolation procedures					
C4	Spill Containment		Tank bunded area		C	C		



Appendix 5 Example format of Performance Standards

P2: PROCESS CONTAINMENT INTEGRITY				
GOAL: To minimise the likelihood of a release of hazardous material by providing appropriate and effective pressure systems and process equipment, taking suitable account of systems for pressure relief and overpressure protection.				
SCOPE/EQUIPMENT	No.	INTERACTIONS	PS Ref.	
P2.1 Vessels P2.2 Pipework P2.3 Exchangers P2.4 Machinery	I1	ESD system.	C2	
	I2	Blowdown and Flare system.	C3	
	I3	Lifting Equipment and Dropped object protection.	P4	
	I4	Blast resistant construction	M2	
Note! For the purposes of this SCE, 'hazardous material' has been defined as any fluid or gas, such that an uncontrolled loss of containment could cause or escalate to fire and/or explosion. Therefore the following systems are considered to be within the scope of this SCE: Oil production and processing, Gas production and processing, Condensate, Gas Injection, Fuel Gas, Helifuel, Vents and Flares, Methanol, Closed Drains, Glycol Regeneration (contactor to flash vessel). Uncontrolled release of toxic gas (H ₂ S) may be also considered safety critical, pending on local operating conditions and fluid composition.	I5	Passive Fire Protection	M2	
	I6	PSD system	P7	
	I7	Relief Systems	P7	
No.	FUNCTIONALITY	REFERENCES	MEANS OF ASSURANCE	REFERENCES
F1	All pressure vessels designed to relevant Industry Standards and with safety margins in accordance with the functional specification	Process data sheets Vessel data sheets P&IDs Equipment Functional Specifications Materials Selection report Piping specification s Applicable Pressure Vessel Design & Construction Code Metallurgical Requirements H ₂ S	Means of assurance is provided by inspection and monitoring activities managed under the Affiliate Asset Integrity Strategy and executed in accordance with the applicable Maintenance Philosophy and Inspection Strategy During the Operations Phase, vessels and associated equipment will be subject to inspection of the type, extent and frequency as determined by the FAME + (or subsequent derivatives) RBI package as appropriate, or by manual amendment thereof as reflected in the Pressure Systems Scheme of	Asset Integrity Strategy Document Maintenance Philosophy Document Inspection Strategy Document Corrosion prevention strategy Document Pressure Systems Scheme of Examination.



Exploration & Production

General Specification

Date : 01/2012

GS EP EXP 407

Rev : 01

Appendix 5

P2: PROCESS CONTAINMENT INTEGRITY

		and HF Service In Humid Environment RG.MAS.B02 Corrosion Monitoring Philosophy	Examination (e.g. to reflect regulatory requirements). All inspections will be undertaken in accordance with the appropriate work instruction for the specific type of equipment and administered under the CMMS. Measurement points defined for each equipment and related to all required inspection techniques (WT, Visual inspection, Radiography, etc.) shall be loaded into the CMMS, together with acceptance criteria. Pressure containment aspects of associated instrumentation will be undertaken at the time of other inspection activities associated with the relevant instrument as administered under the CMMS. Modifications to the Process Containment System shall be carried out in accordance with the Change Control Procedure.	CHE Inspection and Test Plan. Applicable FAME (or subsequent derivatives) RBI Assessment or manual amendment thereof. Appropriate pressure plant inspection work instructions for the equipment type as reflected in the Pressure Systems Scheme of Examination and the CMMS system <i>All applicable Company, Affiliate or Project Standards to be specifically referred to.</i>
F2	All piping and fittings for hydrocarbons and hazardous materials to be designed, built and tested in accordance with relevant piping class specifications and suitable for environmental conditions.		Pipework has been designed, built and tested in accordance with ASME B31.3. During the Operations Phase, means of assurance is provided by inspection and monitoring activities managed under the Asset Integrity Strategy and executed in accordance with the Maintenance Philosophy and Inspection Strategy During the Operations Phase, pipework and associated fittings will be subject to inspection of the type, extent and frequency as determined by the FAME (or subsequent derivatives) RBI package as appropriate, or by manual amendment thereof as reflected in the Pressure Systems Scheme of Examination and the CMMS system. Measurement points defined for each equipment and related to all required inspection techniques (WT, Visual inspection, Radiography, etc.) shall be loaded into the CMMS, together with acceptance criteria. Where temporary clamps are used to carry out a short term repair these shall be subject to routine close visual inspection at a frequency scheduled in CMMS. Pressure containment aspects of associated	Asset Integrity Strategy Document Maintenance Philosophy Document Inspection Strategy Document Corrosion prevention strategy Document Pressure Systems Scheme of Examination. Applicable FAME (or subsequent derivatives) RBI Assessment. Appropriate pipework inspection work instructions as reflected in the Pressure Systems Scheme of Examination and the CMMS system Temporary Repair Clamps fitted to Pipework procedure Instrumentation Integrity Document



Exploration & Production

General Specification

Date : 01/2012

GS EP EXP 407

Rev : 01

Appendix 5

P2: PROCESS CONTAINMENT INTEGRITY

			instrumentation will be undertaken at the time of other inspection activities associated with the relevant instrument as administered under the CMMS. Modifications to the Process Containment System shall be carried out in accordance with the Change Control Procedure.	Change Control Procedure
F3	Design and operating conditions shall be defined for all components and shall include pressure ratings, temperatures and fluid composition. Process equipment and piping shall contain hydrocarbons for foreseeable conditions which shall account for all anticipated internal and external loads, upsets and emergencies.		Assurance by design. Modifications to the Process Containment System shall be carried out in accordance with the Change Control Procedure.	Change Control Procedure:
F4	All hydrocarbon containing equipment to have corrosion allowances consistent for duty and in accordance with TOTAL recommendations, and/or have coatings commensurate with the corrosiveness of service fluids. Anomaly limit standards for Maximum Allowable Wall Thickness shall be defined for all critical hydrocarbon containing systems.		Assurance of initial corrosion allowance and/or protective coatings shall be by design. During the Operations Phase acceptance criteria for any corrosion revealed in service shall be in accordance with the corrosion allowance given for the piping class, vessel design calculations, nationally recognised code or detailed engineering assessment. In service corrosion rates will be monitored by means of coupons and or probes at those location s deemed to be at risk as outlined in the Corrosion Monitoring Philosophy and incorporated in the CMMS system through appropriate measurement points. Activities for the interrogation/sampling of these corrosion units will be undertaken under the CMMS system. Sand probe monitoring of at risk location will be undertaken and maintenance of these units undertaken under the CMMS system.	Applicable Vessel design data sheets Piping Specification References; Nationally recognised engineering codes and standards. Probe and Coupon activities CMMS system. Sand monitors maintenance activities: Corrosion Monitoring Philosophy Document



Exploration & Production

General Specification

Date : 01/2012

GS EP EXP 407

Rev : 01

Appendix 5

No.	AVAILABILITY/RELIABILITY	REFERENCES	MEANS OF ASSURANCE	REFERENCES
A1	Overall containment system to retain capability/integrity throughout design life.		During the Operations Phase process containment systems will be routinely subject to inspection and monitoring as described in section F1 to F4 above, in order to ensure that integrity and continued availability are assured for the design life of the installations. Integrity will be managed in accordance with the Asset Management Strategy. In the event that anomalies arise then the Lead Inspection & Corrosion Engineer shall ensure a thorough investigation and assessment of the anomaly is carried out and appropriate corrective action undertaken to ensure the availability/reliability and integrity of the process containment system is maintained.	Reference F1 to F4 above. Asset Integrity Strategy Document Failure Reporting, Investigation and Correction procedure
S1	Dropped object protection to be provided either by location or as defined in the relevant installation dropped object study (refer also to Performance Standard M1) .	Dropped Objects Study and other relevant documents Fire and Explosion Risk Analysis Prevention of Fire and Explosion and Emergency Response	Survivability criteria is normally addressed during the design phase. During the Operations Phase survivability shall be considered during anomaly/defect assessment and prior to any modifications which shall be carried out in accordance with the Change Control procedure.	Change Control Procedure
S2	Passive Fire Protection: specified vessels and pipework shall be provided with PFP coating to protect the vessels and pipework from jet fire impingement according to Risk assessment studies outcomes.	Risk Assessment Studies Functional Specification for Process Equipment Passive Fire Protection		
S3	Pipework, vessels and equipment to be capable of withstanding explosion overpressure as defined in design basis and other relevant risk assessment considerations.	Stress analysis procedure for piping and vessel support. Structural Design Accidental Events Project, Basis of Design Against Explosion Effects		