NAM

VG document

(Safety and Health document)

NAM Wells – C&WI

Edition 2023

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DISTRIBUTION LIST FOR VG DOCUMENT

The persons below will receive a notification of revision by email. The VG document will only be distributed electronically.

No.	Dept./Body	Function
1	SodM	Inspecteur-Generaal der Mijnen
2	NAM	GM Wells operations
3		Wells Operations Manager C&WI
4		Technical safety Engineering

The VG document will be available via Sharepoint.

Document Owner: **NAM-PTW/O/NL**
Document control: **UPO/T/DD**

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Authorization

		Signature for approval
Editor of document Acknowledges that all relevant information is up to date and meets the requirements as described in the Mining Act and Working Conditions Decree	NAAM: 5.1.2.e	5.1.2.e DATUM: 23-03-2023
Well Operations Manager C&WI Acknowledges that all activities will be executed according to the measures laid down in this document and is responsible for indicating any changes, which might have an impact on the risks described	NAAM: 5.1.2.e	5.1.2.e DATUM: 14-04-'23
GM Wells Operations Declares that acceptance criteria are met and risks are managed to ALARP	NAAM: 5.1.2.e	5.1.2.e DATUM: 18-04-'23

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OVERVIEW OF REVISIONS ON VG DOCUMENT

The policy as documented in "UPO/T Management of Change Policy" [NAM-ASS.PR.01] is applicable in case of changes to this VG document. In this procedure a change notification form (SCAN - Safety Case Amendment Notice) is included which must be filled in.

Overview of revisions		
No.	**Date**	**Reason and nature for revision**
0	15-11-2007	Legal requirements
1	28-03-2013	5-yearly update
2	12-04-2018	5 yearly update / implementation of OSD
3	01-04-2023	5-yearly update

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0. MANAGEMENT SUMMARY

0.1. Introduction

In the period between 2007 and April 2018 a VGM document (also known as HSE case or Safety Case) was set-up and maintained for the Wells activities. By the implementation of the EU Offshore Safety Directive into the Dutch Regulation (Dutch Working Conditions Legislation and Mining Law) the Report on Major hazards (RiGG) has replaced the VGM document for production installations and non-production installations. For other installations (i.e., installations that are placed on a production- / or non-production installation for the exploration and/or exploitation of hydrocarbons) the name of the document is changed into “Detailed Safety and Health document” (abbreviated: U-VG document). This terminology (U-VG document) is not used within NAM, but the content of VG documents does meet the requirements of section 6B of the Dutch Working Conditions Decree.

As a result of legislation, the VG document needs to be updated in case:
- a period of 5 years has elapsed or;
- a significant change of the installation.

The main objective of this document is to demonstrate that all hazards with potential serious consequences have been identified and sufficient suitable barriers and management measures are available so that the remaining / residual risks are tolerable.

This document describes the onshore and offshore activities and equipment under the management of NAM Wells (C&WI).

The hazards that are inseparably related to activities/ installations of contractors are described in the contractor’s VG document / RiGG and are not covered in this document.

0.2. Elements of the previous revision of the VG document (2018)

The most important elements of the conversion from the VGM document into the VG document in 2018 have been:
1. A new description of the Major Accident Prevention Policy;
2. A new description of the HSE Management system;
3. An update of the description of the C&WI activities and supporting information to represent the actual (as-built) situation;
4. An updated bow-tie for the demonstration of the control of Major Accident Hazards by means of HSE critical equipment (SECEs) and - tasks (SCAs) (Lines of Defense);
5. A description of the independent verification and independent well examination system as implemented;
6. A description of the participation of the Works Council (OR) and the involvement and assistance of an external certified expert (Safety Expert, “HVK’er”) during the set-up of this VG document.

0.3. New elements in current revision

1. IOGP life saving rules implemented (see 2.5)
2. Assist & Assure implemented (see 2.7)
3. Safety Refresh implemented (see 2.8)
4. Description Operational Processes and AMS (3.5.2)

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An overview of the evolution of this report, i.e. the different revision dates and reasons for revision (of the VGM document) is given in the chapter “Overview of revisions on VG document”.

0.4. Justification of the new revision

A 5-yearly periodical update of the document to demonstrate that this version of the VG document represents the actual (as-built) situation, both with respect to the description of the activities/equipment as well as the identification and assessment of the hazards related to the activities / equipment.

0.5. Findings and assessment of findings

Findings address the potential for improvement of the hazard management, in case in the existing situation use would be made of the latest techniques.

This 5-yearly update has not resulted in new findings.

0.6. Conclusion

The VG document is representing the actual (as-built) situation, both with respect to the activities / equipment and the organization, date of issue April 2023.

The ALARP demonstration shows that the HSE hazards are managed, and activities / equipment are such that the risk is minimized, and the residual risk is tolerable.

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1. INTRODUCTION

1.1. Owner

This VG document describes the Completion and Well intervention (C&WI) activities of NAM. The contact data of NAM are given below:

Name: Nederlandse Aardolie Maatschappij B.V.
Address (visit): Schepersmaat 2
9405 TA Assen
Address (post): Postbus 28000
9400 HH Assen

1.2. VG document and legislation

Dutch Working Conditions Legislation (Arbeidsomstandigheden Regeling) requires all employers to identify the hazards associated with their activities, assess them, and make sure they are controlled to a tolerable level of risk for people and the environment. For mining companies, specific requirements have been laid down in this legislation as they are dealing with a number of major hazards and potential catastrophic consequences. Each production installation needs to be assessed separately to demonstrate that it can operate safely and to demonstrate that also the mandatory required management system of the company is covering all aspects of operations to assure that all risks are As Low As Reasonably Practicable (ALARP). This demonstration of the safe operation is documented in a so-called “Safety Case” or “Safety and Health document” (VG document)

The NAM Wells department is divided into two subsections, i.e. Well Engineering (WE) and Completion & Well Intervention (C&WI). WE designs, plans and coordinates the drilling of new wells at new or existing production locations. C&WI services on request of operations the wells at on- and offshore production locations / installations with a range of activities. Wells activities such as Well intervention, drilling, workover, and abandonment introduce specific risks which need to be assessed and addressed to make the case for safety.

The implementation of the Offshore Safety Directive (EU Directive 2013/30/EU) in The Netherlands resulted in more stringent requirements with respect to the demonstration of the safe operation of mining installations. These include amongst others the introduction of Safety & Environmental Critical Elements (so called: SECEs)[1], independent verification with respect to these SECEs, well examination, a description of the Corporate Major Accident Hazard Prevention Policy (CMAPP) and an update of the description of the Emergency Response Organization to address environmental pollution and response. Also, the name of the current HSE cases / VG documents changed. For non-producing installations (i.e. installations that are placed on a production – / or non-production installation for the exploration and/or exploitation of hydrocarbons) the name of the document is changed into “Detailed Safety and Health document” (abbreviated: U-VG document).
The terminology “detailed VG document (abbreviation: U-VG document)” [Ref. 9] is not used within NAM, but the content of VG documents does meet the requirements of section 6B of the Dutch Working Conditions Decree.

(1) In the previous versions of the document, up to 2018, the focus was only on Safety Critical Elements (SCEs), as a result of the implementation of the OSD this is broadened to Safety and Environmental Critical Elements.

Instead of addressing the Wells related activities in the Report on Major Hazards (RoMH, also known as Rapport inzake Grote Gevaren (RiGG)) of each production location, it was decided during previous versions to set-up a separate document for these activities and to refer to this document instead.

In this VG document, all maintenance activities on wells performed by Well Services during the operate phase of the wells are included. Workover activities require the use of a third party contracted drilling rig, which party is required to have its own RiGG [2]. For such a situation NAM will prepare a separate document to interconnect the RiGG of the drilling company and the RiGG of the production location. Depending on the actual status of the production facility, this document will be a combined operations script (in case of two or more main activities taking place at the same time in the same area) or a Work Safety Plan (in case the only main activity is related to the presence of the drilling rig).

1.3. Policy

The policy of NAM aims to prevent all incidents, damage to health and welfare of persons and negative effects on the environment.

In the care for HSE[3], amongst others in the management of risks, a systematic approach is followed which is aimed to comply with legislation and regulations, the fulfillment of obligations towards stakeholders and on continuous improvement on the HSE performances.

This VG document describes the implementation of the abovementioned policy in the Wells organization. In Chapter 2 of this document a description is given of the HSSE&SP policy of NAM and NAM Wells.

1.4. Objective

The Wells operational processes have been set up and are implemented so that HSE risks are eliminated or reduced to ALARP (see chapter 5). To achieve this, management measures including HSE have been incorporated into the Wells Management System (WMS) which is fully aligned with the NAM Business Management System (BMS).

The VG document demonstrates that:

- The Wells Management System contains sufficient suitable elements to manage all HSE hazards and continuously improve the management in a way that meets the requirements of the legislation and the Shell HSSE & SP policy.
- All hazards with potentially serious consequences have been identified and sufficient suitable barriers and management measures are available, so the remaining (residual) risks are tolerable and ALARP.
- There are effective facilities for control, emergency response and recovery in case a well incident would occur.

(2) Note that drilling and abandonment activities are also excluded, because these activities are not part of the operating phase of the wells.

(3) The abbreviation HSE (Health, Safety and Environment) is used within NAM as the equivalent of VGWM ("Veiligheid, Gezondheid, Welzijn, Milieu"). The item "Welzijn" (Welfare) is not addressed separately within this document. Where relevant, Welfare related aspects are part of the health item.

1.5. Target groups

The most important target groups for this VG document are:
- NAM Management, which is responsible for the management of all HSE aspects of the operation.
- C&WI, which, as owner of the VG document approves the document and confirms that all risks are managed to ALARP.
- Employees, both of NAM and contractors, working at Wells sites in the Netherlands, to familiarize themselves with the hazards and risks at the site, and how they are managed.
- SodM (the Dutch State Supervision of Mines) to verify that all legal requirements are complied with.

The tasks, authorities and responsibilities of the parties involved in the writing, management and acceptance of the VG document for Wells activities are described in more detail in the BMS.

1.6. Involvement during the set-up of this VG document

This VG document was drawn up for, and by, employees of NAM Wells C&WI. The process was facilitated by Technical Safety Engineering, which took care of processing comments, integration and design of the final document including an internal check of the content of the document.

1.6.1. Expert assistance in drawing up the VG document

During the implementation of EU Directive 2013/30/EU in rev.1 of this document, a certified safety expert has been involved in drawing up the VG document. The assistance and involvement included the following activities:
1. Drawing up part of the NOGEPA standard 83 (RiGG);
2. Evaluating and contributing to the principles for NAM's safety policy;
3. Shaping the risk register for the RiGG, in particular through the use of a standardized hazard list, coordinating the hazard assessment at NAM and involving internal (NAM/Shell) occupational hygienists to identify the health risks;
4. Set-up of the bow-tie principles that was used by/with employees from NAM Wells C&WI to analyze the validity, effectiveness and reliability of the barriers in the bow-ties and improve them where possible (ALARP);
5. Advising managers from NAM and Technical Safety Engineers working within the operational organization about RiGG;
6. Assessing the contents of the VG document that was drawn up by NAM Wells C&WI, prior to submitting it.

Because there are since then, no changes in the type of major hazards and the control of these hazards with respect to bowties and barriers, a certified safety expert has not been involved for the 5-yearluy update.

1.6.2. Involvement of the Staff Council

The Staff Council (OR) has been involved during the update of this VG document. The Staff Council indicated that it was sufficient to provide information to a Staff Council point of contact and to attend a plenary presentation on progress/ results. Employee involvement (line) was also discussed during the consultations with the Staff Council, and the plan of action was supported in this.

The VG document has been presented to the Staff Council for comments/review before it was submitted to SodM.

1.7. Basic principles applicable to the VG document

The following basic principles were used in the writing of the current VG document:

- Application of the management measures is anchored in Well Management System (WMS) and Business Management System (BMS), which contains the HSE management measures (see chapter 3).
- The VG document complements the WMS and cannot be viewed separately in terms of risk management.
- The VG document describes the HSE-critical activities and systems (SECEs) that are of essential importance for making or maintaining barriers or mitigating measures with respect to the management of major hazards.
- The VG document is intended as a document that provides information about the management and control of the activities on site. The VG document is a reference document that can be consulted to gain a better understanding of the organization and the background to HSE hazards and their management.
- A brief description of the organization of NAM is included in the VG document. The document is evaluated, validated and, updated when required.

1.8. Overview of RiGGs within The Netherlands

Figure 1-1 shows the relationships between this VG document and other RiGGs / VG documents within NAM, including contractor documents. This relationship is described at high level in the following paragraph.

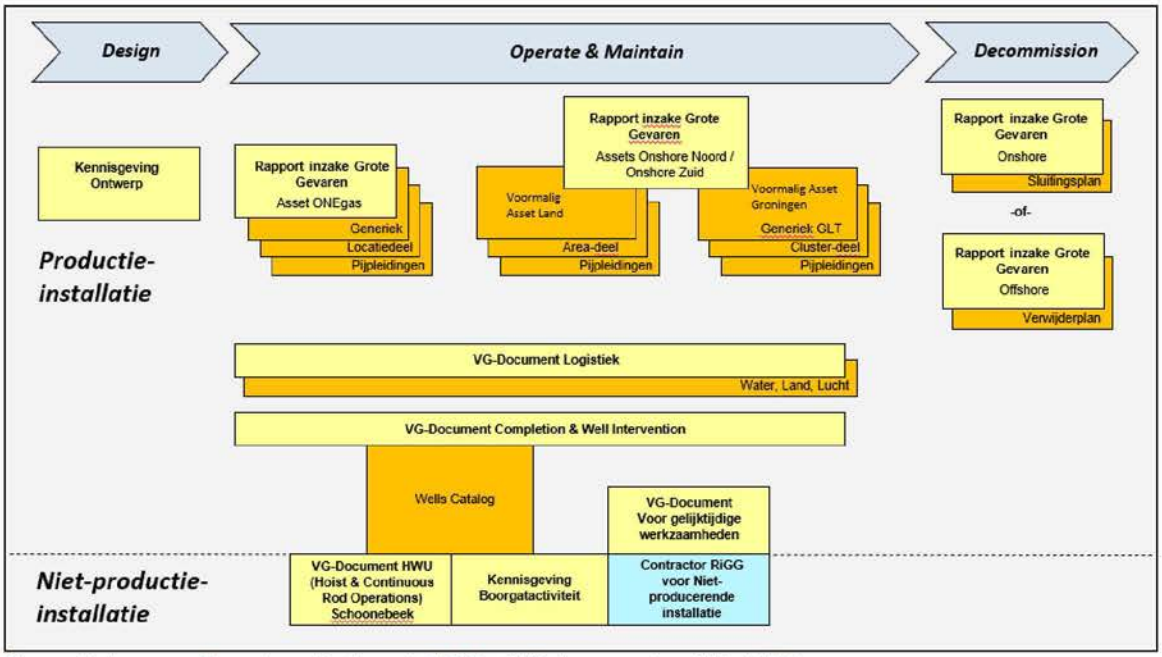

Figure 1-1 Overview of relevant RiGGs / VG documents within NAM

1.8.1. Relationship to other RiGGs / VG documents

From Figure 1-1 it can be noticed that for production installations a RiGG has been set-up. For activities that are not related to a dedicated production installation, but which in potential could

result in a major accident hazard, a separate VG document has been prepared.

For the following activities, in addition to the VG document of NAM Wells - C&WI, a separate document has been set-up:

- NAM Logistics;
- Hoist & Continuous Rod Operations on oil wells in Schoonebeek: VG document HWU Hoist & Continuous Rod.

For non-production installations hired by NAM (e.g. drilling rig or work vessel), the VG-documents are written by the respective contractors. When hired installations are used, the respective RiGG for the installation is offered to NAM and assessed during the composition of the Work Safety Plan (WVP) or Combined Operations (CO) script.

Most of the Wells activities take place at existing sites for which the management of HSE is described in the relevant Asset and Site specific RiGGs.

Usually, it is decided to have the non-production activities (e.g. drilling) completely or partially carried out under the respective contractor's HSE management system. In these situations, a bridging document is written to set out the arrangements clearly in writing.

The logistic transport movements of personnel, equipment and (raw) materials from and to sites for all Wells activities are described separately in the VG document NAM Logistics [Ref. 21] or in the management system of the respective contractor.

1.9. Review / update of VG document

The VG document will be reviewed every 5 years or earlier in case of a significant modification. According to the Mining law a significant modification is defined as “a substantial change that concerns the core”. In the OSD (2013/30/EU) a significant change is defined as ‘a change to the basis on which the original RiGG was accepted, including;

1. physical modifications
2. availability of new knowledge;
3. technology changes;
4. and operational management changes.

Part of the review process in case of changes, is the assessment of the significance of the change on the RiGG / VG document. The outcome of this assessment is documented in a “Safety Case Amendment Notice” (SCAN) and a SCAN register.

During the 5-yearly assessment also attention is paid to the availability of new knowledge (including eventual learnings from incidents) and technology. This is part of the ALARP-assessment.

1.10. Operationalizing

As part of the update of the VG document roll-out sessions will be planned, in case of essential changes, to explain the content of the document to the personnel and discuss their role in the process to manage the risks related to the C&WI activities.

The VG document will be (digitally) available via Sharepoint.

2. HEALTH, SAFETY AND ENVIRONMENTAL MANAGEMENT POLICY[4]

2.1. Introduction

This chapter provides an overview of the information that must be submitted with regard to:
- company policy for the prevention of major accidents;

The requirements that have been set out for this are described in the Mining Decree and Working Conditions Decree and regulations[5] and the implementation of the European Offshore Safety Directive (OSD), chapter IV Prevention Policy, article 19 "Major accident prevention by operators and owners", is specified in more detail in OSD annexes 1.8 and 1.9.

The description of the HSE Care System is structured around the eight elements of the care system and its contents are partly based on the Shell HSSE & SP Control Framework[6] and recorded in NAM's Business Management System (BMS). See Figure 2-1 for a schematic overview.

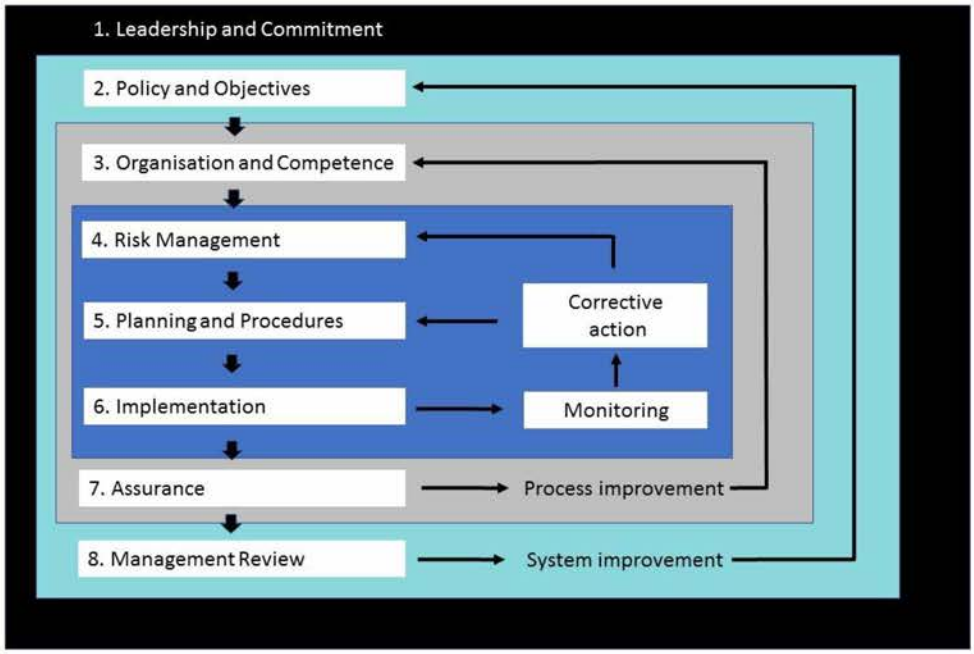

Figure 2-1: Elements of the HSE Care System

(4) Including the description of CMAPP = Corporate Major Accident Prevention Policy in accordance with the OSD.

(5) Decision of 21 December 2016 amending the Mining Decree relating to the implementation of Directive (EU) No. 2013/30 & Decision of 8 February 2016 amending the Working Conditions Decree concerning the implementation of Directive 2013/30/EU and regulations

(6) Shell HSSE & SP Control Framework = Shell Health Safety, Security, Environment & Social Performance Control Framework

2.2. Company policy for the prevention of major accidents

NAM is committed to, and has a policy for, Health, Security, Safety, Environment and Social Performance (also referred to as HSSE policy) which is determined at the highest level and adopted by operating companies, i.e. signed by the CEO of Shell and the MD of NAM. This policy can also be considered as the company policy for the prevention of major accidents. In short, it concerns the following business principles:

- ***Cause no harm to people's health including our own employees and contractors at mining plants and installations;***
- ***protect the environment;***
- ***ensure the integrity of the assets and installations;***
- ***and protect the communities outside the mining sites and facilities against unacceptable risks or consequences.***

Implementation of the company HSSE policy requires a systematic approach with a view to ensuring compliance with the law and continuous performance improvement. It is also our conviction that the prevention of personal injury, and a safe, healthy and environmentally conscious approach to all activities will contribute to successful business operations at NAM.

The policy also focuses on preventing and limiting major accidents. This meets the provisions of the first sentence of Article 6, paragraph 2, of the Working Conditions Act[7]. All contractors working for NAM must support NAM's HSSE policy and must have their own HSSE policy that is aligned with it. The requirements set for the required company policy for the prevention of major accidents on the basis of the Working Conditions Decree[8] are met by the Shell HSSE & SP Control Framework, local NAM HSSE policy and NAM's Business Management System (BMS).

NAM's HSSE policy has been set out in full in Appendix 2.

The HSSE policy is supported by means of:

- **Goal Zero targets** (see paragraph 2.3);
- **basic rules; three Golden Rules and IOGP Life-Saving Rules** (see paragraphs 2.4 and 2.5);
- **process safety requirements/Process Safety Fundamentals** (see paragraph 2.6);
- **a positive influence on safety culture** (see paragraph 2.7)
- **"Safety refresh"** (see paragraph 2.8).

([7]) In accordance with article 6 of the Working Conditions Act, in applying the Working Conditions policy the employer must take all necessary measures to prevent and limit major accidents (mostly with hazardous substances) and their consequences on the safety and health of employees working in the company.

([8]) In particular article 2.42 (Health and Safety care system) paragraph 1, for the application of article 19, paragraph 3, of the Offshore Safety Directive (CMAPP), Article 2.42k (major accidents policy) and Article 2.42l (Additional regulations for risk inventory and evaluation). Detailed rules regarding the content of the supplement to the Health and Safety care system of article 2.42e of the Working Conditions Decree have been laid down by ministerial regulation and elaborated in articles 3.3, 3.4 and 3.5 of the Working Conditions Regulation.

2.3. Goal Zero

A good HSSE policy by itself is not enough. The Goal Zero programme aims to achieve the ultimate target of No Harm and No Leaks. In order to prevent process safety-related incidents hydrocarbon products must be contained “in the equipment and pipelines”. Any leak or spill can harm the environment and as a good neighbour this must be prevented.

The Goal Zero programme is based on the following safety principles:

- Safety is a core value and goes together with sincerity, integrity and respect for others;
- Goal Zero means striving continuously to prevent incidents and injuries;
- Goal Zero changes the way we think and act:
- Goal Zero is achievable.

Goal Zero is measured based on the number of “zero” days. Two Goal Zero performance indicators are used for this:

1. “No Harm” (no work-related incidents (TRCs) involving employees or contractors;
2. “No Leaks” (no work-related safety tier 1 or tier 2 process incidents resulting in the release of hydrocarbons).

The Goal Zero counter can also be reset in response to other incidents, at the decision of senior NAM management.

2.4. The Golden Rules

The three Golden Rules provide guidance on how to act in every operation and activity. These three rules must be applied always in the pursuit of further HSE performance improvement. The rules are:

“You and I....

- Comply; Comply with legislation, standards and procedures;
- Intervene: Intervene in unsafe or non-standard situations;
- Respect: Respect our neighbours.”

These rules emphasise individual responsibility and encourage us to help each other and treat third parties with respect.

2.5. The Life-Saving Rules

After an analysis of fatal incidents at Shell and its contractors globally, it became clear that a significant number of victims could have been saved if several basic rules would have been followed consistently. This resulted in the creation of the 12 Life-Saving Rules.

On 15 September 2021, Shell/NAM switched to new life saving rules; the IOGP Life-Saving Rules. This puts Shell /NAM more in line with its industry partners where these rules are already applied. With these new life saving rules, there is a switch to so-called 'I statements' (I am

responsible) instead of 'do's & don'ts'. This provides more responsibility and ownership to the people themselves. These rules support the Goal Zero program and are aimed at a culture in which people always follow the rules including the three golden rules. All employees are obliged to comply with these rules, in case of violation of them sanctions policy can be applied.

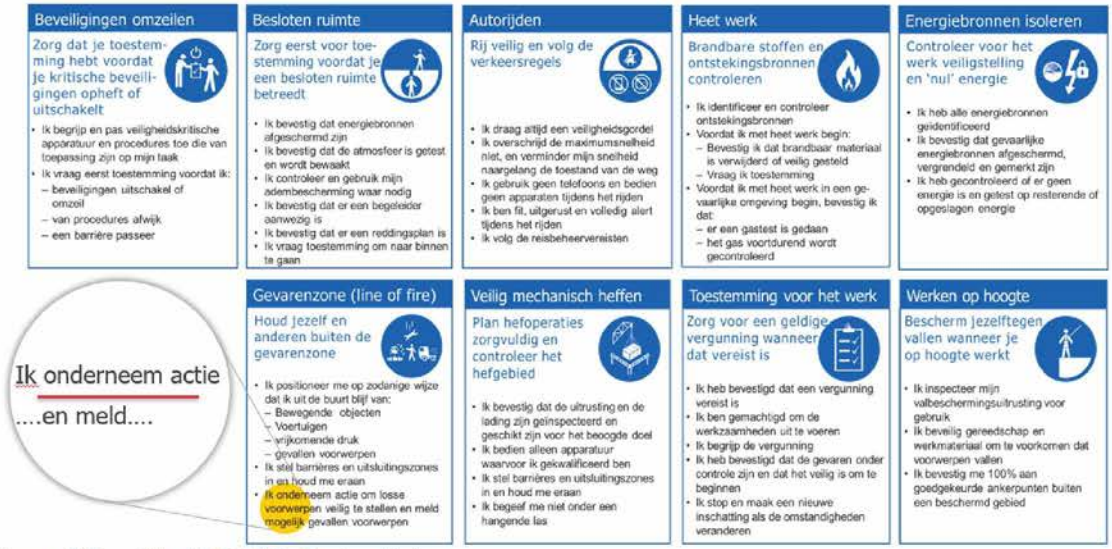

Figure 2-2 The IOGP Life-Saving Rules

2.6. *Process Safety / Process Safety Fundamentals*

Process safety incidents shall always be prevented because they can escalate into catastrophic incidents due to the release of energy or hazardous substances.

Process safety must ensure that:

- hydrocarbons remain in the equipment and pipelines;
- the equipment is operated within the operating envelope;
- units and equipment are correctly maintained.

At NAM, the following principles are applied for integrity and process safety: *"Our assets are safe, and we know it".* Process safety means good asset integrity which consists of three elements in the management system; Design Integrity, Technical Integrity and Operating Integrity as shown in Figure 2-3.

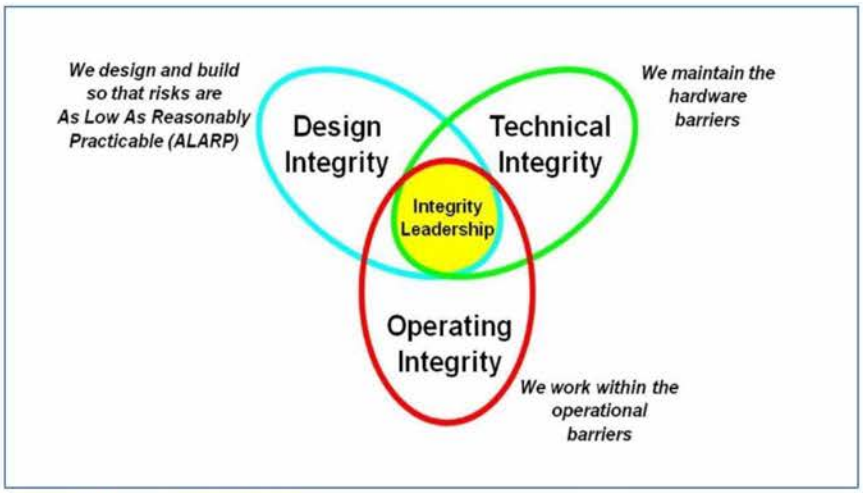

Figure 2-3 Asset Integrity

Installation Integrity starts with safe design (Design Integrity). The installation must subsequently be maintained and inspected during its entire life cycle to ensure that the performance of safety critical systems remains within the design conditions (Technical Integrity). Operation of the installation must be within the operating envelope.

Although process safety incidents do not occur often this type of incident has the potential to result in deaths, severe injuries, serious environmental damage and material damage and damage to reputation. Following incidents such as Buncefield tank farm, the BP refinery in Texas, the management system for this type of accidents has been modified.

At NAM a process safety incident took place whereby an explosion of natural gas condensate vapours during construction work in a storage tank (Warffum) resulted in a fatal incident. During the accident investigation, it became clear that aspects such as the risk identification method and risk communication, required improvement. This led to the introduction of the Project Risk Analysis, (an operational risk analysis under the direct management and responsibility of Operations).

The so-called Asset Integrity Process Safety Management Application Manual (AIPSM) was set up to provide a systematic approach to process safety within the Shell group. This manual, which is mandatory at NAM, sets out the requirements and responsibilities for identifying, managing and communicating process-oriented risks. The contents of the manual can be summarised as follows:

Table 2-1 Asset Integrity Process Safety Management Application Manual (AIPSM)

Subject	**Application in brief** (Ref. AIPSM)
Underlying principles	Compliance with legislation and regulations, and identification and management of Process Safety Risks so that they are ALARP during the entire life cycle of the project/facility.
Design standards	DEM1 – a list of mandatory Shell Design and Engineering manuals for use in the designing of new installations or modifying existing installations. DEM2 – a list of Process Safety Basic Requirements, based on major accidents in the industry, that are of such importance to the safety of the installation that they should be implemented for both new and existing installations.

Subject	Application in brief (Ref. AIPSM)
Risk identification and Management	The recording of HSSE documents and management of process safety hardware barriers.
Tasks and Responsibilities	Appointment of an asset manager who has full final responsibility for the asset. Requirements for management concerning the evaluation of Process Safety Risks in their field of work, setting performance expectations, and providing resources for this.
Assurance	Assurance takes place by means of internal audits, Hardware Barrier Assessments, Health checks, Go Sees etc. This includes so-called "Line of Defense" (LOD) 1 and 2 assurance activities.

The overview of the "Process Safety Fundamentals" introduced in 2017 in Figure 2-4 provides a good overview of the mandatory measures that must be taken to prevent process safety-related incidents.

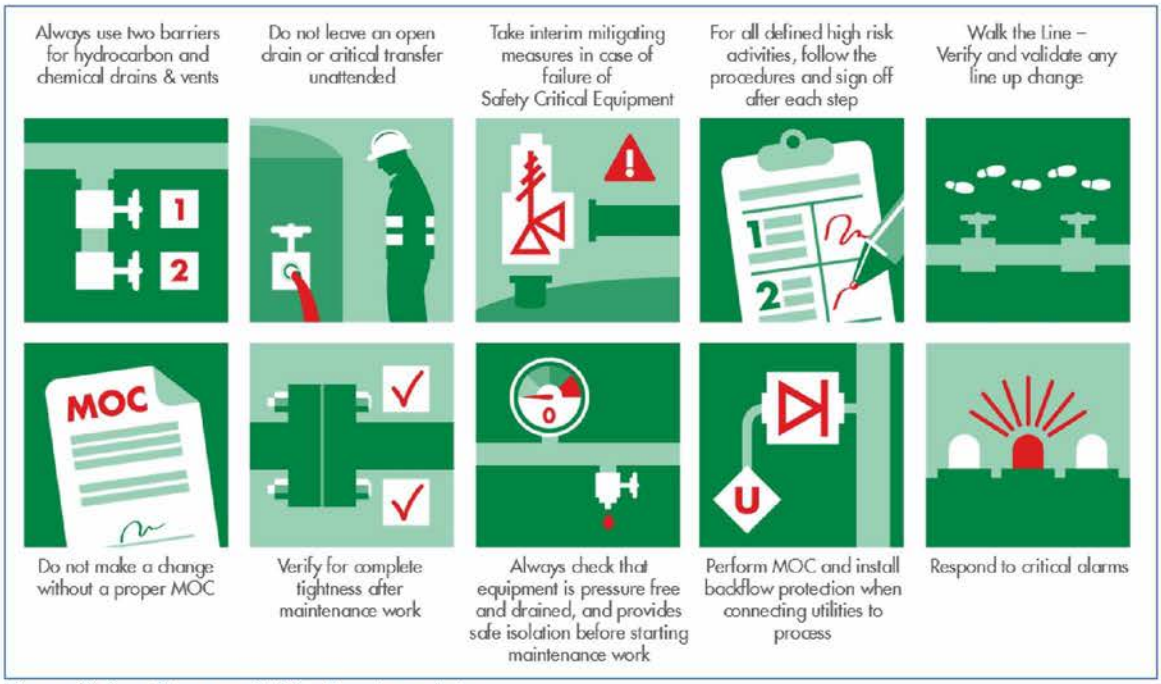

Figure 2-4 Process Safety Fundamentals

2.7. Safety Culture

In accordance with the HSSE policy the company culture must urge all NAM employees to adhere to the business principles. Many different methods are used for this and for further improvement, both top down and bottom up. In general, there is also great awareness of Process Safety for the prevention of major accidents.

Examples **Top down measures** for creating and maintaining a strong safety culture:

- A policy that is promoted systematically and supported by safety campaigns;
- Focus on the behaviour of management (supported by training);
- Leadership sets a good example;
- Structured management field visits ('Go Sees');
- Safety Refresh with learning mindset, psychological safety and human performance principles as important starting points
- Employees encouraged to think along pro-actively;
- Reporting of improvement points on the basis of "near misses" and incidents, and promoting "learning from incidents" (LFI / reflective learning);
- Reward (both individually and collectively), in addition to a focus on specific achievements;
- Implementation of Life-Saving Rules and consequence management;
- Implementation of Process Safety Fundamentals;
- Promotion of "chronic unease" (the understanding that minor faults can be a sign that something is wrong);
- Annual Safety Day;
- Annual Safety Days for contractors;
- Sound expertise, education and training (e.g. providing training Front Line Barrier Management (FLBM);
- Competence requirements and assurance linked to functions.

Examples **bottom up measures** for creating and maintaining a strong safety culture:

- The implementation of Assist & Assure is a structured safety program in which active coaching (assist) and safety assurance (assure) form the foundation of the program. Important elements in the way of working are; asking open questions, everyone actively participates, actively learning incidents, following a 7-step process ("starting work is not the first step") and where a point for improvement is seen, this is picked up.
- It is valuable that Assist & Assure combines existing safety management tools and gives structure with the right leadership behaviour so that human performance, psychological safety and learning mentality are better guaranteed.
- Attitude changes (from individual to collective and vice versa), e.g. by increasing employee involvement by highlighting and discussing incidents that occur in the immediate neighbourhood;
- Safety briefings in the safety room before starting work;
- Reporting and investigating incidents and near misses.

2.8. Safety refresh

Since 2020, a renewed approach to safety ('safety refresh') has been adopted that acknowledges a very simple truth: we are all human beings and as humans we all make mistakes. This does not mean that lower performance standards are acceptable, but that we want to learn quickly from mistakes and know how to prevent mistakes that lead to serious ('life-changing') injuries. That's where the human factor comes in. A learning mindset, psychological safety and human performance principles are important starting points. A human approach to how we deal with safety means creating a learner mindset and an environment where people feel encouraged and welcome to share ideas and admit mistakes (psychological safety). People (human performance) are the key to solutions; they know their work best and understand how effective our controls ('barriers') are for managing risk and what can be done to prevent a mistake that leads to a serious incident, in other words how we can safely fail.

2.9. Summary

The following HSSE principles apply to the application of the HSSE policy for the prevention of major accidents at NAM:

- The Goal Zero programme; No Harm, No Leaks;
- The Golden Rules for behaviour at work: “Comply, Intervene, Respect”.

This is supported by:

- Active promotion and focus on the Life-Saving Rules and Process Safety Fundamentals in the field;
- Safeguarding process safety barriers and maintaining the AIPSM manual;
- NAM carries out a large number of activities to positively promote safety culture, both top-down and bottom-up;
- Safety Refresh'; of crucial importance in particular to deepen and further improve the understanding of the conditions behind our HSE performance.
- Effective implementation of a Safety and Environmental care system, as described in Chapter 3.

3. THE HEALTH, SAFETY AND ENVIRONMENTAL CARE SYSTEM

3.1. The Business Management System (BMS) and the Asset Management System (AMS)

The HSE Care System is an integral part of the NAM Business Management System and is embedded in the NAM Business Management System (BMS). The NAM Business Management System (BMS) is the overall framework of the internal business rules for managing the business in order to ensure that activities are performed in accordance with the requirements in force. BMS has a logical structure for the filing of regulatory documents, that are also referred to as Business Control Documents (BCDs).

Examples of such documents are standards, procedures and work instructions. Documents that are an output of the aforementioned BCDs (such as RiGG documents, emergency and contingency plans and operating manuals) are also part of NAM's business operations but are not maintained as part of BMS.

BMS regulations are available to all users on the NAM intranet. Dedicated access has been created on the intranet for Operations via the Operating Desktop (ODT). RiGG documents, emergency and contingency plans and operating manuals have been included in ODT, because they give direction and establish the framework in which activities take place at NAM.

The Asset Management System has been used for all operational activities since 2017.

The purpose of the Asset Management System (AMS) is to provide a clear Shell-wide control framework for the management of production assets in Shell and to include best practices. The AMS framework describes a series of processes that are required for this. It includes mandatory (by means of standards and manuals) and non-mandatory elements (by means of underlying recommended best practices), and must be used in combination with other Shell Control Framework requirements, for example the HSSE & SP Control Framework, Opportunity Realisation Process (ORP) etc.

The Asset Manager / Site Manager (LVP / HMI) is responsible for compliance with the Asset Management System.

The relationship between the Shell BMS and AMS is shown in Figure 3-1.

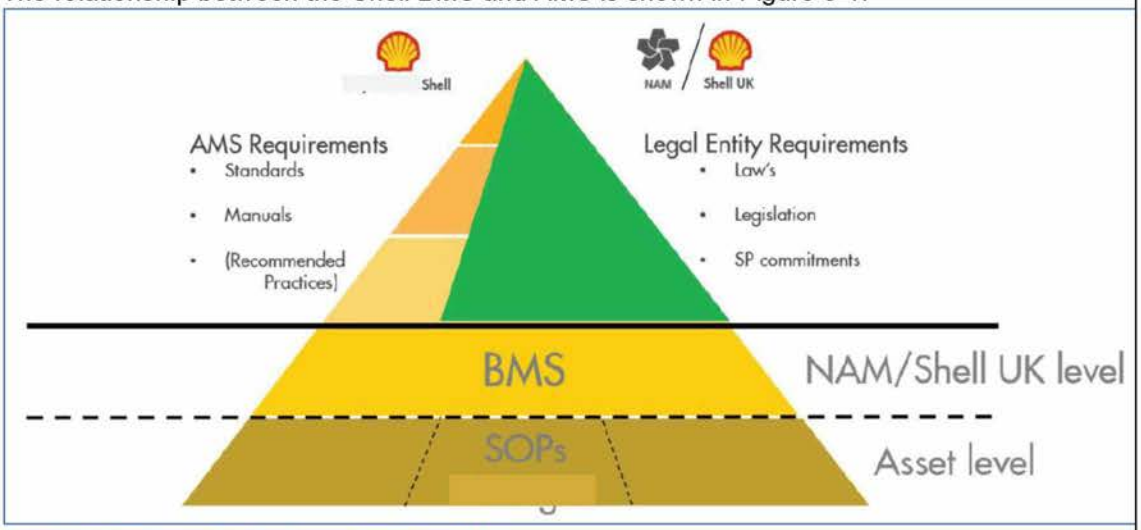

Figure 3-1 Relationship between BMS and AMS

3.2. The HSE Care System: description per element

The HSSE policy as described in chapter 2 is implemented by means of an HSE Care System. This chapter describes the elements of the HSE Care System from chapter 2, Figure 2-1.

These components comply with the requirements imposed:
- in the Working Conditions Decree and Regulations which refers back to the Offshore Safety Directive, annex 1.9. “Information to be provided in respect of a safety and environmental management system”.
- Shell HSSE & SP Control Framework[9].

The Shell HSSE & SP Control Framework provides mandatory regulations for Shell companies including NAM, among other things to ensure that 'Goal Zero' is achieved; no (serious) accidents and no leaks. Implementing these requirements protects people, assets, the environment and communities from unacceptable risk or impact. Through 'Line Of Defence 3' audits by the Shell group, assurance is ensured.

The Shell HSSE & SP Control Framework has been translated for NAM into an HSE-MS 'Standard Workflow (SWFs)' for uniformity and compliance with HSSE&SP. The SWFs integrate the Plan-Do-Check-Act cycle and should be considered the 'HSE governance' for NAM.

Based on this, plans are made for controlling and improving performance with regard to the safety of people and the environment. This results in agreements in the form of procedures, instructions and an annual HSE improvement program (Planning and procedures). This is followed by the implementation of this plan (Implementation), measuring and checking whether the defined goals are achieved (monitoring and reporting) and finally assessing and adjusting the plans (Executive Review in the annual Management Review). Then the PDCA improvement cycle repeats itself as illustrated in chapter 2, Figure 2-1.

NAM’s Environmental Care System (“Bedrijfsmilieuzorgsysteem”) is certified according to ISO 14001.

3.3. Element 1: Leadership and Commitment

Leadership and visible engagement are so essential that they are described as a separate component. Many aspects of this can be found throughout the company and the system, such as in the following subjects:

- initiation of HSSE policy and regulations;
- authorisation of standards, procedures and work instructions;
- initiation of HSSE plans;
- appointment of HSSE experts;
- participation in internal consultations and consultations with contractors;
- approval of RiGG documents and notifications;
- participation in policy teams and emergency organisation crisis teams;
- receiving and responding to Management reports;

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[9] The Shell HSSE & SP Control Framework lays down mandatory rules for Shell companies including NAM, such as ensuring that Goal Zero is achieved; No Harm and No Leaks. The implementation of these requirements protects people, assets, the environment and communities against unacceptable risks or consequences. “Line Of Defence 3” - assurance against this is provided by means of audits by the Shell group.

- participation in Audit Committees;
- incident reviews;
- management field visits.

3.4. Element 2: Policy and Objectives

The HSSE policy and the HSSE principles as described in chapter 2 and included in Appendix 2 form the basis of the HSE Care System.

Additionally, NAM management (VP-LT) has described other policy principles in addition to HSE and NAM's vision and mission in the NAM Corporate Management Overview (NAM CMO).

The policy is based on compliance with current laws and regulations. Direct applicable regulations from legislation are incorporated into the organisation's structures and regulations. As an additional measure NAM has internal design guidelines and manuals. Industry standards are also applied. The following regulatory structure applies to this:

1. Dutch national legislation and/or local legislation and regulations;
2. NAM company standards and/or specifications;
3. NOGEPA/ElementNL standards;
4. Industrial Standards.

NAM's strategic HSSE objectives and targets regarding HSSE performance are based on HSSE policy and external developments. The strategic goals of the HSSE policy have been established for the medium and long term. These goals are documented in the plans and industry agreements with the authorities.

Annual HSSE plans for managing and improving our HSE performance are created on that basis *(see section 3.7 Planning and Procedures)*.

3.5. Element 3: Organization, Responsibilities, Resources and Competence

3.5.1. Organisation

NAM is made up of three producing assets (Onshore North, Onshore South and ONEgas) and a number of functional departments (e.g. Exploration, Wells, Commercial, Legal and HSE).

HSE management is everyone's responsibility (NAM and contractors). The board has ultimate responsibility. To support business operations an **HSSE staff organisation** has been set up to advise the board and asset management. The following distinction is made:
- Corporate HSSE department;
- Asset HSSE departments.

NAM's corporate safety and environment manager provides the HSSE Governance and Assurance structure. Safety and environmental specialists, such as Technical Safety Specialists, Operational Safety Experts and Environment Experts, Radiation Specialists and Occupational Health Experts support the line activities.

In order to achieve optimal protection against ionising radiation, NAM has a **Radiation Protection Service (SBD)**. The preconditions for dealing with radioactive substances are drawn up in the framework of the Nuclear Energy Act on behalf of the Director by NAM's Radiation Protection Advisor.

The **Technical Safety Engineering (TSE)** department supports the organization with respect to hazard analysis and management of process safety and major accident hazards. TSE supports the line organization in drafting and updating of RiGGs / VG documents.

The **production chemicals** department supports the organisation with respect to the use of chemical agents. The department's tasks within the HSSE structure include assessing the burden of chemical agents on HSSE and providing the Chemical Secretariat.

The **company health service (Shell Health)** is tasked with providing advice and carrying out the tasks described in Mining and Occupational Health and Safety legislation, with the emphasis on preventative healthcare.

Security plays an essential role in the NAM Emergency Response organisation. Alarms are communicated and duty staff called up on request. In the event of a disaster, Security will take care of road cordons, escorting the authorities etc. in consultation with the government bodies. Furthermore, this service is responsible for applying NAM's access policy. The service monitors access to the offices and sites and is tasked with their surveillance.

To give substance to so-called tripartite consultation, regular meetings are held between senior management (the Board, Asset Managers, HR and HSE) and the Staff Council. Subjects including organisational changes, as well as HSSE-related issues such as HSE performance including incidents are discussed here. Other important HSSE consultation is held between NAM, contractors and NOGEPA with or without Staff Council participation such as the annual Shell Safety Day, Contractor Safety Day(s) together with the industry, and to which the Staff Council is invited, the Contractor Wells Cluster meeting and HSE Annual Plan co-ordination meeting.

NAM uses a Shell scheme to encourage and protect **Whistle Blowers**. Reporting and addressing suspected violations of the law or the general business principles of Shell/NAM (SGBP) is crucially important to protecting the reputation and value of the Shell (NAM) brand. An independent company - Global Compliance - runs the Shell Helpline, accessible by internet and telephone, in order to receive information and complaints about possible violations of laws, regulations and SGBP. This helpline is available to Shell's customers, suppliers, partners, consultants and employees. NAM also has a Confidential Counsellor.

3.5.2. Business Processes

All Shell Upstream (Exploration and Production) activities are incorporated in the form of business processes within the asset Management System (AMS) in the form of Standards, Manuals en Recommended Practices. An elaboration of the global Shell AMS processes into NAM-specific processes and work instructions (including NAM-specific requirements, for example from laws and regulations) is described and published in the (local) NAM BMS; a process owner is appointed for each business process.

A number of main operational processes are differentiated in the context of RIGG documents for mining plants and installations. These are e.g.:

- **AMS-MP: Manage Projects**
  The process describes the design, construction, modification and abandonment of installations. In the context of RIGG/VG-documents, it mainly concerns risk management activities with regard to the design, construction or functional testing (commissioning) of modifications to existing installations. Within this process, the so-called Discipline Control and Authority Framework (DCAF) is used. DCAF contains control measures and requirements regarding the (safety) studies and expertise in different phases of this process.

- **AMS-WRFM: Well, Reservoir and Facilities Management**
  Establishes the requirements by which Assets continuously restore and safely optimize production. WRFM also aims to achieve industry-leading recovery factors to maximize value delivery. The scope of WRFM includes management of flow and impact of produced and injected fluids in an Asset.

- **AMS-MEC: Manage Equipment Care**
  Defining maintenance strategies (scope and frequency) of installation parts for reliability and process safety; including the definition and implementation of testing and inspection strategies specific to SECEs (Safety & Environmental Critical Elements).

- **AMS-MTO: Manage Threats & Opportunities**
  Het process om (onder andere) risico's (threats) op het gebied van veiligheid en/of productie te identificeren en te managen. Specifiek voor 'asset integrity & process safety' threats geeft dit process de structuur om bedreigingen te elimineren (preventief en/of reactief)

- **AMS-PME: Perform Maintenance Execution**
  Performing maintenance including a framework in terms of compliance with an escalation process specifically for SECEs in case of late execution of safety critical maintenance / inspection and an escalation process in case an SCE no longer meets the performance standards

3.5.3. Company Assets

Company assets are the functional installations (functional assets as installations, pipelines, tank farms, transfer stations, etc.), that NAM operates for the exploitation of the oil and gas reserves in its concessions in a responsible manner.

3.5.4. Safety & Environmental Critical Elements

NAM pays particular attention to controlling hazards that have a major potential impact. Safety-critical and environmental critical systems/components (preventive or mitigating measures) are identified on the basis of the hazard analysis. In the remaining part of this VG document these systems are indicated as Safety & Environmental Critical Elements (SECEs).

Performance standards that use periodic testing/verification to establish whether a norm has been achieved have been drawn up for each SECE. The maintenance system (SAP) contains the routines as well as historical data/findings. If maintenance is not carried out in a timely manner, or if the performance standard is not achieved, this is reported in the Facility Status Review (FSR).

The control of SECEs is assured by means of additional inspections and independent verification, which are described in more detail in chapter 6.

3.5.5. Competence

NAM has a Competence Management System in which competence assurance has a high priority. Within this framework, supplementary competence requirements have been set for the so-called safety-critical functions / activities (SCA's) and are ensured by means of a competence assurance programme. This concerns:
- Frontline Barrier Management competence (FLBM);
- Technical Authorities level 1 and 2 positions;
- HSSE Critical Leader positions.

The competences (including HSE competences) of individuals in these positions are described and assessed against standardised competence profiles on the basis of the HSSE & SP Control Framework. Training budgets and facilities have been set up to further the development of

competences.

NAM has experts who meet the competence requirements for the implementation of HSSE policy (for major accidents) and the delivery and/or approval of notifications and RiGG documents. The Discipline and Control Assurance Framework (DCAF) is part of the assurance framework which focuses on the operation- and safety critical decisions and deliverables. DCAF distinguishes 4 levels of competencies (from TA3 up to TA0) with increasing responsibility and authority. Part of DCAF is the Discipline Authorities Manual (DAM), containing a list of discipline professionals (Technical Authorities, TA's), who have successfully completed the assessment for demonstration of their competency. Based on this demonstrated competency, these persons are assigned as a TA.

For contractors, competence requirements are verified in the FPAL process and/or in the pre-award Capability Assessment, based on the IOGP model [Ref. 16]. Additionally, general HSE access requirements are applicable before work on mining plants and mining installations may be done.

3.6. *Element 4: Risk Management*

Risk management - also referred to as the Hazards and Effects Management Process (HEMP) - is performed through the sequential process steps:
- Identify;
- Assess;
- Control;
- Recover.

Fig. 3.2: Hazards &Effects Management Process (HEMP)

NAM has methods for systematically identifying major hazards and reducing risks to an acceptable level (ALARP). These methods relate to both routine and incidental activities under normal and abnormal conditions during each phase of the E&P life cycle.

The following methods and tools apply to risk management:
- HSSE studies (HEMP) for new developments/projects, including environmental impact assessments (MER) and safety studies (e.g. HAZID, HAZOP, SIL, QRAs) and verification of modifications and projects activities;
- VG documents/RiGG documents, concerning HSE-critical systems and activities;
- Bow-ties for the most serious risks (RAM red and yellow 5A/B);
- Creation of a MOPO (Matrix of Permitted Operations);

- Maintenance of installations, prioritisation of maintenance of safety-critical systems;
- Hardware Barrier Assessments (HBAs)/Process Safety Reviews;
- Health Risk Assessments (or RA for health and safety risks);
- The Environmental Aspect and Effect Register (per relevant process);
- HSSE plans;
- Assurance plans (LOD 1, 2 and 3 and external audits conducted by third parties);
- Incident Classification and investigation.

A risk matrix (RAM) is used for risk assessments in order to control and mitigate standardised identified risks to an As Low As Reasonably Practical (ALARP) level, see Figure 3-3.

SEVERITY	CONSEQUENCES				INCREASING LIKELIHOOD				
	People	Assets	Community	Environment	A	B	C	D	E
					Never heard of in the Industry	Heard of in the Industry	Has happened in the Organisation or more than once per year in the Industry	Has happened at the Location or more than once per year in the Organisation	Has happened more than once per year at the Location
0	No injury or health effect	No damage	No effect	No effect					
1	Slight injury or health effect	Slight damage	Slight effect	Slight effect					
2	Minor injury or health effect	Minor damage	Minor effect	Minor effect					
3	Major injury or health effect	Moderate damage	Moderate effect	Moderate effect					
4	PTD or up to 3 fatalities	Major damage	Major effect	Major effect					
5	More than 3 fatalities	Massive damage	Massive effect	Massive effect					

Figure 3-3 Risk Assessment Matrix (RAM, 2016)

Chapter 5 describes in more detail the hazard analysis process and the risk management for NAM Wells – C&WI.

3.7. Element 5: Planning and Procedures

3.7.1. HSSE Plans

NAM and Asset HSSE plans are created and followed up in the organisation on an annual basis. Follow-up and amendments are monitored. The progress of HSE plans is reported quarterly and discussed in the relevant management teams.

The contents of an HSE plan and improvement measures are established by:
- Goal Zero assessments / Performance results / issues;
- Learnings / trends from incidents;
- Observations from the field and/or Asset Management;
- Audit findings (LOD-2, LOD-3, External Regulatory audits);
- HSE Management Review.

3.7.2. Emergency Response Plans and Response on Emergencies

Onshore and Offshore Contingency Plans (NAM-wide) and onshore On-Site Emergency Response Plans (LNP, specifically for mining plants) and offshore firefighting and rescue plans (BBRP, specifically for platforms) are available. Furthermore, the Blow-out Contingency Plan deals with actions to be taken in the event of a blow-out.

In order to establish a good emergency response plan, it is important to identify any possible emergencies or unusual incidents that may occur. This is achieved partly by learning from incidents that have occurred. Additionally, risk assessments are conducted (see section 3.6) which identify likely unusual incidents, including the RiGG bow-tie analysis. This also takes the consequences of deliberate safety disruptions into account by means of specific security measures.

NAM has an Emergency Response Organisation (ERO), and Emergency Response Room designed to deal with incidents and emergency situations and minimise the impact of a disaster in a structured way.

The Emergency Response Co-ordinator in NAM's HSSE department is responsible for emergency response and emergency response plans. Protocols are in place in case escalation to the NAM crisis management team is necessary. A schematic overview of the escalation from an incident, via emergency up to a crisis is given in Figure 3-3.4.

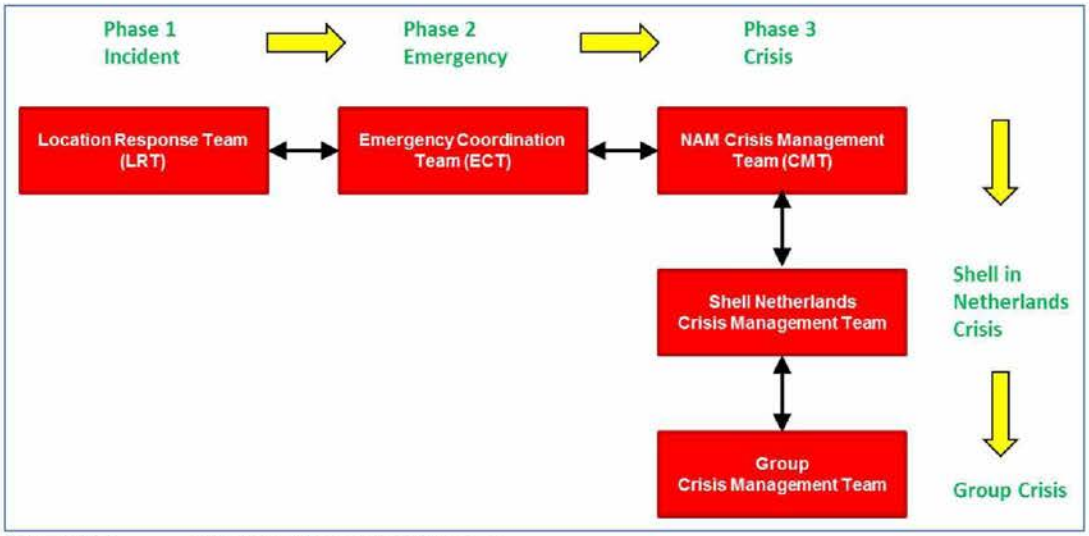

Figure 3-4 ERO and Escalation Process

NAM has in cooperation with Element NL, a contract with the 'Gezamenlijke Brandweer Rotterdam' to provide support in case of calamities like well blowout where huge amount of cooling water or extinguishing foam is needed for a prolonged time.

Management has set up an availability scheme so that regular desktop and full-scale exercises are held to test capacity, proper functioning, and interfaces with other parts of the organisation, external parties and public services.

During periodic exercises (evacuations) Emergency Response and procedures are assessed at various levels and sometimes in association with the relevant public services. Schedules featuring a specific frequency of exercises and various scenarios are drawn up annually for this. A NAM representative, the so-called 'yellow helmet', is available to support the Fire Brigade on-site during an emergency or policy teams in the event of escalation to GRIP 2/3 or higher. Lessons learned during exercises are shared at toolbox talks held by the relevant assets and functions.

Furthermore, NAM has emergency assistance contracts with external parties in case of a blowout (Boots and Coots Services and Wild Well Control Inc.) and for major oil/natural gas condensate spills (OSR Southampton). OSR Southampton is an international organisation that specialises in providing oil spill response. This organisation provides NAM with access to oil spill response equipment and external specialists. More information can be found on the website: http://www.oilspillresponse.com/

NAM is a member of OCES (Operators Co-operative Emergency Services) through Element NL The OCES agreement is an international framework under which offshore operators have agreed to support each other in the event of an emergency. For example, this involves making a drilling rig available to drill a so-called relief well in the event of a blow out and providing support by means of supply vessels. NAM is also a member of OPOL, which ensures that the costs are refunded to parties that have suffered losses as a result of a major incident.

Finally, the Dutch authorities (RWS, Directie Noordzee) have anti-pollution ships and equipment that can be deployed rapidly.

3.7.3. Work Permits

NAM has implemented a Permit to Work (PtW) system for all persons who carry out maintenance work on installations, equipment or parts thereof. The level of knowledge relating to the objective and application of the work permit system is acquired by all concerned with work permits (applicant, issuer, releaser, holder and supervisors in the field, including contractor staff, through mandatory classroom work permit training. Furthermore, there are procedures for communicating about the safe execution of work at shift handovers, co-ordination between production and technical services, suppliers, etc.

3.7.4. Management of Change

Changes take place continuously, both at installation level and organisational level. These changes may be of a permanent or temporary nature and may involve equipment as well as people and procedures. A Management of Change (MOC) policy and procedure is used for this at NAM. The MOC policy sets out the minimum requirements imposed on the management of change [Ref. 17]. The MOC policy is applicable to all facilities and activities within the scope of a RiGG/VG-document. The procedure includes permanent and temporary changes of the following nature:

- Process Changes (Hardware, Process Control and Process Condition Changes);
- Procedural changes in standards, procedures, work instructions or methods that influence HSE-critical activities;
- Organisational changes that influence safety critical (HSE) positions.
  (Applicants for HSE-critical positions are assessed on HSE competences prior to appointment).

Any change that falls within the scope of this policy goes through the seven steps of the step process as described in the underlying procedure [Ref. 18], which is performed prior to the implementation of the change.

For Wells there is a separate Well related Shell eMOCD (Management of Change/Deviations) in place, see 5.9.

3.8. *Element 6: Implementation, Monitoring and Reporting*

3.8.1. HEMP Implementation

Projects are established on the basis of the 5 Year Business Plan. All necessary HEMP studies required for the projects, are planned using DCAF / PCAP, which covers the HSE aspects of the projects. The project activities are included in the rolling annual plan together with well activities, drilling activities, modification activities, and maintenance and inspection activities. Any additional HSE aspects that require closer analysis, concurrent operations for example, are indicated at this stage. Shutdown planning is also performed and is based partly on the HSE aspects of the activities. As the activities continue to crystallise towards the three-month plan and beyond, the HSE aspects take shape and measures are fine-tuned, for example in project HSE plans, Project Risk Assessments (PRAs), tollgates, Permit to Work System, incl. Task Risk Analyses and Assist & Assure.

3.8.2. Monitoring and Reporting

By registering and reporting performance, it is possible to assess whether all activities have actually been carried out in accordance with HSSE policy and its objectives. Corrective measures may be required as a result of this assessment. Performance feedback, in addition to consultation and other means of internal communication, is provided via various written reports and accounts, with the ultimate aim of improving performance through corrective actions. A secondary function of reporting is to inform management, other employees and external parties.

Examples of written and overarching reports in the framework of HSE management include various internal and external HSE performance dashboards and reports and specific environmental data reports.

3.8.3. Incidents; Investigation and Learnings

Reporting of accidents and near misses is promoted in toolbox talks and by spill focal points.

All incidents are logged in Sphera, analyzed within the relevant Asset and learnings are then shared in NAM and Shell. Near misses are reported and assessed. This process is described in the procedure Incident Reporting & Follow-up (NAM-17.WI.04.01).

The risk assessment matrix (RAM) is also used for incidents and potential incidents, to estimate their severity and to align the investigation accordingly.

Incidents and risks are reported in a database system (Sphera) and discussed by asset management (Operations and any other stakeholders including security specialists). These discussions take place during so-called SAFCOM meetings.

The proposed actions are approved and/or supplemented, the follow-up of actions is checked and trends in incidents or risks are updated. Publications (LFIs) and toolbox talks enable learnings to be fed back to the relevant staff.

In accordance with the requirements/agreements, incidents are reported to the relevant authorities, SodM in particular.

NAM

3.9. *Element 7: Assurance*

Within NAM, HSE assurance is embedded in the AMS 'Conduct Assurance' process, with the aim of carrying out assurance activities to demonstrate that;

- the organisation complies with legal requirements (including permits), the Shell HSSE & SP Control Framework, the HSE-MS Standard Workflows (SWFs)', the NAM BMS and other requirements to which it conforms (e.g. ISO 14001 standard);
- the NAM HSE policy and business objectives are achieved;
- opportunities for improvement are identified and assessed.

3.9.1. HSE Compliance

At NAM, the Legal and HSE departments are responsible for ensuring that the HSE Care System is compliant and that reported non-compliances are followed up. For this, the applicable workflows are in the areas of identification, consultation and the dissemination of new HSE legislation and regulations, initiation and management of project permits or layout permits, and reporting and follow-up of non-compliance on the basis of reviews of permit conditions (Environmental Management Act/Environmental Permitting (General Provisions) Act [WABO]) for example.

3.9.2. Asset Integrity Review

The asset integrity review is a specific check that is carried out within the Assets by the technical authorities (TAs). It assesses modifications and changes to standards or deviations from them. During the integrity meeting, the risk register is discussed within the Assets and the status of all installations and safety-critical systems is assessed and reported by the line and the TAs together. This status is also discussed and assessed each month during the Business Performance Review (BPR) and yearly as input for the Business Assurance Letter for senior management of Shell.

3.9.3. Audits and Review

An audit process and review is in place to determine whether the HSE Care System is being complied with in practice. All business processes and areas of expertise are periodically subject to audit and review. A specific audit and review plan, based on the HSSE Annual Plans, is created annually within each asset.

There are three levels of assurance (Three lines of Defence, LOD-1, LOD-2 and LOD-3):

- LOD-1 reviews concern self-evaluation and compliance activities and provide assurance at mining operations/installation level and are reported at Asset and Function level.
  Examples are Asset Integrity Process Safety reviews (AIPSRs) and Hardware Barrier Assessments (HBAs) and Work Permit/Permit to Work check.

- LOD-2 audits are planned by NAM at corporate level; they are conducted independently and are reported to NAM Management.
  An example is an Independent Verification audit.

- LOD-3 encompasses the HSSE & SP Control Framework/Group Audits and is reported to the Board of Royal Dutch Shell.

Additionally, external audits are also conducted by certifying bodes and/or the authorities. These audits also have an important role in the business operations system.
The recommendations resulting from audits and reviews are stored in a database system (RADAR). Follow-up to recommendations is monitored and assessed by management.

3.10. Element 8: Management Review

Management assessment of results is important to the evaluation of the suitability and effectiveness of BMS within a changing environment. This assessment is conducted by corporate and Asset/unit management based on field visits and reviews. The reviews include the annual HSE Management Review (which provides input for the Business Assurance Letter), quarterly reviews and contractor reviews.

Furthermore, consultative meetings with contractors and management are held regularly. Incidents in particular are analysed in addition to HSE performance in all these meetings.

3.11. Wells Management System (WMS)

WMS is a single portal presenting a common understanding of what Wells does, how it is organized, how business is conducted and what principles, policies and standards, including global processes are adhered to.

The Wells Global Management System Manual provides a framework to apply common practices across the global Wells activities. It defines required levels of compliance to HSSE, technical design, technical assurance, competency, and risk management standards for the Wells activities.

3.11.1. Scope of the WMS

WMS is valid for all projects within Wells in P&T, UP and UA Wells organization; some main characteristics of WMS are:

- Alignment with Shell Control Framework and global processes;
- ISO 9001, 14001 set as guidelines for structure;
- Addresses how Wells business is integrated in P&T and upstream;
- Clear definition of Wells processes, standards and guidelines; defines required levels of compliance;
- Integral point of reference for Principles, Policies, and Standards for the Wells Community;
- Provide a single portal to links of existing Wells documents and related Group standards.

The Shell management system components are represented schematically in Figure 3-5.

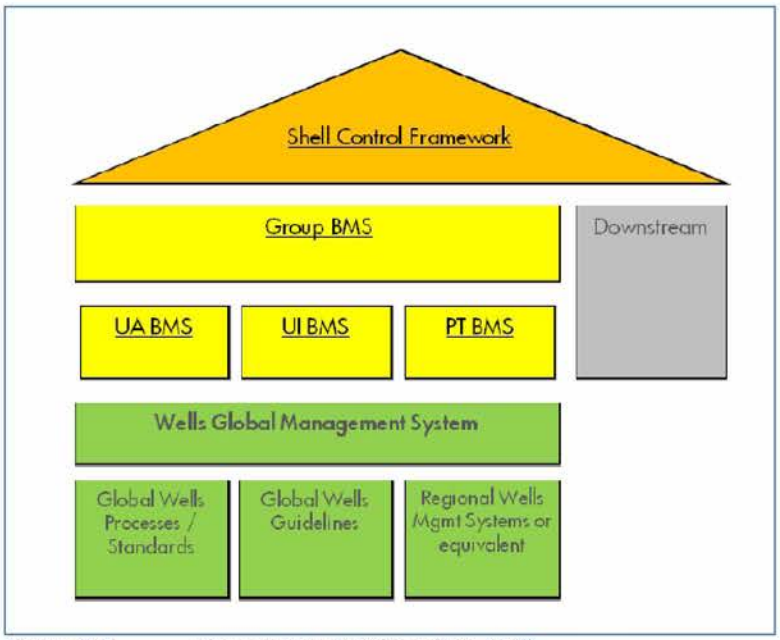

Figure 3-5 Framework of Wells within BMS

4. DESCRIPTION OF C&WI ORGANISATION AND EQUIPMENT

4.1. NAM Wells – C&WI organization

C&WI discipline is part of the Global Manage Wells core business process EP.63 design, drilling, modification, servicing and abandonment of wells. Wells is a department under the global Project &Technology (P&T) organization.

NAM Wells – C&WI is a functional department in NAM that supports the main operational processes of the three producing Assets (North, South and ONEgas). The support mainly involves maintaining integrity, restoring and optimizing production from wells.

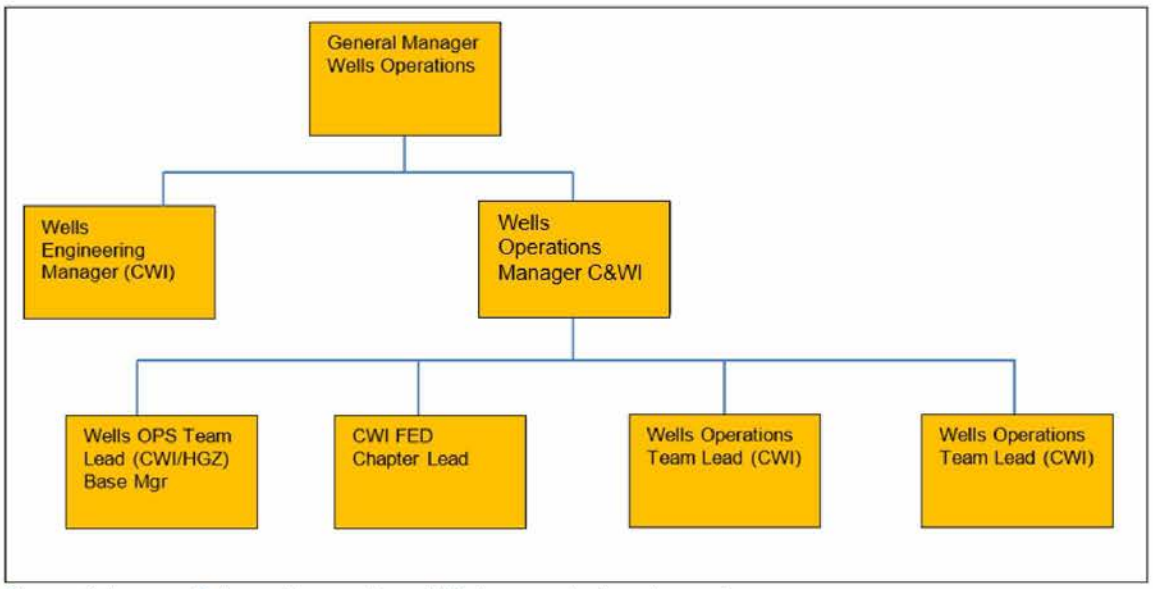

Figure 4-1 Schematic overview of Wells organizational overview

C&WI organization closely collaborates with the Wells Reservoir and Facility Management (WRFM) team that is part of the Asset. With the objective to maintain integrity, restore or optimize production from wells, C&WI designs, prepares and executes well intervention (e.g. servicing, modification).

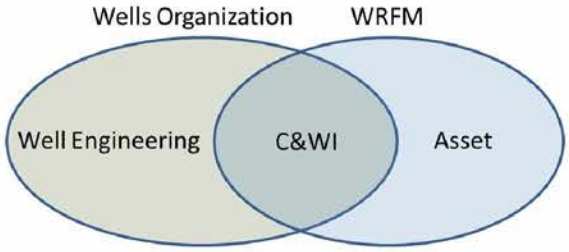

Figure 4-2 Representation of collaboration between Wells - C&WI and WRFM

The NAM C&WI organization consists of the following teams:

- Front End Design Team;

- C&WI Coordinators;
- Hoogezand Operations Base;
- C&WI support team.

4.2. Classification of C&WI Well Intervention Operations

C&WI operations have been divided into four categories as can be seen in Figure 4-3. The same division is used in the NAM Well Services Catalog (EP201709207504), which (additionally) covers the (summarized) operational steps and SECE's found in the bow-ties in this Safety Case with respect to NAM Well Services activities. The Well Services Catalogue is a live document which, based on current experience, requires a regular update. For that reason, it was decided not to include the Wells Services Catalogue as an appendix to this VG document.

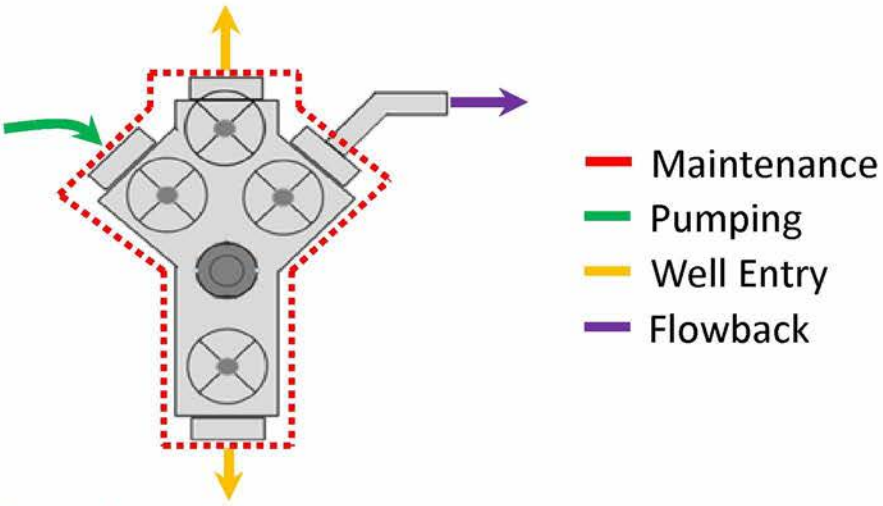

Figure 4-3 Well Intervention categories

The C&WI operational activities based on these four categories can be further divided into the following subcategories each:

- **Well Entry**, consisting of the following activities:
  - **Wireline:** work involving using a cable to lower equipment into a well or to remove it. This work is carried out using both NAM and or hired equipment.
  - **Coiled tubing**: work in which a long steel tube is used to pump liquid or gas (nitrogen) into a well or to place or remove equipment, etc. This work is carried out by a contractor under company supervision.
  - **E-line:** work in which an electric line cable is used in a well to collect real time reservoir data, perforates, perform a water shut-off, etc. This work is often carried out by a contractor under company supervision.
  - **Capillary:** where a control line is installed to introduce a foaming agent into a well in order to improve production in a liquid loading well and extend the life span / production rate of the well.
  - **Velocity string**: application where a liner with small(er) diameter is inserted in the existing well to speed up the gas flow and lift the accumulation of liquids out of the well in order to extend the life span/production rate of the well.
  - **Snubbing/Hydraulic workover:** Snubbing or the use of a hydraulic work-over unit (a rig-less 'heavy duty' technique) is used when lighter deployment methods such as wireline and coiled tubing are not workable. Snubbing can be described generally as

using created force to snub the pipe string into a well against the pressure in the wellbore.

- **Flowback**; Well test work using a temporarily set-up installation connected to the well with the objective of making a well ready for production, produce the well clean, etc. This work is carried out using both NAM and hired equipment and personnel and can be divided into two types of operation:
  - **Production:** where the goal is to flow the well either through temporary PTE or through the facilities.
  - **Depressurizing**: venting of pressure in either the tubing or an annulus.
- **Pumping**, consisting of:
  - **Pumping:** work during which fluid is pumped into a well or circulated in a well. This work is carried out using both NAM and hired equipment and personnel.
  - **Hydraulic stimulation**: is where reservoir rock liquid (with proppants) is pressed under high pressure in a well in order to break open the formation permanently.
- **Maintenance**; wellhead maintenance (WHM) work on the Xmas tree and wellhead. This work is carried out using both NAM and hired equipment and personnel.

These activities are further categorized and illustrated in Appendix 3.

4.3. *Wells delivery Process*

A standard framework is used for selecting, planning, executing and servicing of Wells projects. This framework is known as the Well Delivery Process (WDP) and describes the ORP (Opportunity Realization Process) for Wells activities. (Figure 4-4)

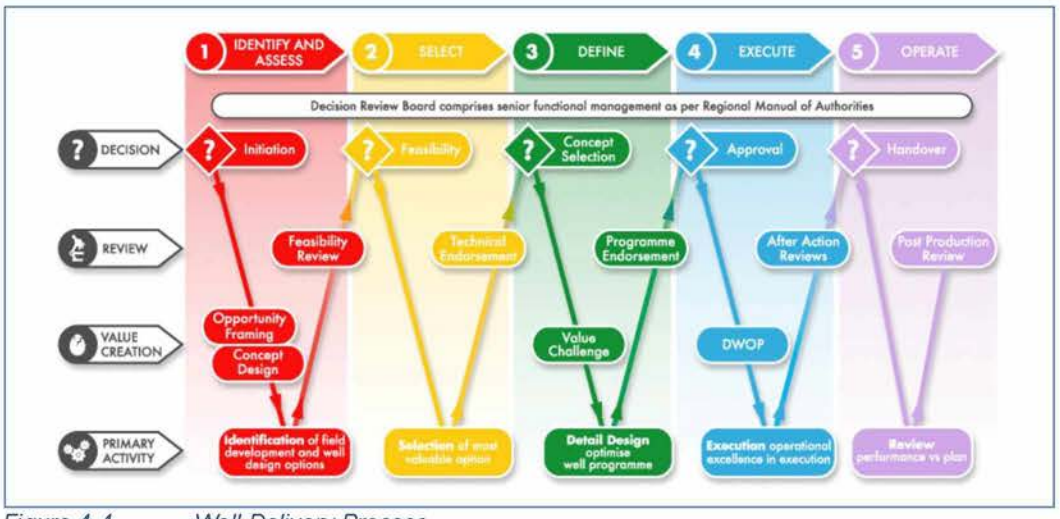

Figure 4-4 Well Delivery Process

Producing Assets use the WRFM process to identify and mature well intervention opportunities. The WRFM process (Figure 4-5) is a scaled version and based on the project & assurance principles of the WDP. Decision gates require the approval of the Technical Authority (TA) and provide assurance on compliance against the BMS.

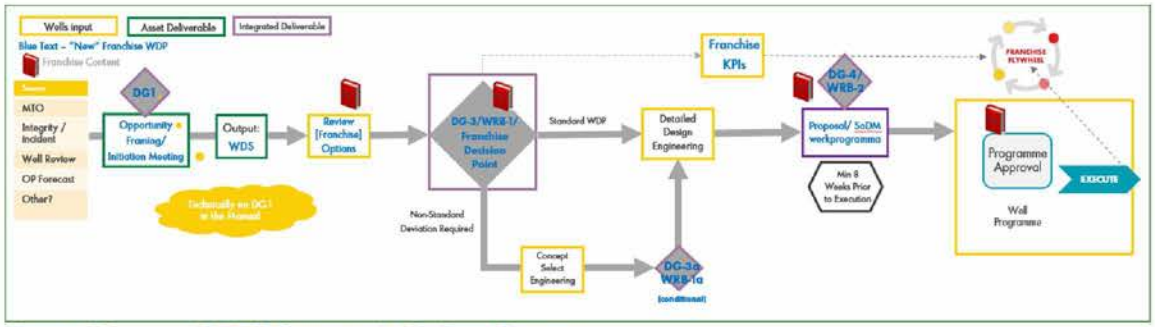

Figure 4-5 WRFM Opportunity Delivery Process

5. HAZARD ANALYSIS & RISK MANAGEMENT

5.1. Well examination

In 2016 NAM implemented internal Well Examination, independent verification of Well operations, following the Offshore Safety Directive [Ref. 5] and subsequent incorporation of the requirements into the Dutch Mining Legislation [Ref. 6].

The Well Examination Team is embedded in the HSE department, independent of the Wells line management. The Well Examination team is directly appointed by the NAM Director and has got direct access to the director in case escalation is required. Well examination takes place on deliverables that have already passed through the Wells technical assurance processes. The well examiner is and has not been involved in the design and decision-making process of the well operation examined.

The Well Examination Process consists of two phases:

- Well Examination of Design and Program, this activity takes place prior to start of the operations.
- Well Examination of Program Execution, this activity takes place once the well operation is executed.

Examination of Design and Program takes place against Dutch mining legislation, Shell Wells Manuals and Company Standards. In case findings and issues raised by the Well Examiner are not resolved the issue will be escalated as per Well Examination Process. In this escalation process, formal notes will be raised. Any notes raised during the program execution phase must be raised by the Wells Team as an incident in Sphera, including corrective actions.

Once a well program has been examined and any issues have been resolved, the Well Examiner will issue a Program Execution Checklist (PEC) to the Wells team. The PEC will detail those critical steps in the signed program that the Well Examiner believes are critical for implementation of the examined design and for maintaining well control. This PEC will be used to confirm the operation is executed as planned. Major changes made during the design or execution of the well operation will be examined by the well examiner.

Well Examination documentation (including the Well Examination Report with the well examiner's findings and the PEC) are stored in the well file and in the well examination team's Document Control Area on SharePoint.

Further details can be found in NAM's Policy on Independent Verification and Well Examination [Ref. 14] and the NAM Well Examination Scheme [Ref. 15].

5.2. Introduction

A hazard is, in the context of this VG document, defined as the potential to cause harm to people (including injury or health effects), or damage to the environment[10].

Hazards are always present on gas production - and gas treatment facilities. To prevent damage to people or the environment, all reasonable control measures must be taken for all foreseeable hazards. Nevertheless, it is not possible to exclude the possibility of the release of the hazard completely. This means that despite the presence of control measures, there is a risk for damage to people and/or the environment. Risk is, in this context, defined as the probability of an unwanted situation in combination with the severity of the occurrence of this unwanted situation. In short: risk is "probability x consequence". A risk for example arises due to failure of control measures. In addition, there are hazards for which practically no control measures are conceivable, or for which the probability of release of the hazard is at such a low level, that the implementation of (additional) control measures is disproportional compared to the risk reduction achieved by the introduction of this control measure. In such a situation, the risk is deemed to be as low as reasonably practicable and is accepted.

The main objective of the VG document is to demonstrate that all reasonably foreseeable hazards are managed as far as possible, so that the risk is minimized, and that the residual (remaining) risk is tolerable and ALARP (As Low As Reasonably Practicable).

The risk level is deemed to be ALARP when, after an objective analysis and risk assessment, it is assessed that the time, effort and costs of further risk reduction are disproportionate to the risk reduction that could be achieved.

ALARP is not a static concept. Due to new insights and techniques as a result of advancing insight, risk reductions that are assessed as impractical can prove feasible in the future. The ALARP demonstration must therefore be confirmed on the basis of periodic (re-) evaluation.

5.3. Demonstration of ALARP

There are three main elements involved in showing that risks are ALARP:

- The design concept must be such that risks for Safety, Health and Environment are prevented or reduced to a minimum as far as is practicable.
- The way in which the activity is carried out or the design is selected must be practical and be state of the art, taking into account the methods used for construction, operation, maintenance and abandonment.
- The qualitative and quantitative evaluation of the risks for both individuals as well as the group on site or in the area surrounding the work must show that the risk has been reduced to a tolerable level.

If the three abovementioned elements have been met, it can be assumed that the activity or installation is ALARP. This is confirmed through review of the acceptance criteria, see chapter 8.

The core of risk reduction consists of a process of identification, evaluation and management of HSE hazards, and restoration should the undesirable event occur. This process is known as HEMP (Hazard and Effects Management Process, see also 3.6). The way in which the hazard analysis is applied to demonstrate that for all reasonably foreseeable hazards all applicable control measures will be taken, is described in more detail in 5.4.

(10) In general, the definition of hazard also includes the potential to cause damage to facilities (Asset), loss of capital, loss of production, as well as damage to Community. Within the context of this VG document, loss of capital or income and damage to Community is not considered. Although such damage is indeed an additional consequence of the incidents described in this document, the management of this damage is beyond the scope of this document.

5.4. Hazard Analysis Process

The requirements for the control measures are more stringent in case the potential hazard leads to more severe consequences. In this VG document, the decision was taken to make the way of demonstration of the control of the hazard dependent on the potential consequences of the release of the hazards.

5.4.1. Steps in the Hazard Analysis Process

In Figure 5-1 an overview is given of the hazard analysis process. As part of this process a number of steps - Identify, Assess, Control, Recover - can be identified which are discussed in more detail below.

Step 1: Hazard identification (Identify)
Hazards are identified according to a Master hazard checklist. The hazards relevant to the C&WI activities are indicated on this list (see Appendix 4).

Step 2: Consequence evaluation (Assess)
The Hazard & Effect Register lists the sources, hazardous incidents (events), scenarios and consequences (see Appendix 5). The potential effect is specified based on the Maximum Credible Accident scenario (MCA) and classified according to the RAM matrix (see § 3.6).

This classification is done for all four categories (i.e. People, Asset, Community and Environment) as included in the matrix. Note that from Major Accident Hazards point of view only the category People and Environment are relevant. The result of the ranking is divided into four categories, i.e. light blue, dark blue, yellow and red risks, in line with the color code of the RAM. In the Risk Assessment Matrix (RAM) 6 severity classes are divided (from 0 to 5). Severity class 5 represents an incident scenario that (more or less immediate) can result in more than 3 fatalities, or in massive environmental damage. The Hazard & Effect Register is included in Appendix 5 and contains a complete overview of hazards, risks and ultimate consequences that are related to the C&WI activities.

Step 3: Managing the hazards (Control)
Consequences (of hazards being released) that are RAM ranked as “red risk” and/or “yellow 5A/B risk” for People or Environment are the so-called Major Accident Hazards. For these MAHs, a bow-tie is set-up to give a complete overview of the barriers (preventive) and mitigating measures that are in place to manage the risk. The current bow-ties are set-up and its validity checked as part of the update of the VG document. An overview of the relevant bow-ties for NAM Wells C&WI are included in Table 5-1. All NAM bow-ties are set up according to a set of principles and rules [Ref. 8].

Step 4: Mitigate incident consequences (Recover)
In case an incident occurs because controls have failed it is necessary to mitigate the consequences and get back to a controlled situation as fast as possible. Those measures are the recovery barriers at the right-hand side of the bow-tie which are mitigating the consequences and escalation potential if the top event occurs.

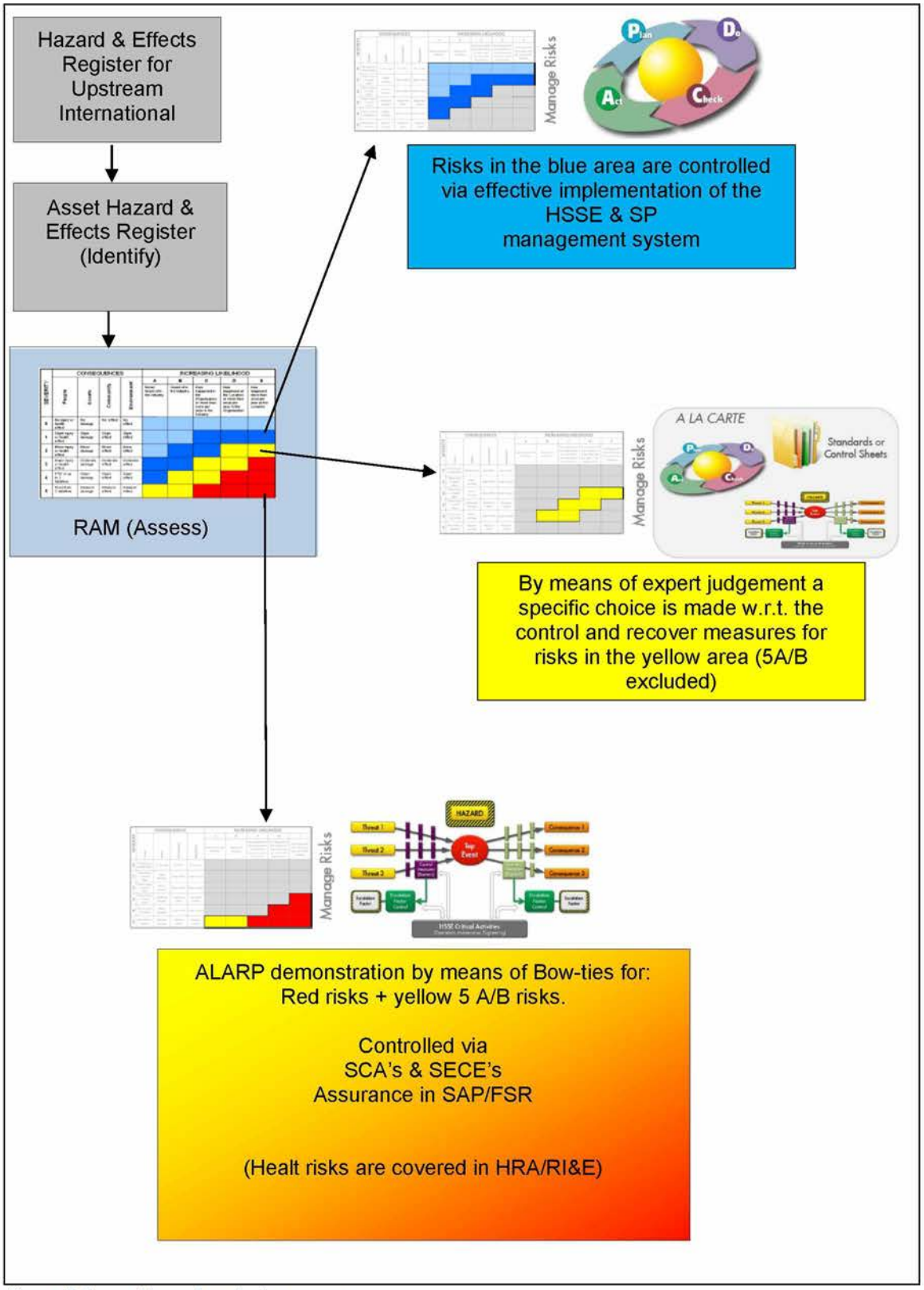

Figure 5-1 Hazard analysis process

For the other hazards, the control/mitigation is described in PEARs[11], HRA(RIE)[12] registry pages or risk analyses. The vision behind this is that at NAM (Asset) level, the most important hazards and risks have been inventoried, described and assessed for the various operational activities, after which it has been determined which existing facilities and measures (barriers) are present or necessary to reduce those risks. These can also be procedures and work instructions (Ref. Working Conditions Data Sheet AI-61).

During the operations, circumstances can occur which deviate from the hazard management, because, for example, SECEs that are part of the standard hazard management do not work properly or are unavailable.

Procedures and work instructions are available as part of the HSE Care System. These describe the technical and operational measures that must be taken to reduce the increased risk in the event that one of the SECEs is not available or only partially available. These measures may include: extra supervision, additional technical provisions, the suspension of work that is not immediately necessary, complete or partial block-in of the installation and/or depressurization.

The Standards “HSE Hazards and Effect Management Process” and the “HSE Case” require the use of bow-ties for severity 5 or high risk classified hazards. The bow-tie model provides insight with respect to:

- The identification of potential hazards/threats, escalation and development of the consequence;
- The identification of required controls to manage the hazards in an effective way;
- ALARP demonstration;
- The visibility and communication of the abovementioned items;
- (In case of an incident): the identification of causes that might have contributed to the failure of controls.

The bow-tie model gives a structured overview of the threats and consequences related to a specific hazard and how this hazard is managed. In principle, there are two kinds of measures that are used to manage the hazard, which are used in combination:

1. Measures to prevent the release of a hazard: so-called barriers. These measures are preferable (prevention policy).
2. Measures aimed to limit the consequences (damage) in case the hazard is (unfortunately) released, so-called mitigating measures.

A graphical representation of the Bow-tie model is shown in Figure 5-2.The model which is set-up for a specific hazard, is explained below using an example.

(11) PEAR: Process Environment Aspects Register; a register included in the ISO certified Environmental Management System, in which the control measures for the particular Environmental aspect is described.

(12) HRA (RIE): Health Risk Assessment (RIE: Risico Inventarisatie en Evaluatie); a register and assessment of personal health and safety hazards for which the control measures are described.

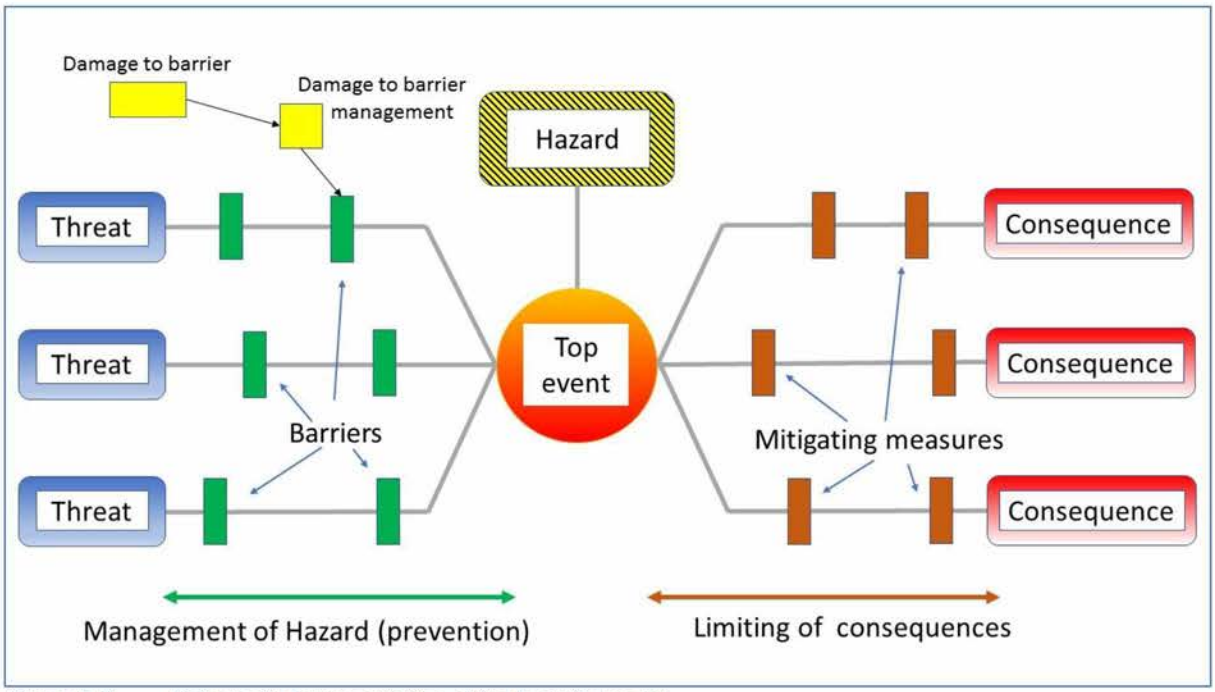

Figure 5-2 Schematic representation of the bow-tie model

The hazard (e.g. hydrocarbons under pressure in well test equipment) is shown in the center of the diagram together with the top event, i.e. the release of the hazard (e.g. loss of containment). On the left-hand side of the bow-tie the potential threats (e.g. overpressure, mechanical impact, etc.) are shown and on the right-hand side the potential consequences (e.g. ignition of hydrocarbons, intoxication in case the gas contains H_2S, etc.).

In between the threats and top event, barriers are in place that can prevent the occurrence of the top event. A typical barrier with respect to overpressure would be a pressure safety valve (PSV). However, barriers can be impaired. For example, the PSV has a wrong setting or the relief capacity of the PSV is insufficient. For this reason, the hazard analysis must always indicate how the integrity of the barrier is managed, for example: by ensuring that the right setting is used and the calibration is carried out by qualified personnel.

If the barriers in a threat line fail unexpectedly, the top event takes place which could lead to several potential consequences, depending on the conditions during this event.

In between the top event and the potential consequences, mitigating measures are in place to limit the ultimate consequences. Taking the example of the release of hydrocarbons from the well test equipment due to overpressure, gas detection will initiate a shutdown of plant and therefore limit the consequences.

The mitigating measures can also be affected / impaired, and therefore a process should be in place to assure the effectiveness of these measures.

When evaluating the control of major accident hazards (in other words, when drawing up the bow-ties) it is important to evaluate whether sufficient barriers and mitigating measures are present for a particular major accident hazard (have all reasonable measures been taken to prevent or limit the hazards in terms of the state-of-art.

Technical systems that are regarded as being an essential barrier or essential mitigating measure are known as Safety & Environmental Critical Systems (the so-called SECE's). An example of a SECE is an ESD system that shuts down the plant upon gas detection (e.g. in case of Loss of containment due to overpressure).

Activities that are assessed as being essential for installing, operating or maintaining/repairing barriers or mitigating measures are called safety critical activities (SCA). An example of such an activity is the testing of the ESD system.

In order to ensure a good control of these hazards and thus minimizing the residual risks, safety critical activities and SECE's must meet certain requirements in terms of quality. These quality requirements are laid down in the Technical Integrity Framework.

Chapter 6 discusses in more detail the SECEs and SCAs, as determined in the analysis of the major hazards.

Based on the updated Hazard and Effect Registers (see Appendix 5) bow-ties are set-up for the following C&WI activities, see Table 5-1. These Bow-ties are included in Appendix 6 of this document.

Table 5-1 Bow-Ties applicable for NAM C&WI activities

Hazard		Bow-tie	Applicable to / part of
No.	Description		
H-01 Hydrocarbons			
H-01.02 H-01.03 H-01.04	Hydrocarbons (formation fluids, sour/sweet)	No. 1C Hydrocarbons in wells and reservoirs	VG document NAM Wells – C&WI
		No. 2A Hydrocarbons in well test equipment	VG document NAM Wells – C&WI

5.4.2. Demonstration of managing hazards by means of "Installation scenarios"

As part of the implementation of the OSD into the Dutch Legislation, Oil & Gas operators are required to set-up so-called installation scenarios for their assets. These Installation scenarios are based on the Major Accident Decree 2015 (BRZO 2015) and the Major Accident Regulation (Regeling Risico's Zware Ongevallen), for which a template is defined in the Publication Series for Hazardous Substances (PGS) part 6 [Ref. 10].

According to the definition as given in PGS part 6, an installation scenario is a series of consecutive events which starts at a root cause, and which develops via the direct cause and the release of the hazardous substance from the containment (installation) to an ultimate consequence. An installation scenario therewith describes a specific path in the bow-tie from a threat on the left-hand side, via the LoC, up to a consequence as shown on the right-hand side of the bow-tie.

The objective of the installation scenarios is to give an overview of the hazards and the measures to prevent the release of the hazard or to mitigate the consequences once the hazard has been released. The selection of the installation scenarios should be such that a complete overview is given of all the hazards and preventive / mitigation measures which can be either technical or organizational. It is not necessary to set-up installation scenarios for all installations or installation parts, for all possible (whether or not combined) direct causes that can lead to a major accident. Especially since several causes that can initiate a Major Accident are controlled in a similar way / by similar type of Lines of Defense (LODs). Therefore, a number of representative installation scenarios are defined, to illustrate the technical and organizational measures that are related to the C&WI operations.

In PGS-6 the following direct causes are divided:
- Corrosion;
- Erosion;
- External load;
- (Mechanical) impact;
- Overpressure;
- Under pressure;
- Low temperatures;
- High temperatures;
- Vibrations;
- Human errors during use, modifications and/or maintenance.

The Installation scenarios for the C&WI operations are included in Appendix 9 of this document.

5.4.3. Parties involved in the Hazard Analysis Process

As part of the update of the VG document the identification and evaluation process has been redone during a number of sessions by a multidisciplinary team consisting of Wells operations / C&WI and Technical Safety. The Hazards & Effect Register gives a complete overview of the hazards, consequences in case the hazard is released, RAM classification and controls to manage the risk.

Based on the results of the Hazard & Effect Register the relevant bow-ties were not deemed to be updated.

5.5. HEMP Studies

Risk assessment methodologies are used to decide on priorities and aim to suggest the elimination of hazards and reducing risks. If possible, hazards are eliminated by the selection and design of facilities, installations and processes. If risks cannot be eliminated, they should be minimized by the use of physical barriers or, as the last action, by systems and personal protective equipment.

The risk management process as applied within the Shell organization is known as “Hazards and Effects Management Process " (HEMP). The different stages in the HEMP process and how it is applied with specific HEMP studies which have been carried out, are described in this VG document.

This section describes the role of the HEMP process in the context of the HSE Care System. HEMP is at the core of the BMS and is applied to all hazards, including Major Accident and work-related hazards. The process is defined in AMS 2.4.3 “Hazards and Effects Management Process” and part of Shell HSSE&SP Control Framework. The Process is applicable to all business processes in the life cycle of an operation from inception to decommissioning.

HEMP consists of four main elements (see also **Error! Reference source not found.**3-2):
- **Identify:** The process which results in a physical description of the hazards.
- **Assess:** The process whereby the results of an analysis of a hazard are evaluated against either judgement, standards or criteria, which have been developed as a basis for decision making.
- **Control:** Prevention of hazardous events being realized, by elimination or avoidance of the hazard, or containment of the hazard, by design or procedure.
- **Recover:** Action taken in response to a hazardous event to eliminate or reduce hazard consequences. Recovery includes automatic and manually operated measures to limit escalation and mitigate against consequences, such as Emergency Shutdown, Active or Passive Fire Protection, and Evacuation Escape and Rescue activities.

HEMP is a live process that is initiated when any modification or change to the Installation's systems or activities is proposed. The effect that the proposed change will have on the risks associated with the major accident hazards is assessed to ensure that the risk levels remain As Low As Reasonably Practicable (ALARP). Work undertaken by a contractor and under that contractor's management system is required to have an equivalent HEMP approach and this is expressly stated in each contract.

HEMP studies are carried out during various phases of the Wells process. HEMP studies are integrated in the "Well Delivery Process" as described in § 4.3. The HEMP studies are intended to:

- provide insight into the accident scenario's
- the effects that can result from the event
- evaluate the quality of the management measures and to continuously maintain and improve them during their life.

The following steps are important for HEMP studies within the Wells delivery process:

1. **Project initiation phase.** During this phase, the focus is on developing strategies, well designs, identification of risks and limitations, required resources, identification of new technologies, etc. Important aspects during these phases are the timely recognition and definition of non-routine critical aspects such as safety, environmental protection, techniques, legislation, personnel.
2. **Conceptual phase.** During these phases, the development/exploration plans are translated to concrete Well Functional Specifications (WFS). In case non-routine and/or critical technologies are involved, further analyses are carried out. Non-technical aspects such as safety, environmental protection, health and legal aspects should be identified, evaluated and completed as far as possible during this stage, so that the drilling work can begin as soon as the drilling rig or C&WI equipment is available.
3. **Detailed design and planning.** During this phase, the detailed drilling and/or C&WI program is drawn up. During this phase, the site is prepared, equipment, materials and assets are made available and the required internal and external permissions such as permits, are obtained, among other things.
4. **Execution.** This phase contains the mobilization, well activities (e.g. drilling, testing and logging) and demobilization, etc.
5. **Maintaining the wells.** During this phase, the focus, in terms of HSE, is directed towards the safe operation and maintenance of the technical integrity of the wells assuring that the performance standards for the wells are met.

Relevant HEMP studies for the project initiation and conceptual phase as part of the concept selection and project execution are HAZID, MIR, Fire Analysis (using Shell Fire, Release, Explosion, Dispersion (FRED) calculation software) and Well Lay-out.
During other phases, attention is particularly focused on the execution aspects of the Wells activities. Relevant HEMP studies are HAZID, HAZOP and TRA. The study results form the basis for the work safety plans and concurrent operation scripts. Results from the studies are also used in subsequent similar projects.

Explosive atmospheres and ignition sources
In 2017 NAM published an explosion safety document ("Explosieveiligheidsdocument") in its Business system [Ref. 20]. This document was prepared with the assistance of Technical Authorities level 1 of a number of technical disciplines and Production Excellence. The EVD provides a coherent overview of policy, processes and activities within NAM that are focused on explosion safety in normal production activities, including start-up and shutdown of installations, and in special situations and activities, where attention for fire and explosion risks is required.

During C&WI activities in which equipment is used that creates a new hazardous area, an updated hazardous area drawing will be prepared for the temporary set-up on the location to visualize the interaction and to prevent a hazardous area conflict.

5.6. The Environment

Choices made during the design determine the emissions produced during the operational phase under normal conditions. The required environmental studies are carried out during the pre-design phase. For new development (installations including wells) and major modifications, a decision may be made to carry out an EIA (Environmental Impact Assessment) Report, whereby the subject of sustainable development is also addressed.

Primary justification for the choices made is provided in the Design RiGG for the installation. All drilling activities have to comply with the “Besluit Algemene Regels Milieu Mijnbouw” (BARMM).

Environmental hazards are included in the HSE hazard analysis. Often, incidents with consequences for the environment are related to incidents caused by the failure of material (integrity) or due to human failure. Possible mitigating measures may be specifically focused on the environment (e.g. the removal of contaminated soil).

A standard set of environmental aspects relevant to NAM is included in the Master Hazard List (group H-99). The management of these aspects is specified in the individual PEAR pages (See also footnote 11 in paragraph 5.4.1).

5.7. Working Conditions

Working conditions hazards (work safety and health) are also an integral part of the HSE hazard analysis. The legal requirement to draw up Risk Identification and Evaluation (RIE) is fulfilled by writing the VG document and, as derivatives, making the Health Risk Assessments (HRA), Project Risk Analyses (PRA) and Task Risk Analyses (TRA).
HRA’s are implemented within Shell in accordance with the Global Shell standard and the results are recorded in a computerized system (SAP).

5.8. Studies for combined operations and execution of work

When necessary due to the nature of the activity, Wells draws up a WVP or CO script for activities related to drilling, well intervention and concurrent operations. A WVP or CO-script is meant as a working document that on a daily basis needs to be consulted to manage the location. Combined with this VG document this also meets the requirements of the Working Conditions Regulation (Arbeidsomstandigheden Regeling), paragraph 3.2, article 3.7, which states that a Safety and Health document must be written for the referring activities.

When drawing up the WVP or CO script, the guideline is that items/elements that are described in the relevant RiGGs are not repeated. Instead, these documents are referred to.

Before the beginning of the work, a toolbox meeting is organized during which the risks associated with the work are discussed.

5.9. Management of well intervention operations at site

C&WI activities are managed and controlled on location under the NAM work permit system. The permit carries a Risk Assessment (RA) that supports managing the identified risks to ALARP.

LVP (Asset representative Responsible for the Site) issues work permits for C&WI activities. The Well Intervention Supervisor (specialist supervisor) is the permit holder and in case of multiple or complex activities, coordinated by a NAM Well Services Supervisor (CWI supervisor) who will co-sign the permit. The organization is shown in Figure 5-3.

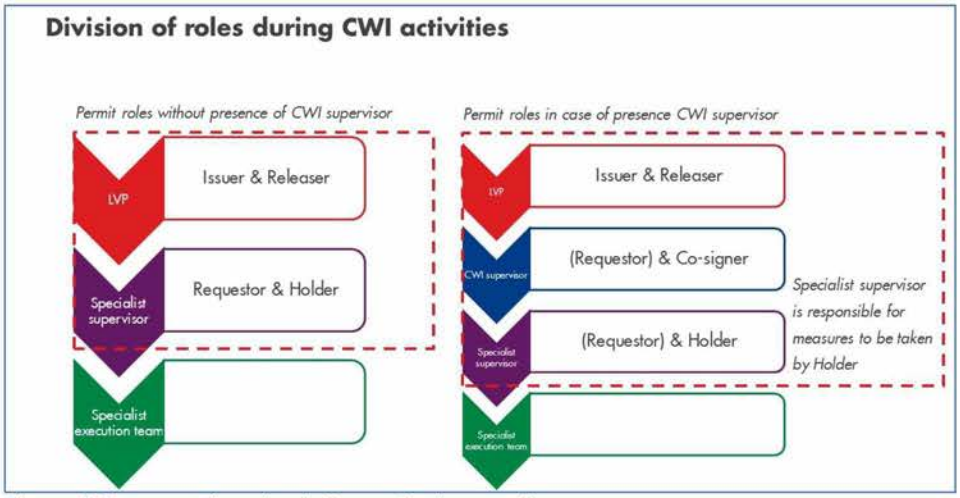

Figure 5-3 Flow chart of organization on site

5.10. Wells management of change

A description of the Management of Change process is given in paragraph 3.7.4.

Within Wells difference is made between changes in work programs and deviations from wells standards and manuals. A software system Wells Management of Change and Deviations (eMOCD) is in place for documentation and assurance of the change/deviation. The basic process for managing any Change is a simple seven stage workflow supported by a governance and assurance structure.

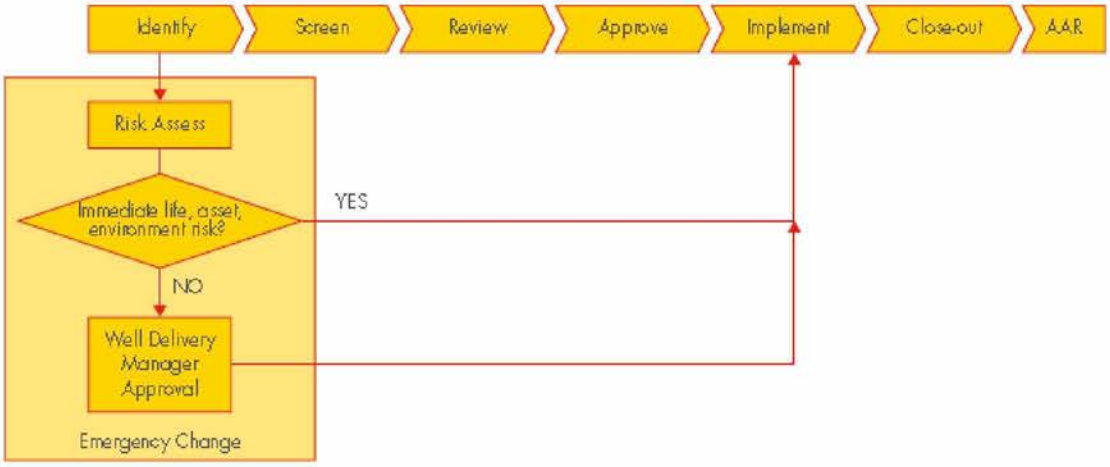

Figure 5-4 MoC process steps

5.11. Risk management in wells

The Risk Management Process as described in paragraph 3.6 focusses on HSSE risks. In addition to these HSSE risks, the Global Well Delivery Process also focusses on the Business risks, as shown in Figure 5-5. This latter category will be addressed in a so called TECOP (Technical, Economical, Commercial, Operational and Political) risk register.

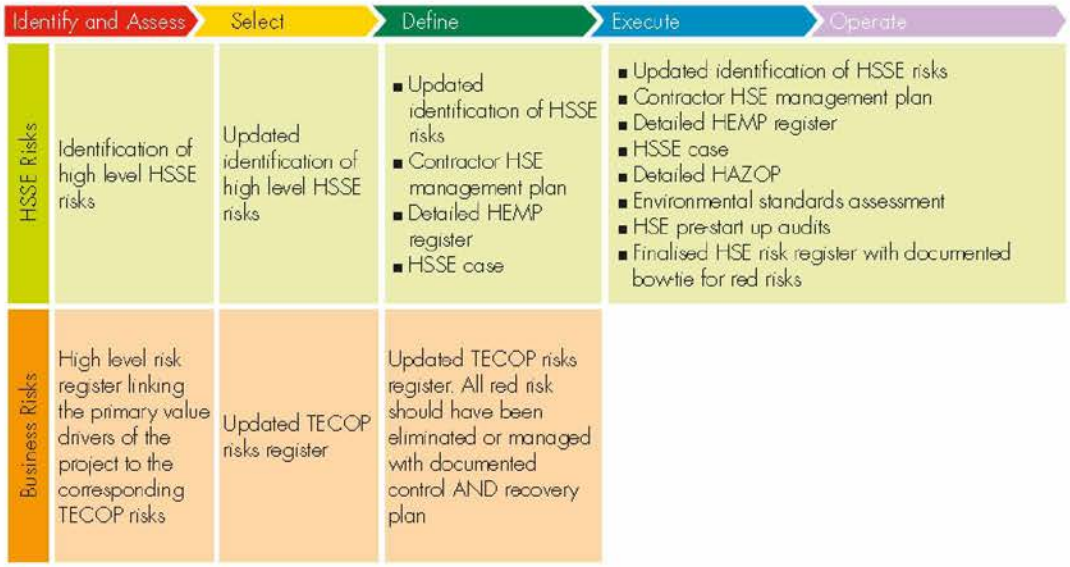

Figure 5-5 Summary of Principal Requirements for Hazard Identification & Risk Management

6. SPECIFIC HSE CRITICAL SYSTEMS AND ACTIVITIES

In this chapter, the HSE critical systems (SECEs) and activities (SCAs) are described in more detail.

An important guideline for SECEs and SCAs is that NAM can only manage these if the respective systems or activities are controlled and/or supervised by NAM.

6.1. SECE & SCA Management System

In this paragraph, the SECE & SCA management system is described in more detail.

6.1.1. General

As mentioned in chapter 3 and 5, a SECE is defined as hardware and essential barrier in the control of major hazard, such as pressure vessels and relief systems. SCA are activities that are assessed as being essential for installing, operating or maintaining/repairing barriers or mitigating measures.

Within Shell a guideline is available for the management of SECEs (Safety Critical Element Management Manual) [Ref. 11]. NAM C&WI based its SECE & SCA management system on the global system but deviates where appropriate. The reason for this deviation is since most SECEs (& SCAs) are owned and operated by third parties. This is a significant difference as the global SECE management system dictates that maintenance strategies are set up with corresponding

preventative maintenance checks. This is only possible when Shell is the owner of the equipment, which is not the case for most of C&WI activities. To ensure third party equipment performance is assured, NAM C&WI conforms to the standards as laid out by the Shell global Wells Manuals, which is part of the Shell HSSE & SP Control Framework. The Shell global Wells manuals describe the standards for hardware and activities related to wells activities. For practical purposes SCAs are included in the SECE & SCA management system, whereas the global Shell SECE management system is only applicable to SECEs.

The NAM C&WI SECE & SCA management system is illustrated by Figure 6-1. The process illustrates how SECEs & SCAs and their performance standards are identified, functionality is assured and how deviations from the standards are managed.

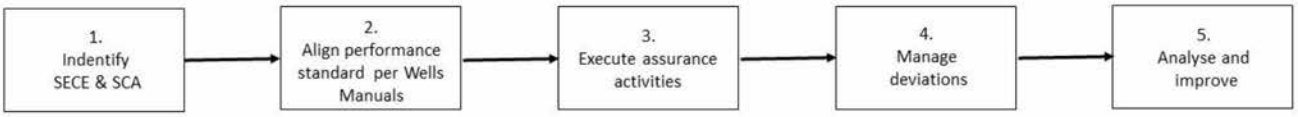

Figure 6-1 NAM C&WI SECE & SCA management process

6.1.2. Identification of SECE & SCA

In the context of this VG document, in which special attention is paid to the control of major accident hazards, systems are regarded as SECE and activities as SCA if they are included in the bow-tie as an essential preventive or consequence mitigative barrier. These major hazards are identified and ranked according to the analysis as described in chapter 5. The bow-ties for the major hazards for C&WI can be found in appendix 6. Its SECEs and SCAs are listed in tables in appendix 7 & 8.

In Appendix 7 an overview is given of the SECEs that are included in the bow-ties for the C&WI activities.

6.1.3. Alignment of performance standards with global Wells manuals

SECEs and SCAs have to meet certain criteria to ensure that the preventive/mitigative barriers function according to the design intent/criteria.

The criteria are described in the NAM C&WI Performance Standards for SECE & SCA [Ref. 25] which is aligned with the Shell global Wells manuals. The document contains for each major hazard all hardware- (SECE), process- (SCA), human- (SCA), or combined barriers with its specification, i.e. minimum assurance task, assurance measures and verification frequency. Should no standard exist in the Wells Manuals for the specific barrier, reference is made to other relevant global Shell standard (e.g. Guide to Temporary Pipework) and local NAM work instructions (e.g. lifting and hoisting).

The *minimum assurance task* describes the functional task of the SECE/SCA. Additionally, the source (manual) is given where this standard is described. The *assurance measure* provides the tests/certificates/systems/activities in place to assure that the SECE/SCA functions according to specifications as described by the minimum assurance task. The *verification frequency* states at which frequency the assurance measure should be performed.

When the global Wells manuals are updated, NAM C&WI Performance Standards for SECE & SCA is reviewed and updated where appropriately.

Most SECE assurances are defined in eWIMS and eWCAT - see § 6.2.

6.1.4. Execute assurance activities

The minimum assurance tasks are adhered to by the execution of assurance measures according to the verification frequency as described in NAM C&WI Performance Standards for SECE & SCA [Ref. 25].

6.1.5. Manage deviations from the standard

Should a non-conformance to a specific assurance task be necessary, then this non-conformance should be managed by a deviation.

Deviation management involves the assessment of risks, identification and execution of mitigating actions and close out of the deviation. A risk assessment is carried out and mitigating actions are established such that the risk is managed to ALARP. All mitigating activities are reviewed and approved by the appropriate Technical Authority prior execution.

NAM C&WI uses an online tool for Management of Change and Deviations called eMOCD and follows the Wells Management of Change and Deviation Manual [Ref. 26].

6.1.6. Analysis and improvement

The performance of SECE & SCA is monitored during work preparation and execution. When it is assessed that the current standard is not optimal, this will be addressed during the After-Action-Review (AAR) of the activity. In the AAR the issue is discussed and based on this discussion the decision can be made to make a permanent deviation from the standards while giving feedback to the custodian of the global Wells Standard to make changes. This feedback is consequently considered during the review of the global Wells Manuals.

6.2. eWIMS, eWCAT & Alltrack

Well Integrity is a term describing the status of a well's ability to function effectively and safely within its operational envelop as defined by the well failure model in the Well Integrity Management Manual (WIMM). Well integrity is focused on ensuring that all Wells are compliant with the Asset Integrity - Process Safety Management Standards (AI-PSM). By complying to the AI-PSM, the standards comply to the Well Integrity Manual as well. The Well Integrity Manual is one of the Wells Manuals from which standards are derived as stated in the NAM C&WI Performance Standards for SECE & SCA [Ref. 25]. Management of Well Integrity is done by electronic Well Integrity Management System (eWIMS), a global electronic database that captures well integrity data for Shell operated wells and process safety management.

The assurance of well control equipment is done by electronic Well Control Assurance Tool (eWCAT), that provides visibility on compliance with barrier policy and competence in place for all well related activities. The system captures the inspection and test due dates for all the well control equipment, certification in well control competence for all key staff involved and the barrier status of the specific well that is being worked on.

Alltrack is a NAM inhouse management system for all NAM-owned C&WI materials & equipment. The system captures material- properties, maintenance documentation/certificates and track & trace.

6.3. Independent Verification

Independent verification of the job Design & Program and job Program & Execution including relevant SECE & SCA assurance is done by Well Examination. Equipment is assured by Certificate Of Conformance (COC) which has to be verified by an Accredited Third Party – according to the NAM C&WI Performance Standards for SECE & SCA [Ref. 25]. These certificates are uploaded into eWCAT for assurance.

6.3.1. Well Examination

See paragraph **Error! Reference source not found.** for information about Well Examination.

6.3.2. NAM inspection

For certain activities, it is deemed necessary/feasible to break the operating envelope of production installation by making a connection between C&WI temporary pipework and production equipment. The new operating envelope of the system must be adhering to the design specification of installation and is assured/verified by NAM inspection. They inspect the new installation.

NAM has its own inspection group that the government (Ministry of Social Affairs and Employment) has appointed to carry out inspections on its behalf. As such, NAM's inspectors have taken over the role of Lloyd's Register (formerly Stoomwezen) for the following tasks:
- Assessing (constructive) amendments in the operational phase;
- Performing re-inspections with fixed time-limits;
- Assessing repairs in the operational phase.

6.4. Competence of Staff

All operational C&WI employees need to be competent to fulfil their tasks properly. The competency requirements are described in the NAM C&WI Performance Standards for SECE & SCA.

For specific functions within Wells additional requirements apply, see items below.

6.4.1. Front Line Barrier Manager (FLBM)

The Shell Group dictates that FLBM positions, and its competencies are identified and assured. A Frontline barrier management position is defined as "position is directly responsible for implementing or maintaining Barriers (controls and recovery) established for managing Hazards with RAM red or yellow 5a or 5b Risks" [Shell HSSE & SP Control Framework Competency Specification Part 1: Frontline Barrier Management Positions].

For Wells the competency for FLBM are assessed by an FLBM discussion, held with assessors that determine whether the candidate has sufficient knowledge/skill to be designated as a FLBM. The outcome of the discussion is recorded for assurance.

Requirements for Wells FLBM are:
- Round-2 certificate;
- IWCF Level 4;
- CWI320 Well control course.

NAM C&WI makes a distinction between non-routine and routine operations. This distinction is

based on the risk level and is assured by a Technical-Authority-2. Routine operations are considered low-to-medium-risk activities and are supervised by Senior Operations Technicians (competencies assured by independent OPITO system and IWCF level 4) and an on-call FLBM in the office. This *indirect FLBM* arrangement is only applicable to routine operations and is approved by the responsible Technical-Authority.

6.4.2. Technical competence

Below an overview is given of the required technical competences of NAM staff specific functions within Wells:

- Drilling supervisors have Shell Round-2 (critical well design and well control).
- Well site drilling engineers have Shell Round-1 (rig equipment and basic well control).
- C&WI supervisors in critical roles will have Shell Round 2 certificate.
- Competence is measured and maintained according to “OPITO Competence Assurance system”.
- Safety critical roles in execution must have a valid IWCF certificate (International Well Control Certificate).
- Other training courses, including work permit courses, SMAT (Safety Management Audit Training), ISO 14001 and Advanced leadership training, etc.

The positions filled depend on the basic training followed, specialized training, general training, level of experience and other evaluations.

6.4.3. HSE courses

For NAM and contractor staff, VCA and VCA-VOL are obligatory depending on the position. Furthermore, everyone, depending on the workplace and activities, must have watched the interactive video for onshore / offshore, be aware of site-specific information and/or must have followed the H_2S course, before permission is given to enter sites and/or carry out work.
The HSSE training matrix (based on the Element.nl training matrix) indicates which training course is obligatory for which workers/contractors, as well as how long the respective training course is valid. All training courses completed are registered into the Personal Safety Logbook (PSL) and vantage system (offshore). This PSL must be shown to the person responsible for granting permission for access so that it is possible to verify that the relevant training courses have been completed.

6.4.4. Drills

Drills are held regularly on site to practice for emergency situations; well control drills are recorded in EDM. Additionally, scenario-based firefighting and rescue plans are present. The Wells personnel is involved with development and improvement of these plans. Persons that have a role in the ERO (Emergency Response Organization) should have completed an ERO training course.

6.4.5. Knowledge of hazards and their management

During the roll-out of this document, the results of the hazard analysis are discussed with all involved persons in Wells who have a leadership or supervisory role, as far as the results apply to their situation. The bow-tie concept is explained as well as the role of those involved in the management of hazards. Attention is given to HSE-critical activities. This document is also made available through the intranet.

6.4.6. Contractor management

As far as SCAs carried out by contractors are concerned, the control of the SCAs will be assured through the contractor's operational management system and the contractor's HSE management system. Contractor supervisor IWCF certificates are recorded in eWCAT.

7. EMERGENCY RESPONSE

7.1. Emergency Organisation

Despite the many technical and procedural measures, the possible actual occurrence of an incident and/or emergency must be taken into account. To be able to adequately react to such a situation in order to limit the results of an incident as far as possible, various procedures have been drawn up by NAM, wherever possible in consultation with the relevant authorities. These procedures are described in the emergency plans (the Onshore and Offshore Contingency Plan and the underlying site-specific emergency plans) that form the basis for the Emergency Response Organization (ERO), see also § 3.7.2.

For the specific situation of a well incident additionally the Blow Out Contingency Plan (BOCP), also known as the Well Control Contingency Plan (WCCP), is applicable [Ref. 24]. The BOCP is embedded in the Emergency Response structure and contains information about available capping equipment, kill plan, relief well location, tank requirements, blowout potential and contracts with Specialist Contractors.

For high risk wells, i.e. wells with a high blowout potential (e.g. Grijpskerk / Norg underground storage wells) or high H_2S concentration a location specific BOCP is prepared.

These emergency plans are aimed at all persons who have a task or responsibility in responding to possible emergencies, both in NAM and the various government bodies. It provides the various government bodies with the necessary information about how NAM emergency organization is organized and how NAM reacts to a possible emergency.

Local government is ultimately responsible for the emergency response. Good cooperation between NAM, contractors and government bodies is essential in the response to an emergency. For this reason, arrangements have been made for raising the alarm quickly and correctly at government services and private organizations. For good coordination during an emergency, a NAM employee will, upon request, take a seat in a possible policy group to be formed by the government. For sites at which Wells activities are carried out, temporary plans are drawn up and published which specify the specific circumstances to which the activities apply. The Asset is responsible for this.

The WCCP also provides information for an emergency well kill scenario (i.e. kill equipment, mobilization time and kill plans).

8. EVALUATION

This part of the VG document forms the basis for the ALARP evaluation. The hazards have been identified, evaluated and the way in which risks should be managed has been indicated, the level of control is directly proportional to level of risk. This makes the link to the separate process management systems included in the management measures.

In order to be judged ALARP, the following acceptance criteria must be met:

A. Demonstrable compliance with the relevant legal requirements, such as:

- Legislation: for example, Environmental Management Act (Wet Milieu Beheer), Environmental Licensing (General Provisions) Bill [Wet Algemene Bepalingen Omgevingsrecht, WABO], Working Conditions Act [Arbeidsomstandighedenwet], Mining Act [Mijnbouwwet], Royal Decree 'Drilling' (Besluit 'Algemene Regels Milieu Mijnbouw' of AmvB 'Boren'), Environmental Activities Decree (including emission requirements for combustion installations), permit requirements, certificates Working Conditions Act, certificate conditions Nuclear Energy Act wrt NORM.
- Guidelines: for example, NOGEPA/Element NL Standard 83 wrt set-up of RiGG, Publication Series on Hazardous Substances [Publicatie reeks gevaarlijke stoffen, PGS], Dutch Soil Protection Guideline [Nederlandse Richtlijn bodembescherming, NRB].
- Agreements: for example, Multi-Year Agreement (Meerjaren Afspraak, MJA)

B. All hazards have been analyzed and management to ALARP levels is demonstrated.

- Identification according to generic list of hazards.
- Analysis of hazards with potentially serious consequences, using a Bow-Tie.
- Management measures for all hazards (low, medium and high potential seriousness) meet the state of the art and are described in the BMS.
- Testing with regard to the implementation of the management measures is implemented at installation level.

C. The remaining risks are regarded as being tolerable if they meet the following criteria:

- The individual risk (IRPA) for employees has been checked conform the risk scheme as presented in Figure 8-1.

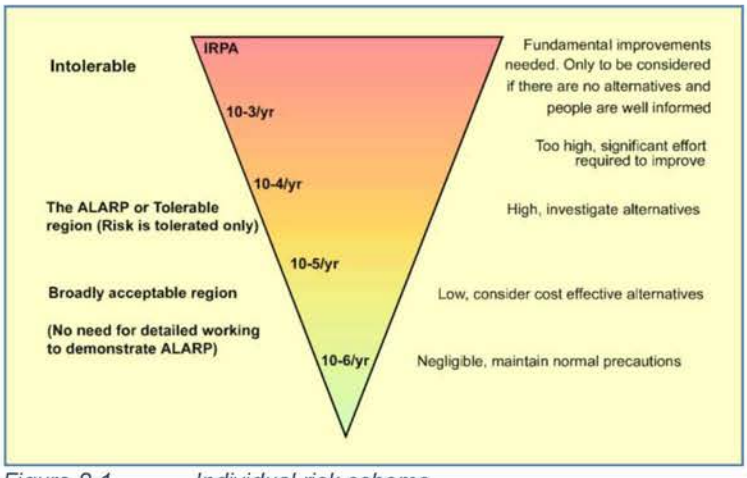

Figure 8-1 Individual risk scheme

D. The personnel involved have been fully informed:

- The personnel involved are aware of the hazards and the management measures.
- The personnel involved have been trained to intervene and/or evacuate safely in the event of an emergency.

In Table 8-1 an overview is given to what degree the C&WI activities comply with these acceptance criteria in order to be able to judge whether these are ALARP.

Table 8-1 Overview of degree of compliance of C&WI activities with acceptance criteria (for judgement of ALARP)

Acceptance criterion A	**Demonstrable compliance with the relevant legal requirements, such as:**
Element	**Explanation**
Legislation and regulations	The specific requirements set out in the Mining and Working Conditions Act (Mijnbouw- en Arbeidsomstandhedenwet) have been used in drawing up the instructions and, where necessary, included in the activity programs (including local permit requirements).
Permits	Not applicable
Agreements	Not applicable
Acceptance criterion B:	**All hazards have been analyzed and management to ALARP levels is demonstrated.**
Element	**Explanation**
Identification on the basis of the hazard list	All relevant hazards associated with C&WI activities are inventoried and evaluated as presented in the Hazard & Effect Register as presented in Appendix 5.
Analysis with Bow-Ties	For potentially serious hazards, Bow-tie analyses have been carried out and recorded: – Hydrocarbons in wells/reservoirs – LOC during well intervention (Bow-tie No. 1C); – Hydrocarbons in well test equipment – LOC during flowing of well (Bow-tie No. 2A); Reference is made to VG document of NAM Logistics for hazards related to road transport, Marine and Helicopter activities. For location specific hazards, referenced is made to the RiGG of the Asset to which the location belongs.
Management measures in the BMS	The management measures can be found in the BMS or in the HSE management systems for the respective contractors. Testing at installation level for non-routine activities, site-specific studies are carried out. For other activities, work HSE analyses are carried out.
Acceptance criterion C:	**The remaining risks are regarded as being tolerable if they meet the following criteria:**
Element	**Explanation**
Individual risk (IRPA) to employees	The individual risk of employees cannot be based on QRA studies that have been performed for production locations since C&WI employees typically switch between locations to perform their activities, both on- and offshore. For that reason the occupational risk was estimated using the OGP Risk Assessment Data Directory [Ref. 23]. Based on a Fatal Accident Rate (FAR) for "all personnel" (Table 2.1, "all locations"), and a multiplication factor for region Europe (Table 2.3, "all locations") an individual risk of $7{,}0*10^{-5}$ / year has been calculated. Note that this value is somewhat higher than the FAR for personnel engaged in drilling operations in Europe (Table 2.4, "combined locations"), i.e. $4.9*10^{-5}$ / year. Compared to the data in Figure 8-1 this risk is in the tolerable region.

Acceptance criterion D:	The personnel involved has been made aware:
Element	**Explanation**
Awareness of the hazards	C&WI staff was directly involved in drawing up the VG document.
Trained	Persons involved in C&WI activities follow a training matrix which aids them to manage risks associated to MAH

Based on the content of Table 8-1 the C&WI activities are evaluated as being ALARP.

NAM

LIST OF APPENDICES

NAM

Appendix 1 Reference Documents, Glossary and Abbreviations

Reference documents

[Ref. 1] Opstellen, autoriseren en indienen van RiGG, Kennisgevingen en VG documenten, NAM-HSE.PR.02, november 2020

[Ref. 2] EPE procedure/activity description: Management of Change for HSE Cases, EP200711254171

[Ref. 3] HSE Case Wells – Generic Part,
Reference No. EP200710261966, Rev 1 dated 28-03-2013

[Ref. 4] HSE Case Wells – Section C&WI,
Reference No. EP200711201062, Rev 1 dated 28-03-2013

[Ref. 5] Directive 2013/30/EU of the European Parliament and the Council of the European Union, 12 June 2013

[Ref. 6] Nederlandse Mijnbouwwet artikel 45l en 45n.3, Mijnbouwbesluit artikel 84c t/m 84g en Mijnbouwregeling artikel 11a.5.1 t/m 11a.5.3

[Ref. 7] NAM Well Services Catalog,
Document number: EP201709207504, Rev 3.3 dated 31-05-2021

[Ref. 8] NAM BOW-TIE: Principles and rules
Document number: EP201708210786, rev. 0 dated 01/12/2017

[Ref. 9] Brief SoDM met betrekking tot Interpretatie mijnbouwwerken
Kenmerk: 17110410 dd 11 juli 2017

[Ref. 10] Publicatiereeks Gevaarlijke stoffen
PGS 6: Aanwijzingen voor de implementatie van het BRZO 2015
versie 1.0 (november 2016)

[Ref. 11] Safety Critical Element Management Manual, SR.14.11269, April 2014

[Ref. 12] NAM Quality Assurance Process Manual for Independent Verification, NAMASS. MA.42, EP201602211609

[Ref. 13] NAM Verification Scheme in Accordance with OSD 2013/30/EU, NAM-ASS.MA.41, EP201508205020

[Ref. 14] Policy on Independent Verification and Well Examination as per Mining Act in NAM, NAM-ASS.PO.40, EP201602211623

[Ref. 15] NAM Well Examination Scheme, NAM-17.SP.11, EP201602201353

[Ref. 16] HSE Management Guidelines for working together in a contract environment
IOGP report No. 423, April 2017

[Ref. 17] UPO/T management of change policy, NAM-ASS.PR.01

[Ref. 18] Management of Change Process Guide, SR.14.10016

[Ref. 19] Shell HSSE&SP CF Competence Manual and Specifications

[Ref. 20] Explosieveiligheidsdocument, NAM Standard, NAM-SAFENG.ST.02, 1 juli 2022

[Ref. 21] VG document NAM Logistics,
Document number: EP201310207662, Rev. 1 dated 01-03-2018

[Ref. 22] Managing Risk guide (RAM guide), version 4, Februari 2022

[Ref. 23] Risk Assessment Data Directory,
Report No. 434 - 12 (Occupational Risk), March 2010
International Association of Oil & Gas Producers (OGP)

[Ref. 24] NAM + ONEgas-West Well Control Contingency Plan
Document number: EP201309206951, Rev 5.0, December 2022

[Ref. 25] NAM C&WI Performance Standards for SECE & SCA
Document number: EP201803212700, Rev 0, April 1st, 2018

[Ref. 26] Wells Management of Change and Deviation Manual
Reference number: WS 38.80.31.11-Gen., Revision 3.2 dated November 2021

Glossary

Term	*Explanation*
Acceptance criteria	The boundary limits within which the HSSE risks for a facility are regarded as being acceptable. The criteria may be both qualitative and quantitative. Generic acceptance criteria in the context of VG documents/RiGGs are defined in the NAM Standards Specification "Writing and submission of HSE cases."
ALARP	(As Low As Reasonably Practicable) Reducing a risk to as low a level as is reasonably practicable means finding a balance between, on the one hand, the risk reduction and, on the other hand, the time, trouble and costs required to achieve the risk reduction. The ALARP level is the point at which, when viewed objectively, the time, trouble and costs required for further risk reduction are no longer in proportion to the additional risk reduction achieved. Synonym: ALARA = As Low as Reasonably Achievable Note: the Cost of Averting a Fatality (CAF) is an important tool in the objective analysis and evaluation of expensive risk reducing measures. Additionally, a comparison with best practices in the industry forms a good basis for the above-named analysis and evaluation.
Asset	This term has two meanings: 1) An installation or a group of several installations and systems 2) Functional business unit of the NAM, charged with the execution of the operational activities. NAM is currently divided in three Assets, i.e. Asset ONEgas (East), Asset North and Asset South.
Barrier	A risk management measure to prevent a hazard from actually happening, or to offer protection if the hazard does happen.
Bow-tie	A model for hazard analysis, in which a hazard is analyzed according to: – the threats that may lead to the hazard (top event); – what measures are present to prevent hazard from occurring; – what the consequences would be if the hazard does occur; – what measures are in place in mitigate the consequences
Environmental aspect	Any part of the activities, products or services of an organization which may be in interaction with the environment. NAM has defined 16 environmental aspects, divided into three categories: exhaustible resources, emissions and disturbances.
Environmental effect	Any beneficial or adverse change in the environment, which is partly or entirely due to the activities, products or services of an organization. Environmental effects are the result of environmental aspects.
EPBM	(Exploration & Production Business Model) A business management model that provides an overview of activities, data and information and their interrelationships. A business model is independent from the organization.
Escalating factors	Factors that can reduce or nullify the reliability and effectiveness of a barrier.

Term	*Explanation*
Fountain Incident/ Sphera	(EP Global) database for registering incidents and monitoring follow-up points of action.
FRED	Consequence modelling software developed and controlled by Shell Global Solutions to determine the effects of emission and distribution of dangerous substances as well as fires and explosions involving dangerous substances.
Hazard	A potential cause of harm to persons, including injury or damage to their health, or to the environment. Note: Within the context of the VG document, the term hazard is defined within a narrow scope. If the definition is broader, potential causes of damage to facilities, capital losses or lost income, or damage to reputation also fall within the definition. Within the VG document, loss of capital or income is not relevant. Damage to the Community is regarded as falling implicitly under damage to persons or the environment.
Hazardous activities	Activities during which the persons carrying them out are exposed to hazards due to the nature of the work or the conditions under which the work is carried out.
HEMP	(Hazards and Effects Management Process) Structured hazard analysis based on the following elements: identification, evaluation, management, restoration. It is essential that all four of these steps are carried out.
Incident	An undesired event of a series of events that (could) lead to injury, illness, material damage, or harm to the environment or third parties.
Interface / bridging document	A document that explains the relationship between the management controls of combined activities carried out in each other's vicinity, and when requires add additional controls.
LSA	(Low Specific Activity) Collective name for radioactive substances from natural origin. See also NAM-RADIAT.SP.01 and SBD work instructions.
MAH (Major Accident Hazard)	With respect to an installation or connected infrastructure: a) An incident resulting in an explosion, fire or loss of control of a well; or leakage of oil, gas or hazardous substances, resulting in - or having a significant probability to result in - casualties or serious injuries. b) An incident resulting in severe damage to the installation or connected infrastructure, resulting in - or having a significant probability to result in - casualties or serious injuries. c) Any other incident resulting in the death or serious injury of five or more persons being present on the installation where the hazard originates or those that are related to an activity on an installation or connected infrastructure; or d) Any major environmental incident that results from the incidents as meant under item a), b) and/or c).
MCA	(Most Credible Accident scenario) Scenario for the worst possible accident that could reasonably be expected to occur.
Mitigating measures	Measures which limit the consequences of a potentially hazardous incident.

Term	*Explanation*
MOPO	(Manual of Permitted Operations) A MOPO defines the limits of safe operation permitted for a specific operation if monitoring and/or mitigating measures are impaired and/or not present. The aim is to maintain an acceptable remaining risk level.
NORM	(Naturally Occurring Radioactive Materials) Radioactive substances from natural origin. See also LSA.
Performance standards	Clear and measurable parameters with regard to SECEs and SCAs (both technical as well as organizational), in order to ensure that acceptance criteria can be met. As far as possible, they are of a quantitative nature. Performance standards are not explicitly included in the VG document. However, references are made to systems and processes where these standards are applied (for example maintenance and inspection schemes).
QRA	(Quantitative Risk Analysis) The systematic identification of potentially hazardous incidents, the estimation of the probability and consequences of these incidents for persons, the environment and facilities.
Radar	Shell database for registering points of action and monitoring follow-up.
RAM	Risk Acceptance Matrix used for assessment of risk using predefined levels of risk (severity and probability) and acceptance limits
RiGG **(previous HSE Case)**	A demonstration that: – The business management system contains sufficient elements to be able to manage all HSE hazards. – All hazards with potentially serious consequences have been identified and sufficient, suitable barriers and management measures are available, which reduce the risk level to ALARP level and residual risks to a tolerable level.
Risk	A qualitative or quantitative estimation of the probability of occurrence of a believable scenario and the “worst case” consequences (effects) of that scenario (probability x effect).
SAP	An integrated business system for finance, contracting and procurement, work management and human resources.
SCA	(HSE-Critical Activity): an activity that is of essential importance for the setting up and maintenance for barriers or mitigating measures (from the hazard analysis). Note: Within the context of hazard analysis for major hazards within the VG document, the above definition applies. Here the VKAs are related to barriers or mitigating measures. Additionally, other activities can also be identified as critical to safety, viz: the activities that are of essential importance for the management of medium and minor hazards.
SECE	(HSE-Critical System): a system identified in the HEMP process as being of essential importance for ensuring asset integrity, the prevention of incidents and/ or the limitation of negative HSE consequences. For example: extinguisher systems, alarm systems, detection systems.
Threat	A potential cause for a hazard occurring.

Term	*Explanation*
Top Event	The occurrence of a hazard. The central point in a bow-tie diagram.
TRIPOD	Detailed analysis of incident, based on the triangle ('TRIPOD') unsafe handling/circumstance, the incident and the underlying hidden defect.
VG document	A VG document demonstrates the identification and control of hazards related to a specific process / activity, that is not part of the RiGG for production installations. For example: the VG-Document for NAM Logistic and the VG-Document for NAM Wells, C&WI. The terminology “detailed VG document (abbreviation: U-VG document)” as mentioned in [Ref. 9] is not used within NAM, but the content of VG documents does meet the requirements of section 6B of the Dutch Working Conditions Decree.
WVP	(Work Safety Plan) Specific plan to clearly and completely describe the risk management for *extraordinary* activities carried out at a site.

Abbreviations	Meaning
AIPSM	Asset Integrity Process Safety Management
ALARP	As Low As Reasonably Practicable *See also Glossary for more detailed information*
AMS	Asset Management System
API	American Petroleum Institute
ATEX	Atmosphere Explosive
BARMM	Besluit 'Algemene Regels Milieu Mijnbouw'
BBRP	Brandbestrijding- en Reddingsplan [Fire Fighting and Rescue Plan]
BCD	Bussines Control Document
BHV	Bedrijfs Hulp Verlening [In-house Emergency Services]
BMS	Bussiness Management System
BOP	Blow Out Preventer
BPR	Business Performance Review
BRZO	Besluit Risico's Zware Ongevallen
CAPEX	Capital Expenditure
CE	Conformité Européenne
CEO	Chief Executive Officer
CMAPP	Corporate Major Accident Prevention Policy
CMMS	Computerized Maintenance Management System
CMO	Corporate Management Overview
CO	Combined Operations
C&WI	Completion and Well Intervention
DAM	Discipline Authorities Manual
DCAF	Discipline and Control Assurance Framework
DEM	Design and Engineering Manuals
DEP	Design and Engineering Practice
DOI	Declaration of re-inspection
DROPS	DRopped Objects Prevention Scheme
DSV	Drilling Super Visor
EIA	Environmental Impact Assessment
EP	Exploration and Production
EPBM	Exploration & Production Business Model *See also Glossary for more detailed information*
ERO	Emergency Response Organization
ER	Emergency Response
ERT	Emergency Response Team
ESD	Emergency ShutDown
eWCAT	electronic Well Control Assurance Tool
FIM	Fountain Incident Management
FLBM	Front Line Barrier Management
FPAL	First Point Assessment Ltd database
FRED	Models for Fire, Release, Explosion and Dispersion *See also Glossary for more detailed information*

Abbreviations	Meaning
FSR	Facility Status Review
H2S	Hydrogen Sulphide
HAZID	HAZard IDentification study
HAZOP	HAZard and OPerability study
HBA	Hardware Barrier Assessment
HEMP	Hazard & Effect Management program *See also Glossary for more detailed information*
HMI	Head of Mining Installation
HR	Human Resources
HRA	Health Risk Assessment
HSE	Health, Safety and the Environment
HSEW	Health, Safety, Environment and Welfare
HSSE&SP	Health, Safety, Security and Environment & Social performance
HWU	Hydraulic Workover Unit
IBOP	Inside Blow Out Preventer
IOGP	International Association of Oil & Gas Producers
IR	Individual Risk
IRP	Incident Review Panel
IRPA	Individual Risk Per Annum
ISO	International Organisation for Standardisation
JRA	Job Risk Analysis
KPI	Key Performance Indicator
KWS	Koolwaterstoffen [Hydrocarbons]
LFI	Learning From Incidents
LNP	Locatie Noodplan [Site Emergency Plan]
LOD	Line of Defense
LRT	Location Response Team
LSA	Low Specific Activity *See also Glossary for more detailed information*
LT	Leadership Team
LVP	Locatie Verantwoordelijke Persoon [Location Responsible Person]
MAH	Major Accident Hazard *See also Glossary for more detailed information*
MCA	Maximum Credible Accident *See also Glossary for more detailed information*
MER	Milieu Effect Rapportage [Environmental Effects Report]
MIR	Milieu-invloedrapportage [Environmental Impact Report] (internal to NAM)
MMI	Mechanical Materials and Integrity
MOC	Management of Change
MOPO	Matrix Of Permitted Operations *See also Glossary for more detailed information*
NAM	Nederlandse Aardolie Maatschappij
NDG	NAM Design Guideline

Abbreviations	Meaning
NOGEPA	Nederlandse Olie en Gas Exploratie en Productie Associatie [Dutch Oil & Gas Exploration and Production Association] (*Replaced by Element NL*)
NORM	Naturally Occuring Radioactive Materials *See also Glossary for more detailed information*
NPR	Nederlandse Praktijk Richtlijn
NSS	NAM Standard Specification
OCES	Operators Co-operative Emergency Services
OCP	Onshore or Offshore Contingency Plan
OD	Outer Diameter
ODT	Operation Desktop
OEM	Original Equipment Manufacturer
OLT	Operations Leadership Team
OM	Operating Manual
OnCP	Onshore Contingency Plan
OPEX	Operating Expenditure
OPOL	Offshore Pollution Liability Association Ltd
ORP	Opportunity Realisation Process
OSD	Offshore Safety Directive
PCAP	Project Controls and Assurance Plan
PAER	Process Aspects and Effects Register
PEC	Program Execution Checklist
PBM	Persoonlijke Beschermings Middelen [Personal Protection Equipment = PPE]
PCE	Pressure Control Equipment
P&ID	Piping and Instrumentation Diagram
PGS	Publicatie Gevaarlijke Stoffen [Publication of Dangerous Substances]
PMS	Process Management System
POS	Proof of Supervision
PPE	Personal Protection Equipment
PRA	Project Risk Assessment
PSBR	Process Safety Basic Requirements
PSL	Personal Safety Logbook
PSV	Pressure Safety Valve
P&T	Project & Technology
PtW	Permit to Work
PU	Production Unit
QRA	Quantitative Risk Analysis *See also Glossary for more detailed information*
RA	Risk assessment
RAM	Risk Assessment Matrix *See also Glossary for more detailed information*
REACH	Registration, Evaluation, Authorization and limitation of Chemical substances
RIE	(Working conditions) Risk Inventory and Evaluation

Abbreviations	Meaning
RiGG	Rapport inzake Grote Gevaren (see also RoMH) *See also Glossary for more detailed information*
RoMH	Report on Major Hazard (see also RiGG)
RWS	Rijkswaterstaat [Directorate General for Public Works and Water Management]
SAP	*See Glossary for more detailed information*
SBD	Straling Beschermings Dienst [Radiation Protection Service]
SCA	Safety Critical Activity *See also Glossary for more detailed information*
SCAN	Safety Case Amendment Notice
SCT	Safety Critical Task
SECE	Safety & Environmental Critical Element *See also Glossary for more detailed information*
SGBP	Shell Global Bussiness Principles
SHIDAC	Structured Hazard Identification and Control
SIEP	Shell International Exploration and Production
SIMS	Structural Integrity Management System
SMAT	Safety Management Audit Training
SMS	Safety Management System
SodM	Staatstoezicht op de Mijnen [Dutch State Supervision of Mines]
SOOB	Summary of Operation Boundaries
SOP	Standard Operating Procedure
TA	Technical Authority
TBV	Taken Bevoegdheden Verantwoordelijkheden [Tasks, powers, responsibilities]
TRA	Task Risk Analysis
TRC	Total Recordable Cases
TRIPOD	Extensive incident analysis tool *See also Glossary for more detailed information*
UP	Upstream
UPBM	Upstream Business Model
VGM	Veiligheid, Gezondheid en Milieu [see HSE]
VGWM	Veiligheid, Gezondheid, Welzijn en Milieu
VCA (VOL)	Veiligheid Checklijst Aannemers [Safety Checklist for Contractors] (Safety course for operational leaders.)
VP	Vice President
WABO	Wet Algemene Bepalingen omgevingsrecht [Environmental Licensing (General Provisions) Bill]
WDP	Well Delivery Program
WE	Well Engineering
WHM	Well Head Maintenance
WIC	Workfloor Instruction Card (dangerous substances)
WIK	Werkvloer Instructie Kaart [see WIC]
WIRA	Well Intervention Risk Assessment
WMS	Well Management System

Abbreviations	Meaning
WRA	Well Related Activity
WSST	Well Site Support Team
HWU	Workover Unit
WVO	Werkveiligheidsoverleg [work safety / toolbox meetings)
WVP	Werk Veiligheids Plan [Work Safety Plan]

Appendix 2 HSSE Policy NAM

INZET EN BELEID VAN SHELL INZAKE GEZONDHEID, BEVEILIGING, VEILIGHEID EN MILIEU EN MAATSCHAPPELIJK OPTREDEN

INZET

Bij Shell verbinden wij ons allen ertoe om:

- De gezondheid van mensen niet te schaden;
- Het milieu te beschermen;
- Efficiënt gebruik te maken van grondstoffen en energie bij onze productie en dienstverlening;
- Onze buren te respecteren en een bijdrage te leveren aan de samenlevingen waarbinnen wij opereren;
- Energiebronnen, producten en diensten volgens deze doelstellingen te ontwikkelen;
- Openbare informatie te verschaffen over onze prestaties;
- Een leidende rol te spelen bij het bevorderen van de beste werkwijze in onze industrietakken;
- Gezondheid, beveiliging, veiligheid en milieu en maatschappelijk optreden net als alle andere kritieke bedrijfsactiviteiten te managen;
- Een bedrijfscultuur te bevorderen waarin alle Shell-medewerkers zich deze uitgangspunten eigen maken.

Op deze manier stellen wij ons ten doel om op het gebied van gezondheid, beveiliging, veiligheid en milieu en maatschappelijk optreden prestaties te leveren waarop wij trots kunnen zijn, om het vertrouwen te winnen van onze klanten, aandeelhouders en de samenleving in het algemeen, om een goede buur te zijn en om bij te dragen aan duurzame ontwikkeling.

BELEID

Iedere Shell-maatschappij:

- Heeft een systematische aanpak van gezondheid, beveiliging, veiligheid en milieu en maatschappelijk optreden, met als doel ervoor te zorgen dat de wet wordt nageleefd en dat deze prestaties voortdurend worden verbeterd;
- Stelt doelen voor verbetering, waarbij prestaties worden gemeten, beoordeeld en gerapporteerd;
- Verplicht aannemers om met betrekking tot gezondheid, beveiliging, veiligheid en milieu en maatschappelijk optreden volgens dit beleid handelen;
- Verplicht dat joint ventures waarover zij de operationele leiding heeft, dit beleid toepassen en wendt haar invloed aan om dit beleid ook in haar andere deelnemingen te bevorderen;
- Voert doeltreffend overleg met buren en met door haar activiteiten beïnvloede gemeenschappen; en
- Neemt gezondheid, beveiliging, veiligheid en milieu en maatschappelijke prestaties op in de personeelsbeoordelingen en beloont dienovereenkomstig.

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Appendix 3 Specific overview of C&WI activities

C&WI activities include:

Wireline
- Measurement of reservoir pressures (SPG, SPTG, FBU, IFO) using memory gauges.
- Dummy runs and HUD measurement.
- Installation / recovery of underground flow control equipment.
- Installation / recovery wireline plugs.
- Determination of liquid level.
- Gas Lift, Chemical, Kill valve injection services.
- Sub Surface Safety Valve (SSSV), replace Storm Choke.
- Tubing integrity study.
- Production logging.
- PVT samples (underground).
- Sand/deposit bailing
- Calliper services
- Fishing.
- Wax cutting.
- Zone change / isolation
- Punch and perforating
- Tubing cutting

Coiled tubing en pompservices
- Nitrogen (N_2) pumps.
- Well stimulation (incl. acid).
- Sand / debris clean-out.
- Water shut-off.
- Pack off (straddle) systems, velocity strings and packers.
- Sand consolidation
- Pumping in liquids (e.g. sweet water, brine, foam, natural gas condensate).
- Leak-off testing.
- Dead pumping well.
- Fishing.
- CT conveyed logging and perforating.

Electric-line services
- Perforating.
- Cement bailing.
- Installing plug for water shut-offs.
- Pack off (straddle) systems and packers.
- Realtime logging.
- FSMT survey (reservoir compaction monitors).
- Well tractor

Well test
- Prepare oil and gas wells for production after drilling phase.
- Production of oil and gas wells using temporarily installed equipment.
- Taking PVT samples.
- Disposal / transfer of liquids.
- Neutralization of produced acid.

Well stimulation techniques
As gas wells mature and the produced gas becomes less able to carry water from the well, a decline in flow rate and production to rates below the anticipated decline curve often results.

- Fracking
  Induced hydraulic fracturing or hydro fracturing, commonly known as fracing, fraccing, or fracking, is a technique used to release petroleum, natural gas or for extraction. This technique of fracturing creates fractures near the wellbore into reservoir rock formations.

Well deliquification techniques

- Velocity string
  A velocity or siphon string is a tube, usually 1" to 3-1/2" in diameter that is placed into the production tubing to increase the flow velocity to the critical velocity needed to lift liquids from the well.
- Foam injection (Capillary String)
  The installation of a capillary string facilitates the injection of a foaming agent to de-liquefy the hydrostatic barrier of water and to be able to produce the well again.

Wellhead and x-mas tree maintenance

- Lubrication and testing of seals.
- Repair/replace X-mas tree and wellhead.
- Leak investigation and inspection.
- Beam pump maintenance and repair (replace rods/plunger).

Workshop

- Assembly of completion parts.
- Repair/replace well control box and control systems.
- Repair and maintain underground flow control equipment.
- Maintenance of NAM wireline and NAM well testing equipment (pressure tests).

For more details on some of these operations reference is made to the NAM Well Services Catalog [Ref. 7].

NAM

Appendix 4 Master Hazard List

Hazard #	Master Hazard List	
H-01.01	**Hydrocarbons (Refined and unrefined)**	
H-01.01	Crude Oil	√
H-01.02	Hydrocarbons (formation fluids/sour process feed)	√
H-01.03	Raw gas (sour)	√
H-01.04	Raw gas (sweet)	√
H-01.05	LPGs (C3 - C4)	√
H-01.06	LNGs (C1 - C2)	√
H-01.07	Natural/fuel gas (C1-C4), sweet/ sour	√
H-01.08	Condensate, NGL (C5-C10)/ Naphtha, Gasolines	√
H-01.09	Coal	-
H-01.10	Chemical feedstocks /Solvents (aliphatic) C6-C12	√
H-01.11	Chemical feedstocks /Solvents (aromatic) C6-C12	√
H-01.12	Hydrocarbon fuels (C9-C16), (e.g. Distillates, Jet, Kerosene, Diesel)	√
H-01.13	Asphalts, Bitumen/Residue, Heavy Ends, Bunker, Coke etc.	-
H-01.14	Hydrocarbons above auto ignition temp	-
H-01.15	Wax (paraffin)	√
H-01.16	Hydrocarbon (C16-C35), Lube Oils	√
H-01.17	Hydraulic Oils	√
H-01.18	Hydrocarbon Greases/HVI Oil	√
H-01.19	Slops (tank bottoms, flush oil)	√
H-01.20	OS Raw Bitumen (Water/Solvent Emulsion)	-
H-01.21	Acid Gas	√
H-01.22	Tail Gas	√
H-01.23	Biofuels (ethanol/hydrocarbon blends)	√
H-01.24	Biodiesel Blended Fuel	√
H-01.25	Thermal Cargo Heating Oil	-
H-01.26	Drag Reducing Agents (DRA) Oil Based	-
H-01.99	Other (not specified above)	√
H-03	**Other Flammable Materials**	
H-03.01	Cellulosic materials (building materials, trash, etc.)	-
H-03.02	Pyrophoric materials (phosphorus, calcium, zirconium, potassium, etc.)	-
H-03.03	Carbon fibre reinforced material	-
H-03.04	Dry vegetation	√
H-03.05	Hydrogen	-
H-03.06	Chemicals (cleaning chemicals)	√
H-03.07	Lab Reagents	-
H-03.08	Hydrocarbon Contaminated Waste	-
H-03.99	Other (not specified above)	-
H-04	**Explosives**	
H-04.01	Detonators	√
H-04.02	Conventional explosives	-
H-04.03	Perforating gun charges	√
H-04.04	Explosive gases (Acetylene, propane, calibration gas, etc.)	√
H-04.05	Distress Flares	-
H-04.99	Other (dusts or unexploded bombs or others)	-

Hazard #	Master Hazard List	
H-05	**Pressure Hazards**	
H-05.01	Hydrocarbons under pressure	√
H-05.02	Gas under pressure (Fire extinguishers, SCBA, Test Gas, Pipe works etc.)	√
H-05.03	Liquid under pressure (fire water, transfer hoses, pipework tests, liquid nitrogen, etc.)	√
H-05.04	Non-HC gas under pressure in pipe works (e.g. nitrogen)	√
H-05.05	Air under pressure	√
H-05.06	Hyperbaric operations	-
H-05.07	Decompression	-
H-05.08	Trapped pressure in equipment	√
H-05.09	High pressure equipment (hydraulic, heavy machinery, forklifts, etc.)	√
H-05.99	Other (not specified above)	√
H-06	**Hazards associated with differences in height**	
H-06.01	Personnel at height	√
H-06.02	Personnel at grade- falls same level (slips, trips & falls)	√
H-06.03	Overhead equipment (Lifting equip, Loading arms, scaffolding, storage, etc.)	√
H-06.04	Personnel under water (diving operations, jetty inspections, pipeline repairs, etc.)	-
H-06.05	Personnel below grade (trenching, excavating etc.)	√
H-06.06	Falling ice/snow	√
H-06.07	Ship/vessel access/egress	√
H-06.08	Falling into the water (jetty, boats, manway, etc.)	√
H-06.99	Other (not specified above)	√
H-07	**Objects under induced stress**	
H-07.01	Objects under tension (i.e. Marine terminal loading arms, cables, springs, anchor cables, vessel mooring ropes and wires, mast stays, overhead doors, fall protecting equipment, etc.)	√
H-07.02	Mooring / Unmooring	-
H-07.03	Vessel Hull Overstressed	-
H-07.04	Objects under compression (Same as H-07.01)	√
H-07.99	Other (not specified above)	√-
H-08	**Dynamic Situation Hazards**	
H-08.01	On land transport (cars, trucks, ATVs, etc.)	√
H-08.02	On water transport (work boats, airboats, work barges etc.)	√
H-08.03	Helicopter Operations (transportation, line flights, leaks, etc.)	√
H-08.04	Ship collision hazard to other vessels and offshore structures	-
H-08.05	Equipment with moving/ rotating parts	√
H-08.06	Use of hazardous hand tools	√
H-08.07	Use of knives, machetes etc.	√
H-08.08	Cargo Vessel Underway (Marine terminals, supply boats, etc.)	-

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Hazard #	Master Hazard List	
H-08.09	Vessel Moored (jetty, wharf. etc.)	-
H-08.10	Vessel at Anchor	-
H-08.11	Vessel under Towage /Pushing Ops	-
H-08.12	Pinch Points	√
H-08.13	Passenger Approach/Exit Aircraft (Helicopter Operations)	√
H-08.14	Demolition	-
H-08.99	Other (not specified above)	√
H-09	**Physical Environment Hazards**	
H-09.01	Weather	√
H-09.02	Sea state/river currents	√
H-09.03	Tectonic activity	-
H-09.04	Unstable snow or soil conditions	√
H-09.05	Confined Spaces	√
H-09.06	Building Location Siting (portable buildings)	√
H-09.99	Other (not specified above)	-
H-10	**Hot Surfaces**	
H-10.01	Process piping equipment 140-302°F / 60-150°C	√
H-10.02	Piping equipment > 302°F / > 150°C	√
H-10.03	Engine & turbine exhaust systems (fire water pumps, vessel exhausts, etc.)	√
H-10.04	Steam piping	√
H-10.05	Food service - preparation (vessel galley, offshore galley, kitchen, etc.)	-
H-10.06	Ships Cargo Heating Systems	-
H-10.07	Heat Tracing (Electrical)	√
H-10.99	Other (Hot surfaces like plates in lab)	-
H-11	**Hot Fluids**	
H-11.01	Temperatures 212-302 °F / 100-150 °C (engine antifreeze and lube oil)	√
H-11.02	Temperatures >302°F / >150 °C	-
H-12	**Cold Surfaces**	
H-12.01	Process piping –13 to –112°F / –25 to –80°C	√
H-12.02	Piping equipment < -112°F / –80°C	√
H-13	**Cold Fluids**	
H-13.01	Oceans, seas & lakes < 50°F / < 10°C	√
H-13.02	Cryogenic Fluids	√
H-14	**Open Flame**	
H-14.01	Heaters with fire tube	√
H-14.02	Direct fired furnaces	√
H-14.03	Flares	√
H-14.04	Welding & Cutting	-
H-04.99	Other (not specified above)	-
H-15	**Electricity**	
H-15.00	Extra Low Voltage 0 – 30V	√
H-15.01	Low Voltage (LV) >30-750V	√
H-15.02	Medium Voltage (MV) >750-38000V	-
H-15.03	High Voltage (HV) >38000V	-
H-15.04	Lightning discharge	√
H-15.05	Electrostatic energy	√
H-15.06	Batteries	√
H-15.07	Stored charge (e.g. capacitors)	-
H-15.08	Arc Flash	-
H-15.09	Electrical Transmission Lines (All Voltages)	√
H-15.99	Other (not specified above)	-
H-16	**Electromagnetic Radiation**	
H-16.01	Ultraviolet radiation (sunlight)	√
H-16.02	Infra-red radiation (e.g. fired eqpt)	-
H-16.03	Microwaves (telecoms, ovens)	-
H-16.04	Lasers	-
H-16.05	E/M radiation: high voltage ac cables	-
H-17	**Ionizing Radiation – Open Source**	
H-17.01	Alpha, Beta – open source	-
H-17.02	Gamma rays – open source	-
H-17.03	Neutron – open source	-
H-17.04	Naturally occurring ionizing radiation (NORM) (pipes, vessels, etc.)	√
H-18	**Ionizing Radiation – Closed Source**	
H-18.01	Alpha, Beta – closed source	-
H-18.02	Gamma rays – closed source	√
H-18.03	Neutron – closed source	-
H-19	**Asphyxiants**	
H-19.01	Insufficient oxygen atmospheres	√
H-19.02	Excessive CO_2 (fire extinguishers)	√
H-19.03	Drowning (docks, storm water ponds, reservoirs, boating)	√
H-19.04	Excessive N_2	√
H-19.05	Halon	-
H-19.06	Smoke	√
H-19.99	Other (not specified above)	-
H-20	**Toxic Gases**	
H-20.01	H_2S, sour gas	√
H-20.02	Carbon monoxide and exhaust gases	√
H-20.03	Nickel Carbonyl	-
H-20.04	SO_2	√
H-20.05	Ammonia	-
H-20.06	Chlorine	-
H-20.07	Welding gases (ozone, phosgene)	-
H-20.08	Tobacco smoke	-
H-20.09	CFCs (old freons)	-
H-20.10	HCFCs (new freons)	-
H-20.11	Ozone	-
H-20-12	Oxides of Nitrogen (NO_x)	√
H-20.13	Benzene	√
H-20.99	Other (not specified above)	-
H-21	**Toxic Liquid**	
H-21.01	Mercury	√
H-21.02	PCBs (Transformers)	-
H-21.03	Biocides	-
H-21.04	Methanol	√
H-21.05	Brines	√
H-21.06	Glycols	√
H-21.07	Degreasers/ Perchlorethylene	√
H-21.08	Isocyanates	-
H-21.09	Sulphanol	-
H-21.10	Amines	-
H-21.11	Corrosion inhibitors	√
H-21.12	Scale inhibitors	√
H-21.13	Liquid mud additives	√
H-21.14	Mercaptans & Odorant additives	√
H-21.15	Alcoholic beverages	-

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Hazard #	Master Hazard List	
H-21.16	Recreational drugs	-
H-21.17	Used engine oils	√
H-21.18	Carbon tetrachloride	-
H-21.19	Grey and/or black water	-
H-21.20	Poly Aromatic Hydrocarbons	√
H-21.21	Methyl Tertiary Butyl Ether (MTBE)	-
H-21.22	Benzene	√
H-21.23	n-Hexane	√
H-21.24	Furfaral	-
H-21.25	MEK	-
H-21.26	Cutting Oils	-
H-21.27	Other Chlorinated hydrocarbons	-
H-21.28	Lube Oil Additives	-
H-21.29	Grease Additives	-
H-21.30	Fuel Additives	-
H-21.31	Herbicides, Pesticides, Rodenticides	-
H-21.32	Toluene	√
H-21.33	Ethylbenzene	√
H-21.34	Xylene	√
H-21.35	Styrene	-
H-21.36	Antifreeze	√
H-21.37	Wax Inhibitors (paraffin)	√
H-21.99	Other (not specified above)	-
H-22	**Toxic Solids**	
H-22.01	Asbestos	√
H-22.02	Man made mineral fibre	√
H-22.03	Silica, crystalline	√
H-22.04	Sodium hypochlorite	-
H-22.05	Powdered mud additives	-
H-22.06	Sulphur/Sulphur dust	-
H-22.07	Pig trash	-
H-22.08	Oil based muds	√
H-22.09	Pseudo oil based muds	-
H-22.10	Water based muds	√
H-22.11	Cement and Cement Slurries	√
H-22.12	Dusts, nuisance	√
H-22.13	Heavy metals (e.g. cadmium, lead, zinc, iron, chromium, nickel, moly, cobalt)	-
H-22.14	Oil based sludges	√
H-22.15	Catalysts (fresh)	-
H-22.16	Catalysts (spent)	-
H-22.17	Wood dust	-
H-22.18	Refractory ceramic fibre	√
H-22.99	Other (HCO/HCOFA, Li, Irgacor SSG)	-
H-23	**Corrosive Substances**	
H-23.01	Hydrofluoric acid	√
H-23.02	Hydrochloric acid	√
H-23.03	Sulphuric acid and strong acids (e.g. phosphoric)	-
H-23.04	Caustic soda and strong alkalis (e.g. potassium, calcium hydroxide)	√
H-23.05	Spent caustic	-
H-23.06	Nitric acid	-
H-23.07	Perchloric acid	-
H-23.98	Other acids (e.g. acetic, sulphamic)	-
H-23.99	Other alkali (e.g. ammonium hydroxide)	-

Hazard #	Master Hazard List	
H-24	**Biological Hazards**	
H-24.01	Poisonous plants	-
H-24.02	Large animals (aligators)	-
H-24.03	Small animals and birds (droppings)	-
H-24.04	Food borne agents (food poisoning, galley, kitchen, etc.)	-
H-24.05	Water borne agents (e.g. coliforms, Legionella)	-
H-24.06	Insects (e.g. bees, spiders)	-
H-24.07	Insect-borne agents (e.g., West Nile, Lyme disease, malaria)	-
H-24.08	Airborne communicable diseases (e.g. Cold, Flu, TB)	-
H-24.09	Blood-borne agents (e.g. HIV, Hep B)	-
H-24.10	Other communicable diseases	-
H-24.11	Algae	-
H-24.12	Microbial growth (e.g. mold, fungus)	-
H-24.13	Tetanus	-
H-24.14	Sewer Borne Bacteria (Fecal Coliforms)	-
H-24.99	Other (not specified above)	-
H-25	**Ergonomic Hazards**	
H-25.01	Repetitive Motion	-
H-25.02	Awkward Posture	√
H-25.03	Physical Effort (push, pull, lift, carry)	√
H-25.04	Sustained Posture (Maintaining static Position)	-
H-25.05	Contact/compression stress	-
H-25.06	Isolated Work Environment	-
H-25.07	Long or Irregular Work Hours	√
H-26	**Physical Agents (see HRA)**	
H-26.01	Noise	√
H-26.02	Heat stress	√
H-26.03	Cold stress	√
H-26.04	Vibration	√
H-26.05	Lighting	√
H-27	**Security Related Hazards (See SRA)**	
H-27.01	Piracy	-
H-27.02	Assault	-
H-27.03	Sabotage	√
H-27.04	Crisis	-
H-27.05	Theft, pilferage	√
H-28	**Use of Natural Resources (See EIA - ISO14000 type E MS)**	
H-28.01	Land take / Footprint	√
H-28.02	Surface/Ground Water	√
H-28.03	Air	√
H-28.04	Trees, vegetation	-
H-28.05	Gravel	-
H-28.06	Habitat and Wildlife	-
H-29	**Psychological Hazards (See HRA)**	
H-29.01	Organization - systems and culture	-
H-29.02	Physical work environment	-
H-29.03	Job demand – work load, deadlines	√
H-29.04	Job demand – hours, shift work, travel, isolation	√

Hazard #	Master Hazard List	
H-29.05	Organizational/job change	√
H-29.06	Lack of/Inappropriate Reward and recognition	√
H-29.07	Lack of respect in work environment	√
H-29.08	Traumatic incident at work	√
H-30	**Hazardous Goods (See Land Logisitics HEMP)**	
H-30.01	Dangerous goods in transport activities	√
H-98	**Emergency Response/HAZmat**	
H-98.01	Response to Process or Transport Emergencies	-
H-99	**Environmental aspects (See EIA)**	
H-99.01	**Hazardous air emissions**	
H-99.01.1	Sox	√
H-99.01.2	Nox	√
H-99.01.3	H2S, sour gas	√
H-99.01.4	VOC	√
H-99.01.5	Toxics Furane / dioxin	-
H-99.01.6	Fine particulates	√
H-99.01.7	Heavy metals	-
H-99.02	**Other Air emissions**	-
H-99.02.1	Greenhouse gases	√
H-99.02.2	Noise	√
H-99.02.3	Odour	-
H-99.02.4	Visual	-
H-99.02.5	Ozone depleting substances	-
H-99.02.6	Light pollution	√
H-99.03	**Surface water**	
H-99.03.1	Impact on water surface	√
H-99.03.2	Impact of effluent (Vol. temp. Quality)	-
H-99.03.3	Toxics in effluent	√
H-99.04	**Soil and Ground water contamination**	
H-99.04.1	Potential for contamination	√
H-99.04.2	Sensitive area neighbors	-
H-99.04.3	Existing contamination	-
H-99.04.4	Contamination risks from neighbors	-
H-99.04.5	Unique Aspect	-
H-99.05	**Waste**	
H-99.05.1	Volume generated	-
H-99.05.2	Routine/non routine	-
H-99.05.3	Hazardous waste	-

Appendix 5 Hazard and Effect Register

In the column “Hazard & Sources” of the Hazard and Effect Register as presented on the next pages the C&WI activities are divided into the following categories (where applicable), i.e.

- Breaking of well containment;
- Pumping into well / well treatment;
- Flowing well medium / well testing;
- Well intervention;
- Utilities;
- CWI general (this category is used in case all of the above-mentioned categories are applicable)

It should be noticed that these categories are aligned with the main C&WI well intervention operations as described in the Well services Catalog [Ref. 7] and § 4.2 of this document.

NAM

HAZARD & EFFECT REGISTER C&WI									
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-01 Hydrocarbons (refined and unrefined)										
H-01.01: Crude oil / H-01.02: Hydrocarbons (formation fluids/sour process feed) / H-01.03: Raw gas (sour) / H-01.04: (sweet) / H-01.07: Natural / fuel gas (C1-C4), sweet /sour / H-01.08: Condensate, NGL (C5-C10) / Naphta, gasolines / H-01.10: Chemical feedstocks /solvents (aliphatic) / H-01.11: Chemical feedstocks /solvents (aromatic) / H-01.15: Wax (paraffin) / H-01.19: Slobs (tank bottoms, flush oil) / H-01.21: Acid gas / H-01.22: Tail gas										
1) Hydrocarbons under pressure in Process installations: • Breaking of well containment • Pumping into well • Flowing well medium (e.g. well testing) • Well intervention	• Exceeding design limits • Mechanical / external impact • Failure of equipment • Human / design error • Local condition (e.g. static electricity)	Loss of containment (LOC): (release of gas, oil, or natural gas condensate - whether or not H_2S containing)	In case of ignition: loss of containment, followed by fire or explosion causing: • Multiple fatalities; • Damage to installation (moderate); • Sustained serious environmental damage in large area by disruption/damage to flora and fauna, soil and/or water pollution and increased greenhouse effect (CO_2 and/or methane)	5B	3B	4B	3B		**See Bow-tie No. 2A: (Hydrocarbons in well test equipment – Loss of containment during flowing of well)**	
			In case of no ignition: dispersion of toxic gas cloud (H_2S) causing: • Multiple fatalities • Asset damage (minor) • Environmental impact (moderate)	5B	2B	4B	3B			
2) Hydrocarbons under pressure in wells and reservoirs: • Breaking of well containment • Pumping into well • Flowing well medium (e.g. well testing) • Well intervention	• Exceeding design limits • Mechanical / external impact • Failure of equipment • Human / design error • Local condition (e.g. static electricity)	Loss of well control: (release of gas, oil, or natural gas condensate - whether or not H_2S containing)	In case of ignition: Blow-out, followed by fire or explosion causing: • Multiple fatalities; • Damage to installation (moderate); • Long-term production losses; • Sustained serious environmental damage in large area by disruption/damage to flora and fauna, soil and/or water pollution and increased greenhouse effect (CO_2 and/or methane)	5C	4C	4C	3C		**See Bow-tie No. 1C: (HCs in well/reservoir – Loss of containment during well intervention**	
			In case of no ignition: dispersion of toxic gas cloud (H_2S) causing: • Multiple fatalities • Asset damage (minor) • Environmental impact (moderate)	5C	2C	4C	3C			
3) Hydrocarbons in storage: • Pumping into well • Flowing well medium (e.g. well testing) • Utilities (storage/handling)	• Exceeding design limits • Mechanical / external impact • Failure of equipment • Human / design error • Local condition (e.g. static electricity)	Loss of containment (LOC): (leakage of oil, or natural gas condensate)	In case of ignition: leakage to environment and possible fire causing: • Personal injury or health effect (major); • Installation damage (minor); • Environmental impact (minor)	3B	2B	3B	2B		• Process 64 Design, Construct, Modify Facilities • Process 72 Maintain & Assure Facility Integrity	
			In case of no ignition: leakage to environment surrounding with eventually evaporation of H_2S causing: • injury / fatality • Asset damage (slight) • Environmental impact (minor)	4C	1C	3C	2C			

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HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-01.05: LPGs (C3 - C4)										
1) Use of propane bottles • Utilities	• Refer to item H-04.04 "Explosive gasses (propane, acetylene, Oxygen)"			-	-	-	-	N/A		
H-01.06: LNG (C1 – C2)										
1) Use of LNG (bulk) • Pumping into well	• LNG is currently not used for well stimulation, and therefore this activity is not reviewed in more detail.			-	-	-	-	N/A		
H-01.12: Hydrocarbon fuels (diesel) / H-01.16: Hydrocarbons (C16-C35), lube oils / H-01.18: Hydrocarbon greases / H-01.23: Biofuels (ethanol / hydrocarbon blends) / H-01.24: Biodiesel blended fuel / H-01.99 Other (Methanol)										
1) Diesel fuel: • Utilities (diesel engines; storage tank)	• Exceeding design limits • Mechanical / external impact • Failure of equipment • Human / design error	Loss of containment (LOC)	Spill of diesel fuel causing: • Environmental impact (minor) • Asset damage (slight)	0D	1D	0D	2D		• Process 64 Design, Construct, Modify Facilities • Process 72 Maintain & Assure Facility Integrity • NAM-71.WI.80.02 Bulkverlading van brandbare stoffen offshore (NL) • PGS15/28/29/30	
1) Diesel fuel: • Pumping into well		Refer to item H-01 "2) Hydrocarbons in wells and Xmas trees", "1) Hydrocarbons in Process installations:"		-	-	-	-	N/A		
2) Methanol (hydrate prevention) • Utilities (storage / handling)	• Exceeding design limits • Mechanical / external impact • Failure of equipment • Human / design error	Loss of containment (LOC)	Leakage to environment followed by fire causing: • Permanent total disability; • Local installation damage (minor); • Environmental impact (minor) • Disruption of operations.	4B	2B	3B	2B		• Process 64 Design, Construct, Modify Facilities • Process 72 Maintain & Assure Facility Integrity • NAM-71.WI.80.02 Bulkverlading van brandbare stoffen offshore (NL) • PGS15/28/29/30	
2) Methanol (hydrate prevention) • Pumping into well		Refer to item H-01 "2) Hydrocarbons in wells and Xmas trees", "1) Hydrocarbons in Process installations:"		-	-	-	-	N/A		
3) Lubrication and seal oil systems (Rotating equipment, Storage tanks) • Utilities	• Mechanical / external impact • Failure of equipment • Human / design error	Loss of containment (LOC)	Spill of lube /seal oil causing: • Environmental impact (minor) • Asset damage (slight)	0D	1D	0D	2D		• Preventive maintenance • Spill control (kit, drip trays) • Contingency plan	

NAM

HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-01.17: Hydraulic oils										
Use of hydraulic oil for operating equipment • Utilities	• Equipment failure • Mechanical / external impact • Human / design error (e.g. maintenance)	Loss of containment (LOC)	Break loose of hydraulic hose / - coupling. • Refer to item H-05.03 "High pressure pump (> 15 barg)"	-	-	-	-	N/A	• Preventive maintenance	
			Spray release (fine mist) of hydraulic oil, followed by fire. • Refer to item "H-04.04: Explosive gasses (propane, acetylene, Oxygen)"	-	-	-	-	N/A		
			Pressurized release of hydraulic oil. Spill of hydraulic oil. In case of exposure, causing personal injury (poisoning)	4B	0B	0B	0B			
H-03 Other flammable materials										
H-03.04: Dry vegetation										
Heat radiation from mobile / temporary flare (e.g. stink flare, silent flare) • Flowing well medium (e.g. well testing)	• Human /design error (wrong flare location selected (too close to sensitive objects) • Exceeding design limits (e.g. flaring at too high flow rate)	(Dry) vegetation exposed to high heat radiation levels from flare	Ignition of dry vegetation causing local fire.	2C	1C	3C	2C		• NAM onshore hazardous area checklist Well Test Equipment – EP201311203437	
H-03.06: Chemicals (cleaning chemicals)										
Flammable/irritating cleaning chemicals • Utilities (handling / storage)	• Equipment failure • Mechanical / external impact • Human / design error (e.g. maintenance) • Local condition (e.g. static electricity)	Loss of containment / exposure to	Ignition of spilled chemicals causing local fire and/or irritation of respiratory system and eyes/skin	2C	1C	1C	1C		• WIC	
H-04 Explosives										
H-04.01 Detonators / H-04.03 Perforating gun charges										
Perforating gun charges / detonators • Utilities (handling/storage) • Well intervention	• Mechanical / external impact • Failure of equipment • Human / design error	Loss of control of charges/ detonators	Handling/storage: Aboveground ignition during storage, use and/or transport can lead to: • Multiple fatalities (up to three); • Local installation damage	4B	2B	4B	0B		• Contractor management • 3rd party procedures • Legal regulations (Law explosives for civil use)	
			Well intervention: Near surface ignition of perforating gun may lead to: • Well integrity issue	2C	3C	3C	0C			

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HAZARD & EFFECT REGISTER C&WI									
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-04.04 Explosive gasses (propane, acetylene, Oxygen)										
Use of gas bottles (Welding activities, torch cutting, Operational applications) • Utilities (handling / storage)	• Mechanical / external impact • Failure of equipment • Human / design error	Exposure to high pressure gas flow (flammable / explosive)	Fire and/or explosion followed by flying parts or launching the entire gas cylinder, causing: • Fatality; • Local material damage.	4B	1B	2B	2B		• PGS 15, Wettelijke eisen drukhouders, certificeringen • HRA/RIE C&WI • Contractor manuals	
H-05 Pressure Hazards										
H-05.01 Hydrocarbons under pressure / H-05.02 Gas under pressure										
1) Refer to H-01.01: Crude oil / H-01.02: Hydrocarbons (formation fluids/sour process feed)				-	-	-	-	N/A		
2) Use of gas bottles • Utilities (handling / storage)	• Mechanical / external impact • Failure of equipment • Human / design error	Exposure to high pressure gas flow	• Refer to item "H-04.04: Explosive gasses (propane, acetylene, Oxygen)"	-	-	-	-	N/A		
H-05.03 Liquid under pressure										
High pressure & high rate pump (> 15 barg) • Pumping into well	• Exceeding design limits • Mechanical / external impact • Failure of equipment • Human / design error	Loss of well control	• Refer to item H-01 02) "2) Hydrocarbons under pressure in wells and reservoirs:"	-	-	-	-	N/A		
High pressure pump (> 15 barg) • CWI General (e.g. pressure testing)	• Exceeding design limits • Mechanical / external impact • Failure of equipment • Human / design error	Loss of containment of fluids under high pressure	Being hit by liquids or parts under very high pressure causing: • Personal injury / fatality (up to 3 fatalities); • Local material damage; • Local environmental damage by air-, soil- and/or water pollution.	4B	1B	2B	2B		• Pressure Control manual for drilling, completion and well intervention operations (WS38.80.31.32-GEN)	

HAZARD & EFFECT REGISTER C&WI									
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-05.04 Non HC gas under pressure / H-05.99 Other (steam)										
Inert gasses (Purging, Leak testing) • CWI General	• Exceeding design limits • Mechanical / external impact • Failure of equipment • Human / design error	Loss of containment (Exposure to high pressure inert gas flow)	Gas flow (N_2, Helium) under high pressure and/or flying parts by rupture of pipelines, causing: • Personal injury/fatality (asphyxiation, launching of individual components) • Local material damage (slight). • Environmental impact (slight).	4C	1C	1C	1C		• Process 64 Design, Construct, Modify Facilities • Process 72 Maintain & Assure Facility Integrity • NAM-72.WI.50.01 • Flensverbindingen en pipeclamp connectors • Contractor manuals • NAM-71.WI.30.01 Het purgen van installaties, equipment en pijpleidingen	
Use of steam: • Flowing well medium (e.g. well testing):	• Exceeding design limits • Mechanical / external impact • Failure of equipment • Human / design error	Exposure to low pressure / temperature steam system failure	Being hit by hot vapour/ liquids or parts under low pressure (<10 bar) causing: • Serious injury or impact on health; • Local material damage; • Local environmental damage by air-, soil-and/or water pollution	4B	1B	1B	1B		• Process 64 Design, Construct, Modify Facilities • Process 72 Maintain & Assure Facility Integrity • NAM-72.WI.24.04 Het afpersen van installatiedelen en pijpleidingen (incl. drainsystemen) • Contractor manuals	
H-05.05 Air under pressure										
Air systems (Instrument- and service air systems) • CWI General	• Exceeding design limits • Mechanical / external impact • Failure of equipment • Human / design error	Exposure to high pressure airflow	Air flow under high pressure and/or flying parts by rupture of equipment, causing: • Fatality; • Local material damage (slight).	4B	1B	1B	0B		• Process 64 Design, Construct, Modify Facilities • Process Maintain & Assure Facility Integrity • NAM-72.WI.24.04 Het afpersen van installatiedelen en pijpleidingen (incl. drainsystemen) • NAM-72.WI.50.01 Flensverbindingen en pipeclamp connectors • Contractor manuals	

HAZARD & EFFECT REGISTER C&WI									
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-05.08: Trapped pressure in equipment										
Maintenance on / opening of pressurized systems: • WHM: Breaking of well containment • Pumping into well • Flowing well medium (e.g. well testing) • Well intervention	• Human / design error (e.g. system opened while not completely depressurized) • Equipment failure (e.g. pressure indicator incorrectly shows that system is depressurized)	Exposure to high pressure release	Release of high pressure and/or flying parts of equipment, causing: • Fatality; • Local material damage.	4C	1C	1C	1C		• NAM71WI7601 (PtW system for safe handover and operation of equipment).	
H-05.09 High pressure equipment										
1) Hydraulic systems: Utilities	• Refer to item "H-01.17: Hydraulic oils"			-	-	-	-	N/A		
2) High pressure pumping with temporary pipework (pressure testing, pump job) • Pumping into well • Utilities	• Refer to item H-05.03 "Liquid under pressure"			-	-	-	-	N/A		
3) Use of hoses and couplings (temporary) Connections) • Breaking of well containment • Pumping into well • Flowing well medium (e.g. well testing) • Well intervention	• Exceeding design limits • Mechanical / external impact • Failure of equipment • Human /design error	Loosening or rupture of hoses / couplings	Being hit by liquids or parts under high pressure causing: • Serious injury or impact on health, fatality; • Local material damage; • Local environmental impact by air-, soil-and/or water pollution (minor)	4C	1C	2C	2C		• Temporary Pipework Manual WS 38.80.32.34-Gen / EP2006-5393	
H-06 Hazards associated with differences in height										
H-06.01: Personnel at height / H-6.99: Other (working on containers)										
Work at height (> 1,8 m) • Utilities (Scaffold construction, Work on ladders,	• Mechanical / external impact (e.g. poor weather conditions); • Human / design error (e.g. no /insufficient	Loss of personal balance	Loss of personal balance and potential for falling from height causing: • Lethal injury	4B	0B	1B	0B		• NAM-72.WI.43.03 (Working on/with fixed scaffolding) • Life-Saving Rules (working at height)	

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HAZARD & EFFECT REGISTER C&WI									
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
containers etc.)	retention on objects at height) • Local conditions (e.g. slip, trips & falls)	Dropped objects	Being hit by dropped object causing: • Fatality; • Limited material damage • Environmentral impact (slight)	4B	1B	1B	1B		• NAM-72.WI.43.03 (Working on/with fixed scaffolding) • DROPS standard • Arbobesluit	
Temporary provisions-Utilities: • Scaffolds (relatively low; some meters) • Mobile Elevated Work Platforms	• Exceeding design limits (of construction) • Human / design error (wrong construction)	Loss of stability / structural failure	Failure of parts followed by collapse causing: • Fatality; • Local material damage. • Environmentral impact (slight)	4B	1B	1B	1B		• Process 64 Design, Construct, Modify Facilities • Process 72 Maintain & Assure Facility Integrity • NAM-72.WI.43.03 (Working on/with fixed scaffolding) • NEN, Keboma standards	
H-06.02 Personnel at grade – falls same level (slips, trips and falls)										
Slip, trip and falls: • Breaking of well containment • Pumping into well • Flowing well medium (e.g. well testing) • Well intervention • Utilities	• Human / design error (e.g. Walkways not free of obstacles, Uneven, slippery floor) • Local conditions (e.g. poor visibility)	Loss of personal balance	Loss of personal balance and potential for falling causing: • Personal injury or health effect (major)	3D	0D	0D	0D		• NAM71WI7601 (PtW system for safe handover and operation of equipment).	
H-06.03 Overhead equipment (lifting equip, loading arms, scaffolding, storage, etc)										
Hoisting and lifting • Utilities (Cranes, Work platforms, Lifting equipment, Forklifts)	• Equipment failure (e.g. failure of hoisting / lifting equipment • Human / design error (e.g. No / insufficient retention of (lifted) objects) • Exceeding design limits (e.g. overloading of scaffold / work platform • Local conditions (e.g. poor visibility)	Loss of control (Dropped object)	Being hit by dropped object causing: • Fatality; • Damage to pressure containing equipment causing Leakage (initiator G-01-01)	4C	1C	1C	0C		• Process 64 Design, Construct, Modify Facilities • Process 72 Maintain & Assure Facility Integrity • NAMLIFHOIP01 (Lifting & Hoisting policy) / NAMLIFHOISP01 (Lifting & Hoisting standard) / NAM71WI7613 (Hef- en hijsactiviteiten)	

NAM

HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-06.05 Personnel below grade (trenching, excavation)										
Work in enclosed spaces (Well cellar): • Breaking of well containment	• Local conditions (insufficient ventilation / accumulation of dangerous substances / heat)	Exposure to environment with insufficient oxygen /too high toxic concentrations	Asphyxiation by lack of oxygen / H2S poisoning causing: • Fatality	4B	0B	1B	0B		• NAM-71.WI.76.03 Besloten ruimte • Life-Saving Rules	
		Exposure to heat	Refer to item H-26.02 "Heat stress"	-	-	-	-	N/A		
H-06.06 Falling Ice/snow										
1) ice / snow deposition on overhead equipment • CWI General	• Local condition (e.g. Changing weather conditions, thaw)	Exposure to falling snow / ice slice	Hit by falling ice/snow slice, causing: • Personal injury or health effect (major) • Local equipment damage (slight)	3C	1C	0C	0C		• Drops awareness • Visual inspection prior to use of equipment	
2) Ice / snow deposition on walk ways • CWI General	• Local condition (Slippery walk ways)	• Refer to H-06.02 "Personnel at grade – falls same level (slips, trips and falls)"		-	-	-	-	N/A		
H-06.07 Ship / Vessel access / H-06.08 Falling into the water										
Offshore CWI activities • CWI General	• Refer to Hazard and Effect register / VG document NAM Logistics (Marine)			-	-	-	-	N/A		
H-07 Objects under induced stress										
H-07.01 Objects under induced tension / H-07.04: Objects under compression / H-07.99 Other (connecting hoses / cabling)										
Equipment under induced stress (e.g. tension, compressed springs, slick line under tension): • CWI General	• Equipment failure • Human / design error • Exceeding design limits • Mechanical / external impact	Loss of control (Exposure to ejecting parts)	Being hit by ejected parts, causing • Fatality; • Local equipment damage (slight)	4B	1B	1B	0B		• Process 64 Design, Construct, Modify Facilities • Process 72 Maintain & Assure Facility Integrity • NAMLIFHOIP01 (Lifting & Hoisting policy) / NAMLIFHOISP01 (Lifting & Hoisting standard) / NAM71WI7613 (Hef- en hijsactiviteiten)	
H-08 Dynamic situations hazards										
H-08.01 On land transport / H-08.12 Pinch points										
Land transport • Utilities	• Refer to Hazard & Effect Register / VG document NAM Logistics			-	-	-	-	N/A		
H-08.02 On Water transport										
Water transport: • Utilities	• Refer to Hazard & Effect Register / VG document NAM Logistics			-	-	-	-	N/A		

NAM

HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-08.03 Air transport /										
Air transport • Utilities	• Refer to Hazard & Effect Register / VG document NAM Logistics			-	-	-	-	N/A		
H-08.05 Equipment with moving/rotating parts										
Equipment with moving and rotating parts (machines, tools) • CWI General	• Human / design error (e.g. rotating / moving parts not / insufficiently protected)	Contact with rotating parts	Come into contact with rotating parts or entrapment, causing: • Fatality	4B	0B	0B	0B		• Process 64 Design, Construct, Modify Facilities • Process 72 Maintain & Assure Facility Integrity • HRA/RIE C&WI • Contractor manuals	
H-08.06 Use of hazardous hand tools / H-08.07 Use of knives / manchetes										
Use of hand tools: • CWI General	• Human/design error • Equipment failure • Exceeding design limits	Contact with rotating and/or sharp parts	Come into contact with rotating/sharp parts, causing: • Personal injury or health effect (major)	3C	0C	0C	0C		• HRA/RIE C&WI • Contractor manuals	
H-08.13 Passenger approach / exit										
Helicopter transport	• Refer to item H-08.03 "Air transport"			-	-	-	-	N/A		
H-08.99 Other										
Hoisting / lifting activities • Utilities	• Refer to item H-06.03 "Overhead equipment"			-	-	-	-	N/A		
H-09 Physical Environment Hazards										
H-09.01 Weather										
Adverse weather conditions • CWI General	• Exceeding design limits (e.g. strong winds) • Local conditions (e.g. high / low ambient temperature, excessive rainfall, Lightning discharge)	Failure / drop down of equipment	Failure of parts caused by strong winds followed by collapse causing: • Injury/fatality; • Local material damage (slight) • Environmental impact (slight)	4B	1B	1B	1B		• NAM14ST01 (Adverse weather working standard offshore) • MOPO (onshore)	
		Exposure to extreme weather conditions	Exposure to extreme weather conditions with heat cramps, exhaustion, stroke or hypothermia, frostbite or impaired manual dexterity. Refer to item H-26.02 "heat stress / H-26.03 "could stress"	-	-	-	-	N/A		
		Exposure to lightning discharge	• Permanent disability/fatality	4B	0B	0B	0B		• NAM14ST01 (Adverse weather working standard offshore) • MOPO (onshore)	

NAM

HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-09.02 Sea state										
Transport by boat • Utilities	• Refer to item H-08.02 "On Water transport / H-08.04 ship collision hazard"			-	-	-	-	N/A		
H-09.04 Unstable soil conditions										
Excessive load stresses • CWI General	• Local conditions (e.g. weak underground)	Collapse / turnover of equipment	Collapse / turnover of equipment causing: • Personal injury/ fatality (up to 3), • Asset damage (moderate) • Environmental impact (minor).	4B	3B	2B	2B		• Observation of local ground bearing pressure during preparation of lay-out	
			In case of well intervention equipment: Loss of well control, Refer to item H-01 2) "Hydrocarbons under pressure in wells and reservoirs"	-	-	-	-	N/A		
H-09.05 Confined spaces										
Activities in Well cellar • Breaking of well containment	• Refer to item "H-06.05 Personnel below grade (trenching, excavation)"			-	-	-	-	N/A		
H-09.06 Building location siting (portable buildings)										
Use of portacabins • Utilities	• Human / design error (e.g. close position of portacabin to live process or CWI equipment)	Exposure of personnel in portacabins to risks related to process equipment (fire / explosion)	Portacabin destroyed by process incident causing: • Multiple fatalities; • Asset damage (minor) • Environmental impact (minor)	5B	2B	4B	2B		• Checklist Facility Siting bemande tijdelijke units NAM (see EP20101130925)	Initiating event for process incident is a release of hydrocarbons from process equipment / wells Refer to corresponding bow-ties.
H-10 Hot Surfaces										
H-10.01 Process piping 60-150 degC / H-10.02 Piping equipment > 150 degC / H-10.04 steam piping / H-10.07 heat tracing										
Use of hot feed boil water (pump truck) / work at well test equipment with hot surfaces: • Well treatment; • Well testing	• Human / design error (hot surfaces not / insufficient protected against direct contact)	Exposure to hot surfaces	Exposure to hot surfaces causing: • Personal injury (burn wounds)	3B	0B	0B	0B		• NAM71WI7601 (PtW system for safe handover and operation of equipment). • WS38.80.31.34 (Well Testing Manual)	
H-10.03 Engine and turbine exhaust systems										
Use of equipment provided with exhaust systems • Utilities	Refer to item H-10.01 "Process piping".			-	-	-	-	N/A		

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HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-11 Hot fluids										
H-11.01 Temperatures 100-150 degC										
Use of hot feed boil water (pump truck): • Well treatment;	• Human / design error • Equipment failure	Loss of containment	Loss of containment, release of / exposure to hot water causing: • Major injury/fatality (severe burn wounds)	4B	1B	1B	1B		• NAM71WI7601 (PtW system for safe handover and operation of equipment). • WS38.80.31.34 (Well Testing Manual) • CWI.WT.WI.NL.12 (Instructie voor het verpompen van foam/KCL met behulp van de foam truck of well extender truck) / CWI.WT.WI.NL.03 (Instructie voor het werken met de pomptruck M364)	
H-12 Cold surfaces										
H-12.01 Temperatures -25 /-80 degC / H12.02 temperatures below -80 degC										
Use of liquid nitrogen (pump truck) for Well treatment • Well intervention • Flowing well medium (e.g. well testing) or JT effect across choke valve of well test package • Flowing well medium (e.g. well testing)	• Human / design error (cold surfaces not / insufficient protected against direct contact where applicable)	Exposure to cold surfaces	Touch of cold surfaces with freezing as a result, causing: • Personal injury (burn wounds)	3B	0B	0B	0B		• Process 64 Design, Construct, Modify Facilities • Process 72 Maintain & Assure Facility Integrity • Contact with cold HRA/RIE C&WI • NAM71WI7601 (PtW system for safe handover and operation of equipment).	
		Loss of containment (brittle fracture)	Equipment failure (brittle fracture) causing Los of well control, refer to Refer to item H-01 2) "Hydrocarbons under pressure in wells and reservoirs"	-	-	-	-	N/A		
			Exposure of steel structures to spilled low temperature nitrogen causing brittle fracture and subsequently: • Asset damage (minor)	0C	2C	0C	0C		• Bunding (around nitrogen tank) • NAM71WI7601 (PtW system for safe handover and operation of equipment).	

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HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-13 Cold fluids										
H-13.01 Oceans / Seas < 10 degC										
CWI activities on offshore locations • CWI General	• Refer to Hazard & Effect register / VG document NAM Logistics (Aviation / Marine)			-	-	-	-	N/A		
H-13.02 Cryogenic fluids										
Use of liquid nitrogen (pump truck) • Well intervention • Flowing well medium (e.g. well testing)	• Refer to item H-12.01 "Cold surfaces"			-	-	-	-	N/A		
H-14 Open Flame										
H-14.01 Heater with fire tubes / H14.02 Direct fired furnaces										
Use of pre start-up heater or boiler for steam production • Flowing well medium (e.g. well testing)	• Equipment failure • Human / design error (e.g. wrong position wrt ATEX)	Loss of containment	Loss of containment, causing release of HC gas resulting in fire/explosion and subsequently: • Fatality • Equipment damage • Environmental impact	4B	2B	1B	1B		• WS38.80.31.34 (Well Testing Manual) requires hazardous area drawing.	
		Loss of ignition control	Potential for ignition of a flammable gas cloud being present due to a release via leak source. Refer to item H-01 "1) Hydrocarbons in Process installations:", H-01 "2) Hydrocarbons in wells and Xmas trees".	-	-	-	-	N/A		
H-14.03 Flares										
Use of flare (e.g. stink flare, silent flare): • Flowing well medium (e.g. well testing)	• Human /design error (wrong flare location selected (too close to sensitive objects) • Exceeding design conditions (e.g. flaring at too high flow rate)	Exposure to heat radiation / noise from flare	Exposure to too high heat radiation levels causing: • Personal injury (minor burn wounds); • Equipment damage vs ignition of vegetation (slight); • Complaints from neighbors (noise /lighting/smoke issues/)	2C	1C	3C	0C		• WS38.80.31.34 (Well Testing Manual) requires heat radiation plots. • Use of sprinkler (where required) • External communication	
		Loss of ignition control	Potential for ignition of a flammable gas cloud being present due to a release via leak source. Refer to item H-01 "1) Hydrocarbons in Process installations:", H-01 "2) Hydrocarbons in wells and Xmas trees".	-	-	-	-	N/A		

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HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-15 Electricity										
H-15.00 Extra low voltage / H-15.01 Low voltage										
Use of elect equipment (LV, 50V-750V) • Utilities (e.g. Cables, temporary provisions, Distribution boxes, Generators, powerpacks)	• Equipment failure (e.g. short circuit) • Mechanical / external impact	Contact with live parts	Contact with live parts with electricity transit through the body, burns or electrocution, causing: • Fatality	4B	0B	0B	0B		• Process 64 Design, Construct, Modify Facilities • Process 72 Maintain & Assure Facility Integrity • HRA/RIE C&WI • DEP 33.64.10.15 Elektrotechnische bedrijfsvoorschriften • NEN1010, NEN3140	
H-15.04 Lightning discharge										
CWI activities during lightning • CWI General	Refer to item H-09.01 "Weather"			-	-	-	-	N/A		
H-15.05 Electrostatic energy										
Build-up of electric charge during: • Well intervention • Pumping into well • Flowing well medium (e.g. well testing) • Utilities	Static electricity is only a Hazard in case of an explosive atmosphere. Therefore static electricity is indicated as a threat for item H-01 "1) Hydrocarbons in Process installations", "2) Hydrocarbons in wells and Xmas trees", "3) Hydrocarbons in storage" and H-03.-6 "Chemicals (cleaning chemicals)"			-	-	-	-	N/A		
H-15.06 Batteries										
Use of batteries for forklifts, vehicles • Utilities	• Failure of equipment (e.g. short circuit) • Human / design error (e.g. wrong connection)	Exposure to / contact with electricity	Electric shock causing: • Personal injury of health effect (minor)	2B	0B	0B	0B		• Correct use of equipment according to user manual	
H15.09 Electrical transmission lines										
CWI activities at locations in close vicinity of electrical transmission lines (e.g. OBLZ) • Utilities (cranes)	• Refer to Hazard & effect register/ VG document NAM Logistics (Hoisting & Lifting)			-	-	-	-	N/A		

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HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-16 Electromagnetic radiation										
H-16.01 Ultraviolet radiation										
UV radiation from flare • Flowing well medium (e.g. well testing)	Not applicable for UV radiation. For exposure to heat radiation of flare: Refer to item H-14.03 "Flares".			-	-	-	-	N/A		
H-17 Ionizing radiation – open source										
H-17.04 Natural occurring ionizing radiation										
Ionizing radiation (open source) NORM: • Well intervention; • Well maintenance • Flowing well medium (e.g. well testing)	• Local conditions: (e.g. contaminated deposits in Tools / tubulars)	Exposure to NORM particles	Exposure to NORM via ingestion or inhalation of radioactive particles with chance for change of the body cells and long term health effects causing: • Fatality due to occupational illness (cancer) via ingestion or inhalation	4B	0B	1B	0B		• HRA/RIE C&WI • NAM-RADIAT.SP.01 Handling radioactivity and radiation (+ Radiation work instructions)	
			Exposure of equipment to NORM during operations leading to: • Equipment contamination (and cleaning costs based on single activity)	0D	2D	0D	0D			
			Exposure of equipment to NORM during operations leading to: • Reputational damage due to unpermitted transportation	0C	0C	2C	0C			
H-18 Ionizing radiation – closed source										
H-18.02 Gamma rays – closed source										
Ionizing radiation (encapsulated sources) • Well intervention; • Flowing well medium (e.g. well testing) • Well treatment	• Human / design error (e.g. incorrect use of logging tool) • Mechanical / external impact (e.g. damage to encapsulation)	Exposure to radiation	Radiation with chance on change of the body cells and resulting in long term health effects, causing: • Fatality due to occupational illness (cancer)	4B	0B	0B	0B		• HRA/RIE C&WI • NAM-RADIAT.SP.01 Handling radioactivity and radiation (+ Radiation work instructions)	
H-19 Asphyxiants										
H-19.01 Insufficient oxygen atmosphere / H-19.02 Excessive CO2 (fire extinguishers) / H-19.04 Excessive N2										
CWI activities in encloses spaces • Utilities (e.g. use of CO_2 extinguishers) • Well treatment (e.g. N2)	• See item "H-06.05 Personnel below grade (trenching, excavation)"			-	-	-	-	N/A		

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HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-19.03 Drowning										
CWI activities on offshore platform • CWI General	• Overside work (e.g. installation of flare booms) • Extreme weather conditions	Loss of personal balance (falling overboard)	Man overboard, causing: • Fatality (drowning)	4B	0B	0B	0B			
H-19.06 Smoke / exhaust gasses										
Use of diesel driven generators • Utilities	• Local conditions (e.g. activities in close proximity to exhaust systems)	• Exposure to exhaust gasses / combustion products	Exposure to combustion products, smoke, soot/fine particles causing: • Personal injury or health effect (major) • Environmental impact (minor)	3D	0D	0D	2D			
H-20 Toxic gas										
H-20.1: H_2S, sour gas / H-20.2: Exhaust gasses / H-20.04: SO_2 (combustion of H_2S) / H-20.12: Oxides of nitrogen (NOx) / H-20.13: Benzene										
• CWI General	• See item H-30 (Dangerous goods), category "toxic" and "highly toxic".			-	-	-	-	N/A		
H-21 Toxic liquids										
H-21.01: Mercury / H-21.04: Methanol / H-21.05: Brines / H-21.06: Glycols / H-21.07: Degreasers / H-21.11: Corrosion inhibitors / H-21.12: Scale inhibitors / H-21.13: Liquid mud additives / H21.14: Odorant additives / H-21.17: Used engine oils / H-21.20: Poly aromatic hydrocarbons/ H-21.22: Benzene / H-21.23: n-hexane / H-21.32: Tolueen / H-21.33: Ethylbenzene / H-21.34: Xylene / H21.36: Antifreeze H-21.37: Wax inhibitors										
• CWI General	• See item H-30 (Dangerous goods), category "toxic", "highly toxic" and "irritating"			-	-	-	-	N/A		
H-22 Toxic solids										
H-22.01: Asbestos / H-22.02: Mineral fibers / H-22.03: Silica, crystalline / H-22.04: Sodium hypochloride / H-22.08: oil based muds / H-22.10: Water based muds / H-22.11: Cement and - slurries / H-22.12: Dusts, nuisance / H-22.14: Oil based sludges (base oil) / H-22.18: ceramic fibre /										
• CWI General	See item H-30 (Dangerous goods), category "toxic", "highly toxic" and "irritating"			-	-	-	-	N/A		
H-23 Corrosive substances										
H-23.01: Hydrofluoric acid / H-23.02: Hydrochloric acid / H-23.04: Caustic soda and strong alkalis (KCl brine)										
• CWI General	• See item H-30 (Dangerous goods), category "corrosive"			-	-	-	-	N/A		
H-25 Ergonomic Hazards										
H-25.02 Awkward posture / H-25.03 Physical effort										
Manual material handling • CWI general	• Local condition (e.g. difficult to access equipment and / or workplace)	Excessive physical load	Excessive physical load, causing: • Personal injury or health effect (major)	3D	0D	0D	0D		• HRA/RIE C&WI	
H-25.07 Long or irregular working hours										
Continuous long or irregular working hours, schedules, shift work • CWI general	• Human / design error (e.g. unexpected events / inadequate resources vs planning)	Physical and mental overload	Physical and mental overload can lead to impact on wellbeing.	3C	0C	0C	0C		• Arbeidstijden regeling (ATR)	

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HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-26 Physical Agents (see HRA)										
H-26.01 Noise										
Use of noise producing equipment (Tools, Machines, chokes, Relief systems, Flares /vents) • CWI general	• Local condition	Exposure to irritating noise (< 80 dB(A))	Exposure to irritating noise with distortion or impeding communication and concentration as a result, causing: • Slight effect on health	1E	0E	0E	0E		• Process 64 Design, Construct, Modify Facilities • Process 72 Maintain & Assure Facility Integrity • HRA/RIE C&WI • DEP 31.10.00.31-Gen (Noise control)	
		Exposure to harmful noise (> 80 dB(A)	Exposure to harmful noise with hearing loss, reduced attention value for signals and communication problems as a result, causing: • Serious impact on health by permanent partial disability or incapacity for work	3D	0D	0D	0D			
H-26.02 Heat stress										
Heat stress / contact • CWI General	• Local conditions (e.g. high ambient temperature, hot surfaces)	Exposure to high ambient temperatures	Exposure to areas with high ambient temperature with exhaustion, or stroke as a result, causing: • Serious injury or impact on health	3B	0B	0B	0B		• Process 64 Design, Construct, Modify Facilities • Process 72 Maintain & Assure Facility Integrity • Contact with hot HRA/RIE C&WI	
		Contact with hot surfaces or hot fluids	• Refer to item H-10 “Hot Surfaces” / H-11 “Hot fluids”	-	-	-	-	N/A		
H-26.03 Cold stress										
Cold stress / contact • CWI General	• Local conditions (e.g. low ambient temperatures, chokes, nitrogen installation)	Exposure to areas with low ambient temperature	Exposure to areas with low ambient temperature with hypothermia or impaired manual dexterity as a result, causing: • Serious injury or impact on health	3B	0B	0B	0B		• Process 64 Design, Construct, Modify Facilities • Process 72 Maintain & Assure Facility Integrity • Contact with cold HRA/RIE C&WI	
		Contact with cold surfaces	• Refer to item H-12 “cold surfaces” /H-13 “cold fluids”	-	-	-	-	N/A		
H-26.04 Vibration										
Use of vibrating hand tools (impact wrench) • Wellhead maintenance • Well testing	• Local condition	Exposure to vibrations above limits	Exposure above limit values with "white fingers", disorder of blood vessels and nervous system, and damage to joints, muscles and bones, causing: • Major impact or health effect	3B	0B	0B	0B		• HRA/RIE C&WI	
H-26.05 Lighting										
CWI activities during darkness / night • CWI General	• Poor lighting is considered as a threat for H-06.02 “Personnel at grade – falls same level (slips, trips and falls)” and H-06.03 “Overhead equipment (lifting equip, loading arms, scaffolding, storage, etc)”			-	-	-	-	N/A		

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HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-27 Security Related Hazards (See SRA)										
H-27.03 Sabotage										
Sabotage by protesters	• Asset related risk, refer to Hazard & Effect Register / RiGG of Asset			-	-	-	-	N/A		
Unauthorized access	• Asset related risk, refer to Hazard & Effect Register / RiGG of Asset			-	-	-	-	N/A		
H-27.05 Theft, pilferage										
Theft of materials	• Local condition (e.g. (scrap)value of materials)	Removal of equipment	Theft of materials can lead to: • Unplanned / not budgeted costs; • Delay of CWI activities, production deferment	0C	1C	0C	0C		• Access to locations is restricted (fence). • Periodic surveillance by security service.	
H-28 Use of natural resources (See EIA – ISO 14000 type E MS)										
H-28.01 Land take / foot print										
• Asset related risk, refer to Hazard & Effect Register / RiGG of Asset				-	-	-	-	N/A		
H-28.02 Surface / ground water										
• Asset related risk, refer to Hazard & Effect Register / RiGG of Asset				-	-	-	-	N/A		
H-28.03 Air										
• Asset related risk, refer to Hazard & Effect Register / RiGG of Asset				-	-	-	-	N/A		
H-29 Psychological Hazards (See HRA)										
General	Stress caused by one or a combination of potential hazards & sources as mentioned below. Exposure to stress factors can lead to acute symptoms such as headache, indigestion, sleep disorder, unrest and chronic symptoms of depression, worse performance, disorder in relationships, psychological disorder (= major health impact).			3C	0C	0C	0C		• Beleidsvoorschrift Welzijn Medewerkers, BV 01.06.01 • Beleidsvoorschrift Verzuim van Medewerkers, BV 01.08.01	Note 1) Top event is not RAM ranked since event doesn't immediately result in an adverse / unwanted consequence.
	Lack of concentration caused by exposure to stress factors can result in unsafe work conditions with the potential for increased likelihood of incidents (i.e. human errors)			1)	1)	1)	1)	N/A		
H-29.03 Job demand – work load, deadlines										
Long or irregular working hours, schedules, shift work	• See item H-25.07 "Ergonomic hazards- Long or irregular working hours"									
Work stress	• Local conditions (e.g. reorganization, lack of recognition, lack of respect, traumatic incident)	Human error	Unrealistic goals and/or poorly functioning organization can lead to: • Depressions, burn out, etc.; • Disruption of operations	1)	1)	1)	1)	1)		Note 1) see for ranking under "General"
H-29.04 Job demand – Hours, shift work, travel, isolation										
Long or irregular working hours, schedules, shift work	• See item H-25.07 "Ergonomic hazards- Long or irregular working hours"									

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HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-29.05 Organizational / Job change										
Reorganization and/or change of job content	• Reorganization and/or change of job content is considered as a threat for stress Refer to item H-29.03 "Work stress"			-	-	-	-	N/A		
H-29.06 Lack of / inappropriate reward and recognition										
Lack of reward and recognition	• Lack of reward & recognition is considered as a threat for stress Refer to item H-29.03 "Work stress"			-	-	-	-	N/A		
H-29.07 Lack of respect in work environment										
Lack of respect in work environment	• Lack of respect in work environment is considered as a threat for stress Refer to item H-29.03 "Work stress"			-	-	-	-	N/A		
H-29.08 Traumatic incident at work										
Involved in a traumatic situation (e.g. fatal incident)	• Involvement in a traumatic incident at work is considered as a threat for stress Refer to item H-29.03 "Work stress"			-	-	-	-	N/A		
H-30 Hazardous Goods										
H-30.01 Dangerous goods handling / activities										
			The risk control measures that have to be taken to reduce exposure to hazardous substances are described per product on a *Work Instruction Card (WIC)* With regard to the management of chemicals in general the following control measures are of importance: • Policy requirement Manage Chemicals, UIE-PROCHM.PO.01 • Procedure Approve Chemicals, UIE-PROCHM.PR.10 This to ensure that all chemicals used in NAM can be used safely and use is in compliance with legal requirements.							
H-30.01	**Explosive substances**	Exposure to persons	Refer to item H-04 "Explosives"	-	-	-	-	N/A		
H-30.02	**Oxidising:** • Strong acids and alkalis • Corrosion inhibitors	Exposure to oxidising substances	Exposure to corrosive substance causing: • Personal injury or health effect (corrosive burns)	4B	0B	0B	0B		• WIC • NAM71WI7601 (PtW system).	
H-30.03	**Extremely flammable:** • Methanol • Natural gas • Hydrogen	• Refer to item H-01.01/H-01.03/H-01.04 (hydrocarbons)		-	-	-	-	N/A		
H-30.04	**Highly flammable:** • Natural gas condensate	• Refer to item H-01.08 (hydrocarbons)		-	-	-	-	N/A		
H-30.05	**Flammable:** • Glycols, DEG, TEG, MEG, • diesel	• Refer to item H-01.12		-	-	-	-	N/A		
H-30.06	**Highly toxic:** • H_2S	• Refer to item H-01.03 (sour hydrocarbons)		-	-	-	-	N/A		

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HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-30.07	**Toxic:** • Mercury; • Natural gas condensate • Methanol • Ammonia • SO_2 • NO_X • VOC	Exposure to toxic substances	Intoxication causing: • Personal injury/fatality (up to 3)	4B	0B	0B	0B		• NSS 00-G-0-12 beheersen van VGWM risico's in het omgaan met kwik • WIC • NAM71WI7601 (PtW system).	
H-30.08	**Harmful:** • Solvents • Kerosene	Exposure to harmful substances	Exposure to harmful substance causing: • Personal injury or health effect (minor)	2B	0B	0B	0B		• WIC • NAM71WI7601 (PtW system).	
H-30.09	**Corrosive:** • Alkalis and acids • Ammonia	Exposure to corrosive substances	Exposure to corrosive substance causing: • Personal injury or health effect (corrosive burns)	4B	0B	0B	0B		• WIC • NAM71WI7601 (PtW system).	
H-30.10	**Irritating:** • brines, cleaning agents, synthetic oils, diesel, cement, flue gas, glycols	Exposure to irritating substances	Exposure to irritating substance causing: • Personal injury or health effect (minor)	2C	0C	0C	0C		• WIC • NAM71WI7601 (PtW system).	
H-30.11	**Sensitizing** • Isocyanides	• Not applicable		-	-	-	-	N/A		
H-30.12	**Carcinogenic** • Natural gas condensate (benzene) • Waste oils • Welding fumes • Asbestos	• Refer to item H-30.07 (toxic)		-	-	-	-	N/A		
H-30.13 / H-30.14	**Mutagenic / Toxic for reproduction** • LSA	• Refer to item H-17.04 (natural occurring ionizing radiation)		-	-	-	-	N/A		
H-30.15	**Hazardous to the Environment** • Oils, diesel	• Refer to item H-01.12/H-01.16/H-01.17 (hydrocarbons)		-	-	-	-	N/A		

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HAZARD & EFFECT REGISTER C&WI										
Hazard & Sources	Threats	Top Event	Consequences	Risk potential				RAM CAT	Controls	Comments /Notes
				P	A	C	E			
H-99 Environmental aspects (see EAI)										
H99.01 Hazardous air emissions – SOX (H-99.01.1)										
• Refer to item H-30.7 "toxic substances"				-	-	-	-	N/A		
H99.01 Hazardous air emissions – NOX (H-99.01.2)										
• Refer to item H-30.7 "toxic substances"				-	-	-	-	N/A		
H99.01 Hazardous air emissions – H2S (H-99.01.3)										
• Refer to item H-30.6 "highly toxic substances"				-	-	-	-	N/A		
H99.01 Hazardous air emissions – VOC (H-99.01.4)										
• Refer to item H-30.7 "toxic substances"				-	-	-	-	N/A		
H99.06 Hazardous air emissions – Fine particles (H-99.01.6)										
• Refer to item H-19.06 "Smoke/exhaust gasses"				-	-	-	-	N/A		
H99.02 Other Air emissions – Greenhouse gasses (H-99.02.1)										
• Refer to item H-19.06 "Smoke/exhaust gasses"				-	-	-	-	N/A		
H99.02 Other Air emissions – Noise (H-99.02.2)										
• Refer to item H-26.01 "Noise"				-	-	-	-	N/A		
H99.02 Other Air emissions – Light pollution H-99.02.6)										
• CWI General (use of light sources to continue activities during darkness)	• Local conditions (unsuitable lighting)	• Exposure to (too) bright lighting.	• Community complaints / traffic blinding	0D	0D	2D	0D		• Correct adjustment of light sources (limited to illumination of the location)	
H99.03 Surface water impact on water surface / toxics in effluent (H99.03.1/3)										
• Asset related risk, refer to Hazard & Effect Register / RiGG of Asset				-	-	-	-	N/A		
H99.04 Soil and ground water: H-99.04.1 potential for contamination										
• Asset related risk, refer to Hazard & Effect Register / RiGG of Asset				-	-	-	-	N/A		

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Appendix 6 Bow-ties

As a result of the Hazard & Effect Register for NAM C&WI the following bow-ties have been set-up:

- NAM Bow-tie No. 1C: HC's under pressure in wells/reservoirs, Loss of containment during well intervention (Blowout);
- NAM bow-tie No. 2A: Hydrocarbons in Well test equipment - Loss of Containment during flowing of well.

Explanation with respect to bow-tie No. 1C

The approach that was follow during the set-up of the bow-tie for well intervention (bow-tie No. 1C) is somewhat different than the set-up of bow-ties for all other NAM activities / facilities (including the bow-tie for well test equipment, see bow-tie No. 2A). The main reason for this different approach is that the activity Well intervention is divided into a number of categories while some of these categories are further divided into different types of operations, see Well Services Catalog [Ref. 7] and Table A6-1 below.

Table A6-1: Well intervention categories, types of operations and threats as included in bow-tie

Well intervention categories	Types of operations	Further specification	Threat included in bow-tie
1. Well entries	– Slickline – Braided line – Coiled tubing – Capillary	N/A	B. Well entry - slick/braided line operations (live well operations) - wire break
			C. Well entry - Coiled tubing line operations (live well operations) - coiled tubing failure at surface
			D. Well entry - Snubbing (loss of slip engagement)
			I. Capillary - retrieving control line from live well (gas release through internal of coil)
2. Pumping	– Direct wellbore treatment – Well bore treatment with displacement – Coiled tubing operations	N/A	E. Pumping - Hydraulic Stimulation (overpressure of well components by high rate pumping)
3. Flowback	– Coiled tubing – Pumping operations – Well test and production	N/A	J. Flowing - Well test (erosion) refers to bow-tie 2A (well test equipment)
4. Well maintenance	– Gate valve maintenance or repair – XMT change out – Annulus valve change out	Flow wetted (WIT) components): – Xmas tree removal – LMGV grease nipple – LMGV bonnet removal – Butech valve (control line)	F. WHM - Flow wetted without closeable equipment/device (e.g. Xmas tree removal, LMGV grease nipple, LMGV bonnet removal)
			H. WHM - Flow wetted without closeable equipment/device (Butech valve (control line)
		Non-flow wetted (SIT) components): – Inner annulus gate valve removal	G. WHM - Non flow wetted without closeable equipment/device (inner annulus gate valve removal)

Following the standard approach would have resulted in a large number of bow-ties for well intervention activities. It was however concluded that the hazards related to these different activities are quite similar, as well as the preventive barriers being used. Furthermore, the relevant hazards during these operations are related to a specific event based upon it was decided to set-up one bow-tie including all operation/activity specific threats. In addition to these dedicated threats also some more generic threats were identified which apply to all well intervention activities, i.e.

- Threat A: Breaking and Reinstatement of Pressure Control Equipment (PCE);
- Threat K: Dropped objects (crane activities);
- Threat L: Excessive lateral movement of well resulting into high mechanical stress at quick union.

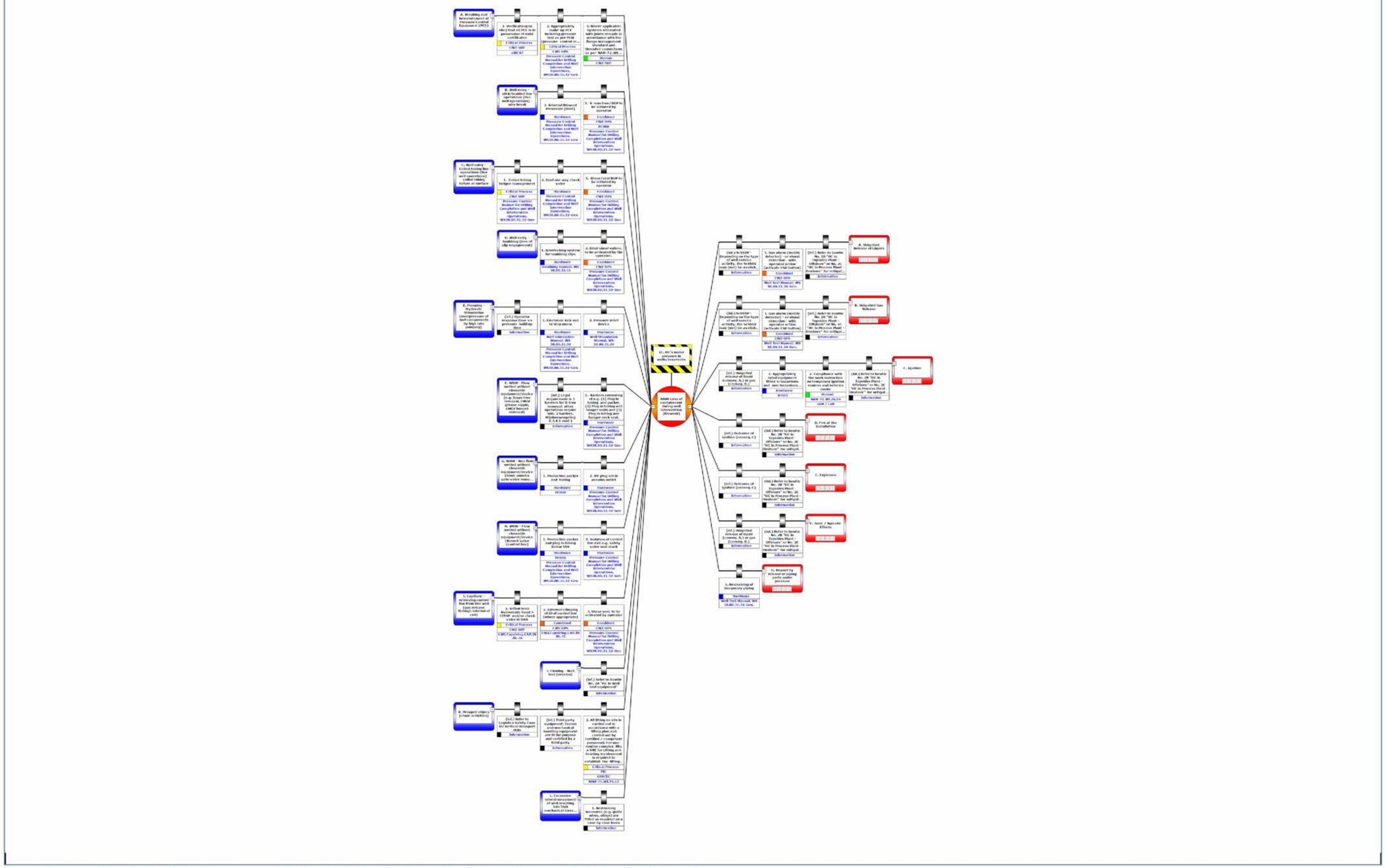

Figure A6-1 Bow-tie No. 1C: HC's under pressure in wells/reservoirs, Loss of containment during well intervention (Blowout)

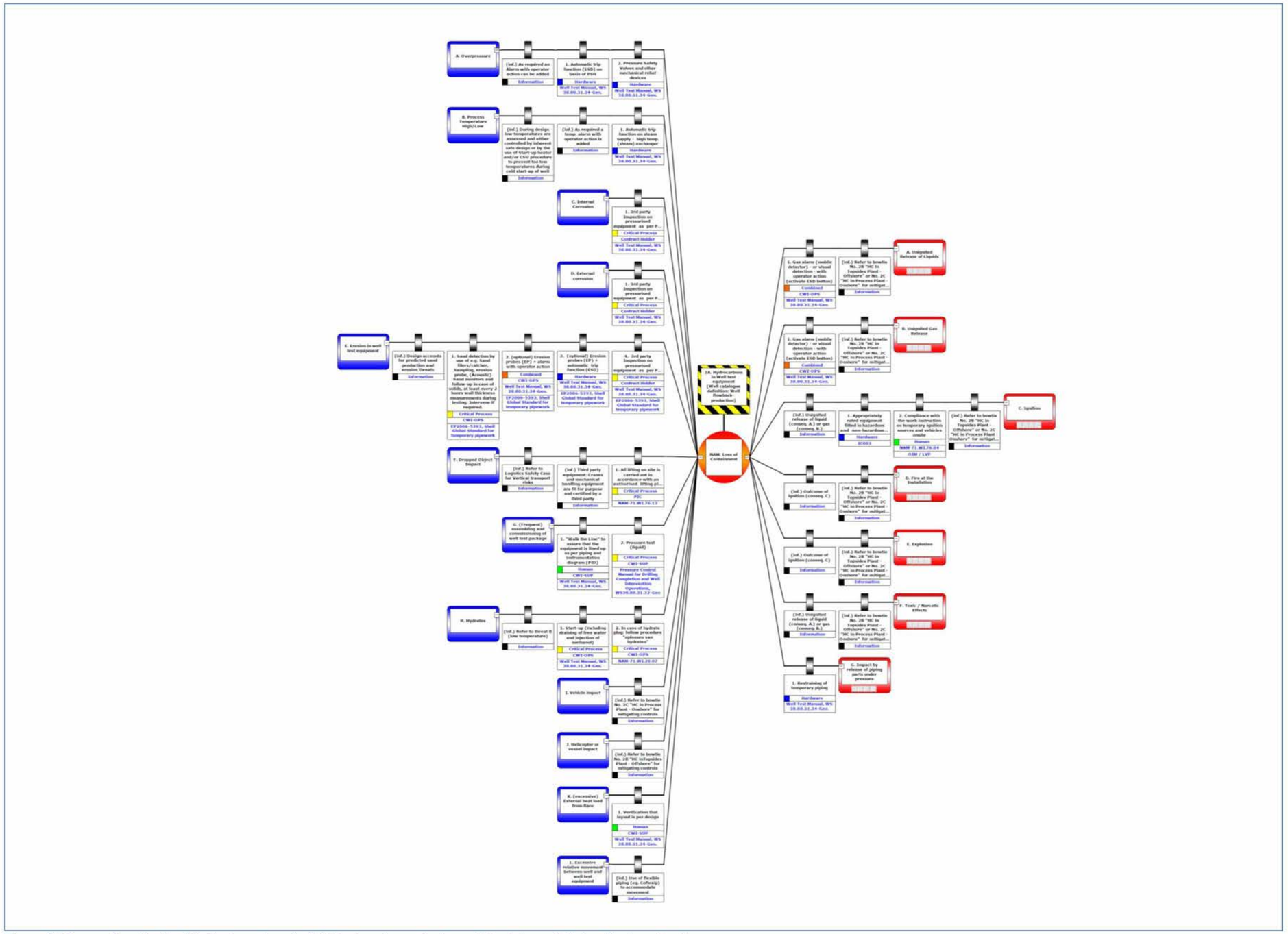

Figure A6-2 Bow-tie No. 2A: Hydrocarbons in Well test equipment - Loss of Containment during flowing of well

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Appendix 7 Overview of SECEs

In the bow-tie for the C&WI activities (Bow-tie No. 1C "HC's in wells – LOC during well interventions" and 2A "HC's in Well test equipment - LOC"), the following SECEs are addressed, see Table A7-1.

More detailed information with respect to the assurance is provided in the performance standard document [Ref. 25].

Table A7-1: Overview of SECEs in NAM C&WI Bow-ties

SECE main group	Bow-tie No.	Threat if system on the left-hand side of the bow-tie	System / item	Assurance
1. Process containment	2A HCs in well test equipment - LOC	A Overpressure	A-2 Pressure Safety Valves and other mechanical relief devices	WS 38.80.31.34-GEN (Well Test Manual)
1. Process containment	1C HCs in wells – LOC during well intervention	B. Well entry - slick/braided line operations (live well operations) - wire break	B-1 Internal Blowout Preventer (iBOP)	WS 38.80.31.32-GEN (Pressure Control Manual)
1. Process containment	1C HCs in wells – LOC during well intervention	B. Well entry - slick/braided line operations (live well operations) - wire break	B-2 X-mas tree / BOP to be initiated by operator	WS 38.80.31.32-GEN (Pressure Control Manual)
1. Process containment	1C HCs in wells – LOC during well intervention	C. Well entry - Coiled tubing line operations (live well operations) - coiled tubing failure at surface	C-3 Shear / seal BOP to be initiated by operator	WS 38.80.31.32-GEN (Pressure Control Manual)
1. Process containment	1C HCs in wells – LOC during well intervention	D. Well entry - Snubbing (loss of slip engagement	D-2 Blind shear valves, to be activated by the operator.	WS 38.80.31.32-GEN (Pressure Control Manual)
2. Ignition control	1C HCs in wells – LOC during well intervention	-	C-1 Appropriately rated equipment fitted in hazardous and non-hazardous areas	IC003 (Certified Electrical Equipment)
2. Ignition control	2A HCs in well test equipment - LOC	-	C-1 Appropriately rated equipment fitted in hazardous and non-hazardous areas	IC003 (Certified Electrical Equipment)
3. Protection system	1C HCs in wells – LOC during well intervention	E. Pumping - Hydraulic Stimulation (overpressure of well components by high rate pumping)	E-2 Pressure relief device	WS 38.80.31.36-GEN (Well Stimulation Manual)
4. Detection system	1C HCs in wells – LOC during well intervention	-	A-1/B-1: Gas alarm (mobile detector) - or visual/audible detection – with operator action (activate ESD button	WS 38.80.31.34-GEN (Well Test Manual)
4. Detection system	2A HCs in well test equipment - LOC	A. Overpressure	A-1 Automatic trip function (ESD) on basis of PSH	WS 38.80.31.34-GEN (Well Test Manual)
4. Detection system	2A HCs in well test equipment - LOC	E Erosion	E-2 (optional) Erosion probes (EP) + alarm with operator action	WS 38.80.31.34-GEN (Well Test Manual) EP2006-5393 (Shell Global Standard for temporary pipework)
4. Detection system	2A HCs in well test equipment - LOC	-	A-1/B-1: Gas alarm (mobile detector) - or visual/audible detection – with operator action (activate ESD button	WS 38.80.31.34-GEN (Well Test Manual)

SECE main group	Bow-tie No.	Threat if system on the left-hand side of the bow-tie	System / item	Assurance
5. Shutdown system	1C HCs in wells – LOC during well intervention	E. Pumping - Hydraulic Stimulation (overpressure of well components by high rate pumping)	E-1 Sand detection by use of e.g. Sand filers/catcher, Sampling, erosion probe, (Acoustic) Sand monitors and follow-up in case of solids, at least every 2 hours wall thickness measurements during testing. Intervene if required.	EP2006-5393 (Shell Global Standard for temporary pipework)
5. Shutdown system	2A HCs in well test equipment - LOC	B. Process temperature high/low	B-1 Automatic trip function on steam supply - high temp. (steam) exchanger	WS 38.80.31.34-GEN (Well Test Manual)
5. Shutdown system	2A HCs in well test equipment - LOC	E. Erosion	E-3 (optional) Erosion probes (EP) + automatic trip function (ESD)	WS 38.80.31.34-GEN (Well Test Manual) EP2006-5393 (Shell Global Standard for temporary pipework)
6. Miscellaneous system	1C HCs in wells – LOC during well intervention	C. Well entry - Coiled tubing line operations (live well operations) - coiled tubing failure at surface	C-2 Dual one way check valve	WS 38.80.31.32-GEN (Pressure Control Manual)
6. Miscellaneous system	1C HCs in wells – LOC during well intervention	D. Well entry - Snubbing (loss of slip engagement	D-1 Interlocking system for snubbing slips	WS.38.80.32.31-GEN (Snubbing Manual)
6. Miscellaneous system	1C HCs in wells – LOC during well intervention	F. WHM - Flow wetted without closeable equipment/device (e.g. Xmas tree removal, LMGV grease nipple, LMGV bonnet removal)	F-1 Barriers consisting of e.g. (1) Plug in tubing and packer, (2) Plug in tubing and hanger seals and (3) Plug in tubing and hanger neck seal.	WS 38.80.31.32-GEN (Pressure Control Manual)
6. Miscellaneous system	1C HCs in wells – LOC during well intervention	G. WHM - Non flow wetted without closeable equipment/device (inner annulus gate valve removal)	G-1 Production packer and tubing	PC008 (Operational well containment)
			G-2 VR-plug set in annulus outlet	WS 38.80.31.32-GEN (Pressure Control Manual)
6. Miscellaneous system	1C HCs in wells – LOC during well intervention	H. WHM - Flow wetted without closeable equipment/device (Butech valve (control line)	H-1 Production packer and plug in tubing below SSV	WS 38.80.31.32-GEN (Pressure Control Manual) PC008 (Operational well containment)
6. Miscellaneous system	1C HCs in wells – LOC during well intervention	H. WHM - Flow wetted without closeable equipment/device (Butech valve (control line)	H-2 Isolation of control line exit e.g. safety valve seal stack	WS 38.80.31.32-GEN (Pressure Control Manual)
6. Miscellaneous system	1C HCs in wells – LOC during well intervention	-	G-1 Restraining of temporary piping	WS 38.80.31.34-GEN (Well Test Manual).
6. Miscellaneous system	2A HCs in well test equipment - LOC	-	G-1 Restraining of temporary piping	Well Test Manual, WS 38.80.31.34-Gen.

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Appendix 8 List of SCAs

The Safety Critical Activities (SCAs), as included in the NAM C&WI bow-ties (Bow-tie No. 1C "HC's in wells – LOC during well interventions" and 2A "HC's in Well test equipment - LOC"), are listed in Table A8-1 and assigned to specific positions within NAM C&WI.

For the C&WI activities the following positions are indicated as HSSE critical based on the abovementioned bow-ties. These positions are linked to the Frontline Barrier Management (FLBM).

Code	**Description**
CWI-OPS	C&WI operator
CWI-SUP	C&WI supervisor
PIC	Person in charge
Incident Controller	Incident Controller
Contract Holder	Contract Holder
OIM/LVP	Offshore Installation Manager / "Locatie verantwoordelijke persoon")

Table A8-1: Overview of HSSE positions in NAM C&WI Bow-ties

Safety Critical position	**Bow-tie**	**Threat / consequence**	**Barrier / safety critical activity**	**Barrier type**
Contract Holder	2A HCs in well test equipment - LOC	C. Internal corrosion	C-1/D-1/E-4: 3rd party Inspection on pressurized equipment as per PED	Critical Process
		D External corrosion		
		E Erosion in well test equipment		
CWI-OPS	2A HCs in well test equipment - LOC	E Erosion in well test equipment	E-1 Sand detection by use of e.g. Sand filers/catcher, Sampling, erosion probe, (Acoustic) Sand monitors and follow-up in case of solids, at least every 2 hours wall thickness measurements during testing. Intervene if required.	Critical Process
			E-2 optional) Erosion probes (EP) + alarm with operator action	Combined
CWI-OPS	2A HCs in well test equipment - LOC	H Hydrates	H-1 Start-up (including draining of free water and injection of methanol)	Critical Process
			H-2 In case of hydrate plug: follow procedure "oplossen van hydraten"	Critical Process
CWI-OPS	2A HCs in well test equipment - LOC	A. Unignited release of liquids	A-1/B-1: Gas alarm (mobile detector) - or visual/audible detection - with operator action (activate ESD button)	Combined
		B. Unignited release of liquids		
CWI-OPS	1C HCs in wells – LOC during well intervention	A. Breaking and Reinstatement of Pressure Control Equipment (PCE)	A-2 Appropriately make-up PCE including pressure test as per PCM (pressure control manual)	Critical process
CWI-OPS	1C HCs in wells – LOC during well intervention	B. Well entry - slick/braided line operations (live well operations) - wire break	B-2 X-mas tree/BOP to be initiated by operator	Combined
CWI-OPS	1C HCs in wells – LOC during well intervention	C. Well entry - Coiled tubing line operations (live well operations) - coiled tubing failure at surface	C-3 Shear/seal BOP to be initiated by operator	Combined

Safety Critical position	Bow-tie	Threat / consequence	Barrier / safety critical activity	Barrier type
CWI-OPS	1C HCs in wells – LOC during well intervention	D. Well entry - Snubbing (loss of slip engagement)	D-2 Blind shear valves, to be activated by the operator.	Combined
CWI-OPS	1C HCs in wells – LOC during well intervention	I. Capillary - retrieving control line from live well (gas release through internal of coil)	I-2 External crimping of ID of control line (where appropriate)	Combined
			I-3 Shear seal, to be activated by operator	Combined
CWI-OPS	1C HCs in wells – LOC during well intervention	A. Unignited release of liquids	A-1/B-1: Gas alarm (mobile detector) - or visual/audible detection - with operator action (activate ESD button)	Combined
		B. Unignited release of liquids		
CWI-SUP	2A HCs in well test equipment - LOC	G. (Frequent) assembling and commissioning of well test package	G-1 "Walk the Line" to assure that the equipment is lined up as per piping and instrumentation diagram (PID)	Human
			G-2 Pressure test (liquid)	Critical Process
CWI-SUP	2A HCs in well test equipment - LOC	K. (excessive) External heat load from flare	1. Verification that layout is per design	Human
CWI-SUP	1C HCs in wells – LOC during well intervention	A. Breaking and Reinstatement of Pressure Control Equipment (PCE)	A-1 Verification (onsite) that all PCE is in possession of valid certificates	Critical Process
			A-3 Where applicable: Systems reinstated with joints remade in accordance with the flange management standard and threaded connections as per NAM-72.WI.50.01/2	Human
CWI-SUP	1C HCs in wells – LOC during well intervention	C. Well entry - Coiled tubing line operations (live well operations) - coiled tubing failure at surface	1. Coiled tubing fatigue management	Critical Process
CWI-SUP	1C HCs in wells – LOC during well intervention	I. Capillary - retrieving control line from live well (gas release through internal of coil)	1. Inflow test: Hydrostatic head > CITHP and/or check valve in BHA	Critical Process
PIC	2A HCs in well test equipment - LOC	F Dropped object impact	1. All lifting on site is carried out in accordance with an authorized lifting plan	Critical Process
PIC	1C HCs in wells – LOC during well intervention	K Dropped object impact	1. All lifting on site is carried out in accordance with an authorized lifting plan	Critical Process
OIM/LVP	2A HCs in well test equipment - LOC	C. Ignition	C-2 Compliance with the temporary equipment work instruction (NAM-71.WI.76.04) prevents ignition potential of temporary equipment	Human
OIM/LVP	1C HCs in wells – LOC during well intervention	C. Ignition	C-2 Compliance with the temporary equipment work instruction (NAM-71.WI.76.04) prevents ignition potential of temporary equipment	Human

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Appendix 9 Installation scenarios C&WI activities

Installation scenarios are typically related to so-called blocked-in systems, i.e. the volume that is present in a (part of the) process system separated by block valves. During C&WI activities there are typically two blocked-in systems depending on the type of activity, i.e. the X-mas tree (whether or not in combination with lubricator / injector head) and well test equipment.

All direct causes as mentioned in PGS-6 [Ref. 10] and paragraph 5.4.2 of this document were evaluated to see if these can lead to a Loss of Containment scenario during C&WI activities. Based on this assessment it was concluded that following two direct causes are not seen as credible / representative with respect to C&WI activities.

- Pressure low: Underpressure is a threat in case the pressure can drop below the minimum design pressure of equipment. A typical scenario is the unloading of the vessel without pressure equalization (e.g. no vapor return line connected during loading/unloading activities, or failure of pressure regulator valve) or a sudden drop in temperature in a fully closed system, e.g. due to excessive rain fall. These scenarios are however not applicable to C&WI activities, and therefore underpressure is not a credible threat for these operations.
- Vibrations: Vibration is a threat for rotating equipment, in case the equipment is not fully balanced when running at a certain rpm. Rotating equipment is used as part of C&WI activities, i.e. pumps for transfer of liquids. However, for the type of pumps that is used during C&WI activities, vibration is not seen as a credible threat. Note that for this reason "vibration" is also not included as a threat in bow-tie 2A (well test equipment) nor bow-tie 1C (well intervention). Note that relative movement between well and well test equipment (Threat L in bow-tie 2A) is recognized as a threat but the failure mechanism in this case is not vibration/fatigue but in external load. This latter threat is considered as applicable for C&WI activities.

All other direct causes as mentioned in § 5.4.2 are used in the definition of installation scenarios for C&WI activities. All scenarios are summarized in Table A9-1 and discussed in more detail in Table A9-2 upto A9-10.

Table A9-1 Overview of Installation Scenarios C&WI activities

Activity	Scenario	Substance	Direct cause	Root Cause	Effect
A. Well intervention	A.1. Uncontrolled release from production well (tBO)	HC gas	Human error	-	Jet fire (3, 10 and 35 kW/m^2)
	A.2. Leaking/passing injector head (Leak size: 6 mm)	HC gas	Human error	-	Flash fire (50% LEL)
	A.3. Rupture of CC instrument connection (Leak size: 5mm)	HC gas + H_2S (500 ppm)	Mechanical impact	Human error	Toxic dispersion (VRW, AGW, LBW)
	A.4. Leaking/passing quick union (threaded) (Leak size: 1 mm)	HC gas	External load	Human error	Jet fire (3, 10 and 35 kW/m^2)
B. Well testing	B.1 Leakage of (temporary) flowline - upstream of choke (leak size: 0,4 inch)	HC gas	Erosion		Jet fire (3, 10 and 35 kW/m^2)
	B.2 (Pinhole) leakage of tube in steam exchange (Leak size: 2 mm)	HC gas	(Internal) corrosion		Flash fire (50% LEL)
	B.3 Ignited release via PSV on separator vessel (L-type orifice, 18,4 cm^2)	HC gas	Overpressure	Closed valve in gas outlet separator	Flash fire (50% LEL)
	B.4 Rupture of (temporary) flowline - downstream of choke (4 inch)	HC gas	Low temperature (brittle fracture)	Operator error	Jet fire (3, 10 and 35 kW/m^2)
	B.5 Catastrophic failure of gas cylinder (pilot gas)	Propane	Temperature high	Operator error	BLEVE (radius of fireball)

Table A9-2 Installation Scenarios A1: Uncontrolled release from well (tubing blowout)

Scenario A1: Uncontrolled release from well (tubing blowout)		
Installation	Equipment for Well intervention	
Description of scenario		
Scenario description	During a well intervention the control over the well is lost due to a wire break, resulting in an uncontrolled release of gas via the tubing of the well (tubing blowout). Immediate ignition of the gas results in a jet fire on top of the Xmas tree.	
Location of scenario	X-mas tree of well	
Threat (Shell bow-tie) Direct cause (PGS-6)	Human error Note 1)	
Root cause (PGS 6)	-	
LOC type	Catastrophic failure Line rupture Overfilling Leakage (approx. 30 mm) Emission **X** Uncontrolled outflow Other, i.e.: -	
Hazardous substance	Natural gas	
Consequences		
Outflow rate / quantity	Maximum outflow rate : 14,4 kg/s (continuously) Based on a tubing blowout potential (tBOP) of 1.5 MNm^3/d (slim well: 3,5 inch tubing, ID = 74 mm)	
Phase during outflow	**X** Gas Gas/liquid Liquid Solid Gas/vapour Vapour/liquid Vapour	
Outflow conditions (pressure and temperature)	Pressure : 360 barg (CITHP) Temperature : 60 °C Vertical outflow direction	
Type of effect (without LODs)	~~Pool fire~~ / ~~Flash fire~~ / Jet fire / ~~Toxic cloud~~ / ~~Explosion~~ / ~~Fireball~~	
Dimension of maximum effect	Heat radiation from ignited flowline release (vertical direction): 35 kW/m^2 : 11 m 10 kW/m^2 : 27 m 3 kW/m^2 : 48 m	
Description of effects	■ Exceeding battery limit of well test area ■ Exceeding battery limit of installation / facility	
Lines of Defense (LODs)		
Preventive Technical LODs		
Type	**Description**	**SECE**
Process Containment	Internal Blowout Preventer (iBOP)	WS 38.80.31.32-GEN (Pressure Control Manual)
	X-mas tree/BOP to be initiated by operator	WS 38.80.31.32-GEN (Pressure Control Manual)
		PC008 (Operational Well Containment)
Preventive Organizational LODs		
Type	**Description**	**Procedure**
N/A	N/A	N/A
Repressive Technical LODs		
Type	**Description**	**SECE**
Ignition control	Appropriately rated equipment fitted in hazardous and non-hazardous areas	IC003 (Certified Electrical Equipment)

Scenario A1: Uncontrolled release from well (tubing blowout)		
Repressive Organizational LODs		
Type	**Description**	**Procedure**
Ignition control	Compliance with the work instruction on temporary ignition sources and vehicles onsite	NAM-71.WI.76.04 (Managing temporary ignition sources)
Detection systems	Gas alarm (mobile detector) - or visual detection - with operator action (activate ESD button)	WS 38.80.31.34-GEN (Well Test Manual)
Classification of Risk (using the Shell Risk Matrix)		
	Without LODs	**With LODs**
Probability of Major Accident	B	See Note 2)
Consequence of Major Accident	5	See Note 2)
Risk classification		See Note 2)
Additional LODs required: No		

Note 1): Note that according to the ground rules of the NAM bow-ties [Ref. 8] human error is not included as a specific threat in the bow-ties themselves as this is a common threat to all barriers.

Note 2): According to the RAM guide 2016 [Ref. 22] the classification of incident scenarios is based on historical events, i.e. without taking into account the presence of (additional) LODs.

Table A9-3 Installation Scenarios A2: Leaking/ passing injector head

Scenario A2: Leaking/ passing injector head		
Installation	Equipment for Well intervention	
Description of scenario		
Scenario description	Incorrect make-up of the injector head creates a leak path during well intervention. As a consequence, gas releases at a height of 10 meter. Delayed ignition of the released gas results in a flash fire. Note that the flash fire will be followed by a jet fire, but since the installation scenario is focusing on one consequence, this second consequence is not included.	
Location of scenario	X-mas tree (top of injector head).	
Threat (Shell bow-tie) Direct cause (PGS-6)	Human error Note 1)	
Root cause (PGS 6)	-	
LOC type	Catastrophic failure Line rupture Overfilling Leakage (approx. 30 mm) Emission Uncontrolled outflow **X** Other, i.e.: Leakage via injector head (6 mm)	
Hazardous substance	Natural gas	
Consequences		
Outflow rate / quantity	Maximum outflow rate : 1,6 kg/s (continuously)	
Phase during outflow	**X** Gas Gas/liquid Liquid Solid Gas/vapour Vapour/liquid Vapour	
Outflow conditions (pressure and temperature)	Pressure : 360 barg (CITHP) Temperature : 60 °C Vertical outflow direction	
Type of effect (without LODs)	~~Pool fire~~ / Flash fire / ~~Jet fire~~ / ~~Toxic cloud~~ / ~~Explosion~~ / ~~Fireball~~	
Dimension of maximum effect	(Downwind) distance to 50% LEL: 2.8 m (height = 13.5 m) NB: The distance to 50% LEL is used for length of flash fire.	
Description of effects	□ Exceeding battery limit of well test area □ Exceeding battery limit of installation / facility	
Lines of Defense (LODs)		
Preventive Technical LODs		
Type	**Description**	**SECE**
N/A	N/A	N/A
Preventive Organizational LODs		
Type	**Description**	**Procedure**
Miscellaneous	Verification (on site) that all PCE is in possession of valid certificates	eWCAT
	Appropriately make-up PCE including pressure test as per PCM (pressure control manual)	WS 38.80.31.32-GEN (Pressure Control Manual)
Repressive Technical LODs		
Type	**Description**	**SECE**
Ignition control	Appropriately rated equipment fitted in hazardous and non-hazardous areas	IC003 (Certified Electrical Equipment)
Repressive Organizational LODs		
Type	**Description**	**Procedure**
Ignition control	Compliance with the work	NAM-71.WI.76.04

Scenario A2: Leaking/ passing injector head		
	instruction on temporary ignition sources and vehicles onsite	(Managing temporary ignition sources)
Detection systems	Gas alarm (mobile detector) - or visual detection - with operator action (activate ESD button)	WS 38.80.31.34-GEN (Well Test Manual)
Classification of Risk (using the Shell Risk Matrix)		
	Without LODs	**With LODs**
Probability of Major Accident	B	See Note 2)
Consequence of Major Accident	3	See Note 2)
Risk classification		See Note 2)
Additional LODs required: No		

Note 1): Note that according to the ground rules of the NAM bow-ties [Ref. 8] human error is not included as a specific threat in the bow-ties themselves as this is a common threat to all barriers.

Note 2): According to the RAM guide 2016 [Ref. 22] the classification of incident scenarios is based on historical events, i.e. without taking into account the presence of (additional) LODs.

Table A9-4 Installation Scenarios A3: Leakage via instrument connection (CC)

Scenario A3: Leakage via instrument connection (CC)		
Installation	Equipment for Well intervention	
Description of scenario		
Scenario description	During a preparation of the well intervention a closed coupled (CC) instrument connection is knocked-off from the flowline resulting in leak path (hole size: 5 mm). The gas from the well is assumed to be sour (i.e. contains H_2S) and therefore the release of gas results in the dispersion of a toxic cloud.	
Location of scenario	Flowline connected to X-mas tree	
Threat (Shell bow-tie) Direct cause (PGS-6)	Mechanical impact (Threat "K" of bow-tie 1C)	
Root cause (PGS 6)	Human error	
LOC type	Catastrophic failure Line rupture Overfilling Leakage (approx. 30 mm) Emission Uncontrolled outflow **X** Other, i.e.: leakage via CC instrument connection (5 mm)	
Hazardous substance	Natural gas	
Consequences		
Outflow rate / quantity	Maximum outflow rate : 0,76 kg/s (continuously) Note: A location is indicated as an H_2S location in case the H_2S concentration in the gas exceeds 100 ppm. As part of this installation scenario a H_2S concentration of 5 times the threshold value is taken into account (i.e. 500 ppm).	
Phase during outflow	**X** Gas Gas/liquid Liquid Solid Gas/vapour Vapour/liquid Vapour	
Outflow conditions (pressure and temperature)	Pressure : 260 barg (FTHP) Temperature : 60 °C Vertical outflow direction	
Type of effect (without LODs)	~~Pool fire~~ / ~~Flash fire~~ / ~~Jet fire~~ / Toxic cloud / ~~Explosion~~ / ~~Fireball~~	
Dimension of maximum effect	Dispersion of toxic cloud, distance (in m) to H_2S concentration: VRW (2.4 ppm) : F-1.5: 50 m; D-5: 47 m; AGW (39 ppm) : F-1.5: 4 m; D-5: 4 m; LBW (72 ppm) : F-1.5: 2 m; D-5: 2 m.	
Description of effects	■ Exceeding battery limit of well test area ■ Exceeding battery limit of installation / facility	
Lines of Defense (LODs)		
Preventive Technical LODs		
Type	**Description**	**SECE**
N/A	N/A	N/A
Preventive Organizational LODs		
Type	**Description**	**Procedure**
Miscellaneous	All lifting on site is carried out in accordance with a lifting plan and carried out by certified / competent personnel. For non-routine complex lifts a SME for Lifting and hoisting involvement is required to establish the lifting plan.	NAM-71.WI.76.13 (Hef- en hijsactiviteiten)
Repressive Technical LODs		
Type	**Description**	**SECE**
N/A	N/A	N/A

Scenario A3: Leakage via instrument connection (CC)		
Repressive Organizational LODs		
Type	**Description**	**Procedure**
Detection systems	Gas alarm (mobile detector) - or visual detection - with operator action (activate ESD button)	WS 38.80.31.34-GEN (Well Test Manual)
Detection systems	Fixed gas detection (H2S) to alert personnel at site - correct functioning verified at location prior to start of activities	-
Classification of Risk (using the Shell Risk Matrix)		
	Without LODs	**With LODs**
Probability of Major Accident	C	See Note 1)
Consequence of Major Accident	4	See Note 1)
Risk classification		See Note 1)
Additional LODs required: No		

Note 1): According to the RAM guide 2016 [Ref. 22] the classification of incident scenarios is based on historical events, i.e. without taking into account the presence of (additional) LODs.

Table A9-5 Installation Scenarios A4: Leaking/passing quick union

Scenario A4: Leaking/passing quick union		
Installation	Equipment for Well intervention	
Description of scenario		
Scenario description	External load on a quick union, a threated connecting between two lubricator pipe sections, caused by lateral movement of well results in a release of gas via the threated connection during the well intervention. Immediate ignition of this gas results in a jet fire.	
Location of scenario	X-mas tree (quick union connecting tree and lubricator pipe)	
Threat (Shell bow-tie) Direct cause (PGS-6)	External load (caused by lateral movement of well) (Threat "L" of bow-tie 1C)	
Root cause (PGS 6)	Human error	
LOC type	Catastrophic failure Line rupture Overfilling Leakage (approx. 30 mm) Emission Uncontrolled outflow **X** Other, i.e.: Leakage via threaded connection (1 mm)	
Hazardous substance	Natural gas	
Consequences		
Outflow rate / quantity	Maximum outflow rate : 0,042 kg/s (continuously) This maximum outflow rate is based on the release rate via the threaded connection for which a typical leak size (d = 1 mm) is taken into account.	
Phase during outflow	**X** Gas Gas/liquid Liquid Solid Gas/vapour Vapour/liquid Vapour	
Outflow conditions (pressure and temperature)	Pressure : 360 barg (CITHP) Temperature : 60 °C Vertical outflow direction	
Type of effect (without LODs)	~~Pool fire~~ / ~~Flash fire~~ / Jet fire / ~~Toxic cloud~~ / ~~Explosion~~ / ~~Fireball~~	
Dimension of maximum effect	Heat radiation from ignited flowline release (vertical direction): 35 kW/m^2 : 1,2 m 10 kW/m^2 : 1,6 m 3 kW/m^2 : 2,2 m	
Description of effects	□ Exceeding battery limit of well test area □ Exceeding battery limit of installation / facility	
Lines of Defense (LODs)		
Preventive Technical LODs		
Type	**Description**	**SECE**
N/A	N/A	N/A
Preventive Organizational LODs		
Type	**Description**	**Procedure**
Miscellaneous (leak test)	Pressure test (liquid) to demonstrate the integrity of the well test package.	WS 38.80.31.32-Gen (Pressure Control Manual for Drilling Completion and Well Intervention Operations)
Repressive Technical LODs		
Type	**Description**	**SECE**
Ignition control	Appropriately rated equipment fitted in hazardous and non-hazardous areas	IC003 (Certified Electrical Equipment)

Scenario A4: Leaking/passing quick union		
Repressive Organizational LODs		
Type	**Description**	**Procedure**
Ignition control	Compliance with the work instruction on temporary ignition sources and vehicles onsite	NAM-71.WI.76.04 (Managing temporary ignition sources)
Detection systems	Gas alarm (mobile detector) - or visual detection - with operator action (activate ESD button)	WS 38.80.31.34-GEN (Well Test Manual)
Classification of Risk (using the Shell Risk Matrix)		
	Without LODs	**With LODs**
Probability of Major Accident	B	See Note 1)
Consequence of Major Accident	3	See Note 1)
Risk classification		See Note 1)
Additional LODs required: No		

Note 1): According to the RAM guide 2016 [Ref. 22] the classification of incident scenarios is based on historical events, i.e. without taking into account the presence of (additional) LODs.

Table A9-6 Installation Scenarios B1: Leakage of flow line upstream of choke

Scenario B1: Leakage of flow line upstream of choke		
Installation	Well test equipment	
Description of scenario		
Scenario description	Sand production from the well will lead to excessive erosion in the flowline of the well test set-up, especially at bends. The most likely consequence of erosion is a leakage of the flowline which after immediate ignition, will result in a jet fire.	
Location of scenario	Flowline, upstream of the choke	
Threat (Shell bow-tie) Direct cause (PGS-6)	Erosion (Threat "E" of bow-tie 2A)	
Root cause (PGS 6)	Sand particles present in gas flow from well	
LOC type	Catastrophic failure Line rupture Overfilling Leakage (approx. 30 mm) Emission Uncontrolled outflow **X** Other, i.e.: pinhole in tube (1 mm)	
Hazardous substance	Natural gas	
Consequences		
Outflow rate / quantity	Maximum outflow rate : 3,3 kg/s (continuously) This maximum outflow rate is based on a leak size of 10% of the flowline diameter (i.e. 0,1 x 4 inch).	
Phase during outflow	**X** Gas Gas/liquid Liquid Solid Gas/vapour Vapour/liquid Vapour	
Outflow conditions (pressure and temperature)	Pressure : 260 barg (FTHP) Temperature : 40 °C Vertical outflow direction	
Type of effect (without LODs)	~~Pool fire~~ / ~~Flash fire~~ / Jet fire / ~~Toxic cloud~~ / ~~Explosion~~ / ~~Fireball~~	
Dimension of maximum effect	Heat radiation from ignited flowline release (horizontal direction): 35 kW/m^2 : 20 m 10 kW/m^2 : 24 m 3 kW/m^2 : 29 m	
Description of effects	■ Exceeding battery limit of well test area ■ Exceeding battery limit of installation / facility	
Lines of Defense (LODs)		
Preventive Technical LODs		
Type	**Description**	**SECE**
Miscellaneous	Design accounts for predicted sand production and erosion threats	-
Shutdown systems	(optional) Erosion probes (EP) + automatic trip function (ESD)	WS 38.80.31.34-GEN (Well Test Manual)
Type	**Description**	**Procedure**
Detection systems	Sand detection by use of e.g. Sand filers/catcher, Sampling, erosion probe, (Acoustic) Sand monitors and follow-up in case of solids, at least every 2 hours wall thickness measurements during testing. Intervene if required.	EP2006-5393 (Shell Global Standard for temporary pipework)
	(optional) Erosion probes (EP) + alarm with operator action	WS 38.80.31.34-GEN (Well Test Manual)

Scenario B1: Leakage of flow line upstream of choke		
Miscellaneous	3rd party Inspection on pressurized equipment as per PED	WS 38.80.31.34-GEN (Well Test Manual)
Repressive Technical LODs		
Type	**Description**	**SECE**
Ignition control	Appropriately rated equipment fitted in hazardous and non-hazardous areas	IC003 (Certified Electrical Equipment)
Repressive Organizational LODs		
Type	**Description**	**Procedure**
Ignition control	Compliance with the work instruction on temporary ignition sources and vehicles onsite	NAM-71.WI.76.04 (Managing temporary ignition sources)
Detection systems	Gas alarm (mobile detector) - or visual detection - with operator action (activate ESD button)	WS 38.80.31.34-GEN (Well Test Manual)
Classification of Risk (using the Shell Risk Matrix)		
	Without LODs	**With LODs**
Probability of Major Accident	B	See Note 1)
Consequence of Major Accident	4	See Note 1)
Risk classification		See Note 1)
Additional LODs required: No		

Note 1): According to the RAM guide 2016 [Ref. 22] the classification of incident scenarios is based on historical events, i.e. without taking into account the presence of (additional) LODs.

Table A9-7 Installation Scenarios B2: Pinhole leakage of tube/shell steam exchanger

Scenario B2: Pinhole leakage of tube/shell steam exchanger		
Installation	Well test equipment	
Description of scenario		
Scenario description	To prevent too low temperatures downstream of the choke, cold gas is first heated-up in a (tube/shell) steam exchanger before entering the choke. Gas flows though the tube side of the exchanger and steam flows at the shell side, which is at lower design pressure (DP) than the tube. A leak in the tube will therefore exceed the DP of the shell side and subsequently result in a loss of containment of gas. Delayed ignition of the gas results in a flash fire. Note that the flash fire will be followed by a jet fire, but since the installation scenario is focusing on one consequence, this second consequence is not included.	
Location of scenario	Steam exchanger	
Threat (Shell bow-tie) Direct cause (PGS-6)	Corrosion (Threat "C" of bow-tie 2A)	
Root cause (PGS 6)	-	
LOC type	Catastrophic failure Line rupture Overfilling Leakage (approx. 30 mm) Emission Uncontrolled outflow **X** Other, i.e.: pinhole leak in tube (1 mm)	
Hazardous substance	Natural gas	
Consequences		
Outflow rate / quantity	Maximum outflow rate : 0,035 kg/s (continuously) This maximum outflow rate is based on the release rate via the pinhole in the tube. Note that the leak on the shell side of the exchanger might be bigger than the leak on the tube side, but this former leak size is not determining the outflow rate.	
Phase during outflow	**X** Gas Gas/liquid Liquid Solid Gas/vapour Vapour/liquid Vapour	
Outflow conditions (pressure and temperature)	Pressure : 260 barg (FTHP) Temperature : 40 °C Horizontal outflow direction	
Type of effect (without LODs)	~~Pool fire~~ / Flash fire / ~~Jet fire~~ / ~~Toxic cloud~~ / ~~Explosion~~ / ~~Fireball~~	
Dimension of maximum effect	(Downwind) distance to 50% LEL: 2,5 meter. NB: The distance to 50% LEL is used for length of flash fire.	
Description of effects	□ Exceeding battery limit of well test area □ Exceeding battery limit of installation / facility	
Lines of Defense (LODs)		
Preventive Technical LODs		
Type	**Description**	**SECE**
Shutdown systems	Automatic trip function (ESD) upon high pressure on basis of PSH (shell side) which will close the ESD valve at the inlet of the well test package.	WS 38.80.31.34-GEN (Well Test Manual)
Process Containment	Pressure Safety Valve (shell side) to release the overpressure in a controlled manner.	WS 38.80.31.34-GEN (Well Test Manual)

Scenario B2: Pinhole leakage of tube/shell steam exchanger		
Preventive Organizational LODs		
Type	**Description**	**Procedure**
Pressure test	Pressure test (liquid) to demonstrate the integrity of the well test package.	WS 38.80.31.32-Gen (Pressure Control Manual for Drilling Completion and Well Intervention Operations)
Repressive Technical LODs		
Type	**Description**	**SECE**
Ignition control	Appropriately rated equipment fitted in hazardous and non-hazardous areas	IC003 (Certified Electrical Equipment)
Repressive Organizational LODs		
Type	**Description**	**Procedure**
Ignition control	Compliance with the work instruction on temporary ignition sources and vehicles onsite	NAM-71.WI.76.04 (Managing temporary ignition sources)
Detection systems	Gas alarm (mobile detector) - or visual detection - with operator action (activate ESD button)	WS 38.80.31.34-GEN (Well Test Manual)
Classification of Risk (using the Shell Risk Matrix)		
	Without LODs	**With LODs**
Probability of Major Accident	B	See Note 1)
Consequence of Major Accident	4	See Note 1)
Risk classification		See Note 1)
Additional LODs required: No		

Note 1): According to the RAM guide 2016 [Ref. 22] the classification of incident scenarios is based on historical events, i.e. without taking into account the presence of (additional) LODs.

Table A9-8 Installation Scenarios B3: Release of gas via PSV on separator vessel

Scenario B3: Release of gas via PSV on separator vessel		
Installation	Well test equipment	
Description of scenario		
Scenario description	During the well test the gas outlet line of the horizontal separator vessel (used offshore) is blocked by a closed hand valve. As a consequence, the pressure inside the separator increases up to the design pressure after which the PSV is activated to prevent further increase in pressure. Delayed ignition of the gas that has been released via the PSV results in a flash fire. Note that the flash fire will be followed by a jet fire, but since the installation scenario is focusing on one consequence, this second consequence is not included.	
Location of scenario	Horizontal separator vessel	
Threat (Shell bow-tie) Direct cause (PGS-6)	Overpressure (Threat "A" of bow-tie 2A)	
Root cause (PGS 6)	Human error	
LOC type	Catastrophic failure Line rupture Overfilling Leakage (approx. 30 mm) Emission Uncontrolled outflow **X** Other, i.e.: activation PSV	
Hazardous substance	Natural gas	
Consequences		
Outflow rate / quantity	Maximum outflow rate : 28,6 kg/s (continuously) The outflow rate is calculated based on a PSV with L-type orifice (i.e 18,4 cm^2) and setting of 90 barg.	
Phase during outflow	**X** Gas Gas/liquid Liquid Solid Gas/vapour Vapour/liquid Vapour	
Outflow conditions (pressure and temperature)	Pressure : 90 barg Temperature : 40 °C Vertical outflow direction	
Type of effect (without LODs)	~~Pool fire~~ / Flash fire / ~~Jet fire~~ / ~~Toxic cloud~~ / ~~Explosion~~ / ~~Fireball~~	
Dimension of maximum effect	(Downwind) distance to 50% LEL: 12 meter. NB: The distance to 50% LEL is used for length of flash fire.	
Description of effects	■ Exceeding battery limit of well test area □ Exceeding battery limit of installation / facility	
Lines of Defence (LODs)		
Preventive Technical LODs		
Type	**Description**	**SECE**
Shutdown systems	Automatic trip function (ESD) upon high pressure on basis of PSH which will close the ESD valve at the inlet of the well test package.	WS 38.80.31.34-GEN (Well Test Manual)
Preventive Organizational LODs		
Type	**Description**	**Procedure**
Miscellaneous	"Walk the Line" to assure that the equipment is lined up as per piping and instrumentation diagram (P&ID)	WS 38.80.31.34-Gen (Well Test Manual)

Scenario B3: Release of gas via PSV on separator vessel		
Repressive Technical LODs		
Type	**Description**	**SECE**
Ignition control	Appropriately rated equipment fitted in hazardous and non-hazardous areas	IC003 (Certified Electrical Equipment)
Repressive Organizational LODs		
Type	**Description**	**Procedure**
Ignition control	Compliance with the work instruction on temporary ignition sources and vehicles onsite	NAM-71.WI.76.04 (Managing temporary ignition sources)
Detection systems	Gas alarm (mobile detector) - or visual detection - with operator action (activate ESD button)	WS 38.80.31.34-GEN (Well Test Manual)
Classification of Risk (using the Shell Risk Matrix)		
	Without LODs	**With LODs**
Probability of Major Accident	B	See Note 1)
Consequence of Major Accident	4	See Note 1)
Risk classification		See Note 1)
Additional LODs required: No		

Note 1): According to the RAM guide 2016 [Ref. 22] the classification of incident scenarios is based on historical events, i.e. without taking into account the presence of (additional) LODs.

Table A9-9 Installation Scenarios B4: Release via rupture of flowline downstream choke

Scenario B4: Release via rupture of flowline downstream choke		
Installation	Well test equipment	
Description of scenario		
Scenario description	Gas from the reservoir is choked to control the flow towards the well test equipment. As a consequence, the temperature of the gas drops (JT-effect). In case of initial (cold) start -up of a well, the temperature might drop below minimum DT of flow line with potential for brittle fracture. In case of brittle fracture, immediate ignition of gas will result in a jet fire.	
Location of scenario	Downstream of choke	
Threat (Shell bow-tie) Direct cause (PGS-6)	Low temperature (brittle fracture) (Threat "B" of bow-tie 2A)	
Root cause (PGS 6)	Human error	
LOC type	Catastrophic failure **X** Line rupture Overfilling Leakage (approx. 30 mm) Emission Uncontrolled outflow Other, i.e.:	
Hazardous substance	Natural gas	
Consequences		
Outflow rate / quantity	Maximum outflow rate : 48,3 (= 32,2 x 1,5) kg/s (continuously) The maximum outflow rate is calculated for an outflow in one direction multiplied by a factor of 1,5 to include backflow.	
Phase during outflow	**X** Gas Gas/liquid Liquid Solid Gas/vapour Vapour/liquid Vapour	
Outflow conditions (pressure and temperature)	Pressure : 40 barg (FTHP) Temperature : 40 °C Horizontal outflow direction	
Type of effect (without LODs)	~~Pool fire~~ / ~~Flash fire~~ / Jet fire / ~~Toxic cloud~~ / ~~Explosion~~ / ~~Fireball~~	
Dimension of maximum effect	Heat radiation from ignited flowline release (horizontal direction): 35 kW/m^2 : 75 m 10 kW/m^2 : 87 m 3 kW/m^2 : 111 m	
Description of effects	■ Exceeding battery limit of well test area ■ Exceeding battery limit of installation / facility	
Lines of Defense (LODs)		
Preventive Technical LODs		
Type	**Description**	**SECE**
Miscellaneous	During design low temperatures are assessed and either controlled by inherent safe design or by the use of Start-up heater to prevent too low temperatures during cold start-up of well	WS 38.80.31.34-GEN (Well Test Manual)
Preventive Organizational LODs		
Type	**Description**	**Procedure**
Miscellaneous	CSU procedure to prevent too low temperatures during cold start-up of well	WS 38.80.31.34-GEN (Well Test Manual)

Scenario B4: Release via rupture of flowline downstream choke		
Repressive Technical LODs		
Type	**Description**	**SECE**
Ignition control	Appropriately rated equipment fitted in hazardous and non-hazardous areas	IC003 (Certified Electrical Equipment)
Repressive Organizational LODs		
Type	**Description**	**Procedure**
Ignition control	Compliance with the work instruction on temporary ignition sources and vehicles onsite	NAM-71.WI.76.04 (Managing temporary ignition sources)
Detection systems	Gas alarm (mobile detector) - or visual detection - with operator action (activate ESD button)	WS 38.80.31.34-GEN (Well Test Manual)
Classification of Risk (using the Shell Risk Matrix)		
	Without LODs	**With LODs**
Probability of Major Accident	B	See Note 1)
Consequence of Major Accident	5	See Note 1)
Risk classification		See Note 1)
Additional LODs required: No		

Note 1): According to the RAM guide 2016 [Ref. 22] the classification of incident scenarios is based on historical events, i.e. without taking into account the presence of (additional) LODs.

Table A9-10 Installation Scenarios B5: Catastrophic failure of gas cylinder (pilot gas)

Scenario B5: Catastrophic failure of gas cylinder (pilot gas)		
Installation	Well test equipment (typically onshore)	
Description of scenario		
Scenario description	During the set-up of the well test package, propane cylinders used for supply of pilot gas for burners of flare are accidentally positioned inside the 12.5 kW/m^2 contour of the silent flare. As a consequence, the propane cylinders are exposed to this critical heat load during the period of flaring, resulting in a BLEVE of a gas cylinder. Immediate ignition of the propane results in a fireball.	
Location of scenario	Proximity of Silent Flare (SF)	
Threat (Shell bow-tie) Direct cause (PGS-6)	External heat load from flare / High temperature	
Root cause (PGS 6)	Human error (Threat "K" of bow-tie 2A)	
LOC type	**X** Catastrophic failure Line rupture Overfilling Leakage (approx. 30 mm) Emission Uncontrolled outflow Other, i.e.:	
Hazardous substance	Propane	
Consequences		
Outflow rate / quantity	Maximum outflow rate : 80 liter (instantaneous)	
Phase during outflow	Gas **X** Gas/liquid Liquid Solid Gas/vapour Vapour/liquid Vapour	
Outflow conditions (pressure and temperature)	Pressure : 30 barg Temperature : 70 °C	
Type of effect (without LODs)	~~Pool fire~~ / ~~flash fire~~ / ~~jet fire~~ / ~~Toxic cloud~~ / ~~explosion~~ / Fireball	
Dimension of maximum effect	Radius of fireball: 8 meter Note: due to the limited duration (few seconds) of the BLEVE, only direct flame contact (radius of fireball / distance to heat load of 35 kW/m^2) are relevant.	
Description of effects	□ Exceeding battery limit of well test area □ Exceeding battery limit of installation / facility	
Lines of Defence (LODs)		
Preventive Technical LODs		
Type	**Description**	**SECE**
N/A	N/A	N/A
Preventive Organizational LODs		
Type	**Description**	**Procedure**
Miscellaneous	Verification that layout of well test equipment is per design (Design of well test set-up, no equipment inside 12.5 kW/m^2 contour)	WS.38.80.31.34-GEN (Well Test Manual)
Repressive Technical LODs		
Type	**Description**	**SECE**
Ignition control	Appropriately rated equipment fitted in hazardous and non-hazardous areas	IC003 (Certified Electrical Equipment)
Repressive Organizational LODs		
Type	**Description**	**Procedure**
Ignition control	Compliance with the work instruction on temporary ignition sources and vehicles onsite	NAM-71.WI.76.04 (Managing temporary ignition sources)

Scenario B5: Catastrophic failure of gas cylinder (pilot gas)		
Classification of Risk (using the Shell Risk Matrix)		
	Without LODs	**With LODs**
Probability of Major Accident	B	See Note 1)
Consequence of Major Accident	4	See Note 1)
Risk classification		See Note 1)
Additional LODs required: No		

Note 1): According to the RAM guide 2016 [Ref. 22] the classification of incident scenarios is based on historical events, i.e. without taking into account the presence of (additional) LODs.

NAM

Appendix 10 Shell Wells Manuals

Number	Status	Title
		HSSE
38.80.00.15	Live	Prevention of Dropped Objects
EP 2006-5393	Live	Shell Global Standard for Temporary Pipework
38.80.31.11	Live	Management of Change and Deviation
38.80.31.10	Live	Wells HSSE & SP
38.80.01.01	Live	Wells Guide to HSSE Assurance

		Wells Governing Documents
SR.11.10895	Live	Global Wells Management System
EP 2008-9087	Live	Wells Framework
38.80.00.10	Live	Manual for Global Wells Publications
SR.14.10765	Live	Global Well Delivery Process
38.80.00.14	Live	Wells Quality Manual
38.80.00.13	Live	Well Cost Estimating
38.80.00.30	Live	Operations Reporting
		Discipline Authority Manual

		Technical
38.80.31.31	Live	Casing and Tubing Design
38.80.31.38	Live	Cementing
38.80.31.32	Live	Pressure Control Manual for Drilling, Completions and Well Interventions
38.80.31.33	Live	Relief Well
38.80.32.32	Live	Rig Start
38.80.32.31	Live	Snubbing
38.80.31.35	Live	Well Abandonment
38.80.31.30	Live	Well Integrity
38.80.31.36	Live	Well Stimulation
38.80.31.34	Live	Well Testing
38.80.31.37	Live	Wellhead and Christmas Tree
38.80.32.30	Live	Borehole Surveying
38.80.01.02	Live	Wells Guide to Small Bore Fitting and Tubing Installation
38.80.01.03	Live	**Wells line of fire**
38.80.31.12	Live	**Wells industrial automation and control systems security**
38.80.32.34	Live	**Temporary Pipework Manual**