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GP 48-50

Major Accident Risk (MAR) Process

This Group Defined ETP has been approved by the GVP Safety and Operations for implementation across the BP Group.

BP GROUP
ENGINEERING TECHNICAL PRACTICES

EXHIBIT # 1734
WIT:

Foreword

This issue of Engineering Technical Practice (ETP) GP 48-50 includes the following significant changes:

1. Improved clarity on scope and applicability of MAR process.
2. Incorporation of offshore MAR methodology.
3. Incorporation of recommended methodology for assessing temporary activities.
4. Significantly reformatted to reflect that much content is actually 'commentary' thus improving clarity of the requirements.

These changes were so extensive that revisions have not been indicated in the margin as is normal practice.

BP believes it is appropriate to supplement its general safety efforts with a specific process safety effort to focus on continuous reduction in the risk of potential major accidents.

The MAR process is a high level quantified risk assessment with a consistent approach for all BP operations that have the potential to give rise to a major accident (i.e., one that could theoretically cause multiple fatalities and/or severe damage to the environment). These include sites that are covered by the U.S. EPA Risk Management Plan (RMP), the European Seveso Directive legislation, and the UK Offshore Safety Case Regulations. The MAR process identifies "societal risk" (i.e., risk of multiple fatalities rather than "individual risk").

The MAR process provides management across BP with an understanding of risk and, thus, where to focus risk reduction efforts. A variety of other hazard identification and risk analysis tools should be used to support risk management in existing operations and capital projects. These may include techniques, such as designing to comply with recognised national and industry standards and codes of practice, hazard identification (HAZID), layers of protection analysis (LOPA), hazard and operability studies (HAZOP), and quantified risk assessment (QRA).

Inherent in the MAR approach is the principle of continuous risk reduction for risks to people and the environment. BP Operation leaders are accountable for risk reduction plans for their operation. The BP Group has however defined a level of societal risk above which the risks and associated mitigation and risk reduction plans are reported to the Group.

This document has been classified as "BP Confidential" because it contains confidential information regarding the type of major accident risks that are reported to the Group level, and it shall be handled in a manner consistent with that classification.

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1. Scope

This GP describes requirements of the MAR process.

2. Normative references

The following referenced documents may, to the extent specified in subsequent clauses and normative annexes, be required for full compliance with this GP:

- For dated references, only the edition cited applies.
- For undated references, the latest edition of the referenced document (including any amendments) applies.

BP

GDP 31-00-01	Assessment, prioritisation, and management of risk.
GDP 44-00-01	Reporting HSSE and Operational Incidents.
GN 48-003	Individual Risk.
GN 48-004	Assessing Major Accident Risk for Temporary Activities.
GP 48-04	Inherently Safer Design (ISD).
GRP STD 01	Group Standard for Integrity Management.

Energy Institute (EI)

PARLOC 2001	Pipeline and riser loss of containment database.

3. Terms and definitions

For the purposes of this GP, the following terms and definitions apply:

Base case MAR study

MAR study reflecting normal operating conditions (all plant running normally and no transient populations due to activities, such as turnarounds or project construction).

BP Operation

BP Strategic Performance Units, Business Units, projects, facilities, sites, and operations.

Catastrophic release

Sudden and total loss of containment representing a "worst case" release event.

Delegated individual

A person with authority delegated by the Group SPA MAR to perform a specific role relating to MAR.

Engineering plan

An annual plan developed by the BP Operation summarising IM and engineering planning and activities, including a programme for implementing Site Technical Practice development.

Entity (BP entity or Operating entity)

Whilst these terms are not used in this GP they have a specific meaning in OMS. If this GP refers to BP Operation it should be interpreted as BP Entity or Operating Entity when working to OMS.

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Group single point of accountability (SPA) MAR

The person at Group level with the overall responsibility for developing and maintaining the MAR process.

Major accident

An incident with the potential for either/or:

a. Three or more fatalities.

b. Major damage to the environment leading to a potentially serious adverse societal reaction as described in Annex E.

Major accident risk (MAR)

The combination of likelihood and consequence of major accidents. This is usually expressed in graphical format as an F-N curve for risks to people, and as an F-E curve for risk to the environment.

Major release

A smaller failure (relative to a catastrophic release) representing a "more likely" release event.

Quantified risk assessment (QRA)

An assessment that quantifies risk based on the likelihood and consequences of major accidents. A MAR study is a type of QRA conducted using a specific methodology, data, and assumptions. Other QRA studies may be both broader ("full QRA") and more detailed ("detailed QRA") than a MAR assessment.

4. Symbols and abbreviations

For the purpose of this GP, the following symbols and abbreviations apply:

AEA	Atomic Energy Authority.
ALARP	As low as reasonably practical.
BLEVE	Boiling liquid expanding vapour explosion.
CRR	Continuous risk reduction.
CVP	Capital value process.
D	Diameter.
E&P	Exploration and Production.
EA	Engineering authority.
ESD	Emergency shutdown.
F-E	Cumulative frequency (F) against environmental impact (E).
F-N	Cumulative frequency (F) against number of fatalities (N).
FBR	Full bore rupture.
HAZID	Hazard identification.

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HAZOP	Hazard and operability (study).
HP	High pressure.
HSSE	Health, safety, security, environment.
HPHT	High pressure, high temperature.
HVAC	Heating, ventilation, and air conditioning.
IM	Integrity management.
ISD	Inherently safe design.
JV	Joint venture.
KO	Knockout.
LD	Lethal dose.
LFL	Lower flammable limit.
LNG	Liquefied natural gas.
LOPA	Layers of protection analysis.
LP	Low pressure.
MAR	Major accident risk.
PERC	Powered emergency release coupling.
PRV	Pressure relief valve.
QRA	Quantified risk assessment.
RMP	Risk management plan.
SCEWO	Safety critical equipment work orders.
SIS	Safety instrumented system.
SIL	Safety integrity level.
SLOD	Significant likelihood of death.
SLOT	Significant level of toxicity.
SPA	Single point of accountability.
SPU	Strategic performance unit.
TEMPSC	Totally enclosed motor propelled survival craft.
TNO	The Netherlands Organisation for Applied Scientific Research.
UKCS	United Kingdom Continental Shelf.

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VCE Vapour cloud explosion.

WEV Weighted expectation value.

5. Applicability

a. GRP STD 01, section 1.2, shall be interpreted and applied as follows with respect to the applicability of the MAR process:

1. If BP does not have operational control of a Joint Venture, BP shall, after an appropriate risk assessment, endeavour to conduct a MAR study with the cooperation of the operator of the JV.
2. If BP relies on a contractor to perform work that would be subject to GRP STD 01 if performed by BP employees, or uses a third party for the movement of BP products, BP shall, after an appropriate risk assessment, endeavour to conduct a MAR study with the cooperation of the contractor/third party.
3. If 1 or 2 applies, the results of the MAR study shall be used to inform BP strategy on continuance or modification of BP involvement in the activity.

b. The following events shall be included in the MAR process if they have the potential to cause a major accident (unless excluded or made optional in 5.d through 5.f):

1. Accidental releases of hazardous materials.
2. External events and natural events with the potential to affect offshore structures.
3. Non process fires on offshore structures.
4. Transportation by helicopter, fixed wing aircraft, or boat if the transport is specifically contracted for the movement of BP workforce to and from BP Operations and if BP could directly affect risks to personnel by a change in the logistics of the operation.
5. Transportation risks due to the movement of BP workforce by road, if the movement of personnel fulfils all of the following conditions:
   a) It is specifically contracted for the movement of BP workforce to and from BP Operations and if BP could directly affect the risks to personnel by a change in the logistics of the operation.
   b) It is a regular operation (greater than once a month).
   c) It involves transportation of more than 5 people.
   d) It involves transportation in a single journey over a distance greater than 50 km (30 mi).

c. The MAR process is used to evaluate events at BP Operations and should only be used to evaluate events arising outside BP Operations (e.g., arising near or next to BP Operations) if:

1. The BP workforce can be affected by those events.
2. BP Operations can take steps to mitigate those events or the risks arising from them. Such an event should be included in the CRR part of the MAR process but not included in the F-N curve.

d. The following should not be included in the MAR process:

1. Accidents affecting onshore buildings (e.g., building fires, natural events, structural collapse, and external impact), unless due to a release of a hazardous substance.
2. Road traffic accidents, unless they:

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a) Involve a release of hazardous material.

b) Involve regular mass transportation as defined in 5.b.

3. Transportation accidents involving BP workforce travelling on normal scheduled services (i.e., public transport).
4. Delayed health effects (e.g., carcinogenic effects), fatal or otherwise, due to accidental or occupational exposure.
5. Pollution arising from long term discharges.
6. Health related events (Legionnaires' disease, food poisoning, occupational exposures, contagious illness, etc.).
7. Occupational safety related injuries or fatalities (slips, trips, falls, construction activities, etc.).
8. Fatalities amongst dedicated emergency responders when tackling an incident.
9. Non accidental events (e.g., design basis events such as flare operation during venting).
10. Events that do not comply with to the definition of a major accident.

e. The following accidental events may be included in the MAR process:

1. Accidental releases of hazardous materials resulting only in economic loss.
2. External events and natural events affecting offshore structures resulting only in economic loss.
3. Major accidental releases of hazardous materials associated with security incidents, including terrorism, sabotage, and theft.

Further guidance on applicability and scope in the MAR context is available from the Group SPA MAR or delegated individual.

f. Before any MAR study is conducted, the scope of the study shall be clearly established and agreed with the BP Operations leader.

6. Objectives of the MAR process

The BP goal is to drive continuous risk reduction throughout the entire range of MAR, with the ultimate goal of no accidents, no harm to people, and no damage to the environment.

6.1. Objectives

a. The objectives of the MAR process are to:

1. Ensure a consistent approach to assessing and quantifying MAR across BP.
2. Provide a basis for identifying areas of higher MAR.
3. Provide assurance that the overall BP MAR is understood.
4. Drive a process of continuous reduction of MAR across BP.

b. BP Operations shall actively seek measures to reduce major accident risk and prioritise their actions based on the level of achievable risk reduction, taking into account such factors as feasibility and cost effectiveness.

The concept of CRR recognises that the resources available to reduce risk are not infinite, but that BP actively seeks measures to reduce risk and prioritise these

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measures in relation to their risk reduction effectiveness. Several options for demonstrating CRR are discussed in Annex D.

6.2. Intent

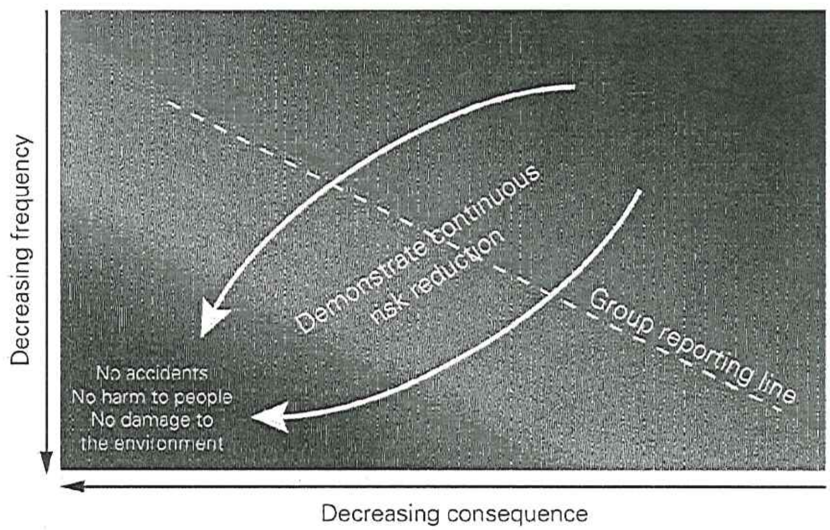
a. The intent of the MAR process is described in Figure 1.

b. GRP STD 01, Element 3, describes the steps to be taken, depending on whether an activity is found to be above or below the Group reporting line.

c. The CRR requirement in the GRP STD 01 for activities found to be below the Group reporting line demonstrates that the group reporting line is not a "target" and that activities that fall below the line may not have fully completed activity in terms of risk mitigation.

The Group reporting line does not define an acceptable/tolerable level of risk but rather a level of risk that is sufficiently high to warrant Group attention.

Figure 1 - Approach to major accident risk



6.3. Features of the MAR process

The benefits of the MAR process are:

- *The approach requires typically approximately a few weeks study per major facility as compared to approximately 1 yr for a full QRA.*
- *The MAR process leads to a consistent evaluation across all operations.*
- *The highest risks receive Group level attention while establishing the principle of continuous risk reduction across all operations.*

The limitations of the MAR process are:

- *The frequencies derived at unit/system level are based on BP historical and worldwide experience and reflect "average" facility design and operational failure rates. Equipment design and/or operation that is much better or worse than the average will generally not be taken into account. An exception to this is the use of the offshore leak data that is based on North Sea data and may be adjusted to reflect local leak experience (see Annex G).*

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- *It is a high level process for the evaluation of MAR and is not intended to provide appropriate design criteria.*

7. Types of risk covered

a. The MAR process shall be applied to major accident events arising from both fixed facilities and transport operations.

b. MAR study shall include the characterisation of three discrete types of risk:

1. The societal risk to the "onsite population". This population includes anyone physically located on BP facilities (including visitors and contractors) and anyone employed in BP Operations or working in oil and gas industry on facilities close to BP Operations. For BP road and rail operations, this definition includes any other users of the infrastructure (motorists and rail passengers), for pipelines, people on pump stations, and for shipping operations, the ship crew.
2. The societal risk to the "offsite population". Offsite population includes anyone offsite and not employed in BP Operations or oil and gas industry. For BP transport operations, this includes anyone living alongside transport routes used by BP Operations but not other infrastructure users, such as motorists and rail passengers. If there are no "offsite" populations affected from the site, this shall be documented in the MAR report.
3. The environmental risk associated with damage to the environment from BP facilities or operations.

Societal risk is framed in terms of the number of people who could sustain fatal injuries if a hypothetical major accident were to occur. Environmental risk is framed in terms of the degree of public reaction to the incident as a reflection of the value society places on a damaged ecosystem.

By definition, the MAR process focuses on the unlikely, high consequence accidents, thereby requiring attention to these risks. It requires development of hypothetical scenarios.

Identification of risk by this process will motivate further continuous improvement but does not imply that BP has subjected or will subject those directly involved in the oil and gas industry or the public, to unreasonable risk.

c. This GP requires the assessment of societal and environmental risk only. Facilities may also choose to assess individual risk and economic risk from major accidents. Guidance on individual risk is provided in GN 48-003.

8. Accountability

a. The BP Operations leader shall be accountable for:

1. Ensuring that a MAR study is conducted in line with the requirements of 10.b, 10.c, 10.d, and 10.i.
2. Ensuring that a report is prepared and reviewed in line with requirements of 10.j.
3. Ensuring that the results and any associated action plan are communicated to the appropriate level.
4. Updating the study and report.

b. The report on the risks and accompanying mitigating action plan shall be owned by the BP Operations leader and shall be reviewed by the facility EA and the SPA for IM.

c. The Group SPA MAR shall be responsible for:

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1. Ownership of the technical aspects of the MAR process.
2. Development and ownership of the onshore and offshore MAR Calculators.
3. Assignment of the Group reporting line to BP Operations.
4. Resolution of issues over scope and applicability of MAR process.
5. Review of MAR reports.
6. Endorsement of MAR study leader competency.

9. Temporary activities

a. The base case MAR study shall include regular and predictable transient activities that are part of normal operations (e.g., normal plant maintenance, drilling, wirelining, and workovers) and populations (e.g., a major sporting event occurring on a weekly basis). For this base case MAR study, the reporting requirements described in the GRP STD 01, Element 3, shall apply.

b. For other transient activities, refer to GN 48-004.

10. Methodology

a. The following assessment methodology steps shall be followed for development of the base case MAR study model:

   1. For a facility or other operations, identify a representative range of hypothetical major accident events (i.e., incidents that could lead to three or more fatalities or to major accident environmental consequences as described in Annex E).
   2. Quantify the hypothetical likelihood of these events. The likelihood of the events will depend on the types of facilities operated.
   3. Quantify the potential physical effects resulting from these events and assess their consequences at the location studied. The potential consequences will be heavily influenced by the location of the facilities. If the time to an escalated event (e.g., BLEVE or boilover) is sufficiently long to allow ample time to conduct a safe evacuation of potentially affected populations, this may be taken into account in assessing the consequence of this event. In this case, there should be a robust demonstration of the effectiveness of the response plans to operate under all conditions (e.g., if the incident occurs in the middle of the night).
   4. Evaluate options to mitigate the likelihood and/or consequences of the events considered.

      The characterisation and prioritisation of risk reduction measures require *an understanding of both the hypothetical consequences of potential major accidents and the likelihood that these hypothetical accidents will happen.*

b. The process shall be performed using the MAR methodology and rule set and the onshore and offshore MAR Calculators that are provided by the Group owners of MAR process. A functionally equivalent assessment, generating an output in the same format, may be used if validated by the Group SPA MAR or delegated individual.

c. MAR assessment

   1. The MAR assessment should be performed inhouse either by site or segment based resource.
   2. The assessment team shall include at least one MAR specialist who shall lead the study and at least one team member familiar with operation of the facility.

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3. The lead assessor shall have received specific MAR training and endorsement of his competency to perform MAR studies by the Group SPA MAR or delegated individual.
4. Endorsement of MAR study leader competency may be delegated in writing by the Group SPA MAR to other MAR specialists within BP.
5. Other members of the assessment team should also have received specific training in MAR process. Any updating of a study shall be reviewed by a lead assessor.

d. If an inhouse resource is not readily available, an external resource in the form of consultants may be used, either as study leader or team member, but only if the consultants have received endorsement of their competency to perform MAR studies by the Group SPA MAR or delegated individual and also have received specific training in MAR technique and tools.

e. Methodology and rule set

1. The methodology and rule set describes how to select hypothetical events that should be included in the assessment.
2. The potential physical effects shall be modelled following the same methodology in Annex A. The onshore and offshore MAR Calculators contain standard event frequency data.
3. Event frequency data are described in Annex C.
4. Deviation from the standard event frequency shall be justified (e.g., using analysis of site specific data) and approved by Group SPA MAR or delegated individual.

   From this input data of event frequency and effects, the program calculates an f-N pair for each event, where f is the hypothetical frequency of the event and N the number of fatalities that could be caused by the hypothetical event. The program generates an F-N curve, which is the predicted cumulative frequency of events F resulting in at least N potential fatalities. Construction of an F-N line is described further in Annex B.4.

f. Potential environmental damage shall be categorised into one of four ranges. These ranges are based on the degree of societal reaction to major environmental damage (see Annex E).

   The program generates a curve representing the cumulative frequency of environmental events resulting in at least a given measure of public reaction.

g. Various curves shall be produced (unless the risk is zero for the particular category):

1. An F-N curve, representing the predicted risk to the onsite population.
2. An F-N curve, representing the predicted risk to the offsite population.
3. An F-E curve, representing the cumulative frequency of environmental events resulting in at least a given measure of public reaction.

h. The curves may be from either a fixed facility and its associated transport operations or from transport of goods that are considered independent of a specific facility.

   In addition to these curves, the tool also lists the events in terms of their risk WEV to aid in the ranking of the events and prioritisation of risk reducing measures. Risk prioritisation is explained further in Annex D.

i. MAR studies for existing operations

1. MAR studies for existing operations should include a site visit. If a business comprises a number of smaller similar operations (e.g., retail stations), it may be sufficient to conduct a study of a sample of the facilities to gain a picture of the overall risk levels.

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2. If the approach in 1 is adopted, the number of sites selected and visited should be sufficiently representative to capture the primary factors influencing MAR (e.g., size of facility, types and scales of operations, numbers and location of onsite personnel, and offsite population density).
3. Total risk should be determined by scaling up the risk from each type of operation by the number of similar operations and totalling across all operation types.
4. In such instances, mitigation opportunities that are identified for one type of operation should be considered for all other operations of a similar type.

j. MAR reports shall be prepared in accordance with a format approved by the Group SPA MAR and Group Legal. Prior to issue, all reports shall be reviewed and audited for completeness by the Group SPA MAR or delegated individual.

11. Group reporting lines

a. MAR study leader shall work with the Group SPA MAR or delegated individual to determine the appropriate Group reporting line for use in a particular operation. The position of the Group reporting line for any particular asset or operation should reflect the scale of the operation.

b. Examples

1. Examples are shown in Figures 2, 3, and 4 for medium, large, and very large fixed facilities and operations. The lines were derived with reference to regulatory precedents and company sustainability.

Figure 2 - Safety group reporting lines - onsite

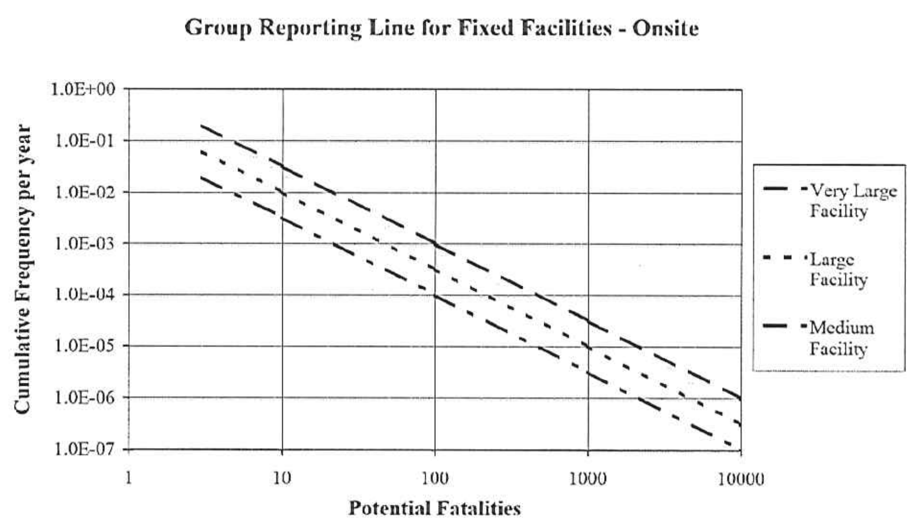

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Figure 3 - Safety group reporting lines - offsite

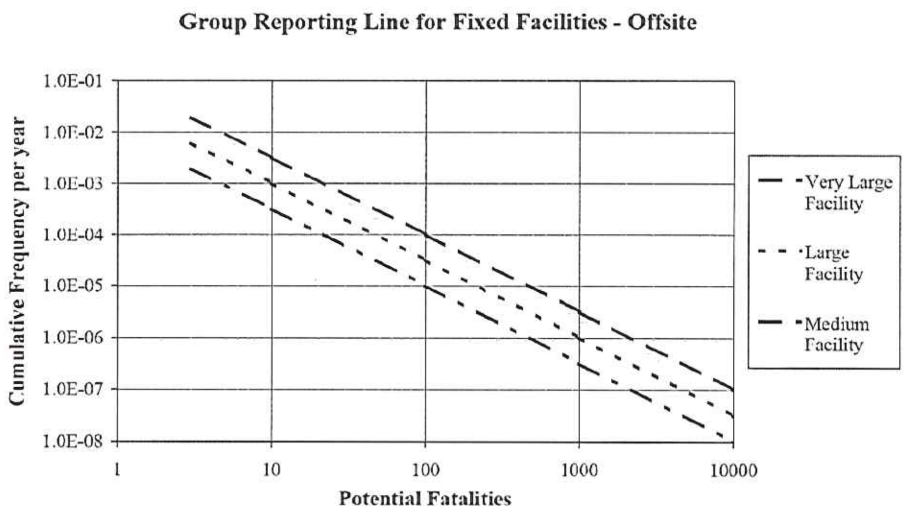
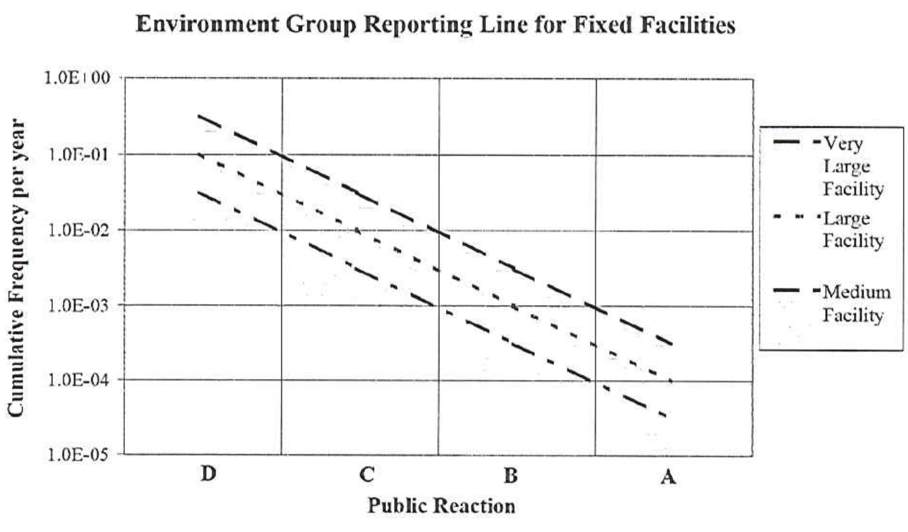


Figure 4 - Group reporting lines - environment



2. A large facility/operation should equate to approximately 1% of Group operations (as measured by, for example, capital value or revenue), a medium approximately 0,3%, and a very large approximately 3%.

3. A typical large facility/operation would be a refinery or major chemical manufacturing facility.
4. A typical medium facility/operation would be a chemical manufacturing facility with one or two processing units.
5. A typical very large BP Operation would be an E&P SPU.

c. For JVs, the total risk (i.e., not just the BP share) shall be compared against group reporting line appropriate to the scale of the total operation.

12. Grouping of operations

a. The assessment process shall be performed on individual facilities or groups of facilities that form natural segments of business.

b. The Group reporting line shall be chosen relative to these groupings. Examples include:

1. A refinery, chemical site, or E&P facility that, due to its fixed location, presents a single source of potential risk to a population or ecosystem. These sites may be made up of processes and equipment operated by many different business units. The risks analysed shall include transportation of materials to the site and products to end users in which this transport complies with the previous definitions.
2. A BP Operation that owns or operates several types of facilities to bring its product to market (e.g., an oil or gas production facility with its dependent associated transportation and terminal infrastructure, such as the pipelines and marine terminals required to deliver the facility product to market).
3. A BP Operation that operates a large number of small assets (e.g., a group of small production platforms or a group of small product distribution and retail sites with their dependent associated transportation infrastructure). In these cases, a representative sample of facilities may be selected for assessment. The overall BP operation profile can be determined on the basis of the numbers of each representative type of facility. If there is significant potential MAR associated with transportation activities, these activities should also be included in the MAR assessment.
4. A BP operation that operates a major multiclient pipeline system, if this is considered to be an operation independent of a specific facility.
5. Group shipping operations.

13. Projects

a. For a MAR assessment, two main types of projects need to be considered:

1. Those that will become a standalone BP operation (e.g., a new large offshore platform or new manufacturing site). These types of projects shall have a separate MAR study and be compared against a reporting line that is specific to the facility being constructed. If the standalone facility is being delivered to an existing BP Operation that has an existing MAR, BP Operation should incorporate MAR study for the new facility into existing MAR at the next MAR update cycle.
2. Those that will add to an existing BP operation and are expected to materially affect the level of MAR (where "materially" is defined in 15.b.1) (e.g., drilling of a new satellite well in an offshore field or construction of a new process unit or debottlenecking of an existing unit on an existing manufacturing site). These types of projects shall be incorporated within the parent facility MAR and shall become the new base case MAR for the facility on startup.

b. MAR considerations in design

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1. The principles for inherently safe design as described in GP 48-04 shall apply to mitigation efforts with the objective of reducing MAR.
2. At Appraise and Select stages, MAR shall be a significant factor in the identification and selection of options. MAR shall be assessed for the range of representative feasible options identified during Appraise.
3. MAR study should be updated as design details that may affect MAR are finalised.
4. The basis for the chosen option should be documented within the requirements of GP 48-04, clause 7.8, and include a consideration of the relative levels of MAR for the options examined.
5. At the end of Appraise, a MAR assessment above the Group reporting line shall be subject to the reporting requirements described in GRP STD 01, Element 3.

c. If MAR assessment shows a risk near or above the Group reporting line, the project may choose to conduct a more detailed or more focussed QRA to identify major risk contributors and help to prioritise actions in support of continuous risk reduction. The results of these studies may be used to revise the base case MAR, provided the studies and the revision to the base case have been reviewed and endorsed by the Group SPA MAR or delegated individual.

This further QRA should not be confused with the base case *MAR, which is performed using a specific methodology, data, and set of assumptions. A comparison between MAR and more detailed studies is provided in 14 .*

d. The MAR assessment shall include an assessment of the MAR for the construction workforce during CVP Execute phase of the project. If the facility is on a greenfield site and there are no hydrocarbons introduced to the facility prior to startup, MAR on the construction workforce may not be needed.

e. A preliminary MAR assessment should be performed, including risks from adjacent third party and BP operations, before any contractual agreements are in place that fix the location of a proposed facility. Similarly, MAR for the construction phase should be performed sufficiently early to identify opportunities for MAR reduction through the method of construction (e.g., offsite modular construction).

f. During Define and Execute stages, there will be opportunities for further refinement using the principles of CRR. This is described further in Annex D.2.4. MAR assessment shall be reviewed and, if appropriate, updated prior to startup.

The MAR assessment may continually evolve as the design progresses through the various phases of a project. Typically, the MAR will be updated at the end of each of the CVP stages.

14. MAR and more detailed studies

The MAR process is a specific example of a QRA with the following features:

- *It is usually conducted by an inhouse team.*
- *Frequencies are mainly defined at unit/system level.*
- *A limited set of release event scenarios are predefined.*
- *Event frequencies (fires, explosions, etc.) are mainly based on historical industry and/or BP data.*
- *Consequences are site specific (but usually normal operations only).*
- *Risk output is presented in a standard format.*
- *Assumptions are fully defined and consistent.*

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By contrast, full QRAs usually have the following features:

- *Usually conducted by a range of external contractors.*
- *Event frequencies synthesised from generic equipment release frequencies.*
- *Ignition and explosion probabilities often based on judgment/model.*
- *Assumptions and output may vary from study to study.*
- *Operational and external causes may (or may not) be separately considered.*
- *Because of the earlier commentary, event frequencies may not always be consistent from one study to another and may not reflect actual experience.*
- *Can account for detail below unit/system level.*
- *Site specific consequences (but usually normal operation only).*

The role of MAR and QRA studies is described in more detail in Annex F. The MAR approach draws on historical experience and produces a consistent approach across BP but cannot address details at subunit/system level. A full or detailed QRA will not necessarily give a more accurate picture of the risks, and the objective of commissioning such a study should not be simply to counter the findings of the MAR study. Targeted detailed QRA studies can provide a greater understanding of key risks identified by MAR process and can help in the determining the benefit of certain mitigation measures as part of the CRR process. In some cases, a full QRA may be specifically required by a regulator or JV partner.

More detailed studies which indicate a different level of risk to that determined using MAR approach may be used to determine whether or not an operation is above the Group reporting line and also for CRR, subject to their endorsement by the Group SPA MAR or delegated individual.

15. Updating of "base case" MAR studies

a. Base case MAR studies shall be periodically updated to account for changes in processes or changes in the exposures of onsite and offsite personnel.

b. For the purposes of updating, "periodically" means:

   1. If there is a change that is expected to materially affect the level of MAR. A change should be regarded as material if it leads to a site moving above or below the Group reporting line or if the onsite, offsite, or environmental risks (as measured by WEV) change by more than 10%.
   2. At least every 5 yr.

c. Such changes may include:

   1. Implementation of risk reduction measures.
   2. Changes to (addition of or shutdown of) processing equipment and storage facilities handling flammable or toxic materials.
   3. Changes in shipments of potentially hazardous materials.
   4. Changes (if known) in activities in the surrounding area (an increase in ship traffic near an LNG terminal, construction of an airport nearby, etc.).
   5. Changes in offsite population densities. Since changes in offsite population can have a significant effect on the offsite risk profile, each BP Operation should maintain a dialogue with local authorities to enable the site to influence the land use in areas near the facility.
   6. Changes to overall onsite population or manning distributions.
   7. Addition of new operations, modifications, or abandonment of existing operations.

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8. A significant change in the overall scale of operations, thus changing the position of the Group reporting line.

16. Confidentiality of information

a. The information that will be contained in MAR assessments and mitigation plans is sensitive from a security standpoint and may also be competitively sensitive. All documents shall be labelled "BP Confidential".

b. Legal review by local legal counsel of the report should be performed prior to any distribution.

c. Contractors may be used to assist in conducting a MAR study, but they shall be operating under a contract that ensures the confidentiality of the information.

d. Decisions regarding the release or disclosure to third parties of MAR documents and other information about the results of a MAR assessment or mitigation plans shall be made with input from BP Legal. If BP decides to release MAR documents or information, the third party recipient should be alerted to the sensitive nature of the material contained in the documents.

17. Further help

Further help on the MAR process can be obtained from the Group SPA MAR or a delegated individual.

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Annex A
(Normative)
Methodology and scenario development

A.1. Methodology

A.1.1. General

a. This Annex describes the details of MAR process that shall be adopted to estimate the MAR at a facility or operation. Its objective is to achieve a representative assessment of the likelihood and consequences of high impact events.

b. Hypothetical scenarios

   1. This process, while valuable and important, has some limitations.
   2. The nature of these assessments requires that BP develop hypothetical scenarios.
   3. By their nature, these hypothetical scenarios assume accidents that might result from identified hazards. These assumptions are a necessary part of this process.
   4. These assumptions are not intended to predict whether or not the event will occur.
   5. The hypothetical scenarios consider very large events with serious consequences to disclose the risks that will be managed.
   6. BP adopts an approach that gives a disproportionately large weighting to larger accidents (i.e., a risk averse approach) in this methodology.

A.1.2. Methodology for onshore operations

The methodology should be separated into five stages:

1. The facilities should be divided into a number of discrete areas. Each of these areas will consist of units that could have a similar risk of hypothetical major accident events (e.g., processing units, atmospheric storage tanks, pressurised storage vessels, road loading areas, marine jetties, pipeline systems).
   a. Similar units that have a significant geographical separation (greater than 50 m [160 ft]) should be assigned to separate areas.
   b. Release frequencies given in Annex C for process units are shown per process unit year and refer to a typical sized unit.
   c. Examples of process units are:
      1. Desalter.
      2. Crude distillation unit.
      3. Vacuum distillation unit.
      4. Naphtha hydrotreater.
      5. Catalytic reformer.
      6. Distillate hydrotreater.
      7. Fluid catalytic cracker.
      8. Hydrocracker.
      9. Visbreaker.
      10. Merox unit.
      11. Coker.

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12. Alkylation unit.
13. Isomerisation unit.
14. Steam reforming unit.
15. Amine unit.
16. Sulphur recovery unit.
17. Acetic acid plant.
18. Purified terephthallic acid unit.
19. Paraxylene unit.
20. Ammonia plant.
21. Ethylene cracker.
22. Polyethylene plant.
23. Polypropylene plant.

d. Definition of unit

1. In some cases, it is not clear whether a process area should be described in terms of a single unit or multiple units.
2. For example, on a refinery, a "hydrogen plant" might be considered as a standalone "steam reforming unit" or as a section of a "hydrocracker".
3. For the purposes of the MAR process, a unit is defined as one in which the obvious components of the unit, the vessels, pipework, coolers, pumps etc., make up a single plot area (typically, this would be in the region of 1 000 m^2 [11 000 ft^2] to 5 000 m^2 [54 000 ft^2] in area).

2. Hypothetical events.

a. For each area, a set of hypothetical events should be defined.

b. The events defined are those involving hypothetical scenarios involving large potential consequences.

c. By definition, this process focuses on unlikely high consequence accidents, thereby requiring attention to these risks.

d. Identification of risk by this process will motivate further continuous improvement but does not imply that BP has subjected or will subject those directly involved in the oil and gas industry or the public to unreasonable risk.

3. Event likelihood and consequence

a. For each hypothetical event, the event likelihood and consequence should be developed and used as input data to the MAR Calculator software.

b. Generic event frequency data that should be used in MAR process are included within the MAR Calculator.

c. Event physical effects (dispersion distance, blast overpressure, etc.) should be calculated using consequence analysis software, such as "Cirrus".

d. Environmental effects shall be characterised using the degree of society reaction to an event as described in Annex E.

e. A rule set to aid consistency in performing the modelling is discussed later.

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4. Physical effect footprint

    a. Each physical effect footprint from each representative event is mapped onto a plot of the facility by the MAR Calculator.

    b. If appropriate, any surrounding areas with industrial or residential population are also mapped by the MAR Calculator.

    c. The number of people within an effect footprint is converted to the number of potential fatalities if the event were to occur by multiplying by a vulnerability factor (see note).

    d. A generic set of vulnerability factors is described later and also included in the MAR Calculator software.

    e. The number affected are separated into those inside and outside working hours for onsite and offsite populations, taking into account whether people are inside buildings or outdoors.

    f. The MAR Calculator software will convert the number of people within an effect footprint to potential fatalities and avoids any double counting. It allows for relevant conditional probabilities, such as wind direction probability and ignition probability.

        Note: A factor that modifies a consequence (e.g., the proportion of people exposed to a physical effect who are fatally injured by the effect) is defined as a vulnerability. A factor that modifies a frequency (e.g., the likelihood that a gas cloud will be ignited and hence give a flash fire effect) is defined as a conditional probability.

5. The MAR Calculator software calculates frequency-consequence pairs (f-N pairs) and/or frequency-environmental reaction pairs (f-E pairs) for each effect. The risks are reported by the software as the cumulative frequency of at least a given magnitude of event, F-N and F-E curves. The software also provides a risk ranking of events based on their WEV.

The method has been designed to give a rapid indication of the risk associated with multiple fatality events and events involving severe environmental damage. The method is not intended to predict events involving one or two fatalities, and the results shown are likely to underestimate the frequency of these lesser consequence incidents. These lesser consequence events are managed by other BP safety management systems.

A.1.3. Methodology for offshore operations

The following methodology for offshore operations should be used:

a. Divide the facility into discrete locations where releases of hazardous materials could occur. The locations should be physically separated by barriers or distance such that releases in one location are unlikely to enter adjacent locations. Examples include:

    1. Process areas of modules separated by solid decks and/or firewalls.

    2. Process equipment on individual platforms within a bridge linked complex.

b. Identify locations where people may be present on the facility.

c. Identify the location and type of escape routes, refuges, and evacuation points.

d. Break process into systems and allocate the systems across the release locations defined under a.

e. Identify the type and number of drilling operations and allocate these across the locations defined under a.

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f. Process, well operations, and drilling hypothetical events

   1. Define process, well operations, and drilling hypothetical events, and evaluate their potential effects on population locations, escape routes, refuges, and evacuation facilities.

   2. Process hypothetical events will include releases from risers, process plant, producing wells, and utilities (e.g., fuel gas system).

   3. Drilling and well operations hypothetical events will include blowouts from development drilling, well workovers, and wirelining/coiled tubing operations.

g. Determine potential fatalities from the immediate impact of the hypothetical events, as well as any potential fatalities due to subsequent escalation and during escape and evacuation.

h. Determine impact on platform populations from nonprocess events, such as ship collisions, earthquakes, wind/waves, structural collapse, sinking, accommodation fires, and dropped objects.

i. Determine potential fatalities while transporting populations to the facility (e.g., helicopter and boat accidents).

A.2. Selection of scenarios - deciding on the hypothetical events

A.2.1. Scenarios for onshore operations

a. Hypothetical events chosen for each selected area should represent a "catastrophic" release. The intent is to go beyond events that might reasonably be expected to occur and identify hypothetical events that are very unlikely to occur but, if they were to occur, could cause multiple fatalities or severe environmental damage.

b. Catastrophic releases from process units

   1. For example, for process units, the hypothetical "catastrophic" release should be the release of the maximum isolatable inventory on the unit over a 60 s period following loss of containment.

   2. The maximum isolatable inventory is the inventory between emergency shutdown valves and is often that contained in the largest vessel on the unit.

   3. If shutdown is not initiated automatically and there is no remote activation, then further consideration should be given to back and forward flows during the 60 s period.

   4. If the vessel is large and the pipework joining the vessel is too small to release the contents in a 60 s period, a longer duration may be calculated if fracture of pipework is thought to be the only significant mechanism of failure.

   5. These types of release are often associated with rupture of equipment, and the effects are modelled using a quasi-instantaneous release of material.

c. Catastrophic releases from storage tanks and vessels

   1. For storage tanks and vessels, the hypothetical "catastrophic" release should be the release of the entire contents of the storage unit.

   2. This could be rupture of the tank shell or a release through an orifice equivalent to the largest pipe diameter attached to a vessel.

   3. If these scenarios would release the inventory in less than 60 s, a release rate should be calculated on the basis of a 60 s release duration.

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d. Major releases to atmosphere from process units, storage tanks, and vessels

    1. A hypothetical "major" release is associated with a hole in equipment that results in a continuous flow of material to atmosphere.
    2. Effects from this continuous type of release can often be modelled by assuming that they reach a steady state limit.
    3. This "major" scenario should be defined as a release of material through an equivalent 50 mm (2 in) diameter hole in a vessel or pipe.
    4. In some cases (e.g., toxic releases), the hazard may be a function of the release duration.
    5. In such cases, an automatic or remotely operated ESD or shutdown system may be taken into account if determining the duration event, provided it has been subject to a SIL assessment.

e. Releases from pipelines

    1. For buried underground pipelines, the rate of release from a full bore guillotine rupture (i.e., release from both sides of the pipeline) should be calculated.
    2. Gas and vapour releases that have to break out of the ground should be modelled as a vertical release from a crater in the ground.
    3. This will have the effect of reducing the velocity of the material released from the crater. The crater diameter should be calculated using the following correlation:

$$W = 1{,}78(D)^{1{,}266}(P)^{0{,}5744}$$

Where: W is the crater width (m).
D the pipeline diameter (m).
P the pipeline pressure (bar).

f. For heavier than air vapours, this will allow the assessment of the hypothetical "worst case", where the cloud is initially pushed upwards and potentially falls back to disperse along the ground. For oil and other liquid releases, the travel of fluid along the ground or via water courses should be modelled. The likelihood of flammable liquids reaching population centres should be assessed, as should degree of environmental impact.

g. The MAR Calculator software, if used for GP 48-50 based studies, will allow input of the following physical effect envelopes from release events:

    1. Toxic cloud from an instantaneous release in D5 and F2 conditions.
    2. Toxic cloud from a continuous release in D5 and F2 conditions.
    3. Drifting cloud/flash fire from an instantaneous release in D5 and F2 conditions.
    4. Drifting cloud/flash fire from a continuous release in D5 and F2 conditions.
    5. Localised fire from an instantaneous release in 2 m/s (6 ft/s) and 5 m/s (16 ft) wind.
    6. Localised fire from a continuous release in 2 m/s (6 ft/s) and 5 m/s (16 ft/s) wind.
    7. Fireball/BLEVE.
    8. Vapour cloud explosion from a cloud drifting into an obstructed area.
    9. Explosion at source.
    10. Environmental effect.

h. The team conducting the MAR study should determine which of the above scenarios are relevant for each section of the facility. Default frequency data for typical events that give

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rise to these effects are included in the software and examples shown in Annex B. If appropriate, other user defined events and effects can be included in the analysis.

A.2.2. Scenarios for offshore operations

a. Release rates should be calculated for medium (50 mm [2 in] D) and catastrophic releases (limited to 100 mm [4 in] D holes for initial event but full bore rupture for escalated events).

b. The hazards will be due to toxic effects from H_2S rich streams, thermal radiation, and smoke from fires and blast overpressure from explosions.

c. The types of fires will be confined module fires, free jet fires, and sea pool fires.

d. Account will need to be taken of whether decks are grated or plated when determining the location of events.

e. Scenarios should reflect the potential for escalation to other inventories, other modules, refuges, escape routes, and structural supports.

f. The following process events should typically be considered:

1. Gas and liquid fires producing no escalation.
2. Gas and liquid fires escalating to other inventories.
3. Gas and liquid fires leading to damage to refuges/structural collapse.
4. VCE sufficient to cause fatalities within module and breach of nonblast resisting module wall.
5. VCE sufficient to cause escalation.
6. VCE sufficient to cause structural deflection and massive escalation.
7. VCE sufficient to cause structural collapse.
8. Unignited toxic releases (e.g., H_2S rich streams).
9. Escalated fires.

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Annex B
(Normative)
Consequence modelling and vulnerabilities

B.1. Onshore operations

B.1.1. Dispersion of flammable or toxic vapours

B.1.1.1. General

a. Vapour cloud scenarios

   1. Vapour cloud scenarios of greatest importance onshore are those that spread at ground level and could affect people or buildings.
   2. These clouds will often have a density equal to or greater than that of ambient air.
   3. For most major releases, the heavy gas model (model D2 in Cirrus) will be relevant.

b. Release rate

   1. The release rate from catastrophic and major events should be estimated in the manner described earlier.
   2. For catastrophic scenarios in which the material has a low flash fraction, evaporation from a pool of released material should be used as the source term for the dispersion calculations.
   3. In cases in which the material has a high flash fraction, it is likely to be more appropriate to input the calculated release rates directly to the dispersion code.

c. Catastrophic release modelling

   1. In many cases, the catastrophic release will be modelled using the "transient" (60 s release) option for the heavy gas model.
   2. This 60 s release is described as instantaneous in Cirrus.
   3. If the catastrophic event cannot fall to ground within the unit area, for example, elevated releases (greater than 3 m [10 ft] height) of gas or flashing gas, use of the momentum dispersion model (model D1 in Cirrus) will be more appropriate.

d. Result of a transient release

   1. The result of a transient release will be an expanding cloud that will drift away from the source.
   2. An example of a 1 min release of propylene at a release rate of 300 kg/s (660 lb/s) is given in Figure B.1 and shows instances of the cloud at different time periods after release.
   3. The plot shows the movement of the LFL contour.
   4. The cloud travels both upwind and downwind of the source location.
   5. The largest single plume occurs after approximately 2 min (126 s), and this cloud has dimensions of approximately 300 m (980 ft) in a downwind direction and 160 m (525 ft) in width.
   6. The entire cloud disperses below its LFL after approximately 6,25 min, and the maximum distance at which it has remained flammable is approximately 950 m (3 100 ft) from the source.

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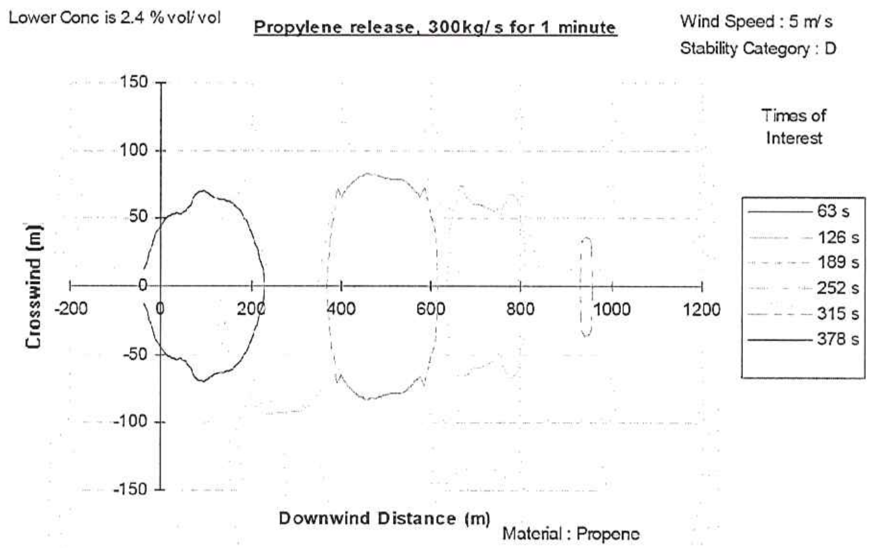
Figure B.1 - Dispersion of transient release



e. Flash fire

1. Ignition at any instance within the duration of the cloud (6,25 min) will result in a flash fire.

2. For modelling purposes, the maximum hazard zone of this flash fire will be an ellipse of 300 m (980 ft) downwind of the source, with a width of 160 m (525 ft).

3. The MAR calculator will ask for input of the maximum hazard distance in the plane of the wind (the sum of the upwind and downwind distance from the source: 50 m [160 ft] + 950 m [3 100 ft] = 1 000 m [3 300 ft] for this example), the maximum plume width (160 m [525 ft]), and the offset of the source relative to the plume contour.

4. The offset is the distance between the furthest upwind position of the contour divided by the total upwind plus downwind distance (50/1 000 = 5%). It is input as a percentage.

5. The MAR Calculator will divide the overall contour into segments to represent the portion of the drifting cloud that could be involved in a single flash fire.

f. Toxic clouds

1. The same input is required for toxic clouds. For toxic clouds, the entire area swept out by the cloud should be treated as the effect footprint in the MAR Calculator (the hazard is not dependent on ignition at a particular instance in time).

2. The exposure time and, hence, concentration of interest to give a lethal dose can be altered to be consistent with the time taken for the cloud to disperse below a toxic dose.

g. State plume

1. Major releases associated with a leak from a 50 mm (2 in) hole will often be more appropriately modelled as a continuous release and will result in the formation of a continuous steady state plume.

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2. In these plume cases, either a momentum or heavy gas model can be used as appropriate (model D1 and D2 in Cirrus, respectively).
3. The hazard zone is described in the same way as for the instantaneous case. A maximum hazard distance in the plane of the wind (the sum of the upwind and downwind distance from the source), the maximum plume width, and the offset of the source relative to the plume contour.
4. A release that has the potential to form a momentum jet should not normally be factored into the modelling, since it will usually be possible for the jet to impinge on an object or the ground, dissipating the momentum in the process. In these cases, a horizontal ground level nonmomentum dispersion cloud should be assumed.

B.1.1.2. End point for dispersion calculations

a. Flammable clouds

1. LFL should be used to define the hazard zone of flammable instantaneous and continuous dispersion clouds that affect people outdoors.
2. LFL should also be used to define the hazard zone of flammable continuous dispersion clouds that affect people indoors.
3. 3,3 times the LFL should be used to define the hazard zone of flammable instantaneous dispersion clouds that affect people indoors. 3,3 LFL is used in these circumstances, since this is the external concentration which, for the purposes of MAR process, is defined as that which would lead to a buildup of flammable vapour concentration indoors.
4. The value of 3,3 LFL has been derived by taking a typical mechanically ventilated building or other normally ventilated building to have a ventilation rate of approximately 6 air changes per hr (once every 10 min).
5. The passage of a typical cloud from a catastrophic release will drift over a specific location in approximately 3 min. Therefore, the outside concentration needed to give an LFL concentration inside a building is 3,3 LFL, based on these typical values.
6. Continuous releases are assumed to carry on for sufficient time to allow an LFL concentration outdoors to build up to an LFL concentration indoors. Hence, there is no distinction made for buildings inside flammable clouds arising from continuous releases.

b. Toxic clouds

1. An LD factor should be used to determine one or more end points for toxic dispersion clouds.
2. If the material has a toxic probit included in Cirrus (typically the TNO green book probit), the dispersion cloud should be modelled to 90% lethality, 10% lethality, and 1% lethality.
3. If this is not available, other authoritative lethality information should be used. Often, toxicology data is not provided in a suitable format for determining lethalities.
4. An example of this type of information can be found in the UK Health and Safety Executive SLOD and SLOT values (representing 50% and 1% lethality respectively). This data can be found at:

   http://www.hse.gov.uk/hid/haztox.htm.

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c. Exposure time

1. Dose is related to exposure time. In the Cirrus model, a concentration will be calculated to give the required dose that is dependent on the exposure time input by the user.

2. For continuous releases, a default of 30 min exposure time or, alternatively, an exposure time related to the duration of the release can be assumed by the user.

3. For transient releases, an exposure time related to the time taken for the cloud to pass over a particular ground position may be used. In this method, the time taken for the cloud to pass a specific point on the ground can be estimated by using the radius of the maximum cloud and dividing this by the wind speed at ground level.

4. The D5 and F2 weather categories refer to wind speed of 5 m/s (16 ft/s) and 2 m/s (6,6 ft/s), respectively, if measured at a height of 10 m (33 ft).

5. At ground level, the wind speed is approximately half of this, so values of 2,5 m/s (8 ft/s) and 1 m/s (3,3 ft/s) should be used in calculating the time of exposure to toxic heavy gas clouds. An iterative process should be used to model the lethal cloud, as the cloud shape will depend on the concentration of interest, which itself will depend on the exposure time.

B.1.1.3. The vulnerabilities to be used in dispersion events

a. Dispersion of flammable materials

1. Dispersion of flammable materials to the LFL boundary accompanied by ignition will give a flash fire.

2. The vulnerability of persons outdoors and within the flash fire is assumed to be 1.

3. As discussed previously, the dispersion of flammable materials to the 3,3 LFL boundary (instantaneous release), or the LFL boundary (continuous release) is assumed to harm people inside buildings.

4. Typically, large dispersion clouds will drift over many buildings, and not all of these could be expected to suffer ingress and ignition of flammable vapours.

5. To cover the situation in which the inhabitants of some buildings will not be harmed by a flash fire, the applicable building vulnerability factors are shown in Table B.1.

6. If buildings will offer little protection against flash fires, for example, those with many open windows, these inhabitants should be treated as if they were outdoors.

7. For flammable vapour releases, the vulnerabilities in Table B.1 or Table B.2 should be used as default values.

b. During a toxic release, people inside buildings can suffer lower concentrations of material but for greater duration. Typically, mitigation steps can be taken, such as closing doors and windows. For toxic releases, the vulnerabilities in Table B.3 should be used as default values in most cases.

Table B.1 - Ignited flammable cloud lethality range for instantaneous releases

	Average vulnerability of people outside	Naturally ventilated building or building with HVAC and no toxic/flammable gas detection system	Building with HVAC, detection, and manual shutdown system	Building with HVAC and automatic detection and shutdown system
Source to 3,3 times LFL	1	0,50	0,25	0,01
3,3 LFL to LFL	1	0,00	0,00	0,00
Beyond LFL	0	0,00	0,00	0,00

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Table B.2 - Ignited flammable cloud lethality range for continuous releases

	Average vulnerability of people outside	Naturally ventilated building or building with HVAC and no toxic/flammable gas detection system	Building with HVAC, detection, and manual shutdown system	Building with HVAC and automatic detection and shutdown system
Source to LFL	1	0,50	0,25	0,01
Beyond LFL	0	0,00	0,00	0,00

Table B.3 - Toxic cloud lethality range for instantaneous and continuous releases

	Average vulnerability of people outside	Naturally ventilated building or building with HVAC and no toxic/flammable gas detection system	Building with HVAC, detection, and manual shutdown system	Building with HVAC and automatic detection and shutdown system
Source to 90% fatality	0,95	0,475	0,24	0,01
90% to 10% fatality	0,3	0,15	0,08	0,00
10% to 1% fatality	0,03	0,015	0,01	0,00
Source to 50% fatality	0,71	0,355	0,18	0,01
50% to 1% fatality	0,07	0,035	0,02	0,00

c. These vulnerabilities are the default values within the MAR Calculator. It is important not to double count potential fatalities within both a source to 90% zone and, for example, a source to 10% zone. Use of the MAR Calculator software avoids double counting.

B.1.1.4. Weather conditions and roughness parameters for dispersion calculations for onshore facilities

a. Toxic and flammable clouds should be modelled in D5 (stability D, wind speed 5 m/s [16 ft/s]) and F2 (stability F, wind speed 2 m/s [6,6 ft/s]) weather conditions.

b. Weather conditions D5 and F2 can be used to represent the entire range of all weather conditions.

c. If unknown for the site, a relative probability of 80:20 should be taken for D5:F2, respectively, with 100% of F2 conditions occurring at night.

d. These probabilities are the default values in the MAR Calculator. In general, the roughness conditions should be defaulted to 0,05.

B.1.2. Modelling of fire thermal radiation

B.1.2.1. Jet fires

a. Thermal radiation

1. For modelling purposes, it should be assumed that both the flame and the thermal radiation from a jet fire can cause fatalities among people, both outdoors and inside buildings (buildings are set on fire).
2. The thermal radiation in general is assumed to have no directional component, but the flame has an obvious directional component due to either being blown by the wind

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and/or the release being in a specific direction. Modelling should be performed for a 5 m/s (16 ft/s) and 2 m/s (6,6 ft/s) wind speed.

b. Catastrophic releases will not normally give rise to pencil-like jet fires but less directional, turbulent fires. Turbulent fires from catastrophic releases should usually be modelled as a pool fire or fireball.

c. Release from a 50 mm (2 in) hole can give rise to a jet fire. This should be modelled typically as a jet release at an angle of 45 degrees to the horizontal (which represents the average orientation between horizontal and vertical).

d. The thermal radiation should be calculated to flux levels of 35 kW/m^2 (11 000 Btu/hr/ft^2) and 12,5 kW/m^2 (4 000 Btu/hr/ft^2).

e. The MAR Calculator requires hazard zones for these two flux levels to be defined with a maximum length equal to the distance between the upwind and downwind boundaries of the flux at ground level, a maximum crosswind length, and an offset of the source relative to the plume contour.

f. The offset is the distance between the furthest upwind position of the contour divided by the total upwind plus downwind distance. It is input as a percentage.

g. The MAR Calculator also allows a "wind independent" jet fire to be defined. This is intended to be used if the jet fire is large and its direction fixed due to the orientation of the source (e.g., a large ignited release through an open pig launcher/receiver door). The orientation of the jet fire will be that of the launcher/receiver.

h. Only radiation effects need be considered, as the upper thermal radiation boundary of 35 kW/m^2 (11 000 Btu/hr/ft^2) is assumed to have the same effect on people and buildings as flame. (The radiation flux levels chosen correspond to approximately 100% fatality and 1% fatality for exposures of 30 s). The vulnerabilities in Table B.4 should be used and are included as the default values in the MAR Calculator.

Table B.4 - Jet fire vulnerabilities

Lethality range	Average vulnerability of people outdoors	Average vulnerability of people inside fire resistant buildings	Average vulnerability of people inside other buildings
Source to 35 kW/m^2 (11 000 Btu/hr/ft^2)	1	0	1
35 kW/m^2 (11 000 Btu/hr/ft^2) to 12,5 kW/m^2 (4 000 Btu/hr/ft^2)	0,1	0	0,05
Less than 12,5 kW/m^2 (4 000 Btu/hr/ft^2)	0	0	0

i. In this context, a "fire resistant building" is one that is designed to provide a habitable environment for its occupants throughout the duration of the fire if the building is subjected to the maximum thermal load from the fire.

B.1.2.2. Pool fires

a. For modelling purposes, it should be assumed that people inside and outside of normal buildings in a burning pool of flammable liquid or inside a turbulent fire would be fatally injured.

b. It is possible that people outside of the fire area can also be harmed by thermal radiation, but this is less likely, as escape is possible.

c. Similar to jet fires, modelling should assume a 5 m/s (16 ft/s) wind and define two hazard zones based on the thermal radiation contours of 35 kW/m^2 (11 000 Btu/hr/ft^2) and 12,5 kW/m^2 (4 000 Btu/hr/ft^2).

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d. The two hazard zones can be drawn as ellipses with a maximum length equal to the distance between the upwind and downwind boundaries of the flux at ground level and a maximum crosswind length.

e. Only radiation effects need be considered, as the upper thermal radiation boundary of 35 kW/m^2 (11 000 Btu/hr/ft^2) is assumed to have the same effect on people and buildings as flame.

f. These hazard definitions are those required as input to the MAR Calculator.

g. Pool fire vulnerabilities are as described in Table B.5.

Table B.5 - Pool fire vulnerabilities

Lethality range	Average vulnerability of people outdoors	Average vulnerability of people inside fire resistant buildings	Average vulnerability of people inside other buildings
Source to 35 kW/m^2 (11 000 Btu/hr/ft^2)	1	0	1
35 kW/m^2 (11 000 Btu/hr/ft^2) to 12,5 kW/m^2 (4 000 Btu/hr/ft^2)	0,1	0	0,05
Less than 12,5 kW/m^2 (4 000 Btu/hr/ft^2)	0	0	0

B.1.2.3. Fireball/BLEVE

a. Calculations

1. Fireball calculations should be based on the normal maximum inventory within the pressure vessel being studied.
2. Calculations should be performed to give the distance from the source to the 100% lethality contour (approximated by the fireball radius) and the 1% lethality contour.
3. These two boundaries can be used to define circular hazard zones.
4. These hazard zones should be centred on the vessel to determine people and buildings affected by the event.

b. The vulnerabilities in Table B.6 should be used with these hazard zones and are the default values in the MAR Calculator.

Table B.6 - BLEVE vulnerabilities

Lethality range	Average vulnerability of people outdoors	Average vulnerability of people inside buildings
Source to 100% lethality (≈ fireball radius)	1	1
100% to 1% lethality	0,1	0
Less than 1% lethality	0	0

c. The values in Table B.6 take no account of the potential for personnel to be evacuated before the BLEVE occurs. BLEVEs can occur for fire engulfment durations of as little as 15 min, even if fixed water sprays are fitted. Passive protection can provide a reliable means of delaying the occurrence of BLEVE for much longer periods. In these circumstances, evacuation may be taken into account, provided it can be demonstrated that the initial fire can be detected and evacuation performed within the time to vessel failure.

d. Failure of a flare KO pot followed by ignition can be modelled as a fireball event or as a turbulent fire using a pool fire model.

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B.1.3. Modelling of vapour cloud explosion overpressure of unconfined obstructed areas

a. Severity of overpressure generation

1. The severity of overpressure generation during a vapour cloud explosion is associated with the volume of obstructions filled by a flammable vapour cloud and not the absolute size of the cloud or the quantity of material released during an event.

2. In this context, an obstructed volume is typically a process unit containing pipes and vessels, with the volume defined by the obvious components of the unit, the vessels, pipework, coolers, pumps, etc.

3. Obvious components of the unit will have a boundary with an obstacle density of 1 m of pipe/vessel or equivalent per m^3 or less (3 ft of pipe/vessel or equivalent per 35 ft^3).

4. Pipetracks adjoined to the unit should not be included in the unit, unless they contain more than three consecutive vertical pipes and have a height of at least half the average height of the unit.

5. The height should not include areas above the main processing equipment that contain only a few obstacles, such as the tops of columns. Volumes containing large single obstructions, such as tank farms, are assumed to not generate explosion overpressures.

b. Typical process area

1. For a typical process area, the entire volume can be assumed to contribute to the explosion if the release is sufficient to fill approximately one third of the volume with a flammable cloud, as the combustion process can push unburned mixture into all the obstructed volume.

2. Therefore, most units containing flammable gasses are assumed to be capable of suffering a major explosion. (An exception would be release of materials that are above their autoignition temperature. These releases should be assumed to catch fire before a flammable cloud could develop.)

3. Adjacent units that have volumes of high obstacle density separated by gaps may not be able to explode as one total volume.

4. In these circumstances, obstructed volumes with a separation distance of greater than half the contiguous length of the adjacent obstructed volume should be assumed to act as separate explosion centres.

c. Obstructed volume

1. It should be assumed that all the obstructed volume of a process unit is involved in an explosion.

2. The exception would be the maximum inventory of flammable vapour that could be released in the unit, if diluted to a vapour air mixture of lower flammable limit concentration is less than one third of the calculated obstructed volume.

3. This is not the equivalent volume of the LFL contour derived from a Cirrus dispersion model but a quiescent mixture.

4. In this case, an obstructed volume of three times the mixture volume should be used to define the unit obstructed volume.

d. The explosion modelling should be performed using the TNO multienergy model with an energy coefficient of 7 (this is the default value in Cirrus). Three circular hazard zones to 300 mbar (4,4 psig), 150 mbar (2,2 psig), and 50 mbar (0,7 psig) overpressures should be assessed.

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e. The average vulnerability of occupants (Table B.7) in buildings within the hazard ranges should be used and are the default values in the MAR Calculator.

f. Similar overpressure vulnerabilities should be assumed for pressure waves generated by a vessel burst.

g. Care should be taken not to double count those within more than one range. Use of the MAR Calculator will avoid this double counting.

Table B.7 - Explosion vulnerabilities

Overpressure range	Vulnerability of occupants in a conventional building	Vulnerability of occupants in a building designed to resist a 200 mbar (2,9 psig) overpressure	Vulnerability of people outdoors
Greater than 300 mbar (4,4 psig)	0,8	0,3	0,3
150 mbar (2,2 psig) to 300 mbar (4,4 psig)	0,4	0,03	0
50 mbar (0,7 psig) to 150 mbar (2,2 psig)	0,05	0	0
Less than 50 mbar (0,7 psig)	0	0	0

B.1.4. Modelling of vapour cloud explosion overpressure of confined obstructed areas

a. Confinement of a vapour cloud

1. In some circumstances, confinement of a flammable vapour cloud, for example, in a building or module, followed by ignition can generate explosion overpressures.
2. As the combustion products of the reaction are approximately eight times the volume of the unburned mixture, pressures up to eight atmospheres could be developed if the confining building was sufficiently robust to withstand this pressure.
3. For a box that does not contain obstacles, the pressure buildup is dependent on the weight of the building material, as it will take longer to move heavier material.
4. In the method in 5., it is assumed that light buildings will vent the explosion at 100 mbar (1,5 psig) and heavier buildings at 200 mbar (2,9 psig).
5. If the building contains obstacles, these obstacles could cause turbulent flame acceleration in a manner similar to that of an obstructed volume in free field. To model the overpressure from an explosion due to ignition of a flammable vapour inside a building or other enclosure, the following method should be used:

    a) Calculate the total volume of the building. If the building is of heavy construction, (e.g., concrete or brick), use this volume in the TNO multienergy model to determine blast overpressure using coefficient 5. If the building is of light construction (e.g., steel cladding), use this volume in the TNO multienergy model to determine blast overpressure using coefficient 4.

    b) Calculate the volume of the obstructed areas within the building. Add an additional 50% to this (but limited to the maximum volume of the building). Use this enhanced volume in the TNO multienergy model to determine blast overpressure using coefficient 7.

    c) Select the "worst case" between method a) and b) for the MAR process.

b. The methodology in a. should be applied to buildings/modules housing equipment for which gas ingress could generate a significant explosion (e.g., a compressor house). This

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would not normally be applied to occupied buildings for which gas ingress could lead to an internal explosion.

B.1.5. Conditional probabilities

B.1.5.1. Ignition probabilities

a. Two categories of ignition probability are used, as the delay before ignition affects the train of physical effects that can occur. These are:

   1. Immediate ignition - ignition within a few seconds of the release occurring. Immediate ignition will not allow the formation of a flammable gas cloud. Hence, this ignition type precludes flash fire and explosion effects.

   2. Delayed ignition - ignition of drifting vapour following at least a few seconds of release of flammable material.

b. The probability of immediate ignition will depend on the cause of the release. Release events caused by mechanical impact have a higher immediate ignition probability than those caused by more quiescent failures, such as corrosion or vibration. The generic ignition probabilities in Table B.8 should be used in the MAR process.

Table B.8 - Generic immediate ignition probabilities for predefined mode

Release cause	Immediate ignition probability
Release caused by high energy mechanical impact	0,3
Other causes	0,1
Average value	0,2

Note

1. The average value has been taken as the default immediate ignition value in the MAR Calculator.

e. Delayed ignition

   1. The probability of delayed ignition will depend on the type and number of ignition sources that are encountered by the cloud.

   2. In general, the probability of delayed ignition if the cloud drifts into areas of uncontrolled ignition sources, such as residential areas, will be greater than that where ignition sources are controlled, for example, on oil or chemical sites.

   3. The onsite probability is greater if the cloud encounters high energy ignition sources, such as furnaces or fired heaters. The delayed ignition probabilities in Table B.9 are used in the MAR Calculator if used in "Predefined" mode.

Table B.9 - Generic delayed ignition probabilities for pre defined mode

Cloud footprint	Delayed ignition probability
Cloud footprint over a large onsite area	0,5
Cloud footprint over a large offsite residential area	0,9

f. If used in "calculate" mode, the MAR Calculator requires the user to specify the location and probability of ignition sources. For this purpose, the delayed ignition probabilities in Table B.10 should be used.

g. If a cloud reaches a large offsite residential area, the probability that it will ignite increases with ignition source density and the distance of penetration. In the MAR Calculator,

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default values of ignition source density are used to calculate offsite ignition probability and associated f-N pairs.

Table B.10 - Ignition probabilities for calculate mode

Description	Type	Value	Units	Comment
Residential/ public areas	Area	Day $7{,}20 \times 10^{-7}$ Night $3{,}60 \times 10^{-7}$	Per person m^2	Default value.
Worker buildings	Area	$5{,}4 \times 10^{-4}$	Per m^2	Default value.
Roads	Area	=(N x 0,1)/A	Per m^2	Where N is the average number of vehicles in the defined area A (m^2) at any specified time. Can be less than 1.
	Length	=(N x 0,033)/L	Per m^2	Where N is the average number of vehicles in the defined length L (m) at any specified time. Can be less than 1.
Car parks	Area	=(N x 0,002)/A	Per m^2	Where N is the average number of vehicles that visit the car park of defined area A (m^2) in a 24 hr period.
Rail lines	Area	=N x 0,007	Per m^2	Where N is the average number of trains that run on the route per day.
Ground flares/fired heaters/furnaces	Point	1	Per unit	
Heavy electrical equipment (nonclassified areas)	Area	$4{,}1 \times 10^{-2}$	Per m^2	
Medium electrical equipment (nonclassified areas)	Area	$1{,}8 \times 10^{-3}$	Per m^2	
Hot work	Area	=N/(730 x A)	Per m^2	Where N is the number of hot work permits (12 hr permit) per yr in a plant area A (m^2).

B.1.5.2. Wind direction effects

a. The actual wind direction probability for the site should be used and input to the MAR calculator.

b. Input can be in terms of an 8 sector, 12 sector, or 16 sector wind rose.

B.1.6. Shutdown and mitigation systems

B.1.6.1. Shutdown systems

a. Credit may be given for emergency shutdown systems if these are likely to act in sufficient time to limit the consequences of an event.

b. For major and catastrophic events considered in MAR process that often involve a high release rate for a short duration, mitigation by shutdown would generally only be the case if shutdown systems are automatically activated by gas detection.

c. A nonmomentum gas cloud can drift approximately 150 m (490 ft) at ground level in 1 min if the wind speed at a 10 m (33 ft) height is 5 m/s (16 ft/s) wind. (The wind speed used in the dispersion codes is that at a height of 10 m [33 ft]. Wind speed close to the ground is approximately half of this.)

B.1.6.2. Mitigation systems

a. Similar credit may be given for mitigation systems if they can be activated in sufficient time to mitigate consequences.

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b. Passive mitigation in particular is significant.

c. Manual systems should be considered unlikely to mitigate catastrophic releases, as these are dependent on personnel who may be immediately affected by the event or too remote to visually observe the event.

B.2. Offshore facilities

B.2.1. General

The primary differences between offshore and onshore facilities are the confinement of the physical effects by walls and ceilings, the relative availability of escape, shelter, and evacuation, and the need to take into account the three dimensional geometry of an offshore installation.

B.2.2. Modelling of dispersion of flammable or toxic vapour for offshore facilities

a. Vapour release

1. Releases of toxic or flammable vapour inside an enclosed offshore module can cause accumulation of the vapour within the confined volume. In this case, use of the free field dispersion models contained in Cirrus would be both inappropriate and unnecessary.
2. The methodology should assess the ventilation rate of the module and use this to calculate the minimum release rate required to fill the module with toxic vapour (vapour at the lethality concentrations assuming a 10 min exposure) or flammable vapour (vapour at the LFL). This release rate should be used to describe the size and frequency of equipment failure that could result in this scenario.
3. Ignition of a flammable vapour filling an offshore module can result in either a flash fire or explosion.
4. If the facility structure does not confine a gas release, allowing the gas to disperse freely beyond the confines of installation, the dispersion models in Cirrus can be used to predict the dispersion distances.

b. The weather stability category over water should be taken to be category D. The roughness coefficient over water should be 0,0 001. If relevant, the wind direction should be input to the offshore MAR Calculator. Use of a wind direction inside confined modules is inappropriate.

B.2.3. Modelling of fire thermal radiation for offshore facilities

a. Jet fires should be modelled in the same way as onshore facilities.

b. Walls or other obstructions that act as barriers to the jet fire should be allowed for, depending on the duration of the potential release and the fire resistance of the barrier.

c. If the distance to the barrier is short compared with the jet fire flame length, the scenario should be treated as an omni-directional turbulent fire.

B.2.4. Jet fire and pool fire thermal radiation

a. Flammable liquid jet fires and pool fires should take into account whether or not the fire is in the open or within an enclosure.

b. If the fire is in the open, similar models to those used in onshore modelling may be used, except care should be taken to assess cases for which a flammable liquid would spread beyond or through a module floor, cascading and spreading the fire into lower modules or to sea surface.

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c. Assumptions on the vulnerability of people in the flame and to thermal radiation offshore should be the same as those given for onshore, with the exception that sheltering behind fire resistant barriers, if designed for the fire duration, should be taken into account during the modelling.

d. Dispersion of smoke and its effect on people and ingress into occupied areas should be assessed.

e. Escalation of a fire incident to cause structural damage and potential collapse of structures should be assessed.

B.2.5. Fireball due to escalation

a. Certain vessels offshore may have the ability to rupture under fire engulfment conditions.

b. Proper consideration should be given, based on an assumption that an initiating pool fire or jet fire impinging on the vessel will have sufficient duration to cause escalation, allowing for runoff to other modules or to the sea surface and provision of blowdown facilities.

c. If an escalation event occurs offshore, the vulnerability of personnel to the hypothetically resulting fireball at the time of escalation is assumed to be 1.

B.2.6. Modelling of vapour cloud explosion overpressure for offshore facilities

a. Explosions offshore occur by the same mechanisms as those onshore. The explosion modelling program in the Cirrus package is designed to predict the overpressure at distances remote from the obstructed volume involved in the explosion, assuming a homogeneous "average" overpressure within the exploding, obstructed volume.

b. While this may still be a valid approach offshore, exceptional care should be taken given that the results only show overpressures remote from the installation itself, often in open sea areas.

c. Offshore personnel will also be affected if they are inside the exploding obstructed volume or close to this explosion centre, due to blast damage to occupied areas.

d. Those in occupied areas near the explosion centre will have vulnerability dependent on the design of the facility and the positioning of blast walls.

e. The strength and positioning of blast walls may often have been decided based on fluid dynamic codes that aim to predict the inhomogeneity of explosion overpressure within the obstructed volume itself.

B.2.7. Vulnerability to hypothetical releases on offshore facilities - immediate impact, escape, and evacuation

a. If assessing the vulnerability of a population group to a particular hypothetical event, consideration should be given to the presence of walls and barriers in shielding occupants from the initial event. Consideration should be given to fire, blast, and smoke impairment of escape ways, as well as impairment of refuges and evacuation points. The criteria in Table B.11 should be used for fire and gas impairment of escape routes and evacuation points.

Table B.11 - Impairment of escape routes and evacuation points

Impairment	Escape routes	Evacuation points
Flammable gas	LFL	LFL
Thermal radiation (kW/m^2) ($Btu/hr/ft^2$)	35 (11 000)	12,5 (4 000)
Smoke concentration (% of source)	15	7

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b. Blast impairment shall take into account whether or not module walls are breached and whether there is major structural damage.

c. Vulnerabilities for various combinations of immediate (full, partial, or low) impact, escape (unimpaired, fire and blast impaired, or smoke impaired), and shelter (remain in shelter or evacuate) possibilities are tabulated in Table B.12, Table B.13, and Table B.14.

Table B.12 - Immediate and escape vulnerabilities

Immediate and escape (mustering) vulnerability type	Immediate fatality rate	Escape (mustering) fatality rate
Full (100% immediate fatalities).	1	0
Partial, Esc. unimp. Evacuate.	0,3	0
Partial, Esc. smoke imp. Evacuate.	0,3	0,1
Partial, Esc. fire/blast/toxic imp. Evacuate.	0,3	0,5
Low, Esc. unimp. Evacuate.	0	0
Low, Esc. Smoke imp. Evacuate.	0	0,1
Low, Esc. Fire/blast/toxic imp. Evacuate.	0	0,5
Partial, Esc. unimp. Shelter.	0,3	0
Partial, Esc. smoke imp. Shelter.	0,3	0,1
Partial, Esc. fire/blast/toxic imp. Shelter.	0,3	0,5
Low, Esc. unimp. Shelter.	0	0
Low, Esc. Smoke imp. Shelter.	0	0,1
Low, Esc. Fire/blast/toxic imp. Shelter.	0	0,5

Table B.13 - Vulnerabilities at evacuation point

Protection of evacuation route and system	Fatality rate at evacuation point
Fully protected or out of range.	0
Partially protected.	0,3
Exposed.	1

Table B.14 - Evacuation vulnerabilities

Evacuation equipment at evacuation point	Evacuation/escape fatality rate	Cold	Warm
Throwover liferaft.	0,2	0,2	0,1
Davit launched liferaft/open lifeboat/escape chutes.	0,1	0,1	0,03
Davit TEMPSC (mounted stern to or clearance greater than 10 m [33 ft]).	0,02	0,02	0,01
Davit TEMPSC (clearance less than 10 m [33 ft]).	0,05	0,05	0,03
Free fall TEMPSC.	0,005	0,005	0,004
Disorderly wet escape.	0,6	0,6	0,3

B.2.8. Vulnerability to nonprocess events

The vulnerabilities in Table 15 should be applied for nonprocess hypothetical events.

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Table B.15 - Vulnerabilities to non process events

Event	Fatality rate
Passing ship collision - leading to structural damage (total loss).	0,5
Passing ship collision - leading to structural damage (severe damage).	0,05
Passing ship collision - leading to catastrophic riser or well release (this only needs to be included for platforms that have exposed risers/wells).	1
Visiting vessel collision - accommodation platform (severe damage).	0,05
Visiting vessel collision - leading to catastrophic riser or well release.	1
Earthquake loading at design strength level - minor damage, no release of hydrocarbons.	0,05
Earthquake loading at ductility level causes platform collapse and release of hydrocarbons.	0,5
Wind/wave loading in excess of design leads to severe damage (e.g., collapse of tall structure).	0,05
Wind/wave loading in excess of design causes platform collapse.	0,5
Floating structure - loss of stability leading to rapid capsize.	0,5
NP11 floating structure - loss of stability leading to slow progression of event.	0,05
NP12 jackup rig collapses (total loss).	0,021 6
NP13 dropped object.	0,1
NP14 accommodation fire.	0,1
NP15 helicopter impacts (fatalities on platform).	0,090 91
TP01 helicopter crash inflight (not survivable).	1
TP02 helicopter crash inflight (survivable).	0,64
TP03 helicopter crash landing/takeoff at platform (not survivable).	1
TP04 helicopter crash landing/takeoff at platform (survivable).	0,25

B.2.9. Ignition probabilities

a. Ignition probabilities should relate to the type of location where the release occurs.

b. The ignition model used in the offshore MAR Calculator is based on Table 9 of the Ignition Probability Review and Model Development - Phase 2 Look Up Correlation Report prepared by AEA for the United Kingdom Offshore Operators Association, the Energy Institute and the Health and Safety Executive, October 2004.

B.3. Modelling environmental impact

In MAR process, environmental impact is defined in terms of societal reaction as described in Annex E.

B.4. Plotting an F-N curve

a. An F-N curve describes the cumulative frequency of an event involving potential harm to N or more persons. During the analysis to estimate risk, various hypothetical events will have been assessed. Each of these events will have an associated frequency of occurrence, f, and an associated number of persons potentially harmed, N.

b. To construct the F-N curve, a list of all the events and their associated frequency and consequence should be compiled and sorted in decreasing magnitude of N.

c. If event E1 is the most severe and has an associated consequence of N1 that occurs at an associated frequency of f1 and the second most severe event is E2 and has an associated consequence of N2 that occurs at an associated frequency of f2, etc., for purposes of constructing an F-N curve, at least N2 persons will be assumed harmed in each of the events E1 and E2. Therefore, the statistically predicted cumulative frequency of harming at least N2 persons is calculated as f1 + f2.

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d. This calculation of the cumulative frequency of at least a given N, where N1 > N2 > N3 > N4, is summarised in Table B.16.

Table B.16 - Development of a F-N curve

Event	Event frequency (per yr)	Event consequence	Cumulative frequency (per yr)
E_1	f_1	N_1	f_1
E_2	f_2	N_2	$f_1 + f_2$
E_3	f_3	N_3	$f_1 + f_2 + f_3$
E_4	f_4	N_4	$f_1 + f_2 + f_3 + f_4$

e. This process is used within the MAR Calculator to plot the F-N and environmental F-E curves.

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Annex C
(Normative)
Standard event data

C.1. General

a. The following event data in this Annex should be used in conducting MAR reviews in accordance with this GP.

b. Onshore data is derived from world average industry and BP data and should be used unadjusted.

c. If events are related to specific operations (e.g., vessel overfills), the results of a specific SIL/LOPA assessment may be used in place of the generic values.

d. Offshore data is derived primarily from North Sea data and should be adjusted to reflect the local historical experience of leaks.

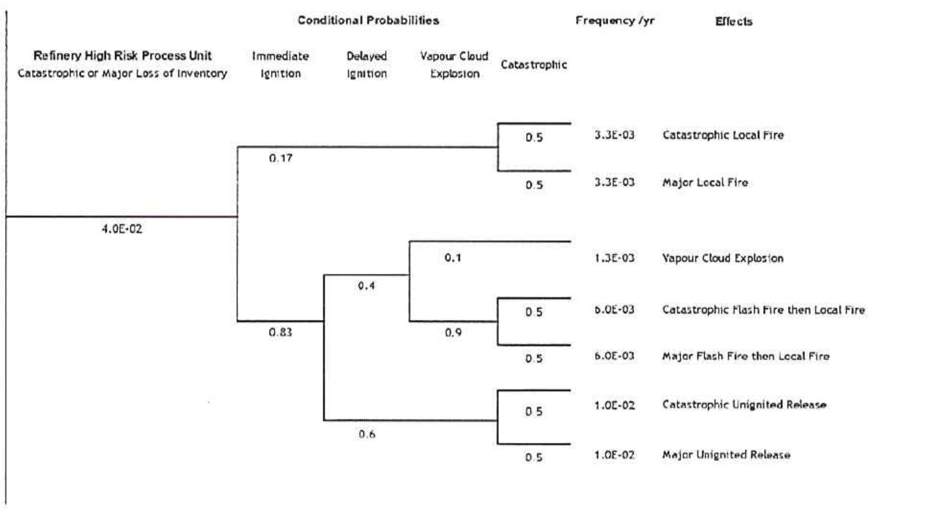
C.2. Onshore data

C.2.1. Process units

C.2.1.1. Higher risk refinery units

Crackers are defined as "higher risk" refinery units (see Figure C.1).

Figure C.1 - Event frequencies for high risk refinery units



C.2.1.2. Higher risk chemical units

Ethylene cracker, HP gas polymerisation (polyethylene/polypropylene), and ethylene oxide units are defined as "higher risk" chemical units (see Figure C.2).

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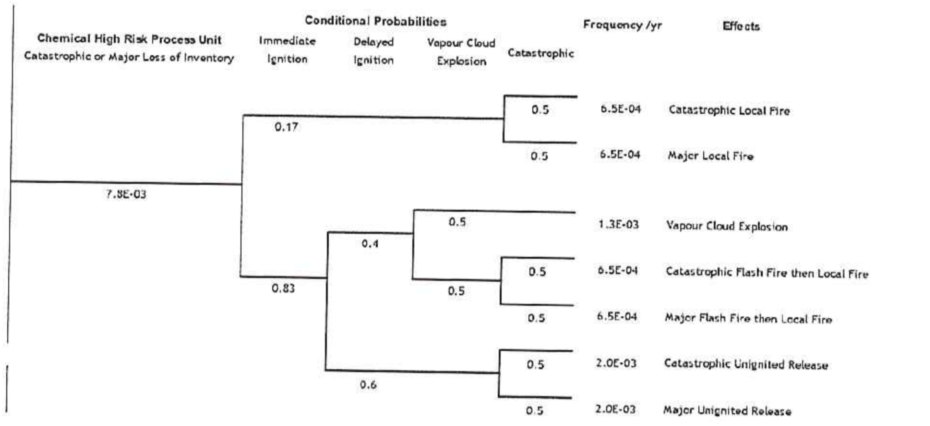
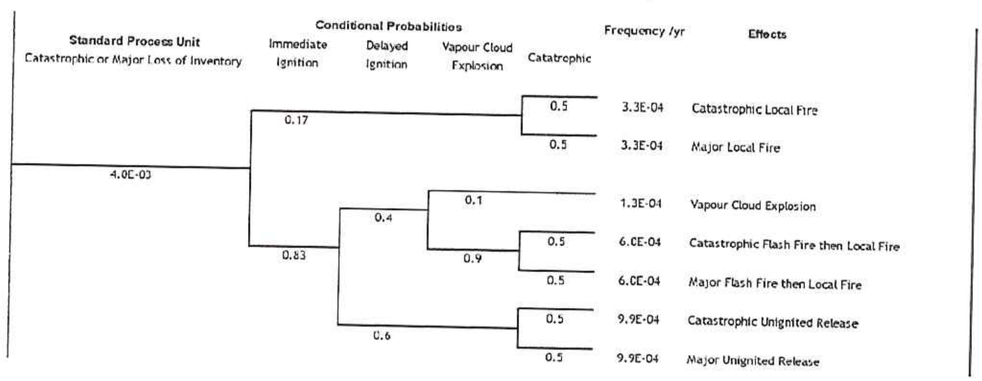
Figure C.2 - Event frequencies for high risk chemical units



C.2.1.3. Standard process units

All other oil and chemical processing units are defined as "standard" process units (see Figure C.3).

Figure C.3 - Event frequencies for standard process units



C.2.2. Process equipment

a.	Greater than 75 mm (3 in) D pipework FBR	6,0 x 10^{-7}/m yr
b.	Greater than 75 mm (3 in) D pipework - 50 mm (2 in) hole	1,2 x 10^{-6}/m yr
c.	Less than 75 (3 in) mm D pipework FBR	1,0 x 10^{-6}/m yr
d.	Less than 75 mm (3 in) D pipework - 50 mm (2 in) hole	5,0 x 10^{-6}/m yr
e.	Greater than 75 mm (3 in) D flange FBR	1,0 x 10^{-6}/flange yr
f.	Greater than 75 mm (3 in) D flange - 50 mm (2 in) hole	2,0 x 10^{-6}/flange yr
g.	Less than 75 mm (3 in) D flange FBR	N/A
h.	Less than 75 mm (3 in) D flange - 50 mm (2 in) hole.	1,0 x 10^{-6}/flange yr
i.	Greater than 75 mm (3 in) D valve FBR	4,0 x 10^{-6}/valve yr
j.	Greater than 75 mm (3 in) D valve - 50 mm (2 in) hole	4,0 x 10^{-6}/valve yr

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k. Less than 75 mm (3 in) D valve FBR — $4,0 \times 10^{-6}$/pump yr

l. Less than 75 mm (3 in) D valve - 50 mm (2 in) hole — $4,0 \times 10^{-6}$/pump yr

m. All pumps and compressors - 50 mm (2 in) hole — $1,0 \times 10^{-3}$/unit yr

n. Heat exchanger failure - 50 mm (2 in) hole — $6,0 \times 10^{-4}$/unit yr

o. Release from PRV (50 mm [2 in] hole) — $2,0 \times 10^{-4}$/unit yr

C.2.3. Atmospheric and refrigerated tanks

a. Catastrophic failure
   1. Single containment wall — $5,0 \times 10^{-6}$/tank yr
   2. Double containment wall — $1,0 \times 10^{-8}$/tank yr

b. Major leak into dike
   1. Single containment wall — $1,0 \times 10^{-4}$/tank yr
   2. Double containment wall — $1,0 \times 10^{-5}$/tank yr

c. Full surface roof fire
   1. Floating roof single skinned tank — $1,2 \times 10^{-4}$/tank yr
   2. Fixed roof single skinned tank — $1,0 \times 10^{-4}$/tank yr
   3. Fixed roof double skinned tank — $1,0 \times 10^{-6}$/tank yr

d. Large bund fire, single skinned tank — $6,0 \times 10^{-5}$/tank yr

e. Escalation of full surface fire to give multiple tank fires — $4,0 \times 10^{-1}$/tank fire

f. Silo explosion — $1,0 \times 10^{-3}$/silo

g. Warehouse fire — $3,0 \times 10^{-3}$/warehouse

C.2.4. Pressurised storage vessels

a. Cold catastrophic failure
   1. Small LPG vessels (less than 5 te [5,5 t]) — $1,0 \times 10^{-8}$/vessel yr
   2. All other hydrocarbon pressure vessels — $5,0 \times 10^{-7}$/vessel yr

b. BLEVE
   1. Vessel has passive fire protection — $1,0 \times 10^{-8}$/vessel yr
   2. Vessel has high integrity protection systems — $1,0 \times 10^{-6}$/vessel yr
   3. Vessel has medium integrity protection systems — $1,0 \times 10^{-5}$/vessel yr
   4. Vessel has low integrity protection systems — $1,0 \times 10^{-4}$/vessel yr

c. Major release during drain operations open drain system — $2,0 \times 10^{-5}$/operation

d. Storage vessel overfill release
   1. High integrity protection systems — $1,0 \times 10^{-6}$/fill
   2. Medium integrity protection systems — $1,0 \times 10^{-5}$/fill
   3. Low integrity protection systems — $1,0 \times 10^{-4}$/fill

C.2.5. Shipping and jetty operations

a. Collision in open sea port — $5,0 \times 10^{-4}$/encounter

b. Collision in wide estuary (greater than 1 km [5/8 mi] width) — $4,0 \times 10^{-5}$/encounter

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c.	Collision in wide river (100 m [330 ft] to 1 km [5/8 mi] width)	$1{,}2 \times 10^{-4}$/encounter
d.	Collision in narrow river (less than 100 m [330 ft] width)	$5{,}0 \times 10^{-4}$/encounter
e.	Grounding in open sea port	$6{,}5 \times 10^{-5}$/km
f.	Grounding in wide estuary (greater than 1 km [5/8 mi] width)	$8{,}0 \times 10^{-6}$/km
g.	Grounding in wide river (100 m [330 ft] to 1 km [5/8 mi] width)	$1{,}6 \times 10^{-5}$/km
h.	Grounding in narrow river (less than 100 m [330 ft] width)	$6{,}5 \times 10^{-5}$/km
i.	Struck when berthed in wide estuary or sea port	$4{,}0 \times 10^{-6}$/encounter
j.	Struck when berthed in wide river (100 m [330 ft] to 1 km [5/8 mi] width)	$9{,}0 \times 10^{-6}$/encounter
k.	Struck when berthed in narrow river (less than 100 m [330 ft] width)	$4{,}2 \times 10^{-5}$/encounter
l.	Gas ship or double hulled liquid carrier	
	1. Probability of rupture on severe impact .	$2{,}0 \times 10^{-4}$/striking
	2. Probability of spill on severe impact	$2{,}0 \times 10^{-2}$/striking
m.	Single hulled liquid carrier	
	1. Probability of rupture on severe impact	$2{,}0 \times 10^{-2}$/striking
	2. Probability of spill on severe impact	$2{,}0 \times 10^{-1}$/striking
n.	Onboard fire escalating to cargo tank fire	$4{,}0 \times 10^{-7}$/berthing
o.	Major spill during hose transfer operations	$1{,}2 \times 10^{-4}$/transfer
p.	Major spill during hard arm transfer operations	$9{,}7 \times 10^{-5}$/transfer
q.	PERC system. Probability of failure on demand	$5{,}0 \times 10^{-1}$/demand

C.2.6. Road and rail transfer operations

a.	Hard arm rupture during transfer operations	
	High integrity protection system	$3{,}0 \times 10^{-8}$/transfer
b.	Hose rupture during transfer operations	
	1. High integrity protection system	$2{,}0 \times 10^{-7}$/transfer
	2. Medium integrity protection system	$4{,}0 \times 10^{-6}$/transfer
	3. Low integrity protection system	$4{,}0 \times 10^{-5}$/transfer
c.	Deluge/passive protection prevents BLEVE of road tanker from escalation of local fire in hazard range of tanker	
	1. No deluge system	$3{,}0 \times 10^{-1}$
	2. Remote manual deluge activation	$1{,}0 \times 10^{-1}$
	3. Automatic deluge activation on fire/gas detection	$3{,}0 \times 10^{-2}$
	4. Passive protection	$3{,}0 \times 10^{-4}$
d.	Deluge/passive protection prevents BLEVE of storage vessel from escalation of local loading fire in hazard range of storage vessel	
	1. No deluge system	$1{,}0 \times 10^{-1}$
	2. Remote manual deluge activation	$3{,}0 \times 10^{-2}$
	3. Automatic deluge activation on fire/gas detection	$1{,}0 \times 10^{-2}$

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4. Passive protection — $1,0 \times 10^{-4}$
5. Mounded or buried — $1,0 \times 10^{-4}$

C.2.7. Road and rail transport

a. Incident data in Table C.1 and Table C.2 have been developed from a UK study on transportation of dangerous substances:

Table C.1 - Event frequencies for road transport

Event Type	Leak /explosion per journey	Puncture per km (open road)	Rupture per km (open road)
Highly Flamm. Liquid			
25 kg/s pool - ign	-	4.4E-9	-
5 te pool - ign	-	-	2.4E-10
12 te pool - ign.	-	-	2.4E-10
Liquefied Flamm. Gas			
Torch Fires	5.2E-10	6.0E-10	-
Flash Fires		1.51E-09	1.7E-10
BLEVEs	5.2E-11	6.0E-11	6.7E-11

Table C.2 - Event frequencies for rail transport

Event Type	Leak /explosion per journey	Puncture per km	Rupture per km (open track)
Highly Flamm. Liquid			
25 kg/s leak	-	1.7E-8	-
Pool fire from release of whole of wagon contents	-	-	1.9E-9
Liquefied Flamm. Gas			
Torch Fires	8.3E-10	4.5E-10	-
Flash Fires	-	1.1E-9	1.3E-10
BLEVEs/Fballs	2.1E-10	3.9E-10	5.0E-11

b. The data specifically relate to UK conditions only, and appropriate modifiers should be used if assessing risks in other countries to reflect the difference in road/rail accident rates and tanker designs.

C.2.8. Pipeline operations

a. Pipeline failures are highly dependent on local conditions.

b. In mountainous areas, natural hazard (e.g., landslide) failures can dominate the failure frequency.

c. In populated areas, third party interference (e.g., diggers) can dominate the failure frequency.

d. Rupture by third parties is highly unlikely if the pipe wall thickness exceeds 19 mm (0,75 in). The following information represents average data and should be used for general guidance only:

1. 6 in to 9 in D pipeline FBR — $7,2 \times 10^{-5}$/km yr

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2. 10 in to 14 in D pipeline FBR — $6,1 \times 10^{-5}$/km yr
3. 15 in to 20 in D pipeline FBR — $5,0 \times 10^{-5}$/km yr
4. 21 in to 32 in D pipeline FBR — $3,8 \times 10^{-5}$/km yr
5. 33 in to 48 in D pipeline FBR — $2,6 \times 10^{-5}$/km yr
6. 6 in to 9 in D pipeline 50 mm (2 in) hole — $1,1 \times 10^{-4}$/km yr
7. 10 in to 14 in D pipeline 50 mm (2 in) hole — $9,2 \times 10^{-5}$/km yr
8. 15 in to 20 in D pipeline 50 mm (2 in) hole $5,7 \times 10^{-5}$/km yr
9. 33 in to 48 in D pipeline 50 mm (2 in) hole — $3,9 \times 10^{-5}$/km yr
10. FBR equivalent event during pig receiver/launcher operations
    a) Without interlocks. — $2,4 \times 10^{-5}$/operation
    b) With interlocks. — $2,4 \times 10^{-7}$/operation

C.3. Offshore data

C.3.1. Hydrocarbon systems

a. The data in Table C.3 has been developed from the OIR 12 UKCS database (OIR is Offshore incident report, a standard form used by UK Health and Safety Executive for collection of data on offshore hydrocarbon releases).

b. 75% of the releases are equivalent to 50 mm (2 in) hole size and 25% equivalent to 100 mm (4 in) hole size.

c. North Sea

1. The OIR 12 data apply to the North Sea that has been subject to a strong regulatory regime following the Piper Alpha incident.
2. Recognising that the North Sea regime may not apply in other parts of the world, a frequency modifier may be applied to the data set to reflect local IM performance.
3. This frequency multiplier should only be applied if it is recognised that leak frequencies are above the North Sea average.
4. The multiplier may be determined using the approach described in Annex G.

C.3.2. Risers and pipelines

a. The failure data for risers and pipelines in Table C.4 have been taken from PARLOC 2001.

b. Medium size failures should be taken as equivalent to a 50 mm (2 in) D hole and large failures as full bore.

C.3.3. Drilling and well operations

The data for drilling and well operations blowouts in Table C.5 have been taken from the Scandpower database.

C.3.4. Nonprocess events

a. The frequency of nonprocess events can be derived from a base case generic frequency modified by up to three location/installation specific "influencing factors".

b. The base case frequencies are as shown in Table C.6.

c. Influencing factors in Table C.7 apply.

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Table C.3 - Offshore systems leak frequencies (OIR 12)

System	Base release frequency/yr
Flowlines - oil	$3{,}20 \times 10^{-04}$
Flowlines - gas	$4{,}16 \times 10^{-04}$
Flowlines - condensate	$2{,}65 \times 10^{-04}$
Import - oil	$7{,}72 \times 10^{-04}$
Import - gas	$3{,}10 \times 10^{-04}$
Import – condensate	$3{,}10 \times 10^{-04}$
Manifold - oil	$1{,}69 \times 10^{-03}$
Manifold - gas	$5{,}12 \times 10^{-04}$
Manifold - condensate	$5{,}12 \times 10^{-04}$
Metering - oil	$2{,}76 \times 10^{-03}$
Metering - gas	$1{,}69 \times 10^{-03}$
Metering - condensate	$1{,}79 \times 10^{-03}$
Blowdown	$2{,}19 \times 10^{-03}$
Closed drain	$1{,}97 \times 10^{-03}$
Open drain	$3{,}95 \times 10^{-03}$
HP flare	$6{,}47 \times 10^{-03}$
LP flare	$3{,}28 \times 10^{-03}$
HP vent	$2{,}46 \times 10^{-03}$
LP vent	$2{,}69 \times 10^{-03}$
Separation - oil test	$1{,}10 \times 10^{-02}$
Separation - oil production	$9{,}19 \times 10^{-03}$
Oil treatment	$4{,}66 \times 10^{-03}$
Produced water treatment - oil	$1{,}16 \times 10^{-02}$
Produced water treatment - gas	$6{,}31 \times 10^{-03}$
Methanol Injection - gas	$8{,}17 \times 10^{-04}$
Methanol Injection - oil	$4{,}29 \times 10^{-04}$
Chemical Injection - gas	$4{,}29 \times 10^{-04}$
Chemical Injection - oil	$5{,}48 \times 10^{-04}$
Export - oil	$1{,}18 \times 10^{-02}$
Export - gas	$1{,}55 \times 10^{-03}$
Export - condensate	$4{,}99 \times 10^{-03}$
Separation - gas test	$3{,}13 \times 10^{-03}$
Separation - gas production	$2{,}28 \times 10^{-03}$
Gas dehydration	$9{,}76 \times 10^{-03}$
LPG/condensate	$1{,}17 \times 10^{-03}$
Sour treatment	$1{,}10 \times 10^{-02}$
Gas compression	$1{,}55 \times 10^{-02}$
Heli/jet fuel	$9{,}56 \times 10^{-05}$
Diesel	$9{,}56 \times 10^{-05}$
Heat transfer oil	$9{,}56 \times 10^{-05}$
Power generation turbine	$2{,}04 \times 10^{-04}$
Fuel gas	$1{,}25 \times 10^{-02}$
Power generation turbine	$3{,}98 \times 10^{-03}$

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Table C.4 - Risers and pipelines leak frequencies

System	Release Frequencies/yr	Fraction large	Frequency per
Steel riser < 9 in	$4{,}68 \times 10^{-04}$	0,50	No. of risers
Steel riser 9 in to16 in	$9{,}10 \times 10^{-04}$	0,50	No. of risers
Steel riser > 16 in	$1{,}25 \times 10^{-04}$	0,50	No. of risers
Flexible riser	$3{,}33 \times 10^{-03}$	0,50	No. of risers
Pipeline in safety zone < 9 in	$1{,}44 \times 10^{-03}$	0,58	No. of pipelines in safety zone
Pipeline in safety zone 10 in to16 in	$9{,}05 \times 10^{-04}$	0,58	No. of pipelines in safety zone
Pipeline in safety zone > 16 in	$1{,}39 \times 10^{-04}$	0,58	No. of pipelines in safety zone
Flexible in safety zone	$2{,}22 \times 10^{-03}$	0,58	No. of pipelines in safety zone
Steel pipeline < 9 in	$2{,}79 \times 10^{-04}$	0,40	No. of km
Steel pipeline 10 in to16 in	$6{,}05 \times 10^{-05}$	0,40	No. of km
Steel pipeline > 16 in	$1{,}32 \times 10^{-05}$	0,40	No. of km
Flexible pipeline	$1{,}03 \times 10^{-03}$	0,40	No. of km

Table C.5 - Drilling and well operations leak frequencies

Operation	Frequency	Fraction subsea	Frequency per
Exp. drilling, shallow gas.	$1{,}30 \times 10^{-03}$	0,36	Wells drilled per yr
Dev. drilling, shallow gas.	$1{,}19 \times 10^{-03}$	0,36	Wells drilled per yr
Exp. drilling, deep (norm.).	$2{,}80 \times 10^{-04}$	0,41	Wells drilled per yr
Exp. drilling (HPHT wells).	$1{,}70 \times 10^{-03}$	0,41	Wells drilled per yr
Dev. drilling, deep (norm. gas).	$8{,}40 \times 10^{-05}$	0,41	Wells drilled per yr
Dev. drilling, deep (norm. oil).	$5{,}30 \times 10^{-05}$	0,41	Wells drilled per yr
Dev. drilling (HPHT wells gas).	$5{,}20 \times 10^{-04}$	0,41	Wells drilled per yr
Dev. drilling (HPHT wells oil).	$3{,}20 \times 10^{-04}$	0,41	Wells drilled per yr
Completion - gas.	$1{,}50 \times 10^{-04}$	0	Operations per yr
Completion - oil.	$7{,}30 \times 10^{-05}$	0	Operations per yr
Wireline - gas.	$1{,}10 \times 10^{-05}$	0	Operations per yr
Wireline - oil.	$5{,}50 \times 10^{-06}$	0	Operations per yr
Coiled tubing - gas.	$2{,}40 \times 10^{-04}$	0	Operations per yr
Coiled tubing - oil.	$1{,}20 \times 10^{-04}$	0	Operations per yr
Snubbing - gas.	$5{,}60 \times 10^{-04}$	0	Operations per yr
Snubbing - oil.	$2{,}80 \times 10^{-04}$	0	Operations per yr
Workover - gas.	$3{,}90 \times 10^{-04}$	0	Operations per yr
Workover - oil.	$1{,}40 \times 10^{-04}$	0	Operations per yr
Producing wells – gas	$2{,}30 \times 10^{-05}$	0	Wells online per yr
Producing wells – oil	$7{,}00 \times 10^{-06}$	0	Wells online per yr
Gas injection wells	$2{,}30 \times 10^{-05}$	0	Wells online per yr
Water injection wells	$3{,}80 \times 10^{-06}$	0	Wells online per yr

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Table C.6 - Frequencies for nonprocess events

Event Type	Event Frequency	unit
Passing vessel collision resulting in total loss, severe damage or signifcant damage	2.59E-04	per year
Proportion resulting in total loss	8.6%	-
Proportion resulting in severe damage	60.0%	-
Visiting vessel collision causing strucutral damage (severe)		
SS01 Calm Sea, Shallow Water (eg GOM Shelf)	4.00E-07	per visit
SS02 Rough Sea, Deep Water (eg North Sea)	1.50E-05	per visit
Visiting vessel collision resulting in hydrocarbon release		
SS01 Calm Sea, Shallow Water (eg GOM Shelf)	8.50E-07	per visit
SS02 Rough Sea, Deep Water (eg North Sea)	1.50E-05	per visit
Earthquake loading at Strength level (SLE) minor damage no release of hydrocarbons.	5.00E-03	per year
Earthquake loading at Ductility level (DLE) causes platform collapse and release of hydrocarbons.	3.33E-04	per year
Wind/wave loading in excess of design leads to collapse of tall structure	1.00E-04	per year
Wind/wave loading in excess of design leads to platform collapse	1.00E-05	per year
Structural failure/loss of stability of floating structures	1.00E-04	per year
Jack-up Rig collapses	7.04E-04	per year
Accommodation fire	4.00E-03	per year
Dropped Object	2.20E-05	per lift
Helicopter Crash inflight	6.00E-06	per hr
Probability accident is not survivable	0.5	-
Probability accident has fatalities	0.15	-
Helicopter Crash landing / takeoff at platform	3.00E-06	per TOL
Probability accident has fatalities	0.35	-
Probability helicopeter falls of helideck after a crash	0.107	
Probability of helideck fire	0.08	-

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Event Type	Event Frequency	unit
Earthquake loading at Ductility level (DLE) causes platform collapse and release of hydrocarbons.	3.33E-04	per year
Wind/wave loading in excess of design leads to collapse of tall structure	1.00E-04	per year
Wind/wave loading in excess of design leads to platform collapse	1.00E-05	per year
Structural failure/loss of stability of floating structures	1.00E-04	per year
Jack-up Rig collapses	7.04E-04	per year
Accommodation fire	4.00E-03	per year
Dropped Object	2.20E-05	per lift
Helicopter Crash inflight	6.00E-06	per hr
Probability accident is not survivable	0.5	-
Probability accident has fatalities	0.15	-
Helicopter Crash landing / takeoff at platform	3.00E-06	per TOL
Probability accident has fatalities	0.35	-
Probability helicopeter falls of helideck after a crash	0.107	
Probability of helideck fire	0.08	-

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Table C.7 - Nonprocess events - Influencing factors

Scenario	Influencing Factor 1	Value of Factor 1	Influencing Factor 2	Value of Factor 2	Influencing Factor 3	Value of Factor 3
Passing Ship Collisions - Structural Failure	CA01 Low Shipping Density	0.1	T01 Well Tower	3	ES01 No ARPA/EWS, Escape possible to other linked platform	0.5
	CA02 Normal Shipping Density	1	T02 Steel Jacket 3 legs	3	ES02 ARPA/EWS, Escape possible to other linked platform	0
	CA03 High Shipping Density	10	T03 Steel Jacket 4 legs	1	ES03 No ARPA/EWS	1
			T04 Steel Jacket more than 4 legs	0.3	ES04 ARPA/EWS	0.5
			T05 Concrete Jacket	0.3		
			T06 FPSO	1		
			T07 Spar	1		
Passing Vessels - Riser/Well Rupture	As above		No	0.01	As above	
			Yes	0.25		
Visiting Vessel Collisions	F01 No Fendering	1				
	F02 Wooden	1				
	F03 Steel	0.5				
	F04 Strengthened Steel	0.25				
Visiting Vessels - Riser/Well Rupture	RF01 Exposed Risers or Wells - No Fendering	0.5				
	RF02 Exposed Risers or Wells - Wooden Fendering	0.5				
	RF03 Exposed Risers or Wells - Steel Fender	0.25				
	RF04 Exposed Risers or Wells - Strengthened Steel Fender	0.125				
	RF05 All Risers and Wells Inboard of Jacket	0.05				

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Scenario	Influencing Factor 1	Value of Factor 1	Influencing Factor 2	Value of Factor 2	Influencing Factor 3	Value of Factor 3
Earthquake	T01 Score 0 - Non Seismic Area	0.01				
	T02 Score 9 - Designed for Seismic Activity	1				
	T03 Score 21 - Not Designed for Seismic, but assessed adequate	2				
	T04 Score 30 - Not Designed for Seismic, and not assessed	10				
Wind/Wave - Collapse	T01 FMS Wind/Wave Score 50 - 100	1				
	T02 FMS Wind/Wave Score 100 - 180	2				
	T03 FMS Wind/Wave Score > 180	5				
Loss of Stability	T01 Semi-submersible (< 5 ballasting operation in/preceding bad weather per year)	1.5				
	T02 Semi-submersible (> 5 ballasting operation in/preceding bad weather per year)	2				
	T03 Ship shape	3				
	T04 Spar	3				
Accomodation Fire	A01 Steel, no fire detection or protection	3	E01 At least 2 diverse routes from all spaces	0.1		
	A02 Steel, with fire detection and protection	1	E02 Inadequate escape routes	1		
	A03 Wooden, no fire detection or protection					
	A04 Wooden, with fire detection and	0.1				
Dropped Objects	D01 WOAD	1				
	D02 HSE All lifting devices	0.75				
	D03 HSE Installation main cranes	0.67				
	D04 HSE Drilling derrick	0.44				
	D05 HSE Other fixed and portable devices	2.73				
Helicopter Accident Data	H01 North Sea	1			H01 Fire fighting facilities in accordance	0.01
	H02 Gulf of Mexico	2.7			H02 Reduced fire fighting facilities	0.1
	H03 All other countries	6.3				
	H04 World Average	3.5				

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Annex D
(Normative)
Demonstration of continuous risk reduction

D.1. Introduction

a. GDP 31-00-01 requires HSSE risks to be assessed and recorded. GDP 31-00-01 also calls for preparation of risk reduction plans to support CRR.

Note: At the time of issue of the revised GP 48-50, GDP 31-00-01 in "implementation draft" form. It is anticipated that, revised as appropriate following the "implementation draft" stage, the Risk Practice will contain these requirements. Please refer to the OMS Library for current version.

b. BP shall also apply continuous risk reduction to all BP Operations with a potential for a major accident in accordance with this GP. For MAR, CRR shall be applied to all identified MARs, taking due account of anticipated societal reaction to environmental damage, as well as other effects.

c. The adoption of a process of CRR does not necessarily preclude growth of a business. For those risks modelled to be above the Group reporting line, reporting requirements are described in GRP STD 01, Element 3. All risks will be managed wholly within the segment or function.

d. Within the BP Operations, the overall objective should be to show that MAR is on a steady decline in line with the principles of CRR. This does not mean that MAR cannot increase within any business or at any site, rather that the increased risks should not only be effectively managed but also should be more than balanced, over time, by risk reductions achieved elsewhere (e.g., due to discontinuance of some operations or through efforts to mitigate risk).

e. If there is a sudden and substantial change in the scale of activity within a segment (e.g., due to acquisitions, divestitures, or major new projects), this change in scale may result in a temporary increase (or decrease) in the overall MAR within the segment. Under these circumstances, it may be necessary to establish a new benchmark against which continuous risk reduction is measured.

D.2. CRR processes

D.2.1. General

a. All BP Operations should have a process in place to demonstrate CRR.

b. In the context of MAR, because of regional cultural differences (e.g., over the applicability of cost benefit approaches), there is no group mandated approach.

c. Segments, with input from the regions, should decide how this can best be achieved and what metrics should be adopted.

d. The MAR process produces the overall risk profile and the risk contributors for a facility. A number of approaches to CRR are described in D.3 to D.5. These approaches may be used in isolation or in combination to arrive at the most effective means of achieving CRR.

D.2.2. F-N based approach

a. The MAR process generates F-N and F-E curves for sites/operations.

b. These can be accumulated to generate curves at SPU, segment, and Group level.

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c. Appropriate Group reporting lines (based on scale of operation) can also be accumulated in the same way.

d. This approach is best suited to reviewing the magnitude of overall risks at segment and Group level.

e. One way of demonstrating risk reduction would be to establish target timescales to progressively reduce the F-N and F-E curves at segment and Group level.

D.2.3. WEV

D.2.3.1. General

a. fN and fE values

1. The MAR process also generates risk WEV for risk contributors in the form of $fN^{1.5}$ and fE values.
2. These values can be used to establish priorities for risk reduction measures.
3. The $fN^{1.5}/fE$ are numeric values, where a higher value represents a greater major accident risk.
4. Therefore, if all risk contributors for a facility, segment, or the Group are listed in terms of $fN^{1.5}/fE$, the highest priorities can be identified for risk reduction purposes.

b. Expected values of onsite and offsite populations

1. If a scenario is able to affect onsite and offsite populations, the overall expected value should take both populations into account.
2. In recognition of the premise that the offsite Group reporting line is one order of magnitude lower than the onsite Group reporting line, the offsite values should be weighted by a factor of 10 (i.e., the combined weighted expectation value for scenario i is given by):

$$WEV_i = \{(f_i N_i^{1,5})_{onsite} + 10*(f_i N_i^{1,5})_{offsite}\}$$

3. The total WEV for a site is given by:

$$WEV_{site} = \{(\Sigma f_i N_i^{1,5})_{onsite} + 10*(\Sigma f_i N_i^{1,5})_{offsite}\}$$

c. Expressions in Table D.1 may be used to determine the WEV for environmental impact.

Table D.1 - Environmental WEVs

Environmental severity category	WEV
Global	f x 3 000
Regional	f x 300
National	f x 30
Local	f x 3

Note:
f = frequency of event.

D.2.3.2. Establishing priorities based on WEV

a. As MAR is calculated by considering both the nature of the accident and the number of people exposed, it can be presented in terms of source and/or target risk. For example, a MAR study output can be given in terms of a risk from an event to all populations or a risk from all events to a single population.

b. If evaluating the risk reduction potential of mitigation measures, a single measure may mitigate multiple risk contributors, and the cumulative benefits of the measure should be used as a basis for prioritising risk reduction measures. A scheme for establishing priorities based on WEV is shown in Table D.2.

Table D.2 - Event prioritisation based on WEV

WEV	Priority
Greater than 3,0	1
Greater than 3×10^{-1}	2
Greater than 3×10^{-2}	3
Greater than 3×10^{-3}	4
Greater than 3×10^{-4}	5
Greater than 3×10^{-5}	6
Greater than 1×10^{-6}	7
Less than1 $\times 10^{-6}$	8

D.2.4. Cost benefit considerations

a. This approach recognises that the resources available for any sustainable business to reduce risk are not infinite and that, for certain decisions, cost benefit analysis of risk reduction measures may be appropriate.

b. Cost benefit analysis is in common use in some parts of the world to demonstrate that risks are being adequately managed, whereas in other locations, the technique is not accepted. For example, in the UK, a cost benefit approach is well recognised in terms of demonstrating the legal requirement to manage risks in accordance with the UK standard of ALARP.

c. Decision making

1. To aid in decision making on further risk reduction, Figure D.1 provides an indication of the indicative resources appropriate to reduce risk priority levels.
2. The total WEV (including onsite, offsite, and environmental impacts as described in D.2.3) should be calculated with and without a proposed mitigation measure (e.g., as in D3) in place and the reduction in WEV (ΔWEV) calculated.
3. The ΔWEV can be converted into a risk reduction priority ranking based on Table D.2.
4. Using the graph, the corresponding indicative resources are reflected for this risk reduction.
5. If the measure involves capital expenditure, the annual indicative resources value should be converted into an equivalent single expenditure by multiplying by the remaining life of the facility.

d. Figure D.1 includes consideration of personnel and environmental risks. If business interruption is also considered, it may be appropriate to use additional resources to reduce the risk.

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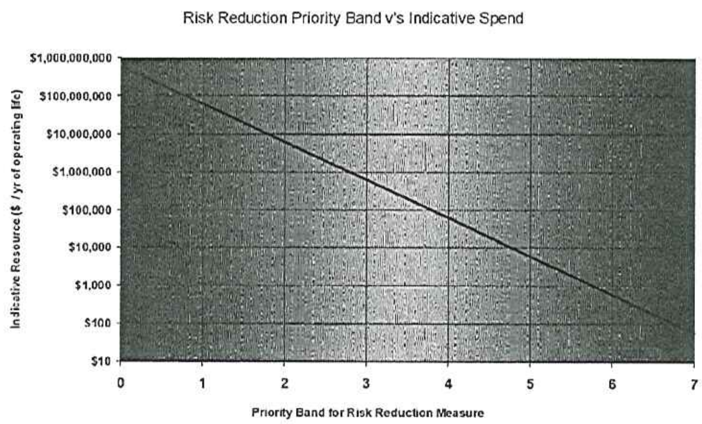
Figure D.1 - Indicative spend versus priority risk reduction



e. Evaluation of whether costs of various mitigation measures lie within their respective indicative spends is intended to inform (but not dictate) a conclusion as to whether each measure is to be implemented or not. For measures for which the decision is not to implement, the reasons should be documented and justified, including addressing effectiveness, feasibility, and WEV.

   1. The cost benefit considerations described in d. have been developed to increase safety and protect the environment.
   2. Mitigation of accidents may also protect against commercial losses, such as property damage and business interruption loss. This aspect may also be included at the discretion of the BP Operation leader

f. Other factors in decision making

   1. WEV analysis should be used as one mechanism to aid technical and business judgment about which options are appropriate to implement.
   2. WEV analysis is not a substitute for such judgment and should never be the only consideration in determining which options are to be implemented.
   3. While not a substitute for onsite technical and business judgment, WEV analysis may aid in decision making by suggesting a potentially appropriate level of resources to expend with respect to any given risk reduction approach.

D.2.5. Continuous risk reduction in projects

a. The application concepts of ISD should be the first means of achieving CRR (as GP 48-04 applies). Prioritisation of further risk reduction measures may be achieved using WEV as described in D.2.3.2.

b. Since the MAR approach does not establish an acceptable/tolerable level of risk, a target cannot be simply established, whereby the process of CRR can be deemed to be complete and the project design frozen.

c. One objective of CRR in projects should be to deliver an operating facility that would not have risks which would immediately feature high up on the segments prioritisation list.

d. Any event with a priority level of 1 to 3 (as described in D.2.3.2) would be expected to feature on such a list. Therefore, projects should seek in the first instance to mitigate any such events.

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e. From thereon, any additional risk mitigation may be assessed using the approach described in D.2.4.

D.3. Risk mitigation measures

a. Risk reduction measures should be:

   1. Tangible (some material difference to current situation is apparent).
   2. Measurable (reduction in frequency and/or consequence is evident).
   3. Sustainable (effectiveness is unlikely to be eroded over time).
   4. Practical (possible to implement).

b. Examples of potential risk reduction measures that should be considered include the following:

   1. Closing down or relocating a facility or operation.
   2. Relocating people.
   3. Reducing the inventory of hazardous fluids.
   4. Substituting a less hazardous fluid.
   5. Selecting a lower risk process over a higher risk one (particularly applicable during the appraise/select stages of projects).
   6. Mitigating the consequences of an accident (e.g., providing blast/fire protection for buildings or modules on offshore platforms).
   7. Apply protective systems, such as passive fireproofing or water deluge systems.
   8. Provision of equipment for emergency isolation, depressuring, or deinventorying.
   9. Addition of a SIS or upgrading the SIL level for an existing SIS.
   10. Developing new or modified procedures.
   11. Increased inspection or use of better inspection techniques.

c. If BP does not own and have operational control of the activity but a MAR study has been conducted (e.g., as described in 5.a, clauses 1 and 2), there may be other risk mitigation measures that may be pursued, including, for example:

   1. Discontinuance or modification of the activity.
   2. Revision of contractual arrangements.
   3. Change of contractors or JV partners.

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Annex E
(Normative)
Categorisation of environmental events

a. Societal reaction to environmental events shall be categorised using the approach set out in GDP 44-00-01, Appendices 1, 2, and 3.

b. To constitute a major accident event for environmental reasons, the potential societal reaction shall be limited to events categorised as severity A to D in those columns.

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Annex F
(Informative)
Comparison of MAR and QRA studies

MAR STUDIES	MAR STUDY (Mandatory under IM Standard)		FOCUSED MAR (If Required) Sometimes known as QRA	DETAILED MAR (If Required) Sometimes known as QRA
APPLICATION	**Projects during Appraise / Select Stage.** *Note MAR to be updated during Define and Execute as appropriate.*	Existing facilities / Operations.	Projects during Define/Execute Stage with scope specific to issues identified in the MAR Study Existing sites with scope specific to issues identified in the MAR Study	Where required by Local legislation (e.g. UK safety case) or Third party (e.g. JV partner).
OBJECTIVES				
Risk Quantification	To identify and evaluate the overall and relative major accident risk to people and/or the environment from a range of options.	To evaluate major accident risk to people and/or the environment.	To quantify major accident risk to people and/or the environment associated with specific aspects of the project/facility/operation.	To evaluate risk for comparison with Legislation or Third party Criteria.
Risk Management	To carry out an option evaluation process using the principles of inherent safety. To demonstrate that any options proposed for further evaluation are below the Group Reporting Line.	To identify facilities above Group Reporting Line. To identify opportunities for Continuous Risk Reduction (CRR) and develop a CRR program.	To provide detailed analysis of major accident risk and demonstrate risk reduction if measures were applied.	To develop a risk management program in compliance with Legislation / Third Party requirements.
HAZARD IDENTIFICATION				
Scope	Broad but shallow. Covers all aspects (hydrocarbon and non hydrocarbon) of the project. Focuses attention on design and siting features which dominate risk levels.	Broad but shallow. Covers all aspects (hydrocarbon and non hydrocarbon) of the facility / operation	Focus on specific aspects of risk including; specific sources of risk (e.g. HF), specific populations (e.g. building occupants), environmental receptors or risk reduction measures.	Scope and depth will be dependent on Legislation / Third Party requirements.
Typical procedure(s)	Defined in GP 48-50.	Defined in GP 48-50.	Use appropriate techniques depending on nature of study.	Use methodology approved by Legislation / Third Party. Where possible use procedure compatible with GP 48-50

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MAR STUDIES	MAR STUDY (Mandatory under IM Standard)		FOCUSED MAR (If Required) Sometimes known as QRA	DETAILED MAR (If Required) Sometimes known as QRA
DETERMINATION OF CONSEQUENCES TO POPULATION AND THE ENVIRONMENT				
Hazardous effects modelling, Fire, Toxic, Explosion	Defined in GP 48-50. Contained in BP MARC and Offshore risk calculator.	Defined in GP 48-50. Contained in BP MARC and Offshore risk calculator.	Use GP 48-50. Any deviations to be documented validated and approved by relevant TA.	Use models approved by Legislation / Third Party. Where possible use models compatible with GP 48-50
Vulnerability Assumptions	Defined in GP 48-50. Contained in BP MARC and Offshore risk calculator.	Defined in GP 48-50. Contained in BP MARC and Offshore risk calculator.	Use GP 48-50 values or develop site specific vulnerability rule set (e.g. overpressure vs vulnerability relationships for specified occupied building). Develop modification factors as	Use values approved by Legislation / Third Party . Where possible use values compatible with GP 48-50
Ignition / explosion probability model	Defined in GP 48-50. Contained in BP MARC and Offshore risk calculator.	Defined in GP 48-50. Contained in BP MARC and Offshore risk calculator.	Use GP 48-50 - BP MARC Offshore Risk calculator approach (based on GP 24-22) or develop site specific rule set . Develop modification factors for mitigation measures.	Use model approved by Legislation / Third party.
Meteorological assumptions	Defined in GP 48-50	Defined in GP 48-50	Use GP 48-50 values or carry out probabilistic assessment of weather conditions on site	Use Legislation / Third party requirements

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MAR STUDIES	MAR STUDY (Mandatory under IM Standard)		FOCUSED MAR (If Required) Sometimes known as QRA	DETAILED MAR (If Required) Sometimes known as QRA
FREQUENCY ESTIMATION				
Generic Frequencies	Defined in GP 48-50. Contained in BP MARC and Offshore risk calculator.	Defined in GP 48-50. Contained in BP MARC and Offshore risk calculator. Scaling may be applied in offshore model given sufficient local release data.	Use GP 48-50 values or carry out site specific study to establish release frequencies and hole size distribution.	Use values approved by Legislation / Third Party . Where possible use values compatible with GP 48-50
Operation Specific Frequencies	Use GP 48-50 data if applicable, otherwise use relevant historical incident data on similar plants.	Use GP 48-50 data if applicable, otherwise use relevant historical incident data on similar plants.	As for MAR Study. If appropriate, develop fault trees to derive frequencies for operational events taking into account protective systems.	Use methodology approved by Legislation / Third Party . Where possible use approach compatible with MAR study.
External Events (natural hazards)	Use natural hazard (seismic, tsunami, wind, landslide etc) return period proposed in project design codes to derive frequency of failure.	Use natural hazard (seismic, tsunami, wind, landslide etc) return period to derive frequency of failure. Use SRS ranking for offshore structures.	Detailed study to derive frequency of failure of various items of plant/structures due to external events exceeding design basis.	Use methodology approved by Legislation / Third Party . Where possible use approach compatible with MAR study.
External events (non natural e.g. vehicle/ship/aircraft impact, dropped object, malicious)	Use GP 48-50 data if applicable, otherwise use relevant historical incident data from facilities with similar scenarios.	Use GP 48-50 data if applicable, otherwise use relevant historical incident data from facilities with similar scenarios.	Use GP 48-50 if applicable. Otherwise carry out detailed site specific study to derive frequency of failure of various items of plant /structures due to external events exceeding design basis.	In accordance with Legislation/Third party requirements. Where possible use approach compatible with MAR study.
Escalation	GP48-50 generic frequencies include accidents from all causes so may be used for this level of study.	GP48-50 generic frequencies include accidents from all causes so may be used for this level of study.	If appropriate, develop event trees for potential escalation sequences which allow effect of risk reduction measures to be modelled.	In accordance with Legislation/Third party requirements. Where possible use approach compatible with MAR study.
Knock-on from surrounding activities	Not normally included in MAR study. Where neighbouring sites have potential for Major Accident risk carry out Focused MAR.	Not normally included in MAR study. Where neighbouring sites have potential for Major Accident risk carry out Focused MAR.	Use GP 48-50 if applicable to model risk from neighbouring site. Otherwise carry out detailed site specific study to derive frequency and consequence of events on neighbouring sites affection facility under consideration.	In accordance with Legislation/Third party requirements. Where possible use approach compatible with Focused MAR study.

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MAR STUDIES	MAR STUDY (Mandatory under IM Standard)		FOCUSED MAR (If Required) Sometimes known as QRA	DETAILED MAR (If Required) Sometimes known as QRA
RISK QUANTIFICATION				
Methodology	GP 48-50 (BP MARC or Offshore Calculator)	GP 48-50 (BP MARC or Offshore Calculator)	GP 48-50 (BP MARC or Offshore Calculator) or detailed methodology.	In accordance with Legislation/Third party requirements. Where possible use approach
Risk output	FN curves onsite and offsite (compared with group reporting lines). Societal Risk WEV and contributions to WEV (targets and sources). **FUTURE** *IR for most exposed person and selected worker groups/building occupants onsite and offsite. IR 100% occupancy at the fence line. Contributions to IR.*	FN curves onsite and offsite (compared with group reporting lines). Societal Risk WEV and contributions to WEV (targets and sources). **FUTURE** *IR for most exposed person and selected worker groups/building occupants onsite and offsite. IR 100% occupancy at the fence line. Contributions to IR.*	Similar outputs to MAR. May include detailed evaluation of a range of mitigation measures. Where the Focused MAR study covers specific issues the output should be fed back into the project/facility/operation MAR study.	In accordance with Legislation/Third party requirements.
Typical conclusions and recommendations.	Rank project options and clearly identify any which are unlikely to meet Group Reporting Lines. Identify lowest risk option. Identify areas of concern where more focused studies will be required to provide input to the MAR study. Give guidance on facility siting issues (e.g. separation distances between process, storage areas and occupied buildings). Advise on recommendations for land use planning outside fence line (e.g. where there are major hazard consequences have effects offsite).	Identify facilities/operations above Group Reporting Line. Identify areas of concern where further studies (e.g. detailed MAR) may be appropriate to gain a better understanding of risk. Provide recommendations for Continuous Risk Reduction.	Confirm that project risk does not exceed BP Group reporting lines. Give recommendations on risk reduction measures to be implemented as part of continuous risk reduction. Identification and detailed evaluation of risk reduction measure(s) using principles of inherent safety and Continuous Risk Reduction.	In accordance with Legislation/Third party requirements.

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Annex G
(Informative)
Offshore methodology - Hydrocarbon leak frequency modifier calculation

G.1. Introduction

a. The frequencies for hydrocarbon leaks within the offshore MAR Calculator spreadsheet are based on UK North Sea data (OIR 12 database).

b. Because BP assets elsewhere can have different leak frequencies than installations within the UK North Sea due in part to differing asset conditions and IM regimes, it is thus necessary to apply a correction factor to these assets to account for these differences.

c. This Annex will explain the procedure that should be used to derive the leak frequency modifier for a specific BP Operation.

G.2. Methodology

a. The correction factor should be found by comparing leak data from the UK North Sea with leak data from the relevant BP Operation and subsequently finding the leak frequency factor. This calculation is complicated by:

1. Differing platform complexities

   a) Leak frequencies are calculated per installation per year.

   b) Hence, if different approaches are used for assessing the number of installations, inconsistency is introduced into the calculation.

   c) In the OIR 12 database, each individual structure is counted, and many of the UK platforms are large integrated units with great numbers of hydrocarbon systems.

   d) Many non UK assets are significantly less complex than UK assets, frequently comprising several small unmanned remote satellites, with the manned complexes consisting of a number of bridge linked platforms with hydrocarbon systems distributed across them.

   e) There is therefore no obvious and direct comparison of these differing assets and, hence, a best fit estimate is required.

2. Quality and availability of data

   a) Data for all UK North Sea operations has been rigorously collected since the early 1990s.

   b) Elsewhere in BP, the availability of leak frequency data is more variable, with the reporting structure often being different from the OIR 12 database, and rigour of reporting is still being developed.

b. Due to the differing conditions of BP assets, it seems inappropriate to omit a leak frequency correction factor, but it is important to recognise limitations in the process of deriving the factor that are posed by the differing platform complexities and the quality and availability of leak data. Hence, to reflect the limited accuracy of the leak frequency factor, only the following broadly categorised factors will be applied:

   1 - As North Sea.

   3 - Half (logarithmic) order of magnitude above North Sea.

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10 - One order of magnitude above North Sea.

c. If there is particular uncertainty regarding the allocation of a leak frequency factor, the report should include sensitivity cases demonstrating this uncertainty.

G.3. Data comparison

a. The following methods for comparing UK North Sea leak data with data from the relevant BP Operation have been identified:

1. Comparison of overall leak data

    a) This approach compares the overall BP Operation leak data, independent of the size of leaks that has been collected over a range of time, with the UK North Sea (OIR 12 database) overall leak data.

    b) Leak frequency is calculated as number of total leaks per platform per year.

2. Comparison of leak data specifying major and significant incidents

    a) This approach compares frequency of major and significant incidents within the BP Operation with frequency of major and significant incidents within the UK North Sea.

    b) Minor incidents are not accounted for in this case, as they are deemed insignificant from a MAR perspective.

    c) The definition of major, significant, and minor incidents is based on the definition in the OIR 12 database.

    d) Leak frequency is calculated as the number of major and significant leaks per platform per year.

3. Comparison of leak data categorised into equivalent leak diameters to differentiate between smaller (25 mm [1 in]) and larger (100 mm [4 in]) leak size

    a) This approach compares the frequency of 25 mm (1 in) and 100 mm (4 in) holes within the BP Operation with the frequency of 25 mm (1 in) and 100 mm (4 in) holes in the UK North Sea.

    b) These hole sizes are equivalent holes sizes.

    c) For each incident, the implied average release rate (i.e., mass released divided by duration) and operating pressure of the system in which the release occurred are used to derive a hole size consistent with these two parameters.

    d) This approach has been used to calculate the release frequencies that are used in the offshore MAR Calculator.

4. Comparison of Tr@ction data (as published in the monthly "E and P Health and Safety Spills and HC Leak and Transport report") - This approach compares the number of leaks, as reported in Tr@ction in the UK, with the number of leaks in the BP Operation.

5. Comparison of MIA data - This approach compares the number of leaks, as reported in the MIA database (that draws on data from Tr@ction) in the UK, with the number of leaks in the BP Operation.

6. Comparison of HiPo data - This approach compares the number of leaks, as reported in the HiPo database (which draws on data from Tr@ction) in the UK, with the number of leaks in the BP Operation.

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b. As leak data is generally reported as the total number of leaks in a given BP Operation, it is important always to calculate the number of leaks per platform per year to be able to compare numbers across BP Operations of differing sizes.

c. For the methods in a. the following factors should also be accounted for:

1. Accounting for all platforms or only for manned platforms

   a) Whether to account for all platforms within the relevant BP Operation or only to account for the manned platforms is a matter of engineering judgment.

   b) It is deemed that if a BP Operation does not have many unmanned platforms as compared with the UK North Sea, only manned platforms should be accounted for.

   c) If the BP Operation has a similar proportion of manned to unmanned platforms as the UK North Sea, the unmanned platforms should be accounted for.

   d) Unmanned platforms can often be deemed less significant from a societal/individual major accident risk perspective.

   e) Unmanned platforms can still pose a significant risk to visitors to the platform and from an environmental risk perspective.

2. Comparing the BP Operation with leak data from the entire North Sea or only from the Southern North Sea -

   a) Whether to account for the entire North Sea or only to account for the Southern North Sea is also a matter of engineering judgment.

   b) If the BP Operation mainly consists of small, noncomplex structures, the comparison should only be with the Southern North Sea data.

   c) Similarly, if the BP Operation operates large integrated units with great numbers of hydrocarbon systems, the comparison should be with the entire North Sea.

d. Comparing BP Operation data with UK North Sea data

1. If comparing BP Operation data with UK North Sea data, it is deemed that comparing frequencies of major and significant incidents provides the most accurate estimate for the leak frequency modifier, as one is comparing leaks of similar sizes.

2. If sufficient data is available, the factor should thus be based on overall frequency of major and significant incidents within the BP Operation, compared with the overall frequency of major and significant incidents within OIR 12 database.

3. Similarly, data from Tr@ction could also be used.

4. Since Tr@ction is still comparatively new, Tr@ction data should only be used once it is deemed that sufficient data has been collected over a large enough duration to be considered representative.

5. It is important that rigour is engaged in ensuring that all leaks are reported and that leaks are reported as major and significant and that rigour is engaged in reporting leaks in Tr@ction.

e. If there is any question regarding the sufficiency of BP Operation data on size of leaks, the available overall BP Operation leak frequencies, independent of the size of the leak, should be compared with the overall leak frequencies as reported in the OIR 12 database. If data in the preferred formats become available at a later stage, the leak frequency modifier should be updated accordingly.

f. If the overall leak data, as well as the major/significant leak data (or the systematically reported Tr@ction data) is available, leak frequency factors for both datasets should be calculated and compared to verify the consistency of the result.

g. Comparing leak frequencies based on equivalent leak diameters of 25 mm (1 in) and 100 mm (4 in) is not recommended, as sufficient data is often not available to deploy this approach.

h. Similarly, it is not recommended to compare leak frequencies based on MIAs, as generally only leaks above 100 bbl are reported, hence not accounting for smaller leaks.

i. Furthermore, rigor of reporting MIAs is still developing, and hence, the consistency of the data is doubtful. As the HiPo database depicts potential incidents, this data should also not be used if evaluating actual leak frequencies.

j. IM matrix

   1. Once the leak frequency factor has been calculated, the obtained factor could furthermore be compared with the IM matrix as a means of assessing the accuracy of the calculated factor.

   2. This matrix shows how the various BP Operations are performing with regards to leading indicators (such as total SCEWO, number of overdue SCEWO, integrity related actions due and completed, and expenditure costs associated with IM) and lagging indicators (integrity related major incidents, integrity related HIPOs, integrity related uncontrolled releases).

   3. The IM matrix does not quantify the indicators in 1. and 2., but it does show how the relevant BP Operation compares with other units, as well as the direction in which the BP Operation is moving.

k. Once the leak frequency factor has been determined, if there is particular uncertainty around the allocation of a leak frequency factor, the report should as mentioned include sensitivity cases demonstrating this uncertainty.

G.4. Sample calculation comparing major/significant leak data

a. In Table G.1, a factor of three should be used.

b. If Tr@ction data were used, the calculation would be the same. One would just look at leaks between 1 bbl and 100 bbl and leaks above 100 bbl.

Table G.1 - Adjustment of leak frequencies

Source	Number of incidents		Number of platforms	Time period (yr)	Number of platform yr	Frequency (release per platform yr)		
	Significant	Major				Significant	Major	Total
BP Operation	30	5	10	5	50	0,00	0,10	0,70
UK Southern North Sea	140	22	71,4	10	714	0,20	0,03	0,23
Adjustment factor						3,06	3,25	3,09

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