



METHODOLOGY FOR DETERMINATION OF SAFETY AND SEPARATION DISTANCES

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METHODOLOGY FOR DETERMINATION OF SAFETY AND SEPARATION DISTANCES

Prepared by AHG-S.9 of Safety Advisory Council

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Amendments to 75/07

Section	Change
	Editorial to align style with EIGA style manual
All	Rewrite to reflect current practices
	Appendix A rewritten with updated modelling

NOTE Technical changes from the previous edition are underlined

Rev 1 Amendments to 75/21

Section	Change
5.1, 6	Update to harm, no harm criterion wording for clarity

1 Introduction

This publication describes the basic principles to calculate appropriate safety and separation distances for the industrial gases industry. It is intended that EIGA members use this publication as an aid to writing or revising any publications that involve specifying safety and separation distances for safe equipment layout.

Historically, the term safety distance has been used for an effect-based distance. This is consequence based and gives conservative safety distances. Because of increasing density of industrial installations, there is a need for more realistic safety distances. This has led to risk-based safety distances.

Determination of safety and separation distances is a subject that requires detailed knowledge of risk and consequence modelling and as such this publication should only be used by specialists with this knowledge.

2 Scope and purpose

2.1 Scope

The work process can be used for the equipment required for industrial and medical gases. These can be in cryogenic liquid, pressurised liquid or the gaseous phase.

This publication is intended to be applied to new installations and may be used for both existing, and modifications to existing, installations to assess safety and separation distances.

Offsite transport and pipelines are not specifically addressed.

2.2 Purpose

The primary objective of this publication is to define a philosophy to determine suitable separation distances for all equipment, pipework and storage to allow EIGA member company experts to develop consistent standards across the industry and avoid escalation scenarios. In a similar way, the safety and separation distances are given to protect personnel. Member company experts using this publication should be familiar with the risk assessment methods, criteria and process modelling described in this publication.

The prescribed methodology is one option for defining safety distances and the attached example shows that this approach reflects a conservative methodology. EIGA member companies might choose other methodologies, such as:

- basic spacing tables;
- consequence based; or
- fully risk based.

Local legislation shall take precedence over this publication.

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions**3.2.1 Definitions in risk assessment****3.2.1.1 Effect**

Immediate or delayed result of an exposure to a hazard.

3.2.1.2 Event

Realisation of a hazard.

3.2.1.3 Frequency

Expression of how often a considered occurrence takes place in a given time.

3.2.1.4 Hazard

Inherent property of a substance, agent, source of energy or situation having the potential of causing undesirable consequences and / or effect.

3.2.1.5 Probability

Expression of the chance that a considered occurrence will take place.

3.2.1.6 Projectile

Debris that is ejected by energy release.

3.2.1.7 Risk

Product of the likelihood and consequence of a given hazardous scenario.

3.2.1.8 Safety distance

Minimum separation between a hazard source and a human, that will mitigate the effect of a foreseeable incident.

3.2.1.9 Separation distance

Distance that will mitigate the effect of a foreseeable incident and prevent a minor incident escalating into a larger incident due to damage to equipment or environment.

3.2.2 Pressure

In this publication bar shall indicate gauge pressure unless otherwise noted i.e., (bar, abs) for absolute pressure and (bar, dif) for differential pressure.

4 Basis of approach

The safety distance is to provide a minimum separation that will mitigate the effect of any foreseeable event. The separation distance will also provide protection for the equipment from foreseeable external impacts such as roadway, flare or activities outside the control of the operation, for example a plant or customer station boundary and prevent it from escalating into a larger incident. In order to do so, the following steps shall be followed:

1. Identify the hazard sources and events, for example release of gas, taking into account the likelihood.
2. Calculate the effects on neighbouring objects and population taking into account mitigating factors.
3. Determine the safe distance to each object or population to meet the minimum hazard criteria.
4. Consider additional prevention or mitigating factors and re-calculate safe distance.

As discussed in 5.1, the safety and separation distances are not intended to provide protection against catastrophic events or major releases, these should be addressed by other means to reduce the frequency and / or consequences to an acceptable level.

The safety distance is a function of the following:

- The nature of the hazard, for example toxic, flammable, oxidising, asphyxiant, explosive and overpressure.
- The equipment design and the operating conditions, for example pressure and temperature and / or physical properties of the substance under those conditions.
- Any external mitigating protection measures, for example fire walls, blast walls, dyking, deluge system, that reduces the escalation of the incident.
- The object that is protected by the safety distance; that is the harm potential, including for example, people, exposure time, environment or equipment.

The provision of adequate distance or separation zones around equipment is a fundamental consideration for safe layout. By understanding the protection afforded by increasing the safety distance, one can optimise the safety protection of a piece of equipment. In most cases the safety distance to provide protection from all possible events is not practicable. Therefore, an assessment of the frequency of the event and the potential consequence is necessary to understand which risks can be reasonably mitigated by a safety distance. If the safety distance is too large, additional mitigating or prevention measures should be considered and the safety distance re-calculated. Figure 1 shows a typical example of such an assessment for a pressure vessel and connecting pipework.

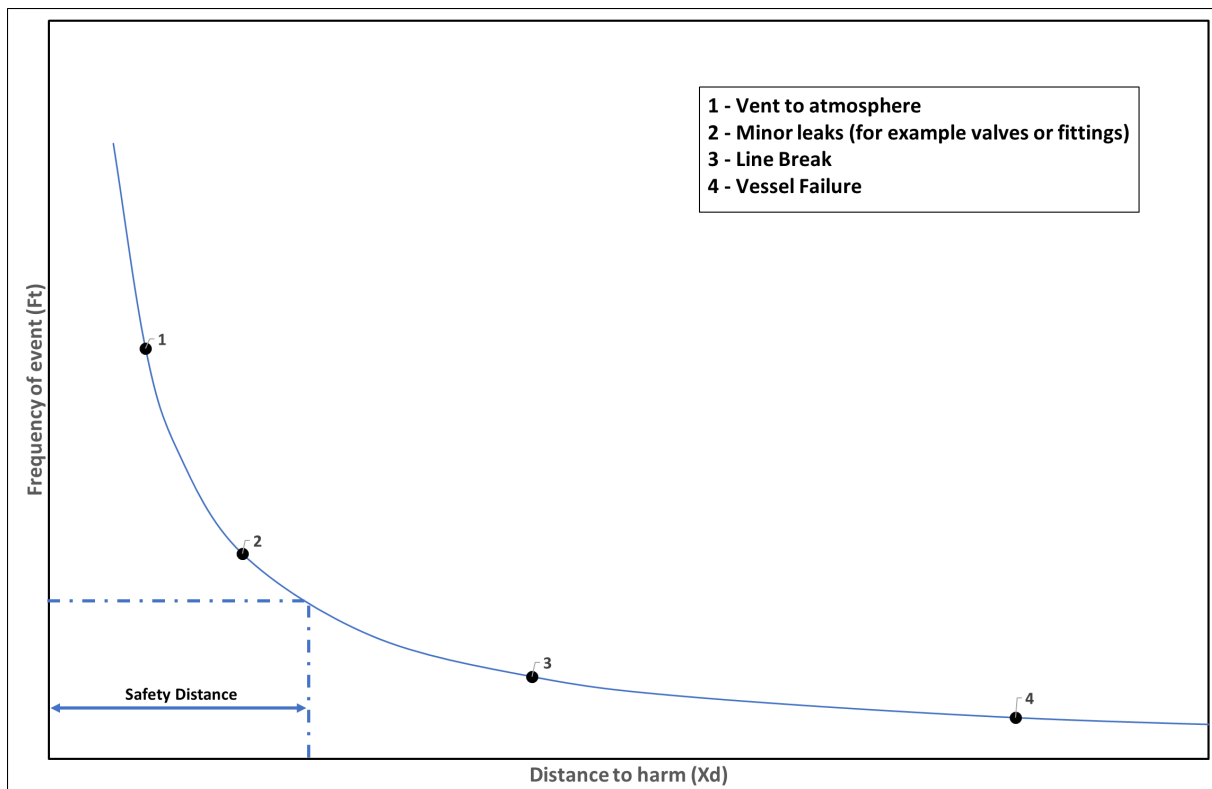


Figure 1 – Safety distance for pressure vessel and connecting pipework

5 Selection of events

5.1 Criteria for determining the individual harm exposure threshold value

The harm exposure threshold frequency should have a legitimate basis, which is generally accepted by authorities and the general public at large to reflect their specific requirement and processes, EIGA companies are invited to define their own criteria. Broadly accepted publicly available values are presented here after.

The risk from a hazardous activity should not be significant when compared with risk in everyday life.

The individual harm exposure threshold, defined as Ft, for determining safety distances is proposed as:

$$F_t \leq 3.5 \times 10^{-5} \text{ per annum.}$$

For events where the risk of harm is below Ft, no safety distance criteria is required. For deviations, which are likely to occur during the life of the equipment or occur during normal operation, for example venting, then the safety distance should be calculated, or mitigation provided to produce a no harm effect.

In Section 6, harm and no harm criteria are discussed in detail. Harm criterion corresponding to a probability of fatality of 1% and no harm criterion corresponding to a probability of fatality of 0.1% are proposed if not defined otherwise by member companies. For less likely events with a frequency between Ft and 100 x Ft harm criterion shall be applied. For more frequent events with a frequency > 100 x Ft no harm criterion shall be applied.

This can be illustrated by Figure 2.

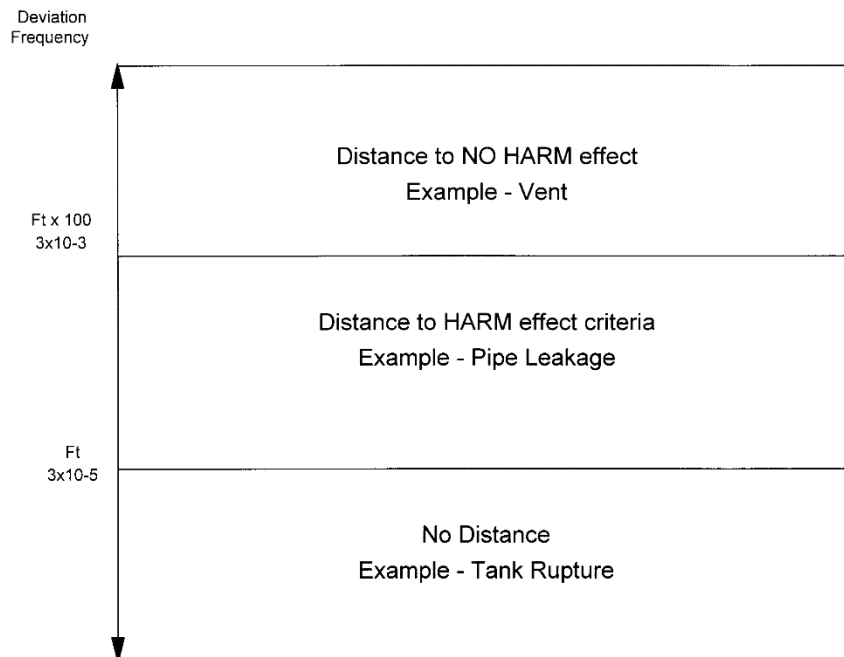


Figure 2 – Harm vs no harm criteria

5.2 Methodology to identify harm potential

5.2.1 Introduction

The objective is to identify foreseeable events, called deviations, from industrial gas processes and equipment which have direct harm potential to other entities, be it neighbouring equipment, activities or persons. In addition, deviations with potential for harm to the industrial gas process from external sources shall also be defined, for example, flammable gas storages and chemical or refinery industries. All of the identified deviations shall then be subjected to the criteria laid down for defining the safety distances in order to obtain those values that should be assigned to justifiable safety distances.

Equipment and processes can be thoroughly reviewed for deviation scenarios using several suitable identification techniques. Some of them are indicated further on in this section.

5.2.2 Basic requirements for deviation review to determine harm potential

In order to conduct a deviation, review of the following is required:

- information on physical / chemical properties of the gases under review;
- construction drawing / flow sheet of the system process equipment or component under review;
- layout / plot plan; and
- a review team made up of experienced and qualified persons with preferably multi-discipline background (production, safety, engineering, depending on the complexity of the review).

5.2.3 Harm / effect checklist technique

This technique is based on the knowledge of actual previous accidents and incidents in the industrial gas industry.

Some contributing factors to industrial gas accidents are given in Table 1.

Table 1 – Contributing factors checklist relevant to the definition of a safety distance

Environmental and mankind	Thermal
Oxygen enrichment	Heat of radiation
Oxygen deficiency	Heat of conduction
Fog – visibility	Heat of convection
Toxic / harmful substance exposure	Flame impingement
Corrosive substance exposure	Cold of conduction
Water / soil contamination	Cold of convection
Kinetic	Cold by impingement
<u>Falling objects</u>	Electric
<u>Projectiles</u>	Arc flash
Shock waves (over pressure from gas or liquid)	Static electricity
<u>Struck by moving vehicle</u>	Electronic interference
Vibration	
Others	
UV radiation	
Metal corrosion	
Material (plastic) ageing	
Chemical reaction / <u>decomposition</u>	
<u>Chemical contamination</u>	
<u>Cold embrittlement</u>	

The type of equipment and components involved in such accidents and the type of leak / event are provided in Table 2. The sources of leaks are often common sources. The safety distances determined on the basis of tables are intended to safeguard against or mitigate harm of such leaks but do not generally safeguard against catastrophic leaks.

Table 2 – Checklist of leak sources and leak scenarios

Type of equipment / component	Type of leak
Pipework	Pinholes, pipe rupture
Flanges	Gasket failure (mechanical failure / burnout / brittleness). Thermal movement / material creep
Weld connection	Weld crack or porosity
Solder connection	Solder crack or porosity, solder melt
Union connection	Thermal movement, leak
Screw connection	Leak, sealant creep, material split
Hose connection	Seal leak, material split, human error
Valves	Stem leak, seat leak, bonnet / housing split, opened by impact
Hoses	Perforation, rupture
Instruments	Element rupture
Regulators	Diaphragm rupture / seal leak / downstream rupture (overpressure). Housing split / flash fire perforation (oxygen)
Solenoid valves	Seat leaks
Pumps	Perforation by oxygen flash fire / seal leak
Cylinders	Perforation, rupture

When using the harm / effect and leak source lists as a checklist, it has been stated that up to 95% of the deviation scenarios will be captured (for more information see Rijnmond Report) [1].¹

The sequence to be followed when performing the analysis should be:

¹ References are shown by bracketed numbers and are listed in order of appearance in the reference section.

1. Make an inventory on (hazardous) substances.
2. Review and list their intrinsic hazards.
3. Make an inventory of equipment / components used in system or process.
4. Identify hazard sources and possible exposed objects such as people and equipment.
5. Review above against harm / effect checklist by asking the questions:

Which equipment or component is a source of harm?

What leak scenarios are possible?
6. Proceed through all sources and exposed objects.

5.2.4 Other identification techniques

The harm / effect checklist can be complemented or substituted with:

- What if / How can analysis;
- Failure Mode and Effects Analysis (FMEA);
- Hazard and Operability Study (HAZOP);
- Event tree and fault tree analysis; or
- Quantitative Risk Analysis (QRA).

5.3 Methodology for the evaluation of the safety distance from the identified hazard events

The event tree in Figure 3 shows the necessary steps for the evaluation of the safety distances required on a given equipment on which hazard sources and sensitive objects have been identified; the process is iterative. The method shall be applied on each couple (hazard source, object) previously defined.

The screening of the foreseeable hazard events, called deviations, associated with the hazard sources and the objects shall be based firstly on probabilities and frequencies, then on harm criteria (see Section 6) as described below.