APPENDIX 2

Methodology for the selection of equipment to be studied

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1. Introduction

The selection of relevant hazardous equipment is a critical step in any risk analysis. If too many equipment are selected, the analysis will be unnecessarily time-consuming. On the contrary, if too few equipment are selected, the risk could be under-estimated.

This appendix describes the method proposed to select equipment on which the identification of accident scenarios will be performed. It must be reminded that, before applying this method, a list with equipment containing potentially hazardous substances must be drawn (see main report).

The method presented here is based on the "VADE MECUM" methodology used in Walloon Region, in Belgium (DGRNE, 2000).

2. Method for the selection of equipment

An equipment containing hazardous substances will be selected as a relevant hazardous equipment **if the mass of hazardous substance in this equipment is higher or equal to a mass threshold**. The threshold depends on the hazardous properties of the substance, its physical state and eventually its location with respect to another hazardous equipment.

If several equipment are permanently connected, the total mass present in the connected equipment must be considered, except if there is no possibility of siphoning off the whole set of equipment in case of a leak on one equipment.

Equipment (like pipes) whose capacity is smaller than the mass threshold but which could release a mass (flow) higher or equal to the threshold in ten minutes are also selected as hazardous equipment.

The rules described hereafter must be followed to calculate the mass threshold for the selection of hazardous equipment.

2.1 Define a reference mass Ma (kg) according to the properties of the substance

	Reference mass Ma (kg)		
Properties of the substance	**Solid**	**Liquid**	**Gas**
1 Very toxic	10.000	1.000	100
2 Toxic	100.000	10.000	1.000
3 Oxidizing	10.000	10.000	10.000
4 Explosive (definition 2a annex 1 Seveso II Directive)	10.000	10.000	---
5 Explosive (definition 2b annex 1 Seveso II Directive)	1.000	1.000	---
6 Flammable	---	10.000	---
7 Highly flammable	---	10.000	---
8 Extremely flammable	---	10.000	1.000
9 Dangerous for the environment	100.000	10.000	1.000
10 Any classification not covered by those given above in combination with risk phrases R14, R14/15, R29	10.000	10.000	---

Remark:

- In the case of a liquid in solution, it is the mass of hazardous substance which must be considered and not the total mass.

2.2 Adjust the mass reference of liquid according to the possibility of vaporisation

For liquids, the reference mass Ma given in the table above must be divided by a S coefficient. A new reference mass Mb is then found: $Mb = \frac{Ma}{S}$

An equipment will be selected if the mass contained M is higher than the reference mass Mb.

S is the sum of the coefficient S_1 and the coefficient S_2.

S must be included in the interval 0.1 – 10.

$$0.1 \leq S \leq 10$$

If $S < 0.1$ then $S = 0.1$

If $S > 10$ then $S = 10$

S_1 coefficient takes into account the difference between the service temperature T_p (°C) and the boiling temperature at atmospheric pressure T_{eb} (°C) according to:

$$S_1 = 10^{(T_p - T_{eb})/100}$$

S2 coefficient is only applied to process with a service temperature lower than 0°C, according to: $S_2 = \frac{Teb}{(-50)}$. In other cases (positive service temperature), $S_2 = 0$.

Temperatures are expressed in Celsius degrees.

Remarks

- For substance states other than liquid, the S coefficient is equal to 1 and $M_b = M_a$.
- The adjustment of the reference mass Ma of liquid by the coefficient S, according to the possibility of vaporisation should be applied only for products for which the evaporation leads to more serious consequences. If the liquid is the hazardous phase, and not the vapour (for example a liquid only dangerous for the environment), the adjustment must not be done because it would increase the mass threshold (Mb) and the equipment could wrongly not be selected.
- In case of mixtures, the boiling temperature to be considered is the temperature at which boiling starts.
- In case of an unstable substance likely to dissociate before reaching boiling temperature, dissociation temperature must be considered instead of boiling temperature.
- In the case of a substance likely to polymerise without dissociation before reaching boiling temperature, the S_1 coefficient is equal to 1.
- The adjustment of Ma is not applied for explosive substances (categories 4 and 5).

2.3 Adjust the reference mass in case of domino effect hazard

For equipment not selected previously (M < Mb), then the following reasoning is applied:

Equipment containing explosive or flammable substances must also be selected as hazardous equipment:

- **if** it is located at less than 50 m from an equipment selected as hazardous following rules explained in paragraphs 2.1 and 2.2;
- **AND if** it contains a mass of hazardous substance higher than a reference mass Mc calculated as: $M_c = S_3 \cdot M_b$

$$\text{with} \begin{cases} 0.1 \le S_3 \le 1 \\ S_3 = (0.02 \cdot D)^3 \end{cases}$$

D is the distance (expressed in m) between the two equipment.

S_3 must be included in the interval 0.1 – 1.

$$0.1 \le S_3 \le 1$$

If $S_3 < 0.1$ then $S_3 = 0.1$

If $S_3 > 1$ then $S_3 = 1$

Remarks:

- The calculation of the new threshold Mc (threshold related to the possibility to generate domino effect) is only made for equipment containing a substance likely to cause a domino effect ("explosive" or "flammable" risk phrase as R2, R5, R10, R12, etc). This rule is not valid for equipment containing toxic substances and is thus not applied.
- Some equipment do not contain hazardous substances but could burst in some circumstances (for example a boiler). These equipment are not selected by this method. However, they must be taken into consideration during the step of analysis of fault trees, as they could be the origin of a domino effect by ejecting missiles which could puncture neighbouring equipment. So, they are not selected as equipment to be studied, but can be considered in the fault tree for some equipment.

3. Table for the application of the method

A table should be built with the following columns in order to compile the data needed to apply the methodology:

- Reference number of the equipment
- Name of the equipment
- Type of equipment (according the typology of equipment defined in the deliverable D.1.C.)
- Substance handled
- Physical state of the substance
- Boiling temperature (in °C)
- Service temperature (in °C)
- Risk phrases
- Hazardous classification

- Volume (in m^3)
- Mass contained in the equipment (in kg) or for flow through equipment (as pipes), the released mass in 10 minutes

For the calculation required by the method, columns should be added as follow:

- Reference mass (Ma in kg)
- S_1 coefficient
- S_2 coefficient
- S coefficient
- Mass Mb (in kg)
- Selection of the equipment (Yes/No) based on the comparison of M and Mb (selection if M > Mb)

And, if the equipment is not yet selected, and only for equipment containing a substance likely to cause a domino effect:

- Name of the nearest selected equipment (selected due to M > Mb)
- Distance from the nearest selected equipment
- S_3 coefficient
- Mass Mc (in kg)
- Selection of the equipment (Yes/No) based on the comparison of M and Mc (selection if M > Mc)

The result of this table is the selection of relevant hazardous equipment. These equipment will be studied according to the MIMAH methodology.

4. Comments

The method for the selection of equipment must not be applied blindly. If an equipment can be hazardous by the presence of an hazardous substance and by the operating conditions inside the equipment, it can be selected as a relevant hazardous equipment and studied according the MIMAH methodology.

For example, a reactor with a risk of run-away or with a mixture near the flammability limits (e.g. air/methanol for the production of formalin) could be selected.

Moreover, some equipment near the plant boundaries could be selected due to their effects on close targets.

It is also possible to select other equipment according to the experience of industrialists about the possibility of accidents on the equipment.

5. References

DGRNE (Direction Générale des Ressources Naturelles et de l'Environnement), Walloon Region Ministry, Belgium, 2000, *Vade Mecum: Spécifications techniques relatives au contenu et à la présentation des études de sécurité,* Cellule Risque d'Accidents Majeurs