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Subject: **Generic Guideline for the Calculation of Risk inherent in the Carriage of Dangerous Goods by Rail**

transmitted by the OTIF secretariat

As an addition to informal documents INF. 3 and INF. 6, which are already available, the Secretariat of OTIF hereby submits to the RID/ADR/ADN Joint Meeting the "Generic Guideline for the Calculation of Risk inherent in the Carriage of Dangerous Goods by Rail" as adopted by the last meeting of the Working Group on standardized risk analysis (Bonn, 3 and 4 May 2005). This revised guideline was sent to the members of the working group after the last meeting and they were given the opportunity of submitting comments on it within six weeks. These comments have not yet been taken into account in this revised draft.

An introduction to the basic principles of risk assessment for chapter 1.9 RID[1]

Revised Draft

(~~April~~ July 2005)

[1] Regulations concerning the International Carriage of Dangerous Goods by Rail

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1. Introduction

1.1 Background

All types of dangerous goods transport by rail must comply with the RID regulations. The objective of these regulations is to ensure safe transport and to minimise the risk of accidents connected with harm to people or the environment by applying general technical and organisational rules for packaging, carrying and handling dangerous goods.

Over and above these safety regulations the Competent Authorities of Member States are allowed to apply certain additional provisions on their territory in case of special risks at certain locations. The relevant regulation is found in Chapter 1.9, "Restrictions on carriage imposed by the competent authorities". In recent years there has been increasing concern in several COTIF Member States about measures originating from national regulations limiting certain rail transport operations, including cross-border transport.

As a ~~result~~ consequence, the RID Committee of Experts started discussions about the competence of national authorities to ~~limit certain transport operations~~ apply certain restrictions on the carriage of dangerous goods. The RID Committee of Experts recognised the need to adapt the regulations in order to ~~limit additional national measures to well justified cases and to deal with provisions originating from other legal areas~~ deal with the question as to when and how additional provisions may be applied. Hence, Chapter 1.9 has recently been extended to give more specific information about fields of application and respective requirements in RID 2005 (for full text see appendix A).

For the following provisions (given in more detail in 1.9.2)

(a) additional safety requirements or restrictions for bridges, tunnels, ports, etc.
(b) provisions for sections with special and local risks (e.g. residential areas)

an additional requirement is given in 1.9.3. In these cases the Competent Authority has to provide evidence of the need for measures. However, owing to the lack of a commonly agreed international standard on risk assessment for this purpose, there is no further specification on how to prove the need (see section 2.1 for definitions of risk related terms). As it is obviously desirable to ensure a certain minimum standard, in 2004 the RID Committee of Experts set up a working group on the standardisation of risk analysis for chapter 1.9 RID. This guideline is an outcome of the working group.

1.2 Guideline Objectives and Application

The objective of this guideline is to obtain a more uniform approach for the risk assessment of the transport (by rail) of dangerous goods in the COTIF Member States and consequently to make individual risk assessments comparable. The guideline should be a reference for risk assessment in situations where the risk of the transport of dangerous goods is relevant. It is based on existing international standards which already cover some aspects of risk assessment for the carriage of dangerous goods by rail (e.g. the Railway Safety Directive 2004/49/EC [6] and the RAMS Standard EN 50126 [7]) and on good practice in COTIF Member States which already apply risk assessment methods for this purpose.

As a result of the RID regulations a high level of intrinsic safety is accomplished in general. However, the RID cannot guarantee absolute safety. Some level of risk will always remain and therefore several European States have already adopted their own assessment models for risk calculation together with their own criteria for risk acceptance. These methods and criteria are commonly derived from national implementations of Council Directive 96/82/EC on the control of major-accident hazards involving dangerous substances (Seveso II Directive, [3]) which excludes some areas, such as the transport of dangerous goods and the intermediate storage outside establishments. Examples of complementary national regulations and standard methods for the assessment and control of risk due to the transport of dangerous goods can be found in the Netherlands [12, 13] and Switzerland [1, 2].

With the Railway Safety Directive 2004/49/EC, development of common safety targets (CST), common safety methods (CSM) and common safety indicators (CSI) by the European Commission will take place within the next few years, which will lead to more specific regulations for risk assessment in the railway sector and which may possibly supersede parts of this guideline. However, at present there is a lack of harmonised guidance on risk assessment for railway operations and for the carriage of dangerous goods by rail in particular.

Therefore, the objective of this guideline is not to prescribe or define new risk calculation models or new criteria for tolerable risks (see definition in section 2.1). The guideline is intended to provide an independent framework for the analysis and evaluation of risk and for the judgement of corresponding safety measures in terms of Chapter 1.9 RID. It aims at the definition of minimum requirements and the recommendation of basic approaches in order to ensure risk assessment which is suitable to prove the need for designated measures as required in 1.9.3 of RID. Compliance with some minimum quality requirements is essential for the acceptance of risk assessment by all national stakeholders and by other COTIF Member States, who are informed about intended provisions by the OTIF Secretariat (1.9.4 of RID).

The guideline focuses on aspects that should be considered in a risk analysis, on minimum contents and on quality requirements with respect to Chapter 1.9 RID. Detailed guidance on risk assessment techniques is beyond the scope of this document. Future amendment of the guideline will be possible in case of major changes in international regulations and in case of substantial progress in scientific and technical knowledge.

2. Basic Definitions and Requirements

2.1 Definition of Technical Terms

Dealing with risk first requires the definition of some technical terms to ensure a common understanding of the guideline. The use of terms in this guideline is based on the ISO/IEC Guide 73 “Risk management – Vocabulary – Guidelines for Use in Standards” [4] and ISO/IEC Guide 51 “Safety Aspects – Guidelines for their inclusion in standards” [5], which is to be applied to safety-related standards. In general, risk can have various shapes, e.g. political, financial, technical or medical, either positive or negative. In the context of this guideline risk is only a transport safety issue. Hence, the more safety specific definitions of risk related terms in ISO/IEC Guide 51 are preferred. ISO/IEC Guide 73 is used to complement the list with definitions for risk management. Comments on the original definitions of Guide 51 and 73 are shown in brackets.

Risk: combination of the probability (between 0 and 1) of occurrence of harm and the severity of harm (“combination” typically means “product”, whereas additional factors, such as **risk aversion** are part of the **risk evaluation** process).

Harm: physical injury or damage to the health of people, or damage to property or the environment.

Risk assessment: overall process of risk analysis and risk evaluation.

Risk analysis: systematic use of information to identify hazards (potential sources of harm) and to estimate the risk.

Risk estimation: process used to assign values to the probability and the consequence of a risk.

Risk evaluation: procedure based on the risk analysis to determine whether the tolerable risk has been achieved.

Risk criteria: terms of reference by which the significance of risk is assessed.

Risk treatment: process of selection and implementation of measures to modify risk.

Tolerable risk: risk which is accepted in a given context based on the current values of society.

Figure 1 gives an overview of the relationship between the processes of risk management which are defined above. As this guideline will concentrate on risk assessment, the processes of risk treatment and all subsequent processes of risk management, such as risk acceptance and risk communication, are not included in figure 1.

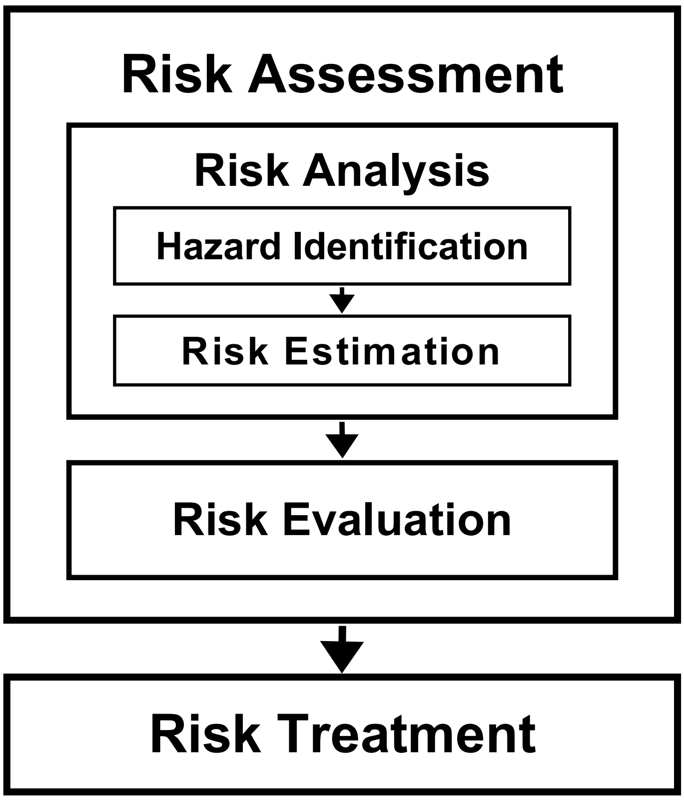

Figure 1: Relationship between risk management processes

The risk evaluation process is based on risk criteria which have not yet been standardised internationally. Some COTIF Member States already have defined criteria for risk evaluation purposes based on national consensus. This guideline does not interfere with these national regulations but addresses the process of risk evaluation for the purpose of understanding the whole risk assessment process. For the risk evaluation at least the following definitions are needed:

Individual risk: risk of an individual person to come to harm (also called “place-bound risk”, depends on the location, definition is not part of ISO/IEC Guide 51 or 73).

Societal risk: risk of all potentially involved persons to come to harm (probability density function (PDF) of individual risks or the integral of this PDF, definition is not part of ISO/IEC Guide 51 or 73).

External risk: risk of harm caused to persons ~~which are not transport operators~~ who are not involved in carriage or passengers or risk of harm to property which is not part of the transport system or infrastructure. (also called “third party risk”, opposite to **internal risk**, definition is not part of ISO/IEC Guide 51 or 73). The definition of risk to passengers as internal or external risk differs between Member States.

Risk perception: way in which a stakeholder views a risk, based on a set of values of concern.

Stakeholder: any individual, group or organisation that can affect, be affected by, or perceive itself to be affected by, a risk. Note: The decision-maker is also a stakeholder.

Risk aversion: additional factor for risk evaluation to account for a more negative perception of high harm events or of events which happen beyond the influence of people or of events of unknown risk etc. (see comment below, definition is not part of ISO/IEC Guide 51 or 73).

Note that in case of using the definition of risk simply as the product of probability and harm one may obtain the same risk value from a *high probability-low harm* event as from a *low probability-high harm* event, although risk perception may be different. To account for ~~this~~ different risk perception, usually an additional factor called risk aversion is used for evaluating the risk (see section 4). Depending on risk perception the risk assessment may also be limited to external risk.

2.2 Basic Requirements

This section includes some cornerstones for risk assessment for the carriage of dangerous goods by rail which are independent from specific details of the whole process.

Quantification of risk: The application of additional provisions in compliance with chapter 1.9 RID is linked with the obligation imposed on the competent authority to provide evidence of the need for measures. This obligation implicates the need to provide information about the level of risk connected with a certain transport situation. ~~Hence, quantitative risk analysis (QRA) methods have to be applied, whereas a qualitative approach is obviously not sufficient for this purpose. A qualitative risk analysis may only be suitable for comparing different options of measures for risk reduction, since the efficiency of applied measures has not to be proven (although desirable).~~

1. Where no alternative comparable route is possible, any restriction should be justified according to the principle set out in the guidelines for quantitative risk assessment in reference to a tolerable risk level used in the Member State (which may be nationally used principles ALARA, ALARP, stand still principle of risk criteria)

2. However, where alternative comparable routes may be used, the competent authority may set up restrictions on the basis of:

a) normally a qualitative comparison between the routes if it is obvious that the proposed restrictions lead to a significant improvement of safety

b) a quantitative comparative risk assessment in other cases.

Separation of risk assessment processes: The risk assessment process is divided into two parts, of a different nature (see figure 1). The first ~~process~~ part is the risk analysis which is required for the quantification of a certain risk related to fields of application given in chapter 1.9.2 (a) and (b) and which has to be as objective and precise as reasonably achievable (see comments on uncertainty below). This "scientific" part is followed by an evaluation of the calculated risk level based on risk criteria which also include political and societal aspects. The clear separation and transparent presentation of both parts is essential for the stakeholders' acceptance of a risk assessment as an objective basis for the decision as to whether measures are needed to reduce risk levels.

Uncertainty analysis: Risk analysis is always connected with uncertainties of different origin (see section 4). In order to be able to use the risk analysis as a basis for a risk evaluation, the derivation (or at least estimation) of uncertainty levels requires special attention. Uncertainty levels are of minor importance in cases of an analysed (estimated) risk being far below the level of tolerable risk. In cases with an uncertainty interval substantially covering more than one zone of the risk classification (e.g. tolerable/unacceptable, see also section 4) an enhanced effort is indispensable, either to reduce further the level of uncertainty of the analysis as far as reasonably achievable or to justify the adequacy of measures under special consideration of uncertainty levels.

Information to be included: The documentation of a risk assessment must contain information on all processes mentioned in section 3.5, either explicitly or as references to documents which are public or available upon request. Transparent and detailed documentation of the risk assessment process is a basic prerequisite for the comprehensible ~~communication~~ documentation of risk.

3. Risk Analysis

3.1 Introduction

The outcome of the risk analysis part of the risk assessment process (see figure 2) is information on the individual or societal risk of the transport situation under consideration. The risk analysis has to derive probabilities of accident scenarios and probable consequences connected with these accident scenarios. Therefore the following sections cover the major aspects of scenario definition, statistical analysis and consequence analysis.

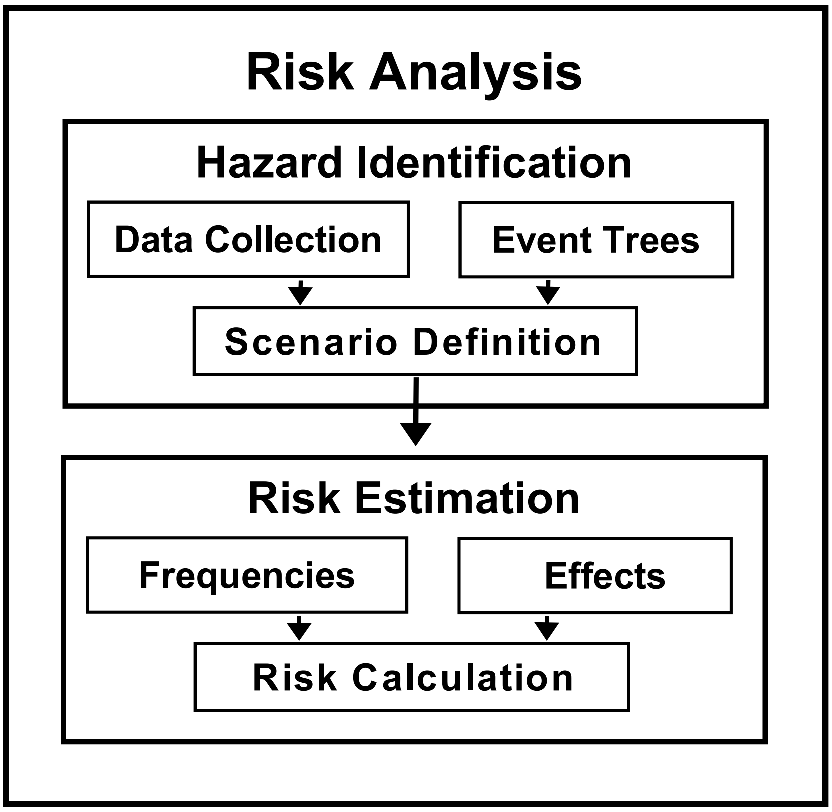

Figure 2: Diagram of risk analysis elements

It is noteworthy that the design of this guideline aims to meet characteristics of freight traffic of dangerous goods by rail within a broad international scope. All COTIF Member States are recommended to use it, although major differences exist between Member States. For example the topology (flat versus mountainous), climate (temperature and wind), the national transport and traffic policy, the amount of mixing of freight and passenger traffic or the population density can cause major differences. The individual countries can also differ with regard to the technical details of the train systems and infrastructure.

These differences restrict the possibility of an in-depth definition of calculation methodologies for a risk analysis. Therefore generic recommendations will prevail.

3.2 Scenario Definition

In order to get a grip on the large number of potential accident scenarios the first step of the risk analysis is the reduction of scenarios to a reasonable number of basic scenarios including a clustering of hazardous substances. In some COTIF Member States there is already a standard scenario classification of dangerous goods accidents in railway transport ([11], [12]).

All compounds or ~~goods~~ substances have their own pattern of chemical and physical properties (flammable, explosive, reactivity with other substances, toxic, radioactive, state of aggregation …). Although the effect of the hazardous goods is a property of the material itself in the first instance, the circumstances also influence the effect that is experienced (e.g. temperature). To avoid the problem of having to describe thousands of compounds, a drastic clustering is recommended. Both the Class (RID) and the Hazard Identification Number (HIN) are suitable for classifying and clustering.

Clustering of substances that is too crude should be avoided in order to reduce the uncertainty of the risk analysis and to ensure a reliable basis for risk evaluation purposes. In addition, clustering of substances should take into account the potential sequence of events of an accident scenario including consequences which may depend on further parameters and circumstances. Hence, a coupled classification of scenarios and substances is recommended.

The structure which is most helpful for the classification of accident scenarios and also for the risk calculation itself is the concept of an ~~fault~~ event tree. Such a structure simplifies the calculation on account of a clear overview and it gives a step-by-step progression in the quantitative composition of the calculation. In Figure 3 an example of an ~~fault~~ event tree is given. In order to optimise an accident scenario classification by ~~fault~~ event tree analysis, absolute frequencies of all scenarios to be clustered should also be taken into account. This section will concentrate on the aspects connected with the structure of the ~~fault~~ event tree; the derivation of quantitative values for conditional probabilities within the tree will be addressed in section 3.3.

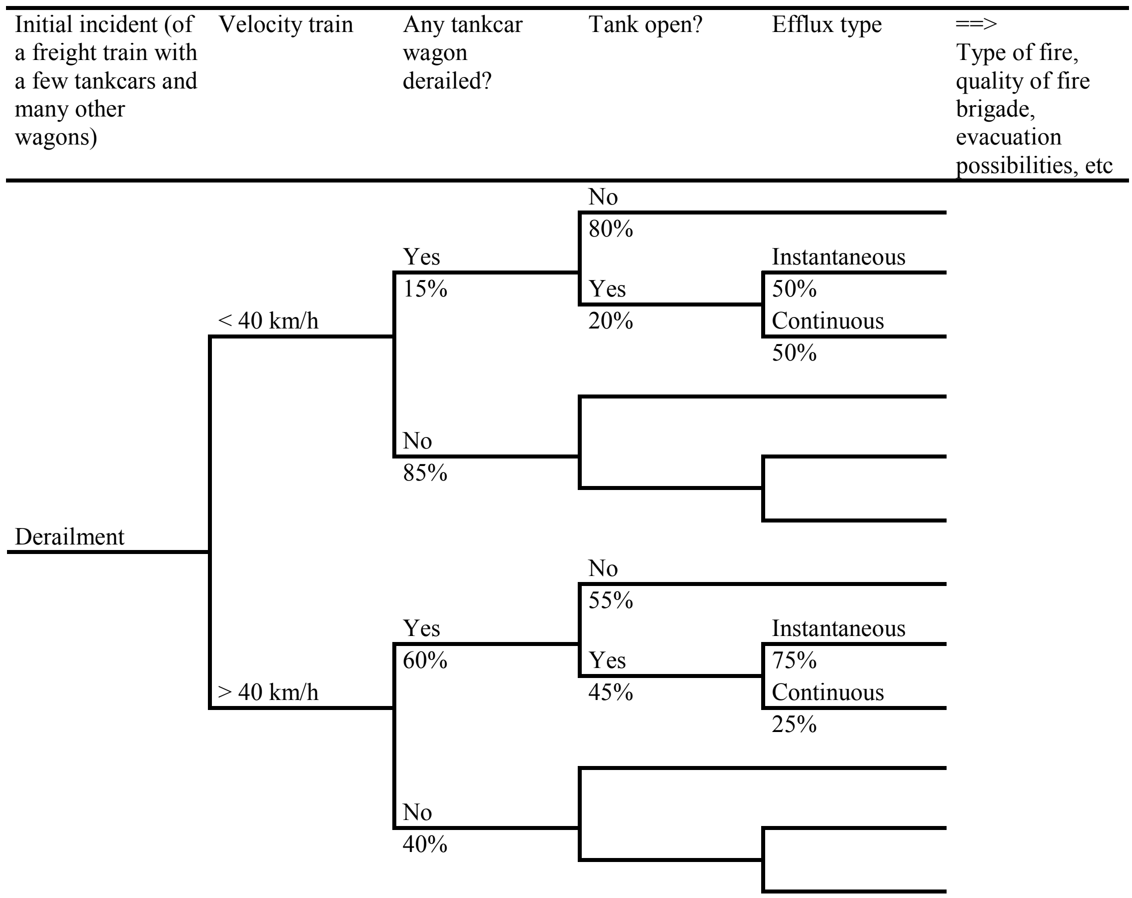

Figure 3: Example of a section of an ~~fault~~ event tree for a rail tank-wagon for inflammable liquids. The quantitative values are arbitrary.

Aspects to be taken into account in ~~fault~~ event tree analysis for the carriage of dangerous goods by rail (either for scenario definition or risk analysis itself) are the following:

Trains and traffic: Data about the rail wagons and railway traffic specifications shall be collected in order to obtain information about potential branching in the ~~fault~~ event tree and about the likelihood of events and scenarios. Many of the following aspects to be considered are recorded in the safety management system (SMS) of railway companies.

- Train safety system

– Types of dangerous goods transported

– Wagons and tank types

– Composition of trains

– Specific safety measures and transport time (day/night)

Railway Infrastructure: It is obvious that the infrastructure needs attention in a risk analysis notwithstanding that it is primarily focused on the vehicle and the transport. Infrastructure includes the whole system of railway hardware (rail including switches, sleepers, overhead wire and portals, signals, level crossings, tunnels, bridges, safety devices, underground cables etc.). It is therefore recommended to incorporate an examination of the infrastructure and to indicate the contributions to the risk. The information needed is part of the safety management system (SMS) of infrastructure companies.

– Track type (open track, residential areas, marshalling yard, bridge, railway station …)

– Track use (mixed/goods only)

– Speed limits

– Safety devices (e.g. hot-box detectors)

– Maintenance

– Level Crossings

– Switches

Primary incident: For a risk assessment in the context of RID chapter 1.9 only major accidents (and incidents with the potential to become major) are considered. Relevant scenarios are the following:

– Derailment

– Train-train collision

– Train-car collision

– Collision with other objects

– Fire

– Sudden tank failure

– 'Runaway' scenario in mountainous regions

In a particular context, influences such as vandalism, terrorism, storm, earthquake and flood may also be of importance. Most of these scenarios need no further explanation. The scenario 'sudden tank failure' incorporates a variety of incidents with sudden release of tank contents due to overpressure after violating filling regulations, corrosion, brittleness or fatigue of the tank material etc.

Release Scenario: Given a primary accident, the final damage is highly dependent on the question of whether the tank resists the impact or not. Minor details of the specific local situation can make the difference. A suitable combination of both casuistry and laboratory and/or outdoor tests must be found for a certain scenario (see also section 3.4). If loss of containment occurs, one has to distinguish between

– Instantaneous/continuous release

– Complete/partial release

3.3 Statistical Data

For each type or scenario a general accident frequency depending on the initial event frequency and on conditional probabilities of the accident scenario branches have to be determined from – in the first instance – appropriate national casuistry. This task requires a large amount of accident data to cover all branches of the scenarios even when the number of scenarios is already reduced by appropriate clustering. In order to obtain statistically significant information on frequencies and conditional probabilities the demands with regard to the number of accidents further increase.

The number of dangerous goods transport accidents is fairly low, which is fortunate for people and the environment, but this limits the statistical significance of accident frequencies and of conditional probabilities within ~~fault~~ event tree branches. Therefore it is highly recommended to consider

- information from international accident databases
- accident data of general freight transport

when deriving statistical data for risk analysis purposes. The applicability of these statistics for the respective dangerous goods transport scenario has to be checked.

Harmonisation of accident investigation and reporting through RID 1.8.5 and Council Directive 2004/49 will improve the basis for international accident statistics and for detailed analysis of accident sequences in future. Systematic differences between national accident statistics due to differences between railway systems, freight quantity, threshold for the definition of accident and other parameters should be taken into account. Special attention should be paid to long term trends in accident statistics due to improved safety levels.

Physical testing or numerical analyses of package performance under impact conditions may also serve as suitable information on conditional probabilities of the ~~fault~~ event tree. Expert judgement has to be avoided as far as possible in order to aim at an objective and reliable database for risk analysis and to provide transparency for quality control.

Further data needed for statistical analysis of accident data are freight car kilometres differentiated by year, freight, track type etc. in order to derive frequencies for each accident scenario. Information about the number of persons injured and killed with similar differentiation is needed to assess the risk level of the whole railway system and to check the plausibility of risk estimation for a certain location.

The compilation and statistical analysis of these data is part of the SMS of railway and infrastructure companies. The reporting of most of these data to competent authorities is mandatory due to RID regulations and Council Directive 2004/49 EC.

3.4 Accident Effect Models

The ~~fault~~ event tree shown in figure 3 ends with the release of a hazardous substance. For the derivation of harm (e.g. fatalities and injuries) further tracking of potential branching of ~~the fault tree or~~ event tree is needed. Factors which affect the conditional probability of a certain sequence of events following a release of hazardous substances depend on the accident location and its surroundings.

Relevant information includes

- Population density in the area around the railway (depending on time of day)
- Nature and the use of the buildings
- Accessibility of the infrastructure for emergency services
- Atmospheric conditions (wind and temperature statistics)
- Topography

Some parameters are only relevant for certain scenarios (e.g. wind statistics for gaseous toxic release) whereas others are needed in all cases. Two geographical (topological) elements are crucial: firstly the distance to the railway, secondly the population densities in all parts of the near surroundings in a grid equivalent to the area of significant impact (e.g. 25 x 25 m to 100 x 100 m resolution).

The nature of the buildings is examined with the purpose of estimating the protection against a fire or an explosion. Inventories of the nature of buildings, including information about their usage, are helpful for calculating of the presence of people (residential/industrial/commercial areas, schools, hospitals, etc.).

Relevant scenarios of impact on people and the environment are

- Explosion
- BLEVE (boiling liquid expanding vapour explosion)
- Fire (flash or pool)
- Atmospheric dispersion of toxic substances
- Contamination of water and soil

In order to derive the consequences of each scenario, first numerical or analytical models have to be used to estimate the physical effects of each scenario (radiation, pressure, concentration of toxic substances, debris impact). Suitable models and equations are given in e.g. [8], [9]. Models used for risk estimation should have been verified previously and compared with real scenarios or model benchmarks.

The degree of simplification inherent in physical models affects the reliability and the level of detail of the risk analysis process. Hence, the choice of models and the number and quality of parameters to be included in the physical analysis should be kept compatible with the level of accuracy needed in terms of risk evaluation (see section 4).

In general, four types of harm or damage are in principle worth examining:

1. People killed during or shortly after the accident
2. People injured
3. Damage to vital buildings and constructions
4. Environmental pollution because of the cargo released

Currently, the consideration of types of harm differs between Member States. To give a reference: in the Netherlands only the people killed are considered, in Switzerland also environmental pollution is incorporated.

Concerning fatalities and injuries the harm to people has to be estimated with the help of statistical physiological models based on the estimated physical effects. These models assign probability figures of injury or death to physical effects as e.g. the exposure to radiation or toxic gases (e.g. [9], [10]). There is still an unsatisfactory level of uncertainty in some of these models depending on the type of effect (e.g. probit functions for toxicity). Hence, a considerable part of the level of uncertainty in risk analysis has its origin in estimation of harm.

The use of objective and transparent methods and the realistic inclusion of mitigating parameters as escape or shelter effects of buildings are indispensable for a proper risk analysis. For example, a systematic use of pessimistic assumptions is counterproductive for a risk analysis. The consideration and discussion of uncertainty levels is part of the risk evaluation process.

3.5 Risk Estimation

The risk estimation process includes the application of the ~~fault~~ event tree and of the physical and physiological models to the location under consideration. It assigns calculated/estimated values of individual or societal risk to all potential accident scenarios on the basis of local data of dangerous goods transport capacity and track utilisation. Following the simple definition in section 2.1 risk is the product of harm and probability. Anyhow, presenting risk as a single probability of harm (e.g. probability of 1 fatality per year) is not common practice in risk analysis. Risk is normally considered as the probable frequency of harm (e.g. frequency of fatalities) either in a spatial context or as a frequency distribution of the level of harm (see below).

For systematic risk estimation the railway track under consideration has to be divided into parts of standard length in order to make risk values comparable to risk criteria. Typical reference lengths for the derivation of risk (per year ~~and track length~~) are 100 m to 1 km. When alternative routes are under consideration the total societal risk of each route is assessed for comparison with each other.

Individual risk is typically depicted as iso-risk contours (e.g. fatalities per year and track length) on a map of the area under consideration giving information about the spatial distribution of risk irrespective of the real actual population density ~~pattern~~ distribution. The presentation of societal risk is a graph of harm (e.g. N people killed) versus frequency F (often called F-N curve). In this case the population density distribution has to be taken into account ~~and a reference length of the railway track on which accidents are considered has to be defined in order to make the estimated risk comparable with risks of other sources e.g. of industrial facilities~~. Examples for both risk types are given in figures 4 and 5.

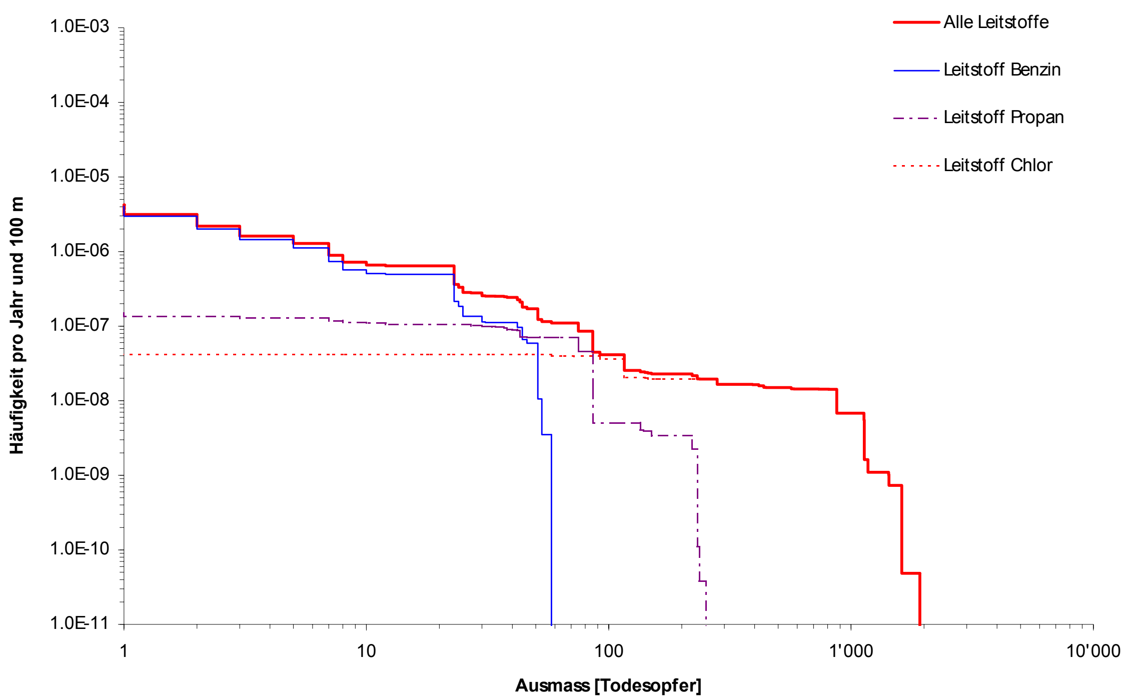

Figure 4: Example of an F-N curve for societal risk due to railway accidents for clustered hazardous substances (from [11])

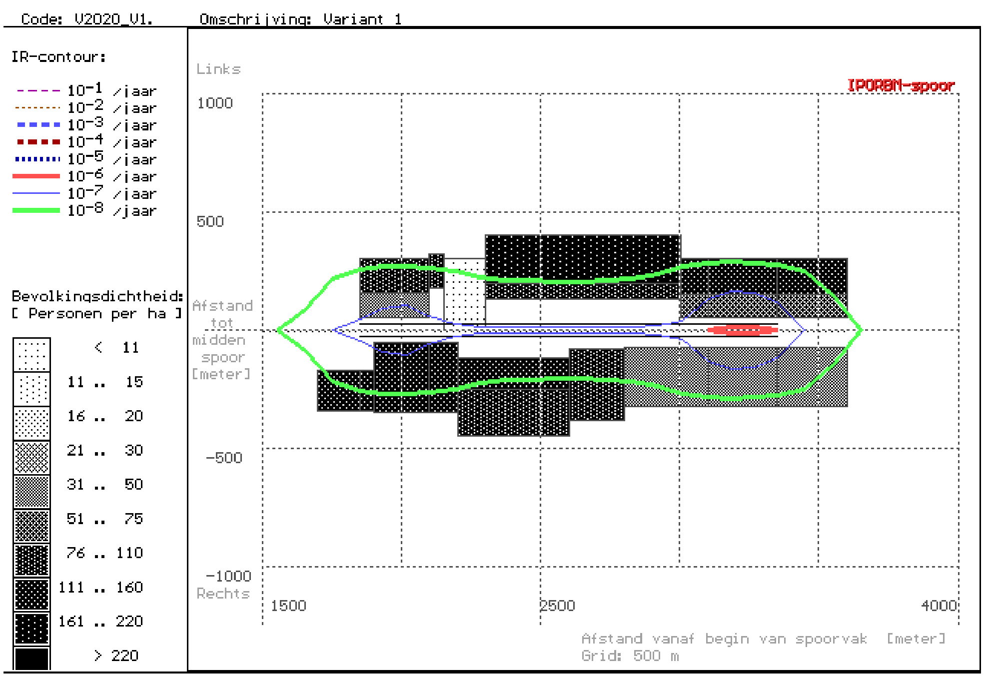

Figure 5: Example of iso-risk curve graphic for individual risk (source: MINVENW, NL)

4. Risk Evaluation

For the time being a COTIF Member State is free according to its national safety policy to define target safety levels ~~according to its national safety policy~~ and to define measures in case of exceedance, as far as these provisions are not contrary to international regulations. ~~However, it is also desirable to harmonize risk acceptance criteria between countries in the future.~~ The first set of common safety targets (CST) for individual and societal risk to be adopted by the European Commission in 2009 [6] will ~~certainly~~ help to harmonise risk acceptance criteria and risk assessment between countries. In particular, the envisaged definition of CST is intended to ensure that the current safety performance of railway systems will not be reduced in any EU Member State.

Approaches to risk evaluation currently differ between COTIF Member States. These differences concern

- type of evaluated risk (individual, societal, environmental)
- level and shape of acceptance and tolerability limits
- zones/categories of acceptance and tolerability.

Each type of risk needs a risk criterion to evaluate whether a risk is tolerable. These risk criteria should be balanced with risk criteria for comparable types of risk (e.g. risks from industrial installations which fall in the regulations of the Seveso II Directive, [3]).

An overview of risk evaluation approaches is given in the RAMS Standard EN 50126 [7]. The ALARP principle (as low as reasonably practicable) applied in the UK defines a zone of unacceptable risk which implicates the need for risk treatment when risk analysis results fall into it. The adjacent tolerability zone with lower risk values gives rise to the introduction of measures as reasonably practicable (ALARP), whereas the acceptable zone with even lower insignificant (residual) risk needs no actions by the competent authority.

A similar approach is found in Switzerland for the evaluation of societal and environmental risk (see figure 6). In this case an additional differential risk aversion is introduced due to the different risk perception between a *low probability-high harm* event compared to a *high probability-low harm* event. An additional feature of this concept is the limitation of risk evaluation to severe damage (e.g. 10 or more fatalities). The approach of the Netherlands is similar but does not include an ALARP or transition zone between tolerable and unacceptable risk.

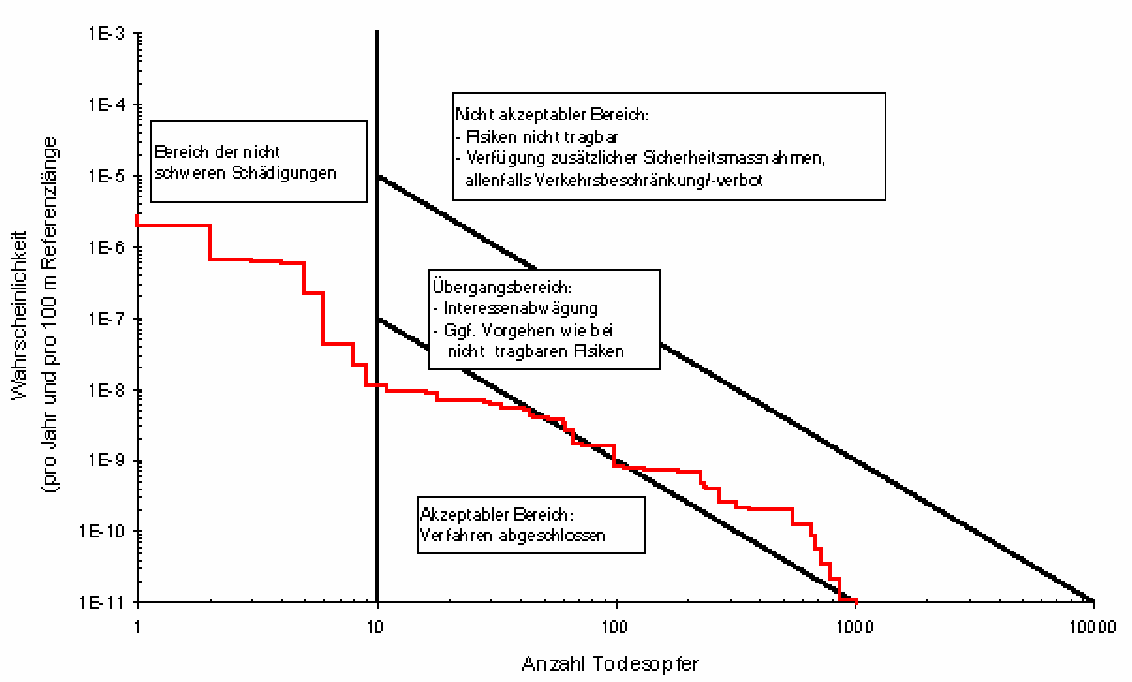

Figure 6: Example of an F-N curve for societal risk with corresponding zones for risk evaluation (from [11])

~~Risk criteria have to meet the following requirements to be suitable for providing evidence of the need for measures in the context of Chapter 1.9 RID irrespective of the actual details of their definition.~~

- ~~application of quantitative acceptance criteria~~
- ~~acceptance criteria balanced with other areas of risk assessment~~

~~A qualitative risk evaluation approach is not suitable to provide this kind of evidence, as the absolute value of estimated risk is not evaluated. Nevertheless, a qualitative approach may be sufficient for the evaluation of alternative measures (see section 5).~~

For a qualitative risk analysis the RAMS standard EN 50126 [7] gives the example of the GAMAB principle (globalement au moins aussi bon, overall at least as good). Application of this principle to route comparison would require at most the same risk level for an alternative route compared to an existing route (stand still principle).

Within the previous sections several potential sources of uncertainty have been discussed (accident statistics, physical and physiological models, time-dependent local boundary conditions, etc.) In terms of an expedient evaluation of risk on the basis of fixed risk criteria it is crucial to aim for a minimisation of uncertainty. Particularly when restrictive measures are envisaged, transparent analysis and discussion of uncertainty within the evaluation process is essential for the acceptance of the measures.

5. Risk Treatment

The risk assessment process provides information on whether ~~a risk is tolerable or not~~ an analysed situation corresponds to a tolerable risk or not. With appropriate documentation of the risk assessment the evidence of the need for measures may be provided as stipulated in Chapter 1.9.3 RID. Nevertheless, the documentation should also contain information about the selection of measures, which is part of the risk treatment process.

It is straightforward to use the same methods and models for the comparison of the effectiveness of different potential measures as were used for the risk estimation. Effectiveness of measures includes aspects such as the potential for risk reduction and the cost to stakeholders. A proper justification of measures increases the chance of their broad acceptance.

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Appendix A

RID 2005

Chapter 1.9

Restrictions on carriage imposed by the competent authorities

1.9.1 A Member State may apply to the international carriage of dangerous goods by rail on its territory certain additional provisions not included in RID, provided that these additional provisions

- are in accordance with 1.9.2,
- do not conflict with the provisions of 1.1.2 (b),
- are contained in the Member State's domestic legislation applying equally to the domestic carriage of dangerous goods by rail on the territory of that Member State,
- do not result in the prohibition of carriage by rail of the dangerous goods covered by these provisions in the territory of the Member State.

1.9.2 The additional provisions referred to in 1.9.1 are:

(a) additional safety requirements or restrictions on carriage
  - using certain structures such as bridges or tunnels[2],
  - using combined transport installations such as transhipment installations, or
  - where the transport operation begins or ends in ports, railway stations or other transport terminals.

(b) provisions according to which the carriage of certain dangerous goods on sections with special and local risks is prohibited, such as sections in residential areas, environmentally sensitive areas, economic centres or industrial zones containing hazardous installations, or to which special conditions, e.g. operational measures (reduced speed, specified journey times, prohibition on trains meeting each other, etc.) apply. Where possible, the Competent Authorities shall establish alternative routes which may be used for each prohibited route or each route subject to special provisions.

(c) exceptional provisions specifying the excluded or prescribed routeing or provisions to be observed for temporary storage resulting from extreme weather conditions, earthquake, accident, demonstrations, civil disorder or military hostilities.

1.9.3 Application of the additional provisions in accordance with 1.9.2 (a) and (b) presupposes that the competent authority provides evidence of the need for measures.

1.9.4 The competent authority of the Member State applying on its territory any additional provisions within the scope of 1.9.2 (a) and (b) above shall notify the Central Office, in general in advance, of the additional provisions. The Central Office shall bring them to the attention of the Member States.

1.9.5 Notwithstanding with preceding paragraphs, Member States may lay down specific safety requirements for the international carriage of dangerous goods by rail, in so far as RID does not cover that area, in particular as regards

- the running of trains,
- operating rules for operations ancillary to transport such as marshalling and stabling,
- management of information concerning the dangerous goods transported,

provided they are contained in its national legislation and are also applicable to the national carriage of dangerous goods by rail in the territory of the said Member State.

These specific requirements shall not concern the areas covered by RID, in particular those listed in 1.1.2 (a) and 1.1.2 (b).

[2] For carriage through the Channel Tunnel and through tunnels with similar characteristics, see also Articles 5 § 2 (a) and (b) of Council Directive 96/49/EC on the carriage of dangerous goods by rail, published in the Official Journal of the European Communities, L 235, 17 September 1996, p. 25.