

# Determination of Explosion Protection Zones in Acetylene Facilities According to DGUV Rule 113-001

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The presentation shows the transfer from old examples to the new (blue) edition of the sample collection within the DGUV rule 113-001 – Collection of technical rules for the avoidance of hazards from explosive atmospheres with sample collection to classify hazardous areas into zones (original name: “DGUV Regel 113-001, Sammlung technischer Regeln für das Vermeiden der Gefahren durch explosionsfähige Atmosphäre mit Beispielsammlung zur Einteilung explosionsgefährdeter Bereiche in Zonen”, published by the German Social Accident Insurance) in accordance of the recommendations of the explosion protection experts from the German Social Accident Insurance, Industriegaseverband (Industrial Gases Association in Germany), authorities and notified bodies.

To introduce into the topic, further contents are the identification and evaluation of examples for explosion hazards, places where explosion hazards are likely to occur (hazard area classification and zones) and measures to avoid explosion hazards or to protect against the consequences of an explosion.

This procedure will be shown using examples for acetylene plants and customers supply systems within the publication DGUV rule 113-001.

In the following the project is described. The project to transfer old examples to new example collection was initiated after consulting meeting with a member company of BG RCI. After identification and evaluation of examples for explosion hazards, places where explosion hazards are likely to occur (hazard area classification and zones), measures to avoid explosion hazards or to protect against the consequences of an explosion the created examples were assessed by explosion protection experts (authorities, notified bodies, industry, ...). Finally the examples were published in DGUV rule 113-001. A selection of examples is shown in the presentation.

## 1. Introduction

The Berufsgenossenschaft Rohstoffe und chemische Industrie (BG RCI) is one of 9 German Social Accident Insurance Institutions for trade and industry within the German Social Accident Insurance.

BG RCI incorporates the German Social Accident Insurance Institutions for the mining industry, for the chemical industry, for the leather industry, for the paper making industry, for the quarrying industry and for the sugar industry.

You may well be asking yourselves what is the common denominator of these apparently disparate German Social Accident Insurance Institutions. Sugar and chemistry may, at first glance, appear to have little in common, but the manufacturing processes of the companies in these industries are in fact very similar. Raw materials are supplied and top-quality high-priority products leave the plant at the end of the process. Because of many similarities the prevention can combine knowledge as already realised in the department explosion prevention with experts from all branches. The former German Social Accident Insurance Institution for Chemical Industry already lead the working group Explosion Protection within the German Social Accident Insurance with its experts from industry, insurance, research and development, authorities and other consultants. So the BG RCI as the successor continues this process.

## 2. Sample Collection as a Part of Regulations on Explosion Protection

This sample collection to classify hazardous areas into zones is the most comprehensive and up-to-date collection of samples known worldwide. The zoning should help responsible persons in companies to conduct the risk assessment in their plants, regarding explosion protection. The first regulations with example collection were implemented in the early 50ies. There were combined in a sample collection. From 2000 the collection was restructured with general examples for gases, burnable fluids and dusts, then special examples and a list of reference to other regulations and information media. So it is a source of knowledge for classification of hazardous areas into zones.

The sample collection is based on experience and knowledge of many experts. Experts are delegated from German Social Accident Insurance, plants with areas, where explosive atmosphere may occur, notified bodies, market surveillance, from institutes for research, consultants and others.

The sample collection is used by operators, authorities, notified bodies, consultants and others. It is a collection of technical rules for avoiding the risks from explosive atmospheres with sample collection for the classification of hazardous areas into zones. The own case may differ from the example in the collection.

But the sample collection has to be and is always actual since a team of explosion protection experts observes the Harmonisation of European Directives carefully, looks out for further development in the technology and the use of new substances and adopts the further development of German law regarding dangerous substances and production safety. In addition relevant national technical rules for operational safety are integrated in the rule. Technical rules are representing State of Technology and are published by the state. Obeying these rules is taken as fulfilling the law. These rules were developed by the statutory accident insurance until 2003 and then transferred into rules provided by the federal ministry, which are now supported by the statutory accident insurance and other institutions. Different statements regarding one topic, e.g. in different rules are avoided by the coordination within this team. The generality in the sample collection is increased by discussing with several explosion protection experts.

## 3. Explosion Protection Basics

Explosive atmosphere does not need a huge amount of burnable substances. A teaspoon of fuel might be enough to create 200 l explosive atmosphere in a barrel, if the vapour from the flammable substance is in a good mixture with oxygen respective air.

But even less volume of explosive atmosphere is dangerous. The common opinion of experts is, that in general 10 l of explosive atmosphere in a room is dangerous, and in smaller rooms even less. 1/10000 of the room volume, e.g. 8 l explosive atmosphere in 80 m<sup>3</sup> are dangerous in case of ignition. If then an effective source of ignition is present, an explosion will occur.

Not only vapours from flammable liquids, but also flammable gas may be an element such as acetylene which can be made to react with oxygen with very little additional energy. Flammable gases are often compounds of carbon and hydrogen. These flammable gases and vapours require only small amounts of energy to react with atmospheric oxygen. Acetylene can even react without air like an in an explosion, if about 82 Volume % or more are present.

To know where special measures to prevent an explosion are necessary, areas, in which an explosive atmosphere may occur, are divided into zones. The definition of these zones is harmonized in the EU:

Zone 0 is a place in which an explosive atmosphere consisting of a mixture of air with flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently.

Zone 1 is a place in which an explosive atmosphere consisting of a mixture of air with flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally.

Zone 2 is a place in which an explosive atmosphere consisting of a mixture of air with flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

In the definitions for zone 0 or zone 20, the terms someone finds "always", "over long periods of time" or "often". The term "frequently" is to be used in the sense of "time mostly". When viewing units here the actual length of operation of an installation is to be used. In other words, hazardous areas of zone 0 or zone 20 are assigned, while if more than 50 % of the operating time of the considered system or if a system component predominates explosive atmosphere. Is considered part of a plant, for example, operated in single-shift operation ten hours a day, this would be more than 5 hours. These include usually only inside plant or the interior of plant components (evaporator, reaction vessel, dust filters, etc.), because if the conditions of the definition of zone 0 or zone 20 are met.

#### 4. The Project

The impulse for the project was a consulting contact by one of the insured companies. Within the discussion it was mentioned that the withdrawing of several rules regarding acetylene would lead to a lack of information and uncertainty. The result of the discussion was the setting up a project group. At this point I would like to thank the members of the project group and their companies for assistance, as there were involved

- Air Liquide Deutschland, Düsseldorf
- BAM (federal institute for materials examination and research), Berlin
- BASI Gas, located south of Karlsruhe,
- BG RCI, Heidelberg
- Linde AG, Munich
- Westfalengas, Münster
- IGV (Industrial Gases Association), Cologne (today: Berlin)

and the members of the project group “Explosion Protection Sample Collection” for their helpful correction hints (experts for explosive atmosphere from several companies, institutes, authorities and accident insurances in Germany).

In the first meeting a first draft showing the transfer from old green to new blue sample collection, also including figures from technical rules for acetylene and code of practice for acetylene was discussed. In site audits and further meetings the participants gained a common basis for further discussions.

The project group renewed the examples on the basis of the before mentioned results. The existing examples were described in more detail and cases according to the different technology standards were added. In addition a new example group for customer supply system was created.

After first presentation at the project group “Explosion Protection Sample Collection”, the correction remarks were adopted within one meeting and then accepted for presentation in the section explosion protection within the department Raw Materials and chemical Industry of the German Social Accident Insurance. There it was granted the permission to be published.

In general determination of the extension as well as the duration and frequency of explosive atmospheres is a result from evaluation of experts. In just a few cases it might be calculated, especially to reduce the zones.

Only in very special cases modelling of scenarios and statistical data are used as a help to evaluate the extension and frequency of a zone. In the example collection for acetylene a calculation was used to proof, that a reduction of zones is acceptable if special technical measures were taken into account.

#### 5. Examples from in sample collection

In the sample collection as neighbourhood is defined: an area of less than a ball with 0.5 m radius. That is the volume of 125 l Explosive atmosphere respective 1/8 of a cubic meter.

In example a1) the computation the amount of the exiting gas results to 125 l explosive atmosphere possible (tube diameter 25 mm x 200 mm at 25 bar).

The following table shows the sample to the above shown situation when emptying cylinders in a production plant for acetylene.

Within the presentation this excerpt from the sample collection to classify hazardous areas into zones is explained. All samples have a reference no. in column 1. In the 2nd column you find a title for the sample group and in column 3 characteristics, comments and prerequisites are defined as well as notes given. The digits in column 4 are the reference in the German technical rule TRBS 2152 part 2. There you find the description what is meant. 2.4.3.4 in the rule means “reducing workflow related discharges into air” and 2.4.4.3 means “technical airflow e.g. by ventilation”. Column 5 shows the Zone and its extension. “in the neighbourhood around” means a distance of maximum 50 cm from the defined source. The last column shows the measures of the constructive explosion protection which limit the effect of an explosion to a safe measure according to TRBS 2152 part 4.



Figure 1: Emptying Cylinders in Production - Stop valve directly at cylinder (photo: Linde AG)

Table 1: Excerpt 1 from sample collection to classify hazardous areas into zones (translated by the author)

No.	Sample	Characteristics, comments, prerequisites, notes	Protection measures according to TRBS 2152 Part 2	Definition of zones to prevent ignition sources according to TRBS 2152 Part 3	Prevention measures according to TRBS 2152 Part 4
4.7.1.11.1	Emptying cylinders in Production	Cylinders are connected to emptying hanger and Rest amounts of acetylene are lead well-directed from the area. Occurrence of dangerous explosive atmosphere while clamping possible.			
4.7.1.11.1.1	In Rooms	Ventilation holes, accumulations in the ceiling area excluded especially in the roof area			
		a1) Reverse currents from tube prevent, e.g. by stop valve in the hanger integrated. In the normal use released acetylene amount does not lead of danger-menacing amount	2.4.3.3 2.4.4.2	Zone 2: in the neighbourhood around emptying connection	None
		a2) Reverse currents from tube not certainly prevent. Vent holes in particular in roof area available, impossible to accumulate beyond roof	2.4.3.4 2.4.4.2	Zone 1: 1m to drain connection Zone 2: additional 2 m cylindrical	None

In example a2) the volume is larger since, there is no stop valve in the pipe direct at the cylinder. In other examples within the sample collection where e.g. longer pipes, like in 1.1.1, are in use, the zone with explosive atmosphere is much larger even with a ventilation. Also an excerpt from the new example group dealing with customers-supply systems is shown in the presentation.



Figure 2: Customers supply system (photo: Linde AG)

Within the presentation details of the overpressure device and a draft of the resulting zone and an additional valve to reduce the discharge of acetylene into the room are shown. The result is a reduction of the zone.

Table 2: Excerpt 2 from sample collection to classify hazardous areas into zones (translated by the author)

No.	Sample	Characteristics, comments, prerequisites, notes	Protection measures according to TRBS 2152 Part 2	Definition of zones to prevent ignition sources according to TRBS 2152 Part 3	Prevention measures according to TRBS 2152 Part 4
4.7.2.1		<b>Customers - supply systems</b>			
		a) Infrequent malfunctions can not be excluded. Liberated gas release with connection and disconnection does not lead to explosive atmosphere	2.4.3.4 2.4.4.2	Zone 1: 3 m around Control device with overpressure protection device into the installation room Zone 2: Other space in room and 0.5 m around the upper openings in the roof construction	None

## 6. Conclusion

Within the presentation only some examples in the example collection for explosion protection are shown. Thereof only 2 examples are shown of the collection for acetylene plants and usage. But there are many more.

In the BGR 104 you find more information on zones, also for other gases, for flammable liquids and burnable dusts. Also the sample collection shows some special plants like waste water treatment or biogas plants. To avoid differences between rules those ones which were checked by the group Explosion Protection within the German Social Accident Insurance, these standards are referenced in part 5 of the sample collection.

As shown in the abstract the examples are based on practical experience from a variety of experts. The examples were audited 3 times before being published.

But of course they are just examples. If someone intends to use them, it is necessary to compare with the own situation and to decide, if they are applicable or if changes are necessary.

**References**

- Explosion protection rules (EX-RL): Collection of technical rules for the avoidance of hazards from explosive atmospheres with sample collection to classify hazardous areas into zones, (DGUV-R 113-001), EX-RL sample collection, [www.exinfo.de](http://www.exinfo.de)
- TRBS 2152 Part 2 (technical rules operational safety - Prevention or restriction of hazardous explosive atmospheres), [www.exinfo.de](http://www.exinfo.de)
- TRBS 2152 Part 3 (technical rules operational safety - avoidance of the ignition of hazardous explosive atmospheres), [www.exinfo.de](http://www.exinfo.de)
- TRBS 2152 Part 4 (technical rules operational safety - Explosive atmosphere - Constructive protection measures, which limit the impact of an explosion to an acceptable level, [www.exinfo.de](http://www.exinfo.de)
- Dyrba, Praxishandbuch Zoneneinteilung, [www.exinfo.de](http://www.exinfo.de)