Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 2103 (06/2000)

Explosion Protection in Nuclear Power Plants with Light Water Reactors (General and Case-specific Requirements)

(Explosionsschutz in Kernkraftwerken mit Leichtwasserreaktoren - allgemeine und fallbezogene Anforderungen)

The previous version of this safety standard was issued 06/89

If there is any doubt regarding the information contained in this translation, the German wording shall apply.

Editor:
KTA-Geschaeftsstelle c/o Bundesamt fuer Strahlenschutz (BfS)
Willy-Brandt-Str. 5 • 38226 Salzgitter • Germany
Telephone +49-(0)1888/333-(0)1621 • Telefax +49-(0)1888/333-1625

KTA SAFETY STANDARD

June 2000	**Explosion Protection in Nuclear Power Plants with Light Water Reactors (General and Case-specific Requirements)**	KTA 2103

CONTENTS

PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 50-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in Bundesanzeiger BAnz No. 231a of December 8, 2000. Copies may be ordered through the Carl Heymanns Verlag KG, Luxemburger Str. 449, 50939 Koeln, Germany (Telefax +49-221-94373603).

All questions regarding this English translation should please be directed to:

KTA-Geschaeftsstelle c/o BfS, Willy-Brandt-Str. 5, 38226 Salzgitter, Germany

Comments by the editor:

Taking into account the meaning and usage of auxiliary verbs in the German language, in this translation the following agreements are effective:

shall	indicates a mandatory requirement,
shall basically	is used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. It is a requirement of the KTA that these exceptions - other than those in the case of **shall normally** - are specified in the text of the safety standard,
shall normally	indicates a requirement to which exceptions are allowed. However, the exceptions used shall be substantiated during the licensing procedure,
should	indicates a recommendation or an example of good practice,
may	indicates an acceptable or permissible method within the scope of this safety standard.

Fundamentals

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safety related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against the damage arising from the construction and operation of the facility (Sec. 7 para. 2 subpara. 3 Atomic Energy Act), in order to attain the protection goals specified in the Atomic Energy Act and Radiological Protection Ordinance (StrlSchV) and which are further detailed in "Safety Criteria for Nuclear Power Plants" and in "Guidelines for the Assessment of the Design of PWR Nuclear Power Plants against Incidents pursuant to Sec. 28 para. 3 of the Radiological Protection Ordinance (StrlSchV) – Incident Guidelines".

(2) Criterion 2.7 "Fire and Explosion Protection" of the Safety Criteria for Nuclear Power Plants specifies that protection measures against explosions are required in nuclear power plants. The Incident Guidelines specify the extent of these explosion protection measures by stating that the system design shall incorporate protection measures against this incident (design basis accident). This is achieved by taking appropriate explosion protection measures that prevent an occurrence of this incident or prevent the occurrence of impermissible impacts from this incident.

(3) With regard to explosion protection measures in nuclear power plants it is assumed that the industrial safety regulations, the accident prevention regulations of the German trade unions as well as other regulations under public law and, especially, the "Guideline for Preventing Danger from Explosive Atmospheres, with a Collection of Examples – Explosion Protection Guideline (EX-RL)" are fulfilled. In accordance with Sec. 8 para. 3 Atomic Energy Act, the nuclear licensing authority may grant certain exemptions.

(4) In order to meet the requirements of EX-RL specifically with respect to explosion protection in nuclear power plants with light water reactors (LWR), the present safety standard, KTA 2103, specifies explosion protection measures in such a way that the possibility for the occurrence of an explosion that would adversely affect the function of safety related plant components becomes so low that the protection measures specified under para. 2 can be considered as being met.

(5) The considerations regarding explosion protection in nuclear power plants take all substances into account which can generate explosive atmosphere or other explosive mixtures, in as far as these substances are either brought on to or can penetrate into the nuclear power plant site or in as far as they can be generated inside of the nuclear power plant site.

The substances considered in this safety standard are, e.g.: the hydrogen used for cooling the generator, for the hydrogenation of the reactor coolant and of the gaseous waste processing system, the hydrogen gas generated during battery operation, the counter gas methane, other flammable gases (such as welding gases) and flammable liquids (such as gasoline, diesel fuel, paints and solvents).

(6) This safety standard does not deal with protection measures against the special danger from explosions as specified under Section 1 para. 2.

1 Scope

(1) This safety standard shall apply to nuclear power plants with light water reactors. It specifies the requirements for sustaining the function of safety related plant components in the case of danger from the explosion due to substances that can generate an explosive atmosphere or other explosive mixtures in as far as these substances are either brought on to, or can penetrate into, the nuclear power plant site or as they can be generated inside of the nuclear power plant site.

(2) This safety standard does not apply to the protection measures against the danger from explosions which may arise

a) when handling dangerously explosive materials in accordance with Sec. 1 para. 1 Explosives Act (SprengG),
b) when handling explosive substances outside of the nuclear power plant site, with the exception of the requirements specified in Section 6 of this safety standard with respect to the use of gas warning devices,
c) from hydrogen released during a loss of coolant accident (light water reactors) and other hydrogen generated by radiolysis,
d) in the exhaust gas system of nuclear power plants,

   N o t e :
   Cf. KTA 3605 "Treatment of Radioactively Contaminated Gases in Nuclear Power Plants with Light Water Reactors".

e) in diesel generator facilities of nuclear power plants.

   N o t e :
   Cf. KTA 3702 "Emergency Power Generating Facilities with Diesel Generator Units in Nuclear Power Plants".

(3) This safety standard does not apply to protection measures against fires resulting from explosions but it does deal with measures ensuring that the fire protection equipment and facilities are not affected by any detrimental explosion pressure loads (cf. Section 4.3 para. 3).

N o t e :
Fire protection measures – including fires as consequential events and explosions – are dealt with in the safety standard series KTA 2101 "Fire Protection in Nuclear Power Plants".

2 Definitions

N o t e :
Definitions 2 through 4 and 6 through 9 were prepared in accordance with the wording in Explosion Protection Guideline (EX-RL).

(1) Work place

A work place is a local area designated for a specific work procedure even if more than one person are involved.

(2) Explosive atmosphere

Explosive atmosphere comprises explosive mixtures of gases, vapors, mists or dusts with air including the regular admixtures(e.g. humidity) under atmospheric conditions.

Atmospheric conditions are characterized by an overall pressure between 0.8 bar and 1.1 bar and a mixture temperature between -20 °C and +60 °C.

(3) Atmosphere or other mixtures, dangerously explosive

Dangerously explosive atmosphere or other dangerously explosive mixtures are explosive atmospheres or other explosive mixtures in hazardous amounts. An amount is considered as being hazardous if its ignition could cause personal injury or damage to safety related plant components as a direct or indirect impact of the explosion.

(4) Explosion endangered areas

Explosion endangered areas are areas where the danger of explosion exists, i.e., where a dangerously explosive atmosphere or other dangerously explosive mixtures can occur on account of the local or operational conditions.

(5) Provision (of flammable gases and flammable liquids)

Provision of flammable gases and flammable liquids means making these substances available in the required amount for the work shift at or near the place of their deployment or in the rooms where the work tasks are performed.

N o t e :
"Provision" in itself does not comprise the actual storage (cf. definition 11).

(6) Explosion protection

Explosion protection comprises all measures taken as a protection from the dangers of explosions.

(7) Primary explosion protection

Primary explosion protection comprises those measures that prevent or reduce (in space, time or amount) the formation of a dangerously explosive atmosphere or of other dangerously explosive mixtures.

(8) Other explosion protection

Other explosion protection comprises those measures that prevents the danger of ignition of a dangerously explosive atmosphere or of other dangerously explosive mixtures or that limit the explosion impacts to an extent that they can be considered as harmless.

(9) Explosive mixture

An explosive mixture is a mixture of gases or vapors among each other or with mists or dusts in which a successful ignition would lead to a self-sustained propagation of the reaction.

(10) Nuclear power plant site

The nuclear power plant site is the correspondingly fenced-in area that belongs to the nuclear power plant unit or units.

N o t e :
Within the scope of this safety standard, the term nuclear power plant site does include the buildings, not however, in general, the cooling towers, the information center, outdoor switchyards and the parking areas.

(11) Storage (of flammable gases and flammable liquids)

Storage of flammable gases and flammable liquids means their stockpiling in stationary or mobile storage tanks for supply purposes.

N o t e :
"Storage" in itself does not comprise the actual provision (cf. definition 5)

(12) Standard state (with respect to the volume of a gas)

The standard state of the volume of a specific gas is its volume at 1.013 bar and 0 °C.

3 Basic Requirements

(1) For explosion protection purposes the pertinent rules and regulations shall be complied with in all areas of the nuclear power plant site; these rules and regulations are, e.g., VbF, TRbF, AcetV, DruckbehV, TRG, TRB, ExVO, ElexV, VBG 15, VBG 61, DIN EN 1127-1, DIN EN 60 079-14 (VDE 0165 Part 1), DIN EN 50 014 (VDE 0170/0171 Part 1), DIN EN 60 034-3 (VDE 0530 Part 3), DIN VDE 0510-2, ZH 1/8, ZH 1/8.1, BGI 518 and, especially, EX-RL. Supplements and additional requirements are specified in the following paragraphs. These take account of the hazards possibly exceeding the regular measure as specified in EX-RL (cf. EX-RL Secs. D 2.3 last paragraph and E 2.2 third-to-the last paragraph.).

(2) The function of safety related plant components shall be ensured by explosion protection measures. In addition to the general explosion protection measures specified in EX-RL the following measures shall be taken :

a) A check in accordance with EX-RL Section E 2.2 (third- to-the-last paragraph) shall be performed to establish whether or not the existing or possibly created explosive atmosphere or other explosive mixtures in the remaining explosion-endangered areas are or will be present in amounts that would have impermissibly adverse effects on the function of safety related plant components.

b) If the check under item a shows that impermissibly adverse effects are possible, then additional protection measures shall be laid down and performed as specified in paras. 3 to 7 which, in turn, refer especially to Sections 4 and 5.

c) Furthermore, additional measures shall be taken and requirements met as specified under Sections 6 to 9.

(3) Within the scope of this safety standard (cf. Section 1) only those substances specifically mentioned in Section 5 which are able to generate an explosive atmosphere or other explosive mixtures are basically permitted to be handled in the individually specified areas and under the individually specified conditions.

N o t e :
Section 5 comprises case-specific requirements for those substances that can generate an explosive atmosphere or other explosive mixtures and that commonly are used or are present in nuclear power plants.

(4) The requirements specified under Section 4 are met if the measures specified under Section 5 are taken. In these cases it is not required to consider that any dangerous amounts of flammable gases and vapors would be drawn in that are set free on the nuclear power plant site.

(5) The requirements specified under Section 5 apply, provided, the safety related plant components are protected by structural means against external impacts from blast waves due to chemical reactions in accordance with Guideline "Blast Waves". If these structural measures have not or have only partly been implemented, this shall be considered as a deviation in accordance with para. 6.

N o t e :
In the cases covered by Section 5 it is ensured that, when fulfilling the requirements specified in that section in conjunction with the requirements of Guideline "Blast Waves", even an explosion within the nuclear power plant site but outside of the buildings and plant components to be protected will not cause overpressures at these buildings and plant components that would exceed the maximum overpressures specified in Guideline "Blast Waves" (0.45 bar, 0.3 bar, respectively).

(6) If, within the scope of this safety standard (cf. Section 1), the requirements deviate from those specified under Section 5 or if substances are used that could generate a dangerously explosive atmosphere or other dangerously explosive mixtures as specified under Section 2 that are not dealt with under Section 5, then, as specified under Section 4, case-specific protection measures shall be specified and implemented.

(7) During particular operating conditions (e.g., during maintenance procedures), if the function of safety related plant components are not or are just partly required, any requirements of this safety standard going beyond those in the pertinent rules and regulations (cf. Section 3 para. 1) may be deviated from, provided, an explosion will not have any impermissibly adverse effects on the individual function of those safety related plant components that are required for the specific operating condition.

4 General Requirements

4.1 Primary Explosion Protection

(1) With regard to protecting the function of safety related plant components from impermissibly adverse effects special preference shall be given to the primary explosion protection.

N o t e :

a) According to guideline Sec. C 5 EX-RL, primary explosion protection is only "in general to be given … safety-related preference". This general measure, however, is not sufficient for the especially endangered areas dealt with in this safety standard; thus, primary explosion protection must be given "special preference" (cf. Sec. E 2.2 EX-RL, third-to-the-last paragraph).

b) Primary explosion protection measures include, in accordance with Sec. E 1 EX-RL,

ba) substitution of flammable substances, especially flammable gases and flammable liquids, by non-combustible or fire-resistant substances,

bb) reduction of the amounts of provided or deployed substances that could generate an explosive atmosphere or other explosive mixtures,

bc) limitation of the possible volumetric flow or amount of those substance released during an operational occurrence that could generate an explosive atmosphere or other explosive mixtures,

bd) increased safety related requirements regarding the confinement of those substances that could generate an explosive atmosphere or other explosive mixtures,

be) surveillance of the atmosphere by gas alarm monitors that would automatically initiate protection measures,

bf) technical (artificial) ventilation of rooms in accordance with Sec. E 1.3.4.2 EX-RL,

bg) inertisation.

(2) A dangerously explosive atmosphere or other dangerously explosive mixtures that, in accordance with EX-RL Sec. B 5, could occur

- on account of gases, vapors or mists:
  continuously, over a long period or frequently (Zone 0)
- on account of dusts:
  continuously, over a long period or frequently (Zone 20),

are not permissible in the following rooms:

a) rooms with safety related plant components,

b) rooms from which impermissibly adverse effects on the function of safety related plant components could arise.

(3) The minimum goal of primary explosion protection is to achieve that only limited explosion-endangered areas can occur in the rooms specified under para. 2 items a and b

- on account of gases, vapors and mists:
  only occasionally (Zone 1) or seldom and then only over a short period of time (Zone 2)
- on account of dusts:
  in the form of clouds of flammable dust occasionally (Zone 21) or only over a short period of time (Zone 22).

4.2 Other Explosion Protection

(1) If the rooms specified in Section 4.1 para. 2 items a and b cannot be completely protected by the primary explosion protection such that the occurrence of explosion-endangered areas cannot be completely prevented, i.e., that remaining areas of Zone 1, 2, 21 or 22 exist in these rooms, then the following applies in addition to the primary explosion protection.

In these areas other explosion protection measures – beyond those generally applied in accordance with EX-RL – shall be taken (cf. Sec. D 2.3 EX-RL, last paragraph and E 2.2 EX-RL, fourth-to-the-last paragraph).

N o t e :
Suitable measures are, e.g., a combination of other explosion protection measures in accordance with Secs. E 2 or E 3 or E 2 and E 3 EX-RL .

(2) Explosion protected components that are tested and certified for deployment in a dangerously explosive atmosphere shall not be deployed in any area endangered by other explosive mixtures (cf. Section 2 para. 3) without additional certification.

4.3 Combination of Events

(1) It is not required to assume the simultaneous occurrence of an explosion with an independent plant-internal incident (design basis accident) or of an independent external event.

(2) All events that are independent of the handling of explosive substances and that can lead to explosions shall be analyzed within the frame work of this safety standard; in case of an identified explosion hazard, protection measures shall be taken. In specifying the protection measures for the substances named under Section 5 these events have already been considered.

(3) Fire shall be considered as a consequential event of explosions. The explosion protection shall ensure that the fire protection equipment and facilities are not subjected to any special pressure loads from the explosion. This requirement is fulfilled by meeting the specifications under Section 5 of this safety standard.

5 Case-specific Requirements

N o t e :
Special reference is made to the specifications under Section 3 and there, in particular, to paras. 3 through 7.

5.1 Storage and Bottling of Flammable Liquids

(1) The storage and bottling of flammable liquids is treated in pertinentrules and regulations; especially the “Ordinance on Flammable Liquids (VbF)” and the corresponding “Technical Standards for Flammable Liquids (TRbF)” shall be adhered to. Supplements and additional requirements are specified in the following paragraphs.

(2) Flammable liquids in vessels with a capacity larger than 1 liter may only be stored and handled if these vessels comply with the requirements of the Dangerous Substance Ordinances GGVS or GGVE; other vessels with a capacity larger than 1 liter are not permitted without a protective enclosure.

(3) Liquids with a flash point lower than or equal to 55 °C in a single depot shall basically be stored only up to an amount of 1000 liters and, basically, only in vessels with a capacity not larger than 200 liters. These depots shall not be located in buildings housing safety related plant components. The only exceptions are subterranean tanks for storing gasoline (carburetor fuel); their storage capacity shall be limited to a maximum of 100,000 liters. The storage tanks and associated filling stations shall be located at a distance of more than 30 meters from the intake openings of the ventilation systems and from the entrances and exits to buildings. All depots shall be inspected in accordance with Sec. 13 VbF even if the exemption limits in accordance with Secs. 8 and 9 VbF are not exceeded.

(4) The storage of flammable liquids with a tendency of self-disintegration (unstable substances) or explosive reactions (e.g. Nitromethane) is not permissible.

(5) Whenever more than 30 liters of flammable liquids with a flash point lower than or equal to 55 °C are either supplied to or removed from the storage depots, the type and amount shall be documented in writing. In intervals of no more than one year a written inventory shall be prepared and an examination carried out regarding the proper condition of the depots and vessels - including the vessels outside of depots.

(6) The following applies to rooms in which safety related plant components are located and to rooms where an explosion would have impermissibly adverse effects on the function of safety related plant components:

a) It is not permissible to store flammable liquids with a flash point lower than or equal to 55 °C.

b) Flammable liquids shall be provided only in amounts not exceeding those required in the next work shift.

(7) Residual quantities of flammable liquids with a flash point lower than or equal to 55 °C in the controlled area shall either be directly removed from the controlled area – provided the corresponding release permit has been issued – or they shall be limited to 100 liters in the controlled area and shall be

stored in a depot in accordance with Secs. 6.22 through 6.28 TRbF 110 such that no impermissibly adverse effects on the function of safety related plant components can occur. This storage does not require a renewed documentation of the liquids as specified under para. 5, first sentence.

5.2 Provision and Deployment of Flammable Liquids

N o t e :
The term deployment shall comprise all activities associated with processing and other applications, not however, activities associated with storage and bottling (cf. Section 5.1).

(1) Any provision and deployment of flammable liquids is subject to the pertinent rules and regulations; of particular importance are EX-RL and the German Accident Prevention Regulations. Supplements and additional requirements are specified in the following paragraphs.

(2) The provision and deployment of liquids specified under Section 5.1 para. 4 are not permitted on the nuclear power plant site.

(3) The provision and deployment of liquids with a flash point lower than or equal to 55 °C and of liquids the maximum working temperature of which lies over or just under (up to about 5 K) the flash point of the liquid (cf. Sec. D 2.1b EX-RL) shall be limited to the amounts required for the specific task; however, the amounts per work place shall not exceed

a) regarding provision, 100 liters,

b) regarding deployment, 30 liters, however, in an individual fire zone, 100 liters,

provided, pertinent rules and regulations do not specify lower limit values. Other than inside of laboratories, any provision and deployment is permissible only on the basis of a written work sheet. This work sheet shall also specify the necessary protection measures (e.g. ventilation). If several of these work sheets were issued, the respective tasks shall not endanger each other. After work completion, the residuals of such liquids, including waste material incorporating such liquids, shall be removed without delay.

(4) Deviating from para. 3, the application of biocides in the form of flammable liquids for the treatment of the cooling tower water (e.g. stabilized Acrolein) is permitted up to the amount required for one biocide treatment.

(5) The following additional requirements apply to the deployment of the liquids as specified under para. 3 in rooms housing safety related plant components:

a) Work procedures (e.g. surface treatments) with such liquids shall be performed only in conjunction with the use of technical (artificial) ventilation.

b) The removal of unused amounts from these rooms shall be certified in writing and shall be monitored.

c) Pipe lines carrying such liquids are not permissible.

(6) The effectiveness of the technical (artificial) ventilation required in accordance with para 5 a) and the necessary protection type shall be checked by expert personnel of the licensee. The following shall apply in this context:

a) Those personnel are considered as experts with respect to this requirement who, on account of their professional training and experience, have sufficient knowledge of air conditioning and ventilation and are familiar with the legal health and safety regulations, the German Accident Prevention Regulations, the guidelines and generally accepted engineering standards (e.g. DIN standards and VDE regulations) to assess the safety state.

b) A random check of the local concentration of flammable gases and vapors that could generate under unfavorable conditions can be performed, e.g., by using mobile gas alarm equipment, provided, their functionality has been certified in accordance with Section E 1.4 EX-RL (prototype test).

5.3 Hydraulic and Lubrication Oils

(1) Oil supply systems shall meet the pertinent rules and standards. Supplements and additional requirements are specified in the following paragraphs.

(2) Oil supply systems shall be constructed and operated such that, in the case of a leakage, the occurrence of explosive mixtures of oil mists, oil vapors and oil solutions of gases with air are prevented or are at least restricted to such an extent that no impermissibly adverse effects on the function of the safety related plant components can occurr.

N o t e :
If the requirements specified under paras. 3 or 4 are complied with, no impermissibly adverse effects on the function of the safety related plant components need to be assumed as originating from explosive oil mist clouds caused by the formation of soot on the oil supply systems.

(3) In the case of oil supply systems with an operating overpressure less than or equal to 10 bar, the requirement specified under para. 2 is met if the following conditions are fulfilled:

a) The coast-down temperature of the oils (i.e., the oil temperature as it runs from the component that causes the heating up of the oil) shall not exceed 60 % of the flash point (measured in °C) of the respective oil.

b) The oil, under permissible operating conditions, shall not have a tendency of disintegrating into components with a low boiling temperature that would enable the formation of explosive mixtures by releasing vapors and gases already at temperatures below the flash point of the oil.

(4) In the case of oil supply systems with an operating overpressure higher than 10 bar, the requirements specified under para. 2 are met, provided, the following conditions are also fulfilled in addition to the requirements under para. 3:

a) In regular intervals to be specified (depending on the individual test results), the oils shall be analyzed with respect to the content of components with a low boiling temperature and with respect to solutions of flammable gases in oil.

b) The results of the analyses specified under item a shall be documented in writing.

c) If the mass content of components with a low boiling temperature in the oil is impermissibly high with regard to the formation of explosive mixtures, then suitable measures shall be taken to convert the oils into a state permissible under the operating conditions.

d) The oils of the hydraulic systems for the locks leading inside the reactor building, of the elevating oil system of the primary coolant pumps and of the hydraulic system of the assembly machine in the control rod drive chamber are exempted from the requirement that the oils shall be checked in specified time intervals.

e) In order to restrict the possible leakage from pipes, valves, etc., it shall basically be avoided to use screw connections and connections with plane flanges. In the case connections of this type are unavoidable, the formation of oil mist clouds from spray jets shall be prevented by the installation of proper shields such as baffle sheets, baffle discs or baffle pipes.

5.4 Storage and Filling of Flammable Gases

5.4.1 General Requirements

(1) The pertinent rules and regulations shall apply to the construction and operation of the gas depots and their

distribution networks; in particular, the regulations ExVO, ElexV, EX-RL and VBG 61, the AcetV, the DruckbehV including the pertinent Technical Regulations for Pressure Vessels (TRB) and the Technical Regulations for Pressurized Gasses shall apply. Supplements and additional requirements are specified in the following paragraphs.

(2) Any flammable gases that have a tendency for dangerous self-disintegration or explosion-like reactions shall basically not be brought onto the nuclear power plant site; the exception is acetylene, provided, it is handled as specified under Section 5.4.2 para. 6 and, applicable to laboratories, under Section 5.5.6.

(3) Flammable gases shall basically be stored in a central gas depot as specified under Section 5.4.2; the exceptions regarding other types of storage are specified under Section 5.4.3.

(4) The central gas depot and the other depots specified under Section 5.4.3 shall not be located in rooms from which the function of safety related plant components can be adversely affected to an impermissible extent.

(5) Gas supply lines shall basically not be guided through rooms housing safety related plant components; necessary feed lines are the exceptions, provided, they are designed such that the function of safety related plant components cannot be adversely affected to an impermissible extent.

5.4.2 Central Gas Depot

(1) The only flammable gases that may be stored in the central gas depot are hydrogen, methane, propane and butane as well as acetylene under the following volumetric and other restrictions.

(2) The following applies to the storage of hydrogen in compressed-gas containers: 5000 m³ (standard state) in compressed-gas containers with a capacity of up to 50 liters.

(3) The following applies to the storage of hydrogen in pressure vessels:

a) Of the maximum allowed volume specified under para. 2, a maximum amount of up to 2500 m³ (standard state) may be stored in one or more pressure vessels.
b) The pressure vessels shall have a safety distance of 50 meters away from the outer walls of buildings housing safety related plant components and from such outdoor components as well as from the intake openings of the ventilation systems. This safety distance shall be measured from the outside wall of the pressure vessel. This safety distance shall also apply to the pressure vessel vehicle during the filling procedure.
c) Structures having dampening effects shall be avoided in the direct vicinity of compressed-gas container for hydrogen.

(4) The following applies to the storage of methane: 500 m³ (standard state) in compressed-gas containers with a capacity of up to 50 liters.

(5) The following applies to the storage of propane and butane: All together 200 kg (in pressurized liquid form) in compressed-gas containers with a capacity of up to 30 liters.

(6) The following applies to the storage of acetylene: 50 compressed-gas containers with a capacity of up to 40 liters per bottle.

5.4.3 Gas Depots for Laboratories and Workshops

(1) Gas depots may be installed for the flammable gases stored in compressed-gas containers that are required in laboratories and workshops if this is necessary for operational reasons (e.g. long transportation routes).

(2) The capacity specifications for compressed-gas containers under Section 5.4.2 paras. 2, 4, 5 and 6 shall be met.

(3) The maximum permissible number of compressed-gas containers shall be specified according to the number of bottles required per day plus the necessary reserve bottles.

(4) The gas depots shall normally not be located in the direct vicinity of intake openings of buildings in which safety related plant components are located.

N o t e :
This safety measure results from requirements related to general explosion protection.

5.5 Provision and Deployment of Flammable Gases

5.5.1 Hydrogen for Cooling the Generator

(1) The design, construction and operation of the hydrogen supply system including the applied component parts are subject to the pertinent rules and regulations; in particular, EX-RL and DIN EN 60 034-3 (VDE 0530 Part 3) shall be fulfilled. Supplements and additional requirements are specified in the following paragraphs.

(2) All compressed-gas containers of the hydrogen supply system with the exception of the emergency hydrogen supply specified under para. 8 shall be located in the central gas depot.

(3) The hydrogen supply system of the generator shall be constructed from standardized seamless steel pipes at least of type PN 10. Cast iron valves are not permissible. The hydrogen supply pipe line from the central gas depot to the generator hydrogen supply system shall be designed and constructed in accordance with VBG 61.

(4) Normally, no flanges shall be mounted into the supply line located inside of building structures. If they are unavoidable, they shall basically be designed and constructed in accordance with VBG 61 Sec. 12. If in exceptional cases the flanges of certain low pressure systems (e.g. hydrogen recombination systems) cannot meet VBG 61 Sec. 12, they shall be assumed to be potential leakage locations and shall be flushed by a sufficiently large air flow such that any possibility for the formation of a dangerously explosive atmosphere is prevented.

(5) The hydrogen discharged from the central hydrogen supply shall be continuously surveilled by a suitable monitor (e.g. a flow meter or a volumetric flow monitor); this discharge consists of a hydrogen volume released in an uncontrolled way and of a hydrogen volume discharged in a controlled way over time. The following applies to the monitors:

a) Whenever an upper limit value is exceeded the hydrogen make-up shall be automatically interrupted from outside of the turbine building
b) This interruption shall trigger an alarm in the control room.
c) The upper limit value set point of the surveillance equipment specified under item a shall be formed as the sum of the monitored controlled removal of hydrogen and the maximum permissible uncontrolled release of hydrogen from the generator and its auxiliary equipment.
d) In accordance with DIN EN 60 034-3 (VDE 05030 Part 3), the maximum permissible uncontrolled release shall be specified at 18 m³ (standard state) in 24 hours.
e) The sum of the monitored controlled removal of hydrogen volumes shall not exceed 250 liters (standard condition) in one hour.
f) The volume required for filling or refilling hydrogen (e.g. in to adapt the gas pressure in the generator to changed load conditions) shall not be counted in determining whether the limit value specified under item a has been met.

g) A failure of voltage supply of the measuring equipment shall trigger an alarm and shall be repaired within a short period of time.

h) The alarm equipment and the measuring equipment shall be subjected to function tests during inservice inspection (e.g., in the case of light water reactors in time intervals of one refueling cycle).

(6) In the vicinity of the generator, the formation of a dangerously explosive atmosphere (hydrogen/air mixture) from potential leaks shall be prevented by sufficient aerating (ambient air).

N o t e :
If the natural air movement caused by thermal circulation and rotating parts of the generator is not sufficient, sheet metal air conductors can be employed to better distribute the operational air currents and, thereby, prevent the formation of a dangerously explosive atmosphere.

(7) The following applies to the physical structure of the rooms:

a) None of the rooms in which hydrogen could be released shall have any cavities that are closed at the top.

b) Sufficient venting shall be provided in order to prevent the formation of an explosive atmosphere.

N o t e :
The term "sufficient venting" is specified for the individual rooms of the turbine building in DIN EN 60 034-3 (VDE 0530 Part 3) under consideration of the limits of the room volumes specified therein.

c) Switch gear shall be located or constructed such that none of the hydrogen supply equipment in its vicinity can be damaged in case of a short circuit.

(8) The following applies to the emergency hydrogen supply:

a) In order to ensure the hydrogen supply to the generator even in the case of abnormal occurrences – during normal operation any hydrogen loss is replenished from the central hydrogen depot – a stationary installation may be provided in the turbine building for use as an emergency hydrogen supply; the necessary compressed-gas containers for hydrogen shall be brought into the turbine building only when required and, then, only temporarily.

b) In the pressurized hydrogen gas bottle assembly specified under item a up to eight compressed-gas containers with a capacity of 50 liters each may be linked by means of connecting elbows to a manifold. However, only two of the connected pressurized hydrogen gas bottles may be used simultaneously for extracting hydrogen. Free connections shall be isolated by means of high-pressure intermediate valves.

c) Whenever the facility is supplied from a compressed-gas container assembly, the number of emptied bottles shall be used to check whether or not the uncontrolled release of hydrogen is larger than 18 m³ (standard state) in 24 hours. If this limit value is exceeded the procedure to be used shall be in accordance with DIN EN 60 034-3 (VDE 0530 Part 3).

d) The exchange of compressed-gas containers shall be recorded in writing.

(9) The continuous hydrogen supply to reduce the oxygen in the generator winding cooling water shall be interrupted whenever the volume of hydrogen make-up exceeds the nominal value by 20 %. The nominal value shall be limited to 500 liters (standard state) per hour.

5.5.2 Hydrogen for the Recombination of Oxygen

N o t e :
Hydrogen is used for binding the oxygen present in the exhaust gas system by means of combustion in a recombiner as well as for gassing the primary coolant.

(1) In supplying hydrogen to the exhaust gas system and to the primary coolant of PWRs and BWRs and to the volumetric control system of PWRs the pertinent rules and regulations shall be applied; in particular the ExVO, ElexV, EX-RL and VBG 61 shall be fulfilled. Supplements and additional requirements are specified in the following paragraphs.

(2) All compressed-gas containers of the hydrogen supply system shall be located in the central gas depot.

(3) The pipe lines used for the hydrogen supply shall be designed in accordance with VBG 61. The test pressure of the pipe lines shall be equal to 1.5 times the maximum operating pressure.

(4) No flanges shall normally be built into the supply lines. If they are unavoidable they shall basically be designed in accordance with VBG 61 Sec. 12. If in exceptional cases flanges of certain low-pressure systems do not meet VBG 61 Sec. 12, they shall be considered as potential leakage locations and shall be aerated by sufficiently large air streams to prevent the formation of a dangerously explosive atmosphere at the flanges.

(5) The hydrogen taken from the central gas depot shall be continuously monitored by suitable means (e.g. volumetric flow meter). Whenever the volumetric flow of hydrogen exceeds its nominal value by 20 % it shall be automatically interrupted outside of the reactor building, the reactor auxiliary building or the turbine building. However, the flow shall not be exceeded by more than 300 liters per hour. An alarm shall be triggered whenever the limit values specified above are exceeded.

5.5.3 Counter Gases for the Surveillance of Radioactivity

(1) Gas flow counters used for measuring radioactivity shall be designed in accordance with the pertinent rules and regulations. Supplements and additional requirements are specified in the following paragraphs.

(2) The gas flow counters shall basically be operated with a methane/argon mixture in the volumetric ratio of 10 to 90. Exceptions are permissible in the case of:

a) radioactivity measurements in laboratories,

b) mobile measurement devices, provided the counter gas volume in each measurement device does not exceed
   - 100 liters in the case of gaseous methane, standard state,
   - 200 milliliters in the case of liquid propane,
   - 200 milliliters in the case of liquid butane.

c) mobile measurement devices for the determination of the tritium content of the room atmosphere, provided, they are not deployed in rooms with a free volume under 50 m³ and the volume of the methane in the compressed-gas container does not exceed 3 m³ (standard state).

d) stationary measurement devices which, due to their location and due to the intrinsic volume limitation of devices, cannot have impermissibly adverse effects of the function of safety related plant components.

5.5.4 Counter Gas Methane for the Generator Protection

(1) The pertinent rules and regulations shall be applied; in particular the ExVO, ElexV, EX-RL and VBG 61 shall be fulfilled. Supplements and additional requirements are specified in the following paragraphs.

(2) All methane, with the exception of the emergency methane supply under para. 4, shall be drawn from the central methane supply system .

(3) The volumetric methane flow shall be monitored during operation with the aid of a measuring device. The following applies:

a) Whenever the nominal volumetric flow is exceeded by 20 % further methane flow to the measuring devices shall be automatically interrupted and a corresponding alarm issued.

b) It shall be ensured by operating instructions that whenever an alarm is issued a search for the leakage is started without delay and the leakage is repaired. Furthermore, it shall be ensured that – in case the leakage in the measurement gas system cannot quickly be repaired – the corresponding pipe line section is taken out of operation.

(4) In order to prevent consequential effects from a malfunction in the central methane supply, an emergency methane supply may be installed for the continued supply of the measuring equipment with methane. The following applies:

a) The emergency gas supply may be installed in the turbine building.

b) The emergency gas supply may consist of up to four compressed-gas containers with a capacity of 50 liters each. They may be shunted together by connecting pipes to a single collecting pipe.

c) Only two of the connected pressurized methane gas bottles may be used simultaneously for extracting methane. Any free connections shall be closed off by high-pressure intermediate valves.

d) The exchange of compressed-gas containers shall be recorded in writing.

5.5.5 Fuel Gases for Welding, Cutting and Related Work Procedures

(1) The pertinent rules and standards shall be applied to the use of fuel gases; in particular ZH 1/77 and VBG 15 shall be fulfilled. Supplements and additional requirements are specified in the following paragraphs.

(2) When working with fuel gases in rooms with safety related plant components and in rooms from which an explosion could adversely affect the function of safety related plant components to an impermissible extent, only single bottle units shall normally be used; the number of these units shall be kept as small as possible. Only a single burner tool may be attached to one single bottle unit. The single bottle unit shall be removed from these rooms after completion of the task or in case of a longer interruption of the task (e.g. over night).

(3) In individual cases an autogenous (oxyacetylene) welding in the reactor building is permissible, provided the corresponding work permit states the location, time and plant condition and no more than five work places are active simultaneously.

(4) The Acetylene Ordinance (AcetV) additionally applies when using acetylene.

(5) TRG 280 additionally applies when using liquefied gas.

5.5.6 Flammable Gases and Oxidizing Agents in Laboratories

(1) The pertinent rules and standards shall be applied to the use of flammable gases and oxidizing agents in laboratories; in particular the guideline for laboratories ZH 1/119 shall be fulfilled. Supplements and additional requirements are contained in para. 2.

N o t e :

a) Requirements with regard to structural separation as fire protection are dealt with in KTA 2101.2.

b) Other substances than air or oxygen are used as oxidizing agents, e.g. nitrous oxide (laughing gas). In the presence of flammable substances, the oxidizing effect of laughing gas is similar to that of oxygen.

(2) In case of the supply from the central gas depot specified under Section 5.4.2, the volumetric flow of flammable gases shall be monitored by measuring equipment. Whenever the intended maximum volumetric flow is exceeded by 20 % the supply shall be automatically interrupted.

5.6 Battery Facilities

(1) The requirements of KTA 3703 and DIN VDE 0510-2 shall apply to the design, construction and operation of battery facilities. The following additional requirements shall be complied with as far as explosion protection is concerned.

(2) In order to prevent the accumulation of dangerously explosive mixtures in the battery rooms of battery facilities a technical (artificial) ventilation shall basically be installed; furthermore, the danger of ignition in the direct vicinity of the hydrogen source of the batteries shall be prevented by basically taking technical and administrative measures. These requirements do not apply to battery facilities equipped exclusively with gas proof batteries.

(3) To ensure proper air circulation, the function of the air-conditioning and ventilation system shall be monitored by technical or administrative means. This requires monitoring the air flow or taking at least the following measures:

a) monitoring the branch-off for the ventilator motors in the corresponding switch gear,

b) monitoring the speed of belt driven ventilators and

c) periodic function test of the ventilation system.

(4) The permissible interruption time, t_0, of the technical (artificial) ventilation of a battery room is calculated from the following equation:

$$t_0 = \frac{V_r \cdot f}{Q} \qquad (5\text{-}1)$$

where

t_0 : permissible interruption time (in hours), in which, under the assumption of a uniform distribution, the volume fraction of hydrogen in volume V_r may increase by 0.8 %.

N o t e :
0.8 % corresponds to one fifth of the lower explosion limit of hydrogen in air.

V_r: air volume (in m³) of those room parts in which the released hydrogen can mix with air when the technical (artificial) ventilation is interrupted.

Q : minimum value of the volumetric air flow (in m³/h), to be calculated with a factor s = 5 in accordance with Sec. 7.1 DIN VDE 0510-2 and under consideration of the amperage, I, of the charging current.

f : numeric value 5 or 1. The numeric value of f depends as follows on the value of the amperage, I, used in calculating the volumetric air current Q:

a) f = 5 if the value of the amperage used is in accordance with Table 3 DIN VDE 0510-2.

b) f = 1 if the amperage used corresponds to the actual charging current.

(5) In case of a parallel operating system in accordance with Sec. 4.1 KTA 3703 measures shall be taken to the effect that, within the permissible interruption time, t_0, calculated as specified under para. 4, effective compensatory measures can be taken (e.g. repair of the ventilation system, installation and

operation of a replacement ventilation system, activation of ventilation dampers).

(6) In the case of charge-up operation with voltages above the compensating charge voltage then, prior to manually switching to the rectifier unit, it shall be checked that the ventilation system is in operation in addition to taking the measures required in accordance with Sec. 4.6.3.2 para. 3 and Sec. 6 para. 2 KTA 3703. During such charge-up operation this check shall be repeated in intervals equal to the permissible interruption time, t_0, calculated as specified under para. 4 for the operation at the individual charging current strength.

6 Protection against the Penetration of Flammable Gases and Vapors from Outside – Deployment of Gas Warning Devices

N o t e :
This section deals with the deployment of gas warning devices as protection against flammable gases and vapors from the outside (cf. Guideline "Blast Waves"). However, the questions as to when and under what conditions such deployment will become necessary are not treated in this safety standard.

(1) If flammable gases and vapors set free outside of the nuclear power plant site have to be prevented from penetrating into the buildings via the ventilation system, then measures in accordance with Sec. E 1.4 EX-RL shall be taken. Supplements and additional requirements are specified in the following paragraphs.

(2) A gas warning device shall be employed.

(3) The gas warning device shall have been tested in accordance with EX-RL and VBG 61 with respect to its suitability for the intended deployment by a testing office approved by the Principal Association of German Trade Unions. The device shall meet ZH 1/8, ZH 1/8.1 and BGI 518; the suitability shall be certified in the test report.

(4) The measuring detectors of the gas warning device shall be arranged such that a timely alarming and triggering of the switching measures can occur. This means that the measuring detectors shall be located either directly in front of the inlet opening of the supply air duct or at a suitable distance as far away as out to the plant site security fence.

(5) The decisive factors with regard to a timely alarming and the triggering of the switching measures are:

a) the distance of the gas path, s_G, between the location of the measuring detectors and the location of the first ignition source to be expected during normal operation in the building to be protected,

b) the time span, t_G, required by the gas/air mixture to travel along the gas path, s_G,

c) the time span, t_S, required for closing the ventilation system after triggering of the gas alarm,

d) the alarm delay time, t_A, as that time between a sudden change of concentration at the input of the gas warning device and the change of the measurement value reaching a ratio A (in %) of the total change. This value shall be taken from the test report specified under para. 3 which normally certifies the alarm delay time, t_A, for a ratio A = 20 % (i.e., $t_A = t_{20}$).

(6) The sum of time span, t_S, and alarm delay time, t_A, of the gas warning device shall be compared to the time span, t_G. The following condition shall be fulfilled:

$$t_A + t_S \leq t_G \qquad (6\text{-}1)$$

(7) The alarm threshold of the gas warning device shall basically be adjusted to a value of between 10 % and 20 % of the lower explosion limit (UEG) of the expected gas mixture. In exceptional cases, the alarm threshold may be adjusted to 30 % UEG or 40 % UEG, provided, the alarm delay time, t_A, of the gas warning device has been certified at t_{30} or t_{40} in the safety report in accordance with EX-RL. In these cases, the value t_A in Equation (6-1) shall be replaced by t_{30} or t_{40}.

(8) Switching measures with respect to interrupting the air supply to the building to be protected shall be triggered whenever a gas alarm is triggered from at least two separate measurement locations.

7 Tests and Inspections

Insofar as tests and inspections are not specified in the pertinent rules and regulations and in Section 5, the shall perform the following tests and inspections and shall specify the testing intervals for these tests:

a) The depots and provision areas for substances that can generate a dangerously explosive atmosphere or other explosive mixtures shall be checked for their proper condition.

b) The plant components containing or conducting substances that can generate dangerously explosive mixtures shall be checked with respect to leak tightness and their proper condition including that of the airing and venting measures as well as of the measuring and warning devices (gas warning devices in accordance with BGI 518).

8 Instructions

Persons handling substances on the nuclear power plant site that can generate an explosive atmosphere or other explosive mixtures or who work in explosion-endangered areas shall be properly instructed.

Note:
The requirements are implicitly contained in different sections (e.g. fire protection, health and safety protection at the workplace) of the Guideline Relating to the Assurance of the Necessary Knowledge of the Persons otherwise Engaged in the Operation of Nuclear Power Plants (GMBl. 1980, page 652).

9 Documentation

The documentation shall contain written reports on:

a) the results of the assessment of the explosion hazards performed as specified under Section 3 for the protection of the function of the safety related plant components,

b) the possibly required general protection measures as specified under Section 4,

c) the case related protection measures taken as specified under Section 5 and

d) the results of the tests and inspections as specified under Section 5 as well as Section 7 items a and b.

Appendix

Regulations Referred to in this Safety Standard

Regulations referred to in this safety standard are only valid in the version cited below. Regulations which are referred to within these regulations are valid only in the version that was valid when the later regulations were established or issued.

AcetV		Ordinance on acetylene facilities and calcium carbide depots (Acetylene Ordinance – AcetV) of February 27, 1980, (BGBl. I, p. 173, 220) most recently amended by Ordinance of December 12, 1996, (BGBl. I, p. 1914)
DruckbehV		Ordinance on pressure vessels, gas pressure vessels and filling plants (Pressure Vessel Ordinance – DruckbehV) of April 21, 1989, (BGBl. I, p. 843) most recently amended by Law of June 23, 1999, (BGBl. I, p. 1435)
ElexV		Ordinance on electrical installations in areas with the danger of explosions (ElexV) - in the version promulgated on February 27, 1980 (BGBl. I, p. 173, 214)
ExVO		Ordinance on releasing devices and protection systems (11th GSGV) into explosion-endangered areas – Explosion Protection Ordinance – 11th ordinance regarding the Safe Plant and Equipment Act (11th GSGV), the article 1 of the 2nd ordinance for the Safe Plant and Equipment Act and the ordinances for the Safe Plant and Equipment Act promulgated on December 12 1996 (BGBl. I, p.1914))
GGVE		Ordinance on the national and international transportation of dangerous goods on railway systems (Dangerous Goods Ordinance Railway Systems – GGVE) promulgated on December 12, 1996 (BGBl. I, p. 1876)
GGVS		Ordinance on the national and international transportation of dangerous goods on roads (Dangerous Goods Ordinance Roads – GGVS) promulgated on December 12, 1996 (BGBl. I, p. 1886) in the version promulgated on December 22, 1998 (BGBl. I, p. 3993, 1999 BGBl. I, p. 649) most recently amended by ordinance of June 23,1999 (BGBl. I, p. 1435)
SprengG		Act on explosive materials (Explosives Act – SprengG) of September 13, 1976 (BGBl. I, p. 2737) in the version promulgated on April 17, 1986 (BGBl. I, p. 577), most recently amended by law of June 23, 1998 (BGBl. I, p. 1530)
VbF		Ordinance on the storage, filling and transportation facilities for flammable liquids on land (Ordinance on Flammable Liquids – VbF) of February 27, 1980 (BGBl. I, p. 173, 229) in the version promulgated on December 13, 1996 (BGBl. I, p. 1937, corrected 1997 p. 447)
Guideline Blast Waves		Guideline for considering the protection of nuclear power plants against blast waves from chemical reactions in the design of nuclear power plants with respect to stability and induced vibrations as well as to safe distances as promulgated by BMI on August 1, 1976 – RS I 4 - 513 145/1 - (GMBl. p. 442)
KTA 3703	(06/99)	Emergency power generating facilities with batteries and rectifier units in nuclear power plants
DIN EN 1127-1	(10/97)	Explosive atmospheres - Explosion prevention and protection - Part 1: Basic concepts and methodology; German version EN 1127-1:1997
DIN EN 50014 VDE 0170/0171 Part 1	(02/00)	Electrical apparatus for potentially explosive atmospheres – General requirements; German version EN 50014:1997 + Corrigendum:1998 + A1:1999 + A2:1999
DIN EN 60034-3 VDE 0530 Part 3	(07/97)	Rotating electrical machines - Part 3: Specific requirements for turbine-type synchronous machines (IEC 60034-3:1988); German version EN 60034-3:1995
DIN EN 60034-3 Supplement 1 VDE 0530 Part 3 Supplement 1	(07/97)	Rotating electrical machines - Part 3: Specific requirements for turbine-type synchronous machines; Guideline for the erection and operation of turbine-type synchronous machines with hydrogen as coolant; Supplement 1 (IEC 60842:1988)
DIN EN 60079-14 VDE 0165 Part 1	(08/98)	Electrical apparatus for explosive gas atmospheres - Part 14: Electrical installations in hazardous areas (other than mines) (IEC 60079-14:1996); German version EN 60079-14:1997
DIN VDE 0510-2	(07/86)	Batteries and battery installations - Part 2 Stationary battery installations
BGI 518	(08/99)	Gas alarm equipment for the explosion protection – Deployment and operation Principal Association of the German Trade Unions

EX-RL	(06/96)	Guidelines for preventing danger from explosive atmospheres, with a collection of examples (Explosion Protection Guideline – EX-RL) Principal Association of the German Trade Unions
TRbF 110	(07/80)	Administrative regulation for the implementation of the technical standards on combustible liquids; TRbF 110 "Store rooms" Federal Minister of Labor and Social Affairs
TRG 280	(09/89)	General requirements on compressed gas containers - Operation of compressed-gas containers Federal Minister of Labor and Social Affairs
VBG 15 BGV D 1	(01/93)	Welding, cutting and related working methods Accident Prevention Regulation of the German Trade Unions
VBG 61 BGV B 6	(04/95)	Gases Accident Prevention Regulation of the German Trade Unions
ZH 1/8	(04/82)	Safety rules for requirements on the characteristics properties of stationary gas alarm equipment systems in for explosion protection systems Principal Association of the German Trade Unions
ZH 1/8.1	(04/82)	Principles for testing of the working order of stationary gas alarm systems for explosion protection Principal Association of the German Trade Unions
ZH 1/77 BGR 117	(04/91)	Guidelines for working in vessels and narrow rooms Principal Association of the German Trade Unions
ZH 1/119 BGR 120	(10/93)	Guidelines for laboratories Principal Association of the German Trade Unions