Note:
This is a translation of the RSK statement entitled
"Scheibenübergreifende Unverfügbarkeiten aufgrund elektrischer Kopplungen zwischen redundanten Scheiben des Notstromsystems deutscher Kernkraftwerke"
In case of discrepancies between the English translation and the German original, the original shall prevail.

RSK statement
(472nd meeting of the Reactor Safety Commission on 14 January 2015)

Section-wide unavailabilities due to electrical coupling between redundant sections of the emergency power system of German nuclear power plants

CONTENTS

1 Background

At its 215th meeting on 13 December 2011, the RSK Committee on ELECTRICAL INSTALLATIONS (EE) was informed about event report 06/2011 concerning the loss of an essential-supplies busbar GD with inadvertent actuation of the rotational speed monitoring of converters GZ10 to GZ40 of the Grohnde nuclear power plant (KWG) on 20 November 2011. During the event, there was a simultaneous temporary voltage drop in the output signal of the rotational speed monitoring system in all 220 V DC busbars of the emergency power system (D1), which was interpreted as a frequency drop by the downstream evaluation electronics, and as a result the converters GZ10 to GZ40 cut off simultaneously.

At KWG, loads of the 220 V DC busbars are supplied by a diode-decoupled supply, also across redundancies. In order to avoid impermissible voltage surges that could occur due to this supply under certain fault conditions, the negative conductors of the 220 V DC busbars of all redundancies are galvanically connected to each other. Due to these electrical connections, the simultaneous voltage drop was possible, which then led to a cross-redundancy failure of the converters in combination with corresponding limit settings of the speed monitoring devices.

To the knowledge of the EE Committee, this circuitry of the 220 V DC busbars is also used in other German plants.

The RSK was requested by the BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, now Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)) to advise it on the generic aspects of the event [2], which, according to the request, is to include other electrical couplings in the emergency power system of the German nuclear power plants with regard to a potential for cross-redundancy effects beyond the circumstances of the event at KWG.

2 Consultations

At the 215th meeting on 13 December 2011, the EE Committee was informed about the event at KWG.

The Committee informed the RSK about the state of affairs at the 443rd RSK meeting on 15 December. After presentation of the advisory request [1], the RSK asked the EE Committee at the 445th RSK meeting on 29 February/01 March 2012 for consultations and the preparation of a draft statement.

Following consultations at the 217th EE meeting on 14 March 2012, VGB was asked to provide information on the PWR plants in operation [2].

At the 223rd EE meeting on 21 November 2012, VGB presented its report [3] and, in addition to clarifying the causes of the KWG event, addressed in particular the Committee's questions listed in [2].

At the 225th EE meeting on 30 January 2013, GRS reported on Information Notice WLN 2013/01 “Loss of an essential-supplies three-phase AC busbar with inadvertent actuation of the speed monitoring of all rotary converters at the Grohnde nuclear power plant” [4], [5]. The EE Committee concluded its consultations on the event at KWG after discussion. With regard to the generic aspects in connection with the BMU's advisory request, the Committee deliberated on pending issues [6].

At the 226th EE meeting on 13 March 2013, the BMU added two further questions to its advisory request [7]. The Committee deliberated on a first draft of the statement and continued its discussions at the 228th, 229th and 233rd meetings on 15 May 2013, 18 June 2013 and 20 November 2013, adopting the draft at the 234th meeting on 18 December 2013.

The Committee submitted the statement to the RSK for the first time at its 464th meeting on 20 March 2014. Further revisions were made at the 236th and 237th EE meetings on 23 April 2014 and 21 May 2014, respectively. The RSK discussed and adopted the statement at its 472nd meeting on 14 January 2015.

3 Assessment criteria

The defence-in-depth concept is used as the basis for the assessments. In this context, the relevant requirements of the nuclear regulatory framework, such as the Safety Requirements for Nuclear Power Plants [8] and the relevant Nuclear Safety Standards of the KTA (in particular KTA 3701 [9] and KTA 3703 [10]) are also consulted. Also included in the considerations are international rules and regulations of generic validity (IEC 61225 “Nuclear power plants - Instrumentation and control systems important to safety - Requirements for electrical supplies”, currently published by DIN as a draft standard [11], IAEA SSR-2/1 Safety of Nuclear Power Plants: Design [12], IAEA NS-G-1.9 Design of the Reactor Coolant System and Associated Systems in Nuclear Power Plants [13], and the WENRA Reference Levels [14]).

4 Background regarding the safety significance of meshing/coupling across several systems or redundancies

4.1 Terms and definitions

The terms “meshing” and “coupling” are not clearly defined, neither in German regulations nor in practice. They are often used synonymously. In the Safety Requirements [8], the term “segregation” is defined as “separation of *system parts* to avoid mutual disturbance”, but in the definition of the term, system parts are understood to mean components within a system. Coupling or meshing between redundancies can cause functional dependencies. Gradual differences between the two terms are not considered in the following, but these terms are used synonymously here. In the following, the term “meshing” is therefore used exclusively in the sense of "meshing of redundancies".

4.2 Characteristics of meshing in the emergency power systems of German plants and protective measures to avoid possible systematic failures

The following descriptions are based on the explanations in the GRS report [15]. Electrical connections that have to be considered in the context of a meshing of redundancies in the emergency power system result from galvanic connections, possibly via diodes for directional energy flow, and can usually be cut by circuit breakers.

In principle, different forms of meshing have to be assumed, explained below for the KWG plant:

a) Meshing that is automatically connected in the event of a failure of individual busbars of the emergency power system. For example, at KWG, if the voltage is below 0.8 U_N for longer than 0.5 s in one of the essential-supplies 380V three-phase busbars (GA to GD), the busbar supply is switched to the 380 V emergency busbar of the neighbouring redundancy FJ to FM. This is to ensure the supply of the loads of the GA to GD busbars even if the supplying busbars of the redundancy proper are de-energised (so-called "grid bypass")[1].

b) Meshing that is permanently effective, such as common earthing, the (L) connection of the 220 V DC systems EB to EE or dual supplies of load or busbars.

c) Meshing that is connected manually in the event of repairs or other maintenance work. The GE busbar supplied by the standby converter can supply any of the GA to GD busbars.

In addition to the possibility of overloads, possible cross-redundancy disturbances due to short circuits, earth faults, faulty circuits, overvoltage and external and internal hazards must be taken into account in the design of a meshed emergency power system. The decoupling of the diodes of the dual supply and the versatile monitoring measures (e.g. for voltage monitoring, overcurrent monitoring and the specific in-service inspections (described in [15])) are to be regarded as particularly important measures. With regard to external and internal hazards, such as an internal fire, meshing can have both advantages and disadvantages. With appropriate structural separation, an unmeshed system can be assumed to have full availability of the unaffected subsystems. In the case of a meshed system, the possible disturbances, e.g. due to error voltage input, must be assessed. On the other hand, a meshed system can increase the availability of the power supply to loads, e.g. in the redundancy affected by an internal fire, and thus enhance the reliability of accident control.

[1] This type of meshing does not exist in all plants. In other plants, a switch-over to the redundancy's own 380 V emergency busbar is executed.

4.3 Requirements of the national regulations related to the avoidance or permissibility of meshing in the emergency power systems of nuclear power plants

In order to avoid possible systematic failures across redundancies in the subsystems of the safety system, the "Safety requirements for Nuclear Power Plants" 3.1 (3) c) [8] require the "*segregation of redundant subsystems, unless this is conflicting with safety benefits*" as a design principle.

Regarding emergency power supply facilities in particular, Section 3.9 (2) demands:

The emergency power supply facilities shall be constructed redundantly, physically separate, as a rule unmeshed, functionally independent of each other, and protected from each other, with the degree of redundancy of the emergency power supply facilities having to correspond at least to the degree of redundancy of the process-based equipment to be supplied.

Meshing of the individual trains of the emergency power supply facilities is admissible in individual cases if it has been demonstrated that this will not inadmissibly lessen the reliability of the emergency power system. Here, special care shall be taken that none of the possible failures to be considered must lead to the failure of more than one train.

The KTA Safety Standards contain the following requirements regarding meshing in the emergency power system, some of which correspond verbatim to the specifications of the Safety Requirements listed above:

KTA 3701 [9], Section 5.7 "Functional independence":

(1) In order to be functionally independent, the emergency power system shall consist of redundant non-interconnected trains each of which has individual feed-ins as well as individual emergency power generating and distribution facilities, cable ducts and auxiliary systems.

(2) In exceptional cases emergency power loads may be supplied from more than one train of an emergency power facility, if the required reliability of the supplied system can, thus, be achieved and it is demonstrated for each individual case that the reliability of the emergency power system is not inadmissibly reduced by this measure. These interconnections shall be designed such that no failure possibility to be considered can cause the sequential failure of more than one train.

With regard to possible systematic failures, KTA 3701, Section 5.3 "Protection against Failure Initiating Events within the Emergency Power System" demands:

(2) The possibility and effects of common cause failures in the emergency power system shall be analyzed. Depending on the results of these analyses, additional measures shall be taken at the component or the system level such that a violation of the protective goals does not anymore have to be assumed (robustness against common cause failures).

5 Explanations regarding the DC power supply

5.1 Structure and function

The 220 V DC power supply is structured as an isolated DC power supply system. This concept is intended to ensure that earth faults are reliably detected and the danger posed by short circuits between conductor and earth is minimised. In addition, a single earth fault will not cause the 220 V DC power supply to fail. Based on reliability analyses, the dual supply of safety-critical load is common in German nuclear power plants. This circuit variant of the dual supply from two redundancies includes the electrical connection of the reference conductors ((L) conductors) to prevent voltage doubling in the event of two unfavourably located earth faults. In the 24 V DC supply in the D1 and D2 grid, there is no such meshing.

The 220 V DC power supply is used to supply power to the converters for the secured three-phase power supply, to supply control voltage to the switchgear, and to supply power to solenoid valves, oil pumps and other direct-current (DC) consumers.

5.2 Advantages and drawbacks of dual supply

The dual supply is intended to achieve greater reliability through higher security of supply in the event of individual faults compared to a redundancy-related single supply. This applies in particular to the control voltage of the switchgear and the supply to the reactor protection cabinets. In addition, maintenance work on individual busbars will not result in the associated loads becoming unavailable.

The dual supply is the basis for the verification of accident control in German plants.

Drawbacks of the dual supply arise when diodes fail. The failure effects of diodes include blocking (becoming highly resistive) and conduction (loss of directional blocking effect) [15]. In the second case, a non-reactive connection is created between two redundancies, which allows energy to flow in both directions.

The galvanic coupling of redundancies therefore harbours a potential for systematic failures (functional dependency). It requires special attention and a special procedure for modifications, possibly through a staggered approach of dealing with one redundancy after the other and/or through extended tests/analyses.

6 Background to the event at KWG (event report 06/2011)

6.1 Concept of the secured three-phase power supply

The structure of the secured or uninterruptible three-phase power supply within the emergency power system is shown in the circuit diagram [1d] of KWG.

The secured uninterruptible three-phase power supply supplied by the converters is used to ensure the power supply for three-phase consumers, which should also be available in the event of a loss of offsite power until the start-up phase or in the event of a failure of the emergency diesel generators. A brief interruption of the supply to the connected loads (e.g. containment isolation dampers of the ventilation system) of the secured uninterruptible three-phase power supply will not impair accident control [4].

The system has four rotary converters GZ10 - GZ40, which are assigned to Redundancies 1 to 4, and a standby converter GZ41, which can replace one of the rotary converters GZ10 - GZ40 if the latter becomes unavailable. The converters are used to supply the uninterruptible three-phase busbars GA to GD. Figure 1 shows the concept of redundancy allocation.

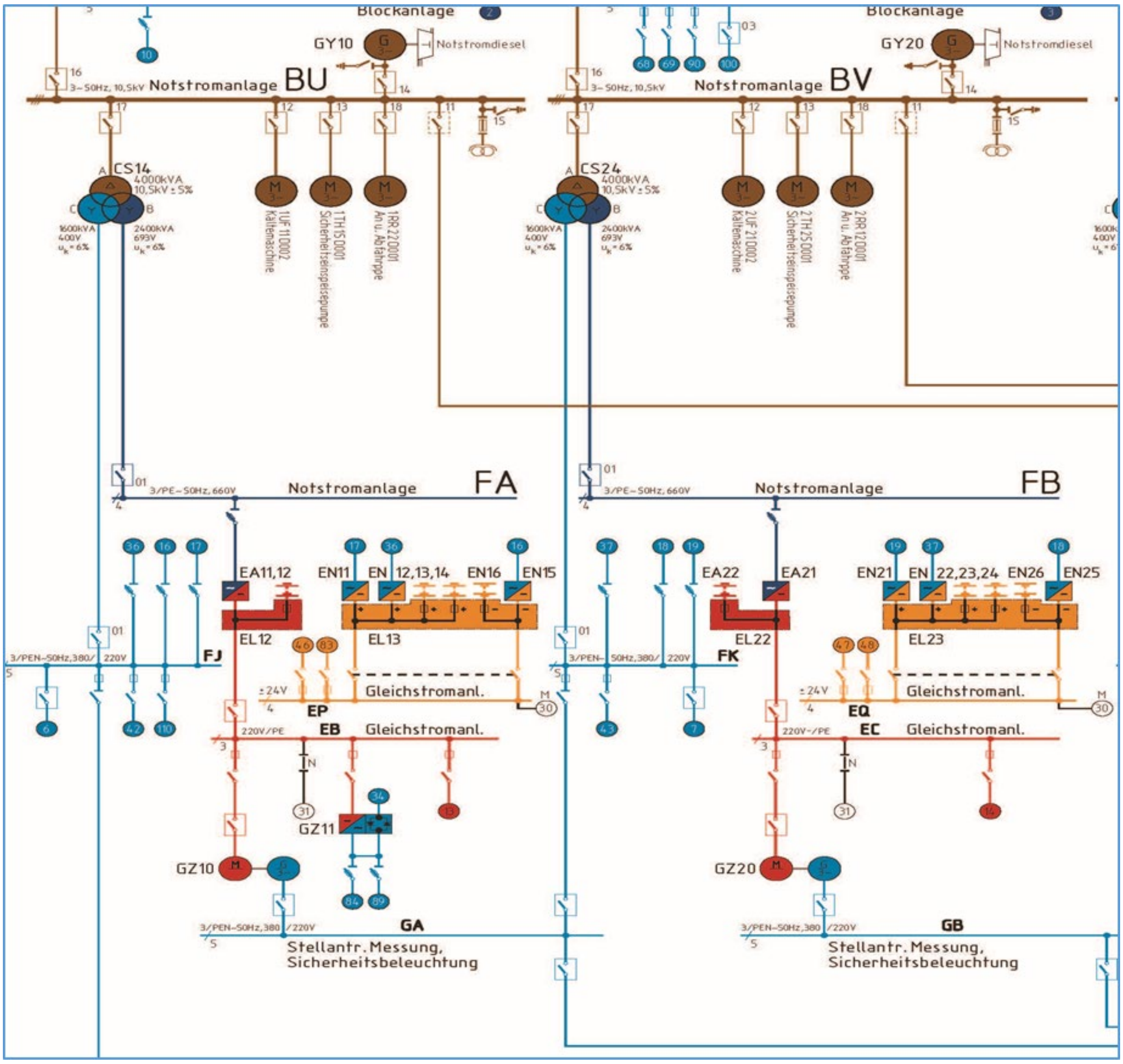

Figure 1: Structure of the secured three-phase power supply using the example of Redundancies 1 and 2

The converters are supplied in series from the 220 V DC trains EB to EE, which in turn are supplied via rectifiers and batteries. The rectifiers themselves are also connected - each allocated to one train - to the 660 V emergency busbars FA to FD. In addition to the 660 V emergency busbars, each emergency power redundancy has a 380 V busbar (FJ to FM). Both the 660 V and 380 V emergency busbars are supplied via the emergency power transformers CS14 - CS44 from the 10 kV emergency busbars BU to BX.

In addition to the train-related supply, there is a "grid bypass" for the uninterruptible three-phase busbars (this refers to the switchover to the uninterruptible emergency power supply) in the neighbouring redundancy. This grid bypass is utilised in the event of the failure of a rotary converter by automatically switching to the associated 380 V emergency busbar after 0.5 s if the voltage falls below a minimum voltage (0.8 x U_N) in the secured GA - GD three-phase supply switchgear [1c]. In the example of Redundancy 1, this means that if the GZ10 transformer at KWG fails, the system will not switch to its own emergency busbar FJ but to that of the neighbouring redundancy FK.

6.2 Sequence and cause of the event at KWG

One of the technical causes of event 06/2011 was found to be the sensitivity of the rotational speed monitoring system used on the converters of KWG to brief voltage drops in the 220 V DC supply. This was detected during laboratory tests carried out after the event [1c]. There was a brief voltage drop in the two-digit microsecond range, which was interpreted by the evaluation electronics as a drop in the rotational speed of the converter. With a limit value setting in the upper measuring range of the rotational speed monitor, this effect leads to a response of the MIN rotational speed limit value and subsequently to the cut-off of the affected converter as intended [1c]. The sensitivity of the rotational speed monitor to such voltage drops is due to the circuit concept of the device.

Following event 06/2011, the circuit breaker (type 3WE made by Siemens) of the residual-heat removal pump of Redundancy 4 was identified as a possible source of the voltage drop that led to the converters being cut off. Deposits from contact erosion of the circuit breaker contacts were also found in the control section of the circuit breaker and a voltage drop in the control voltage was concluded from this [4].

This voltage drop could affect the converters in all redundancies at the same time, as the (L) conductors of the supplying 220 V DC busbars are connected across all redundancies in order to fulfil a requirement of KTA Safety Standard 3703 [10] for the control of double earth faults.

The sequence of events in the case of a failure of all four rotary converters corresponded to the design except for the malfunction of the grid bypass in Redundancy 4, which was due to an additional random failure. In Redundancies 1 to 3, the grid bypass functioned properly, so that the operational and safety-related loads supplied by busbars GA to GC were supplied again after a de-energised pause of approx. 0.5 seconds.

6.3 Precautions against recurrence

The operator of KWG has taken several measures to prevent a recurrence of such an event.

Firstly, the "tachometer faulty" limit value for speed monitoring was reset to the original value of 160 V (corresponding to 40 Hz) [1c].

To avoid undesired cut-offs of the converters due to short-term fluctuations in the output signal of the tachogenerators used in the speed monitoring of the converters, timing relays were installed in the signal path of the corresponding trip limit values for the MIN speed, so that transient voltage drops or interference signals cannot cause the affected converter to be cut off [1c].

A similar measure is currently being tested for tripping the rotational overspeed actuation at 240 V (60 Hz) [1c].

Furthermore, frequency monitoring was retrofitted to the secured AC busbars GA to GD. This monitors the busbars for underfrequency and overfrequency and reports deviations from the set value with a time delay via a conventional signalling system and computer signalling system in the control room [1c].

In future, routine maintenance of the 3WE circuit-breakers will be carried out at the manufacturer's factory, in contrast to the previous practice of having this carried out by specialised KWG personnel. An integral part of this maintenance is the complete disassembly and cleaning of all circuit-breaker assemblies as well as the preventive replacement of wearing parts [1c].

7 Answers to the questions of the BMU

7.1 Question 1

For what reasons exactly were the electrical couplings in the emergency power system of German nuclear power plants between individual sections or across several sections provided, in particular with regard to the dual supply of loads?

Dual supplies exist in the area of the 24 V and 220 V GS supply and serve the purpose of increasing the availability and reliability of the power supply for operational and safety-related equipment (see 5.2). This means that these loads are supplied with power even if their assigned emergency power redundancy is de-energised. The same statement applies to the "grid bypass" to the neighbouring redundancy (see 6.1).

In addition, there are connections to neighbouring redundancies in the form of so-called "repair couplings", which are inserted manually if necessary in order to be able to supply loads even when emergency busbars are disconnected.

7.2 Question 2

To what extent do electrical couplings in the emergency power system, in the emergency power system supplying the emergency feedwater system (pre-convoy and convoy plants) or in the remote shutdown stations of the German nuclear power plants between individual sections or across several sections correspond to the state of the art in science and technology with regard to the aspect of section-wide unavailability (prevention or control)?

Meshing is permitted also in the emergency power system if the regulations are applied. According to the Safety Requirements [8] 3.9 (2), the following applies specifically to emergency power systems:

Meshing of the individual trains of the emergency power supply facilities is admissible in individual cases if it has been demonstrated that this will not inadmissibly lessen the reliability of the emergency power system. Here, special care shall be taken that none of the possible failures to be considered must lead to the failure of more than one train.

According to KTA 3703 4.1 (3) [10], in addition to strictly train-specific supplies, the following meshing is permissible for emergency power facilities with batteries and AC/DC converters in nuclear power plants:

a) supply of the power loads of one train from the associated train and from a neighbouring train of the battery facility by means of diode-decoupled dual supplies,
b) connection of one rectifier unit to the diesel emergency power facility of the same train, connection of the second rectifier unit to the diesel emergency power generator of a neighbouring train.

In this respect, 4.1 (4) of [10] requires that when choosing a diode-decoupled dual supply (variant a)) or a dual supply on the rectifier side (variant b)), the connections to the neighbouring train shall be designed such that none of the failure possibilities to be considered can cause more than one train to fail.

KTA 3704 4.1.1 (6) [16] requires i.a. the following for the circuit design concept for converter facilities:

In each train, one interconnection shall normally be provided between the converter emergency power switchgear and the diesel emergency power switchgear of either its own train or of a neighboring train (Figures 4-1 and 4-2). This interconnection shall normally be activated by a switch-over device after failure of the power supply from the converter taking the requirements specified under Section 4.5.4 into account. Interconnections to a neighboring train shall be constructed such that no failure possibility to be assumed can cause the failure of more than one train.

Another form of meshing is the common (L) conductor of the 220 V DC supply. As already explained in 5.1, these busbars are operated as an isolated system, i.e. they are not earthed. As most of the loads on these busbars have diode-decoupled dual supplies, a common (L) conductor for all four redundancies is realised to avoid voltage doubling in the event of double earth faults.

As far as the RSK is aware, apart from the event at KWG, there have been no events that could be attributed to this type of meshing in the many years of use of the 220 V DC supply in conjunction with the principle of dual supply in German nuclear power plants. The KWG event showed that despite the voltage drop affecting all redundancies through the (L) conductors, the 220 V DC supply was not affected and the 380 V three-phase supply was available again after a short interruption (0.5 s).[2]

[2] Three redundancies at KWG, as the switchover failed due to a single failure in one redundancy.

7.3 Question 3

What alternative possible solutions are there to the existing couplings, e.g. modified earthing concept, complete electrical decoupling of the sections, concepts of a diverse structure of the sections in relation to each other?

Three different solutions are being realised in the AREVA plants currently being planned or built:

1. Diode-decoupled dual supply of the 220V DC loads with connection of all sections via the L conductor, as implemented in the German plants. (Angra 3)

2. Diode-decoupled dual supply of the 220V DC loads forming pairs. This means that there are only certain dual supplies (e.g. Redundancy 1&2 and Redundancy 3&4). In this case, only the (L) conductors of the corresponding redundancies (1&2 or 3&4) are connected to each other. (Olkiluoto 3)

3. Strict separation of redundancies, dispensing with the dual supply of the 220V DC loads. (Flamanville 3 and Taishan 1&2)

Various concepts are used in the 220 V DC power supply in accordance with national regulatory requirements and the requirements of future operators.

Each of these solutions requires a comprehensive analysis in view of systems engineering of the consequences of such a configuration of the DC voltage supply with regard to accident control. In particular, the focus is on whether the required individual fault tolerance is given for the control and actuation of safety-relevant loads (e.g. building isolation valves).

7.4 Question 4

And with reference to the consultations on the event at the Forsmark nuclear power plant in Sweden:

Have all the necessary findings been derived from the event at the Forsmark nuclear power plant, Unit 1, on 25 July 2006 for the German plants with regard to the prevention or control of section-wide unavailabilities?

As a result of the event at Unit 1 of the Forsmark nuclear power plant on 25 July 2006, the influence of voltage transients in the grid and their effects on the auxiliary power supply and the power supply by emergency power systems were investigated for all German plants. In particular, the third part of the 1st recommendation of WLN 2006/007 [18] addresses safety-relevant deviations, especially those that can lead to cross-redundancy failures. In the opinion of the RSK, the findings from the event and the subsequent investigations include all generic aspects regarding the prevention or control of section-wide unavailabilities as a result of voltage transients in the grid. Plant-specific examinations are still being carried out with regard to their implementation.

In the event of undervoltages in the auxiliary power supply or in subsystems of the emergency power system, it can be assumed, apart from the case of "phase losses", that due to the design concept the existing protection devices prevent cross-redundancy effects with sufficient certainty [19].

7.5 Additional questions posed by the BMU

Question a:
What solutions that reflect the state of the art in science and technology can be recommended to prevent adjustments, such as those made here to a single limit value by personnel actions, from not being clearly safety-related?

It would be possible, for example, to discuss a diverse design of the converter devices of individual sections or a division of the trip functions of a single limit value e.g. into two technically different limit values to be set for different trip functions, so that the individual setting processes are clearly safety-directed.

According to the information available [4], the aim after event 07/2009 was to detect converter operation at insufficient frequency. In the opinion of the RSK, this would have required the installation of an additional warning limit value upstream of the existing limit value that triggers shutdown. Such a staggered monitoring and protection concept (signalling before shutdown) is shown as an example for various applications in Tables 3-1 to 3-4 of KTA 3705 [17].

This leads to the conclusion that, wherever possible, a strict separation of the signalling and protective functions should be maintained. The abandonment of the pure protective function "shutdown at low speed", which has been proven in operation since commissioning, and the rededication to a combined protective and monitoring limit value was one of the interlinked causes of event 06/2011 at KWG.

However, it is obvious that such a concept cannot in principle act as a precaution against unintended effects of limit value adjustments in the sense of Question a.

As the limit value change that preceded event 06/2011 was not based on an incorrect setting in the sense of a mix-up or unintentional erroneous action, but took place after the conclusion of a proper modification procedure in accordance with the operating manual, technical measures (e.g. circuitry-wise limitation of the adjustment range, abandonment of adjustment options on the front panel of the module, sealing of adjustment potentiometers) are not effective against unintentional effects of such changes.

The potential for faults due to incorrect settings, as was the case with the event, can only be reduced but not totally eliminated by a combination of measures, such as

- administrative specifications

- sequential, redundancy-related implementation and corresponding lead time for testing
- specifications for impact analyses to identify CCFs in the event of flaws in the design or execution.

Question b:
How does the committee assess this and other concepts (refers to the improvement measures planned by the operator, see i.a. VGB presentation at the 223rd meeting of the RSK-EE committee on 21 November 2012) for the control of DC voltage drops, e.g. due to a prolonged or permanently recurring electric arc (flickering/intermittent contact)?

Especially with the existing concepts in the German systems with (L) bridges to all sections, is an earth fault due to this type of contacting so reliably controlled that a simultaneous failure of several converters does not have to be postulated?

Following event 06/2011, the following precautions against recurrence were taken or planned at KWG:

- resetting of the "tachometer faulty" limit value for speed monitoring to the original value of 160 V
- use of timing relays to suppress the effects of short-term fluctuations in the output signal of the tachogenerators used to monitor the rotational speed of the converters
- consideration of the use of comparable measures for tripping rotational overspeed excitation
- retrofitting frequency monitoring in the secured AC busbars GA to GD
- changes to the responsibility for the maintenance of the 3WE circuit breakers.

These measures were intended to prevent the recurrence of a similar event at KWG. During the event, there were no voltage drops in the 220 V busbars themselves that were relevant for the other loads. Due to the circuitry design, only the limit value formation of the KWG-specific rotational speed monitors (tachogenerators) of the rotary converters was affected.

Voltage drops in the 220 V busbars due to motor starts in the underlying secured three-phase busbar are taken into account in the system design. Additional voltage drops in these busbars are conceivable due to equipment faults in the form of rectifier failures, interruptions in the current path of the batteries/rectifiers, or busbar short circuits. Short circuits in load branches are selectively switched off. An earth fault in an isolated system will neither lead to an arc nor to a static voltage drop, as a single earth fault does not form a circuit that loads the system.

Since 1995 and before the limit value adjustment, there have been 11 earth faults in the busbars EB to EE at

KWG. In two cases there was a full earth fault ((L-) and (L+) to earth), similar to a short circuit (L-) to (L+). In no case did this result in loads being impaired or transformers being switched off.

The causes for the cut-off of the rotary converters at KWG were due to:

- the KWG-specific use of tachogenerators and the circuitry for monitoring the speed of the rotary converters
- an incorrectly set limit value.

Both aspects are to be checked in other plants on the basis of Information Notice 2013/01, so that a similar failure of rotary converters need not be postulated once the corresponding investigations have been completed. Irrespective of this, the operating experience available confirms the proper functioning of the secured three-phase supply even under the influence of random failures such as the occurrence of earth faults in the 220 V DC supply.

8 References

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[1a] Bericht Eon-Kernkraft BF-WN 2011 „Bewertung des Ausfalls aller rotierender Umformer – Bewertung des abdeckenden Kühlmittelverluststörfalls mit gleichzeitigem Notstromfall“, 25.11.2011,

[1b] Untersuchungsbericht Eon Anlagenservice, Stand 27.11.2011

[1c] Arbeitsbericht Eon-Kernkraft E-ET 2011 „Ereignis Ausfall GZ10-40 D001 – Zusammenfassung aller Untersuchungen und Ergebnisse“, 02.12.2011

[1d] E-Übersichtsplan Kernkraftwerk Grohnde (KWG)

[1e] Kurzstellungnahme der GRS, A621, leb, 21.12.2011

[2] Schreiben der RSK/ESK-Geschäftsstelle an den VGB, „Scheibenübergreifende Unverfügbarkeiten aufgrund elektrischer Kopplungen zwischen redundanten Scheiben des Notstromsystems deutscher Kernkraftwerke“, E218_BR16.04.2012_VGB, 16.04.2012

[3] VGB POWERTECH, „Scheibenübergreifende Unverfügbarkeiten aufgrund elektrischer Kopplungen zwischen redundanten Scheiben des Notstromsystems deutscher Kernkraftwerke“ – „Berichterstattung des VGB vor der RSK-EE am 21.11.2012“, Foliensatz

[4] GRS, Weiterleitungsnachricht WLN 2013/01 „Ausfall einer gesicherten Drehstromschiene bei fehlerhafter Anregung der Drehzahlüberwachung aller rotierenden Umformer im Kernkraftwerk Grohnde“

[5] M. Leberecht, GRS, „Ausfall einer gesicherten Drehstromschiene bei fehlerhafter Anregung der Drehzahlüberwachung aller rotierenden Umformer im Kernkraftwerk Grohnde“, 30.01.2013, Foliensatz

[6] RSK-Ausschuss ELEKTRISCHE EINRICHTUNGEN, „Scheibenübergreifende Unverfügbarkeiten aufgrund elektrischer Kopplungen zwischen redundanten Scheiben des Notstromsystems deutscher Kernkraftwerke“, Beitrag Reßing, 03.01.2013

[7] Ergänzende Fragen an den Ausschuss Elektrische Einrichtungen (EE) der Reaktor-Sicherheitskommission im Zusammenhang mit den Beratungen zum Beratungsauftrag „Scheibenübergreifende Unverfügbarkeiten aufgrund elektrischer Kopplungen zwischen redundanten Scheiben des Notstromsystems deutscher Kernkraftwerke“ vom 31.01.2012. RS I 3 – 17018, 12.03.2013

[8] Sicherheitsanforderungen an Kernkraftwerke, 20. November 2012

[9] Sicherheitstechnische Regel des KTA, KTA 3701, „Übergeordnete Anforderungen an die elektrische Energieversorgung in Kernkraftwerken“, Fassung 6/99

[10] Sicherheitstechnische Regel des KTA, KTA 3703, „Notstromerzeugungsanlagen mit Batterien und Gleichrichtergeräten in Kernkraftwerken“, Fassung 2012-11

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