RSK-STATEMENT
22. July 2004 (374th meeting)

Requirements for the demonstration of effective emergency core cooling during loss-of-coolant accidents involving the release of insulation material and other substances

Preliminary remark: The following statement updates the statement on the "Effectiveness of the systems for emergency core cooling upon the release of insulation material during loss-of-coolant accidents" issued as a result of the 320th meeting of the Reactor Safety Commission on 16 September 1998 [11].

1 Advisory request

In its letter referenced RS I 3 14203/29 of 25 April 2003 [1], the BMU asked the RSK to discuss at its 362nd meeting on 8 May 2003 the topic of "Findings in the suction area of the residual-heat removal pumps of the Biblis A plant". The BMU further specified its advisory request in its letters referenced RS I 3 17018/1 of 12 May 2003 [2] and RS I 3 - 17018/1 of 19 May 2003 [3], asking the RSK to resume the discussions relating to the "Intake area of the residual-heat removal pumps" and to present the state of the art in science and technology with consideration of the results of recent investigations carried out by the licensees and the GKSS Research Centre Geesthacht GmbH.

In particular, the BMU asked for the discussion of the following points:

- Discussion of the current state-of-the-art regarding residual-heat removal, including the methods applied to ensure effectiveness of emergency core cooling, such as modifications of strainer size and pressure differences,

- Clarification of the leak size to be assumed for the investigation of clogging of the sump strainers according to the state of the art in science and technology,

- Explanation of the safety significance of the different postulated cases as well as of the reasons, advantages and drawbacks of the postulated 2A (double-ended break) and 0.1A leaks, respectively,

- Explanation of the boundary conditions under which a loss-of-coolant accident with a challenge of the residual-heat removal pumps is controlled, and answer to the question whether it is admissible or even necessary to switch off residual-heat removal pumps during emergency core cooling,

- Discussion of the results of recent experiments concerning residual-heat removal and

- Description of international developments concerning of measures to control the "Barsebäck" problem to derive the state of the art in science and technology.

The results of the discussions are to be formally presented to the BMU in a statement.

2 Course of the discussion

At its 11th meeting on 14 May 2001, the RSK Committee on PLANT AND SYSTEMS ENGINEERING heard and discussed a report by GRS on the preparation of an assessment basis concerning the behaviour of insulation material following loss-of-coolant accidents (LOCA) [4]. At its 12th meeting on 20 September 2001, the committee heard and discussed a report by the licensees relating to the experiment programme established to demonstrate assured sump suction [5].

At its 362nd meeting on 8 May 2003, the RSK began discussing the topic of the BMU's advisory request, hearing and subsequently discussing reports by the licensee, the Hesse Ministry for the Environment, Rural Areas and Consumer Protection (HMULV), TÜV Nord and TÜV Süddeutschland [6]; [7]; [8]; [9]; [10]. It asked the RSK Committee on PLANT AND SYSTEMS ENGINEERING to discuss the licensees' experiments on the behaviour of insulation material and the resulting consequences for the statement by the RSK on the effectiveness of the systems for emergency core cooling upon the release of insulation material during loss-of-coolant accidents (320th meeting on 16 September 1998) [11] once the relevant final reports were available.

At its 363rd meeting on 4/5 June 2003, the RSK continued its discussion, hearing a report by GRS on the international procedure of assessing the assurance of sump suction following a loss-of-coolant accident with consideration of insulation material release as well as a report on the leak-before-break concept on the basis of experiments carried out with austenitic and ferritic pipes. The RSK requested a detailed comparison with international procedures concerning the treatment of the release of insulation material during a LOCA and asked the RSK Committee on PLANT AND SYSTEMS ENGINEERING to report about the results of its discussions concerning the evaluation of the licensees' experiments relating to the findings in the intake area of the residual-heat removal pumps in the KWB-A nuclear power plant at the RSK's 364th meeting on 10 July 2003.

To structure the discussions of the generic aspects of the possible clogging of sump suction openings during a LOCA, the RSK set up an ad-hoc working group at its 364th meeting on 10 July 2003. This group convened on 25 August 2003 and prepared a proposal how to structure the discussion of generic aspects of the possible clogging of the sump suction openings during a LOCA, which found the approval of the RSK at its 365th meeting on 18 September 2003 [37].

After that, the RSK Committee on PLANT AND SYSTEMS ENGINEERING heard a report at its 19th meeting on 2 July 2003 on the topic of "Biblis nuclear power plant, Unit A, experiments concerning the retention of insulation material in the sump suction area of the emergency core cooling and residual-heat removal pumps" by the licensees and the expert organisations TÜV Süddeutschland and TÜV Hannover/ Sachsen-Anhalt as well as a report by Mr. Sandervag, SKI, on the topic of "Generic issues of clogging in the sump suction area during a loss-of-coolant accident with consideration of Swedish findings" [12 - 22]. The RSK Committee on PLANT AND SYSTEMS ENGINEERING reported the results of its discussions to the RSK at its 364th meeting on 10 July 2003 [23; 24] and continued its discussions at its 20th meeting on 4 September 2003, at its 22nd meeting on 18 November 2003, and at its 23rd meeting on 18 December 2003 [25-36]. At the committee's 24th meeting on 5 February 2004, GRS presented a synopsis of the proposals of GRS and the licensees for the assessment basis for generic issues of the possible clogging in the sump suction area during a loss-of-coolant accident. The committee continued its discussions and the preparation of a draft statement at its 25th, 26th and 27th meeting on 30 March, 6 May and 17 June 2004, respectively, as well as at a meeting of an ad-hoc working group on 8 July 2004.

3 Assessment Criteria

The general criterion for the safety-related assessment of the release of insulation material during a loss-of-coolant accident is the assurance of core cooling. For this purpose it has to be demonstrated for each plant that

- the amount of the insulation material deposited inside the core remains below the amount at which core cooling is no longer guaranteed,
- load transfer resulting from the pressure differences due to the deposition of insulation material on the sump suction strainers and their supporting structural elements is ensured,
- no cavitation takes place in the residual-heat removal pumps that will lead to an inadmissible reduction in flow rate.

4 Recommendations for the provision of evidence

During its discussions, the RSK came up with the recommendations listed below as regards the evidence of assured sump suction and emergency core cooling following a postulated leak accident with consideration of the release of insulation material. These recommendations update the recommendation issued as a result of the 320th meeting of the Reactor Safety Commission on 16 September 1998 [11] as there have been new insights from further national and international experiments and analyses which require a revision of the recommendation resulting from the 320th meeting of the RSK.

The present recommendation follows several principles:

- The procedure recommended here applies to plants with pressurised water reactors. Individual aspects where plant configuration is comparable can also be applied to boiling water reactor plants.
- The recommendation concerns the evidence for events at Safety Level 3. In addition, accident management measures are recommended.
- The present findings mainly rest on experiments and do not allow a fully analytical treatment of the topic. They do show, however, that it is not possible to preclude without corresponding evidence that there may be an inadmissible pressure loss at the sump strainers or a pressure drop in the core, caused by insulation material released during a loss-of-coolant accident. The procedure described in the following represents the conditions to be fulfilled in future upon the provision of evidence.
- The procedure recommended in the following is to take into account any existing uncertainties with a view to achieving an enveloping overall result. Here, it is possible in principle to use the results of type-specific or generic studies if they can be adequately applied to the plant in question.
- The measures to be provided for the control of events at Safety Level 3 have to be thus devised that no accident management measures are required by design.
- Depending on the design of the sump strainers, an inadmissibly high pressure drop that may lead to insufficient cooling of the reactor core may occur either at the sump strainers or in the core as a result of an obstruction of the coolant flow through the fuel elements. In view of possible additional accident management measures and their feasibility and effectiveness, the size of the sump strainers and the mesh size have to be designed in a way that any possible inadmissibly high pressure loss could only occur at the sump strainers. For this case, accident management measures have to be provided to limit or reduce pressure loss.

The requirements listed below for the provision of evidence and the measures apply to all leak sizes requiring sump operation during the course of the accident.

- **Leak location**

Those leaks have to be considered for the provision of evidence for which the insulation material released will lead to the most adverse conditions as regards pressure loss at the strainers or entrainment into the core. This has to be explained in the analysis comprehensively and specifically for each plant.

- **Release of insulation material and other substances**

The actual condition of the insulation and the materials used has to be recorded and documented.

The calculation of the amount of insulation material released shall be done according to the so-called NRC Cone Model [38]. Here, the amount released is calculated as shown in the table below, dependent on the leak size (equivalent diameter D), the distance from the leak location (distance L), and the kind of insulation material, with a 90° opening angle of the cone:

	Distance	**Release**		
Region		**Cassette-type insulation**	**Mat insulation**	**Conventional insulation**
1	$L \leq 3\,D$	100 %	100 %	100 %
2	$3\,D < L \leq 7\,D$	50 %	100 %	100 %
3	$7\,D < L \leq 30\,D$	0 %	0 %	100 %

Experiments have been performed to prove the validity of these assumptions [39]. In the calculation of the amount of insulation material released in the case of cassette-type insulation, those half cassettes that surround the assumed circular leak location on the pipe affected have to be fully considered.

For cassettes which are partly hit by the jet cone in regions 1 and 2 and which mostly lie outside the jet cone, the cassette region lying outside the jet cone has to be attributed to region 2. As concerns any insulation material that is protected within the cassettes, e. g. by canvas jackets, it has to be assessed case-by-case whether additional assumptions have to be made for the areas lying outside the jet cone.

The effect of a shift of the jet direction upon the rupture of pipes (pipe whipping), which may lead to a widening of the area of insulation material that will be hit, has to be considered case-by-case for each plant in the determination of the release.

As a result of the flow from the leak, other substances (such as coatings, concrete particles, dust, foils and fire protection materials) may be washed into the sump. The amount of such materials released has to be estimated case-by-case for each plant and taken into account in the assessment.

- **Transport within the containment**

So far, no integral experiments exist relating to the transport of insulation material within a PWR containment. It can be concluded from the event at the Barsebäck-2 plant as well as from small-scale Swedish and US experiments [16], [22] that more than half of the amount of insulation material released will be retained inside the containment. For German plants, it has to be taken into account that - unlike in similar foreign pressurised water reactors - no spray system exists that during the course of an accident would allow the further washing-off of insulation material debris.

The assumption to be made when providing evidence that 50% of the insulation material and other substances released is transported into the sump can be considered as conservative for German plants. Thereby no differentiation is to be made concerning leak locations and sizes.

- **Transport in the sump water**

Internationally, the transport in the sump water is specified by postulates as the corresponding phenomena cannot yet be treated fully analytically. The German licensees have therefore carried out large-scale experiments in order to determine the amount of insulation material that can be transported in the sump (deposition on the strainer plus penetration) [19], [33]. Results are mainly available for the insulation material MD 2 (83). The influence of different insulation materials, mixtures of fibre and particle insulation as well as other substances on the transport is currently being investigated.

To provide evidence, the transportable fraction of the amount of insulation material transported into the sump has to be determined by representative experiments and defined conservatively.

Assuming a turbulent flow in the sump as a result of the leak jet, pressure loss at the sump strainers has to be determined for the insulation material MD 2 (83) for a transport fraction of 20% to 40% and the correlated particle size distribution of the insulation material. Other transport fraction values require backing up by experiments. For the mineral wool RTD 2 and insulation materials other than MD 2 (83) as well as combinations of fibrous and particulate materials, the transport rates have to be defined conservatively on the basis of experiments. Here, scaling effects also have to be considered.

- **Pressure loss at the sump strainers**

Pressure loss at the sump strainers depends on a number of parameters, such as the kind and particle size distribution of the insulation material transported to the sump strainers, the amount of insulation material deposited on the strainer, the particles clogging the screen, the area and screen size of the sump strainer, the temperature of the sump water, and the oncoming-flow velocity at the strainer. In this connection, the most unfavourable failure combination of the residual-heat removal pumps regarding deposition and flow velocity at the strainer has to be assumed.

There are presently no validated approaches available for putting these parameters in a generally applicable equation for the pressure loss. Therefore the expected pressure losses at the sump strainer are generally determined by experiments. The RSK recommends to follow this procedure for German plants, too. For the leak locations and sizes to be considered, the kind and scope of the materials released and deposited on the strainers has to be determined according to the above-mentioned approach, and the resulting pressure loss has to be determined experimentally considering plant-specific conditions. A safety margin has to be added to this pressure loss by adequately considering also the other conservative assumptions.

In the case of strainers with a small mesh size, it has to be conservatively assumed that the entire transportable material will deposit on the strainer. If strainers with large mesh size are used, the return of penetrated insulation material via the leak into the sump has to be considered. To take this effect into account, the deposited amount measured in the experiments has to be increased for the calculation by 50% of the measured penetration amount.

Special attention has to be paid to the so-called thin bed effect that occurs when the strainer is covered by a thin (several millimetres strong) layer of fibres or of mostly fine fibrous particles forming a compact filter bed (only possible at low transport rates in the sump). The resulting pressure loss may actually be higher than the one induced by a considerably larger amount of fibres (and particles). The RSK therefore recommends to limit the simultaneous use of particular and fibrous insulation materials in the plants to an extent that the above-mentioned effect will only have little consequence.

It has to be shown for the short-term (blow-down) and long-term (residual-heat removal) phase that the loads resulting from the pressure differences over the grid structure of the strainer can be transferred to the supporting and concrete structures.

- **Penetration of insulation material through the strainer**

The penetration of insulation materials and other substances through the strainer depends mainly on the kind and particle size distribution of the materials, the degree of deposition of debris on the strainer, the flow velocity, and the mesh size of the strainer. The penetration to be assumed for the further provision of evidence has to be determined plant-specifically - like the pressure loss across the strainer - with consideration of the least favourable occlusion of the strainer expected for the absolute value of penetration. In this connection, the worst sump configuration and number of RHR-pumps available has to be assumed.

- **Pump suction head**

The residual-heat removal pumps require sufficient net positive suction head (NPSH) so that they will not cavitate. In the cavitation mode, coolant throughput is restricted and may possibly be too low to ensure sufficient core cooling.

It has to be shown that following the switch to sump operation, considering the pressure loss on the sump strainer determined for the least favourable strainer clogging, there will be no inadmissible impairment of the function of the residual-heat removal pumps through cavitation. In the opinion of the RSK, a sufficient safety margin has to be kept for this purpose.

According to the RSK's PWR Guidelines, the analysis of the effectiveness of emergency core cooling is to be based on leaks of size of 2A (double-ended break) for leaks in the reactor coolant lines (RCL) (Ch. 21.1 (2)). According to Ch. 22.1.3 (3), the calculations for the net positive suction head of the residual-heat removal pumps following the switch to sump operation are to be based on the assumption of atmospheric pressure prevailing in the containment. If this procedure is followed, current designs show sufficient reserves to prevent cavitation without consideration of an increased pressure loss at the sump strainers due to the deposition of insulation material.

At increased pressure loss due to the deposition of insulation material at the sump strainers, effective emergency core cooling may under certain circumstances not be demonstrated when applying the calculation procedure stipulated by the RSK Guidelines (Ch. 22.1.3 (3)). In such cases, the procedure described below has to be followed:

The calculation procedure stipulated in the RSK Guidelines (non-consideration of positive containment pressure) result in very large design margins. Against this background and considering the short-term operating mode at high sump temperatures, the RSK believes that the consideration of positive containment pressure is admissible under the following conditions:

- The temperature and pressure conditions in the containment atmosphere and the sump have to be determined conservatively in a comprehensible manner with the help of validated computer codes with regard to low pressures and high sump temperatures. The net positive suction heads of the residual-heat removal pumps have to be determined using these calculated values and with consideration of the conservatively determined pressure losses at the sump strainers that are caused by the insulation material deposited on the strainers.

- The thus determined net positive suction head has to be greater than the net positive suction head that is necessary to prevent cavitation. To assess whether the safety margin is sufficient, the reserves to prevent cavitation that have been determined have to be indicated and compared with the corresponding value calculated according to the RSK procedure (without consideration of insulation material).

A further condition that has to be fulfilled is that the pressure loss at the strainer may only result in negligible steam generation that will not lead to a considerable reduction of coolant throughput.

- **Pressure drop inside the core due to the deposition of insulation material**

Part of the insulation material that has penetrated the sump strainer may deposit on the fuel assembly bottom end structures and spacers. The remaining part (extra-fine particles) will be entrained by the coolant flow and return into the containment sump.

It has to be shown that the insulation material deposited in the core will not inadmissibly impair heat removal from the core. The influence of other materials potentially transported into the core has to be assessed. Upon providing evidence, the conservative assumption has to be that the entire material that has penetrated the strainer will be transported into the reactor pressure vessel. Deposition in the core has to be determined conservatively by experiments with consideration of the flow distribution in the RPV and retention in the core. If no experiments are available, it has to be assumed conservatively that the entire material that has penetrated the strainer will deposit in the core.

For the analyses regarding coolability of the core with deposited insulation material, the least favourable combination of leak location and injection configuration of the residual-heat removal pumps has to be assumed individually for each plant.

The pressure drop at the fuel assemblies applied in the provision of evidence has to be determined by experiments in dependence of the fuel assembly type and the amount of insulation material that has entered, of the kind of insulation material, and of the temperature, flow velocity and chemical composition of the coolant. An extra safety margin has to be put on this pressure drop, with adequate consideration of the other imponderables. Here, the influence of other materials potentially entering the core also has to be assessed.

The maximum admissible pressure drop in the core due to material deposition has to be determined and evidence of sufficient core cooling has to be provided by means of analyses carried out with qualified thermal-hydraulic computer codes. Heat removal from the core must not be inadmissibly impaired. Heat removal is ensured if no steam is generated inside or flows from the core after the switch to sump operation. Here, the RSK Guideline stipulates that thermal-hydraulic boundary conditions have to be applied that cover leaks up to 2A (double-ended break) size.

Heat removal from the core is ensured if the pressure drop in the core that is due to the material deposition on the fuel assemblies lies below the pressure drop level that has been determined as admissible.

- **Residual-heat removal system components**

Apart from the fuel assemblies, pumps, valves and heat exchangers may also be impaired in their function by the entry of insulation material. It has to be shown that the functions of the emergency core cooling and residual-heat removal system that are necessary for accident control and which may be impaired by an entry of insulation material and other substances are ensured without restriction.

- **Long-term behaviour**

As regards possible changes in pressure loss over longer periods of time, the influence of corrosion of containment internals induced by borated water should be investigated. Corrosion particles that deposit on the fibrous bed of the strainer may increase pressure loss.

The expected corrosion rate of metallic surfaces in the area of the sump water has to be estimated for the provision of evidence and taken into account with regard to its effects on the pressure loss at the sump strainers and the pressure drop in the core.

According to present knowledge, the boron content of the sump water merely influences the viscosity of the coolant if mineral wool is used as insulation material (in contrast to the use of glass wool). Chemical reactions with the mineral wool need therefore not be expected. The state of knowledge regarding the long-term influence of borated sump water on the pressure loss at the sump strainer should, however, be further backed up by experiments. For this purpose, experiments have to be performed using relevant combinations of insulation materials to support the assumptions made.

- **Cleanliness of the plant**

Due to the contribution of other substances ("latent debris") that may settle in a fibrous bed of insulation material and may lead to a further increase in pressure loss at the sump strainers, special attention has to be paid to cleanliness, absence of corrosion, and the adhesion of coatings in the containment. The use of materials such as fire protection materials, cover sheeting, adhesive tape and materials that may be transported into the containment sump during a loss-of-coolant accident has to be kept as low as possible. After work inside the containment and following a refuelling outage it has to be ensured that all unnecessary materials have been removed, and cleanliness in the containment has to be checked prior to restart.

Dust may collect on surfaces of containment internals and in ventilation ducts. As the ventilation ducts may be destroyed in the event of a loss-of-coolant accident, these should be kept as clean as possible on the inside. According to present knowledge, the influence of particles like dust on the pressure loss at the strainers cannot be excluded and should therefore be investigated experimentally. It has to be shown that the influence of dust will not lead to inadmissible pressure loss (thin bed effect) at the strainer and a pressure drop in the core (see also section "Pressure loss at the sump strainers").

- **Accident management measures**

To ensure core cooling during sump operation in the course of a loss-of-coolant accident beyond-design-basis, measures at Safety Level 4 (accident management measures) have to be provided that will sufficiently limit or reduce a possible inadmissible pressure loss at the strainers without challenging core cooling. The accident management measures have to be thus designed that pressure loss at the sump strainer can reliably be limited and a significant increase of penetration and entry of insulation and other material into the core is precluded. For the initiation and execution of these accident management measures, criteria have to be provided solely on the basis of measurements that are also available following a 2A (double-ended break) loss-of-coolant accident. The criteria and measures have do be described in the emergency operating procedures.

5 Answers to the BMU's questions

In its discussion of the items listed in the letter from the BMU [1-3], the RSK arrived at the following conclusions:

- Discussion of the current state of the art regarding residual-heat removal, including the methods applied to ensure effectiveness of emergency core cooling, such as modifications of strainer size and pressure differences.

In principle, the RSK considers a sufficiently large strainer size and a fine-meshed screen (approx. 3 mm) as a suitable measure for sump strainers to limit pressure loss at the strainers and penetration of insulation material through the strainers and thereby to ensure core cooling.

Strainers with fine-meshed screens are furthermore also to be given preference under the aspect of accident management measures as they ensure that foreign material will mainly deposit on the strainer and inadmissible pressure loss will - if at all - therefore occur at the strainer, where Safety Level 4 measures can be applied.

The demonstration criteria, postulated cases and limits to be derived from experiments that have to be used for the provision of evidence are described in Section 4.

- Clarification of the leak size to be assumed for the investigation of clogging of the sump strainers according to the state of the art in science and technology,

- Explanation of the safety significance of the different postulated cases as well as of the reasons, advantages and drawbacks concerning the postulated 2A (double-ended break) and 0.1A leaks, respectively.

These two questions have not yet been finally discussed by the RSK. Until this has been done, a 0.1A leak may be applied as basic postulated case for the release of insulation material in accordance with the statement of the RSK (Appendix 3 to the summarising minutes of the 320th meeting of the RSK on 16 September 1998) [11] for piping for which the break preclusion has been demonstrated.

- Explanation of the boundary conditions under which a loss-of-coolant accident with a challenge of the residual-heat removal pumps is controlled, and answer to the question whether it is admissible or even necessary to switch off residual-heat removal pumps during emergency core cooling.

The details of the requirements for the demonstration of compliance with the requirements of Safety Level 3 are given in Section 4. Here, according to the general requirements of the regulations, no manual actions are to be provided within 30 minutes following the onset of the accident. After 30 minutes, the throttling measures laid down eventually in the operating instructions are possible in principle. A switch-off for the purpose of limiting pressure loss at the sump strainers is not necessary by design if the above-mentioned requirements are fulfilled.

Beyond-design-basis event sequences that may lead to inadmissible differential pressures at the sump strainers and which require measures that may include an intentional switch-off of residual-heat removal pumps have to be assigned to Safety Level 4. Corresponding instructions have to be included in the accident management manual.

- Discussion of the results of recent experiments concerning residual-heat removal

The RSK has discussed in depth the experiments performed on the part of the licensees [32], [33], [34] and taken them into account in the procedures recommended in Section 4.

- Description of international developments concerning measures to control the "Barsebäck" problem to derive the state of the art in science and technology

International results have been considered inasmuch as it was taken into account upon the application of these results to German plants that no containment spray system is available and that cassette-type mineral wool insulation is used rather than glass wool embedded in thin metal sheets or as mattress. A final assessment of the situation regarding break postulates for foreign plants has not yet been made.

6 Recommendation

The RSK asks the BMU to provide in about a year reports about the technical situation concerning the following issues:

- Description of how far a shift in the direction of the jet in the case of a pipe break (pipe whipping) may lead to an increased release of insulation material and other substances,

- Transport behaviour of insulation material other than MD 2 (83) as well as of other substances ("latent debris") in the sump and their consequence on pressure loss at the sump strainer,

- Influence of the "thin bed effect" on pressure loss at the strainer,

- Long-term behaviour and chemical effects (corrosion) due to boric acid,

- Functional performance of components affected by fibrous deposits in residual-heat removal mode,

- Effectiveness and compatibility of accident management measures limiting or reducing pressure loss at the strainer, and status of their implementation,

- Applicability of the recommendations to boiling water reactors.

Consultation documents

[1] Schreiben des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit (Az.: RS I 3 - 14203/29) vom 25.04.2003 an die RSK-Geschäftsstelle, betr.: Kernkraftwerk Biblis A, Information vom 17.04.2003 über einen Befund im Ansaugbereich der Notnachkühlpumpen der Anlage Biblis A

[2] Schreiben des BMU (Az.: AG RS I 3 - 17018/1) vom 12.05.2003 an die RSK-Geschäftsstelle, betr.: Atomkraftwerk Biblis, Block A, Befunde im Ansaugbereich der Notnachkühlpumpen, Stellungnahme der RSK zu dem Meldepflichtigen Ereignis vom 17.04.2003

[3] Schreiben des BMU (Az.: AG RS I 3 - 17018/1) vom 19.05.2003 an die RSK-Geschäftsstelle, betr.: Atomkraftwerk Biblis, Block A, Befunde im Ansaugbereich der Notnachkühlpumpen, Meldepflichtiges Ereignis vom 17.04.2003

[4] TOP 3: Verhalten von Isoliermaterial bei KMV-Störfällen
Dr. Michael Maqua, GRS
Tischvorlage, 14.05.2001

[5] E.ON Kernkraft
Nachweis der gesicherten Sumpfansaugung
- Versuchsprogramm der deutschen KKW-Betreiber 2001 -
A. Zühlke, E.ON Kernkraft, Bereich-TA
Folienkopien, 20.09.2001

[6] Kernkraftwerk Biblis, Block A
Befund im Ausaugbereich der Notnachkühlpumpen
RWE Power, Folienkopien, 08.05.2003

[7] Biblis A, Nachweissituation für den Ist-Zustand der Anlage
RWE Power, Folienkopien, 08.05.2003

[8] Bericht der Landesbehörde zu Befunden im Ansaugbereich der Notnachkühlpumpen KKW Biblis, Block A (Stand 07.05.2003, zur Unterrichtung der RSK)

[9] TOP 4, Kernkraftwerk Biblis, Block A

„Befund im Ansaugbereich der Notnachkühlpumpen"
TÜV Nord-Gruppe, Folienkopien, 08.05.2003

[10] Barsebäck, WLN 14/92
Großversuchen zu deutschen DWR-Anlagen infolge Ereignis in Barsebäck 2
TÜV Süddeutschland, Bau und Betrieb, Folienkopien, 08.05.2003

[11] Anlage 3 zum Ergebnisprotokoll der 320. Sitzung der Reaktor-Sicherheitskommission am 16.09.1998
Wirksamkeit der Notkühlsysteme bei Freisetzung von Isoliermaterial bei KMV-Störfällen
STELLUNGNAHME

[12] Notiz vom 20.05.2003 „Leckpostulate (DWR) Primärkreis" von Herrn Wieland

[13] RSK-Leitlinien für Druckwasserreaktoren
Ursprungsfassung (3. Ausgabe vom 14.10.1981) mit Änderungen vom 15.11.1996
Fassung 11.96

[14] RWE Power Aktiengesellschaft
Eintrag von Mineralwolle in den Sumpfbereich bei DWR
Ergebnisse neuerer Versuche und Übertragung auf die Anlage Biblis A
EN-U/Dr.Pa/Ro, 23. Juni 2003

[15] Auszug aus dem Ergebnisprotokoll der 362. Sitzung der RSK am 08.05.2003
(TOP 4: Kernkraftwerk Biblis, Block A (KWB-A))
Befund im Ansaugbereich der Notnachkühlpumpen

[16] U.S. Nuclear Regulatory Commission
Draft Regulatory Guide 1.82 Rev. d
Water Sources For Long-Term Recirculation Cooling Following A Loss-Of-Coolant Accident, February 2003

[17] Gesicherte Sumpfansaugung nach KMV
Spezifische Randbedingungen in deutschen DWR im Vergleich zu ausländischen Anlagen
Framatome ANP FANP/NGPS Waas
Folienkopien, 02.07.2003

[18] Biblis, Block A, Rückhaltung von Isoliermaterial
Versuchstechnische Absicherung der Nachweisführung zu Druckverlust und Kerneintrag
RWE Power. EN-U/Dr.Pa, 02.07.2003
Folienkopien

[19] GKSS-Großversuche zum Absetzverhalten und zur Rückhaltung von Isoliermaterial im RSB-Sumpf
TÜV Süddeutschland, 02.07.2003, Folienkopien

[20] Kraftwerk Biblis, Block A
Versuche zum Thema: Vergrößerung der Sumpfsiebe
Hannover, 28.06.2003
TÜV Hannover/Sachsen-Anhalt e. V., Folienkopien

[21] Auslaugverhalten und Druckverlustmessungen von Isoliermaterial der Reaktorkühlkreisisolierung (Lieferung GKN-2) unter simulierten LOCA-Bedingungen
Siemens-Arbeitsbericht, Erlangen, 16.12.1989

[22] Safety Issues of Strainer Clogging in Sweden
Bonn, 02-01.07.2003, Oddbjörn Sandervag, SKI
Folienkopien

[23] RSK-Information RSK364/4
Bericht des Vorsitzenden des Ausschusses ANLAGEN- UND SYSTEMTECHNIK über die 19. Sitzung des Ausschusses am 02.07.2003
Kernkraftwerk Biblis, Block A
Versuche zur Rückhaltung von Isoliermaterial im Sumpfansaugbereich der Not- und Nachkühlpumpen

[24] TOP 4 der 364. RSK-Sitzung am 10.07.2003
Bericht von der 19. AST-Sitzung am 02.07.2003 zu Versuchen zur Rückhaltung von Isoliermaterial im Sumpfbereich der Not- und Nachkühlpumpen
Edmund Kersting, Folienkopien

[25] U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation, Washington, DC 20555
NRC-Bulletin 2003-01: Potential Impact of Debris Blockage on Emergency Sump Recirculation At Pressurized Water Reactors, June 9, 2003

[26] Auszug aus dem Ergebnisprotokoll der 11. AST-Sitzung am 14.05.2001, TOP 3

[27] Bericht des Vorsitzenden des Ausschusses ANLAGEN- UND SYSTEMTECHNIK über die 19. Sitzung des Ausschusses am 02.07.2003
RSK-Information Nr. RSK364/4 vom 09.07.2003

[28] Generische Fragen zur möglichen Verstopfung im Sumpfansaugbereich bei einem Kühlmittelverluststörfall
Dr. Michael Maqua, Dr. Bernhard Pütter, Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH, Köln
Tischvorlage für die 20. Sitzung des RSK-Ausschusses Anlagen- und Systemtechnik

[29] Überblick zum Thema „Auswirkungen der Freisetzung von Isoliermaterial bei KMV“
Tischvorlage, GRS, 04.09.2003

[30] RSK-Information RSK365/5.2
Überblick zum Thema „Auswirkung der Freisetzung von Isoliermaterial bei KMV“, 18.09.2003

[31] Überblick zum Thema „Auswirkung der Freisetzung von Isoliermaterial bei KMV“
RSK-Information Nr. RSK 365/Info-5.2 vom 03.09.2003

[32] Bestätigung der gesicherten Sumpfansaugung und ausreichenden Kernkühlung nach KMV bei DWR im Rahmen der Untersuchungen nach Eintritt des Barsebäck-Ereignisses
Arbeitsbericht, Framatome ANP, KWU NDS4/98/014A, 27.10.2003

[33] Experimenteller Nachweis der gesicherten Sumpfansaugung nach einem Kühlmittelverluststörfall bei KWU Druckwasserreaktoren
Technischer Bericht, Framatome ANP, NGES1/2002/de/0210, 06.11.2003

[34] Generische Fragen zur möglichen Verstopfung im Sumpfansaugbereich bei einem Kühlmittelverluststörfall
Framatome ANP Seeberger/Waas RSK-AST am 18.11.2003, Folienkopien

[35] „Generische Fragen zur möglichen Verstopfung im Sumpfansaugbereich bei einem Kühlmittelverluststörfall“, 18.11.2003,
Bericht der Hochschule Zittau/Görlitz (FH), Institut für Prozeßtechnik, Prozeßautomatisierung und Meßtechnik (IPM)
R. Hampel, W. Kästner, Folienkopien

[36] Generische Fragen zur möglichen Verstopfung im Sumpfansaugbereich bei einem Kühlmittelverluststörfall
Bericht der GRS: Vorschlag für eine praktikable Bewertungsgrundlage
Dr. Michael Maqua, GRS, 18. November 2003, Folienkopien

[37] RSK-Information RSK365/5.1
Strukturierung der Beratung generischer Aspekte einer möglichen Verstopfung der Sumpfansaugöffnungen bei einem Kühlmittelverluststörfall, 18.09.2003

[38] U. S. Nuclear Regulatory Commission
Containment Emergency Sump Performance
NUREG-0897, Revision 1, 01.10.1985

[39] Blow-down Investigations on Performance Insulating Systems
Battelle, B.I.G. V-32.608, August 1995