Federal Environment Agency – Austria

ETE Road Map

according to Chapter IV and V of the
"Conclusions of the Melk Process and Follow-Up"

Item 1

High Energy Pipe Lines at the 28,8 m Level

Preliminary Monitoring Report

Report to the Federal Ministry of Agriculture, Forestry, Environment and Water Management of Austria

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seibersdorf research

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Disclaimer

The Specialists' Team was not tasked with performing any kind of licensing review of the Temelín Nuclear Power Plant, and nothing in this report may be construed to represent any such review. The responsibility for and the review of the Safety and the Licensing of the Temelín Nuclear Power Plant exclusively remains with CEZ a.s. as the owner of the facility, and with the SÚJB as the designated Nuclear Regulatory Authority under Czech law, respectively.

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Masthead

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Note to the Reader

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EXECUTIVE SUMMARY

The Republic of Austria and the Czech Republic have, using the good offices of Commissioner Verheugen, reached an accord on the "Conclusions of the Melk Process and Follow-up" on 29 November 2001. In order to enable an effective use of the "Melk Process" achievements in the area of nuclear safety, the Annex I of this "Brussels Agreement" contains details on specific actions to be taken as a follow-up to the "trialogue" of the "Melk Process" in the framework of the pertinent Czech-Austrian Bilateral Agreement.

Furthermore, the Commission on the Assessment of Environmental Impact of the Temelín NPP - set up based on a resolution of the Government of the Czech Republic - presented a report and recommended in its Position the implementation of twenty-one concrete measures (Annex II of the "Brussels Agreement").

A "Roadmap" regarding the monitoring on the technical level in the framework of the pertinent Czech-Austrian Bilateral Agreement as foreseen in the "Brussels Agreement" has been elaborated and agreed by the Deputy Prime Minister and the Minister of Foreign Affairs of the Czech Republic and the Minister of Agriculture and Forestry, Environment and Water Management of the Republic of Austria on 10 December 2001.

The Federal Ministry of Agriculture, Forestry, Environment and Water Management entrusted the Umweltbundesamt (Federal Environment Agency Ltd.) with the general management of the implementation of the "Roadmap". Each entry to the "Roadmap" corresponds to a specific technical project.

Item No.1 "High Energy Pipe Lines at the 28,8 m Level" of Annex I of the "Brussels Agreement" covers the integrity of the main steam and feed water piping at the 28,8 meter level of the Temelín reactor buildings, where this piping transits from the respective containment penetrations to the turbine hall. This issue is frequently referred to as "High Energy Line Breaks" or HELBs. The objective regarding this item as stated in Annex I of the "Brussels Agreement" is to "e*nsure that the safety case demonstrating appropriate protection against high energy pipe breaks and consequential failures of the steam and feed water lines, complies with requirements and practices widely applied within the EU and that an appropriate combination of measures are in place".*

The Roadmap specified that a Specialists' Workshop would be held in Prague in the 2nd half of 2002 to discuss this issue.

The approach by the Czech side

The key element in the monitoring process was a Specialists' Workshop on the "Roadmap" item No. 1 "HELB" and "Roadmap" item No. 2 "qualification of valves" (PN 3) conducted in Prague on 7 and 8 November 2002 in the framework of an additional expert meeting according to Article 7 (4) of the Bilateral Agreement of the Exchange of Information on Nuclear Safety. In view of the interrelation of the two issues, the Czech hosts deemed it useful to treat both items at the same workshop. The analysis of the information made available there is the basis for the present Preliminary Monitoring Report of the Specialists' Team.

In a series of presentations the outline of the solution for the HELB item was described by Czech experts, along with the way the Licensing Authority had accepted these solutions.

The areas presented by the Czech side in a number of presentations at the Specialists' Workshop were related to the broad scope of the "Comprehensive Safety Case Revisit" (CSCR) initiated by SÚJB and accepted endorsing the original decisions of the regulatory authority. Information about the following areas was presented and discussed:

- Design
  - Codes, Standards, Rules and Regulations Applied and Compared to those within EU
  - Load Definition: Qualification of BRU-A and SGSV for Steam-Water Mixture
  - Pipe Break Probability, Probabilistic Fracture Mechanics Overview
  - "Superpipe" Concept Application on Steam and Feed Water Lines Overview
- Thermal Hydraulics
  - Thermal-Hydraulics Analysis and Dynamic Calculations Overview, Steam Water Hammer and Water Overfill.
  - Pressurised Thermal Shock Overview
- Materials
  - Material Properties
  - Material Flow Accelerated Corrosion Overview
- In-Service Inspection
  - Measurement of Operational Displacement
  - Ultrasonic Testing: Non-Destructive-Evaluation Modifications, Qualification, Procedures and Results

The approach of ČEZ a.s. to resolve the safety issue "consequences of secondary piping failure at the 28,8 meter level" of the Temelín Nuclear Power Plant (as approved by SÚJB) is to rely on break exclusion for the main steam and feed water piping from the containment penetration to the isolation valves.

The descriptions identified the approach taken, but as overviews they provided only limited insight into the results and how these were obtained. A number of the questions posed by the Specialists' Team was considered by the Czech side to exceed the level of detail or the scope of the Roadmap Workshop activities. Consequently, both sides agreed that the pertinent Czech-Austrian Bilateral Agreement is the appropriate framework giving the opportunity for further discussion and sharing additional information on these issues.

The presentations provided an insight into the extensive work accomplished by the plant operator and its technical support organisations to consolidate the safety case in the framework of the "Comprehensive Safety Case Revisit" (CSCR) for judgement by the licensing authority.

The approach by the Austrian Specialists' Team

A Specialists' Team of 15 international experts was committed by the Umweltbundesamt (Federal Environment Agency Ltd.) on behalf of the Austrian Government to give technical support for the monitoring on the technical level of the implementation of the HELB Issue as listed in Annex I of the Conclusions of the Melk Process and Follow-up. This specific technical project is referred to as project PN2 comprising altogether seven predefined "project milestones" (PM).

To focus preparatory work of the Austrian Specialists' Team and to guide the Austrian Delegation through the Specialists' Workshop, but also to enable proper preparation of the Specialists' Workshop on the bilateral level, in a **first step,** Project Milestone 1 (PM1), the safety objective was broken down to Verifiable Line Items (VLIs) (see ANNEX B). Based on the Defence in Depth principle, they were applied to qualify Temelin NPP's safety features consistency.

In a **second step** the Specialists' Team prepared a list of documents (PM2) - the Specific Information Request – SIR, considered to contain the kind of information required to provide profound answers to the VLIs (see ANNEX D).

The **third step** in the preparatory work for the Workshop also included identification of standards and practices applied within the European Union Member States for the HELB issue (France and Germany). Special focus was placed on the practice in France and the US, since the operator of ETE referred to codes, rules and regulations of these countries. In the Briefing to the Austrian Delegation (PM3) these elements of the monitoring were presented to the mission participants.

At the Workshop on HELB and Valve Qualification in Prague on 7 and 8 November 2002, experts from the plant operator, technical support organisations, and the licensing authority made fifteen well-prepared slide beamer presentations, characterised by one presenter as being of an overview nature. Within the limitations spelled out above, questions from the Specialists' Team were mostly answered during the workshop.

Following the Workshop in this **fourth step** (PM4), the Specialists' Team reviewed the Specialists' Workshop and the Specialists' Team members provided contributions to the Preliminary Monitoring Report (PMR). Based on information currently available, the Specialists' Team has characterised several results that have become evident as follows:

The application of the French Tronçons Protégés concept requires short, weld-free pipe segments. The Temelín break exclusion application comprises lengthy pipes with many welds. Further monitoring should therefore focus in some detail on the acceptance process of this novel approach and its endorsement requirements in a case-by-case licensing procedure.

In addition, contemporary practice in German and French licensing approaches foresees acceptance of break exclusion demonstration only in addition to physical separation (e.g. with each steam-line or feedwater-line in its own compartment up to the main isolation valves or with spatial separation). During the presentation at the Specialists' Workshop the Czech side reported the results of their evaluation of a separation wall splitting the 28,8 meter level into two halves. While the construction was considered to be technically feasible, concerns arose due to the adverse influence of such a wall on maintenance and in-service inspections of near-by located components and equipment. According to the information presented, the implementation of other forms of physical separations also seems to be difficult with the given Temelín design. At the present time the plant operator does not plan to build such a separation wall.

The Specialists' Team would be interested in receiving information about the bases on which the Regulatory Authority accepted this unique approach. The following items are of specific interest in this context:

- Given the existing piping layout in place at Temelín, break exclusion application, without considering the consequences of the postulated HELBs on the equipment related to safety, does not seem to conform to contemporary practice in German or French licensing.
- Break exclusion requires 100 % surface and volumetric inspection of all welds in the break exclusion area (US NRC requirements in this regard do not permit any exceptions).
- The NDT (Non Destructive Testing) approach described by the operator's experts at the Workshop is currently not qualified for all difficulties encountered during inspections of the welds at the steam and feed water lines.
- Break exclusion applications (e.g., German KTA and French Tronçons Protégés) require post-weld heat treatment and post-weld surface treatment. The Specialists' Team was told at the Workshop that neither of these treatments has been performed for welds in the break exclusion area at Temelín until now. Therefore in future special consideration should be given to assure that the state of the welds conforms to break exclusion requirements.
- Material tensile properties data used to demonstrate the stress criteria fulfilment are neither the code-based nominal values nor the minimum values certified from the manufacturer of the piping material actually installed. If either of these values were used, the break exclusion stress criteria would not be met. Instead, the properties values used are derived from samples, for which evidence of representativity for the original piping material has not been provided. Close examination should be considered for the available sources of material data. If available, their qualification to enhance the materials properties' database should be verified.
- Based on the information presented at the Workshop, the full functionality of the pipe whip restraints cannot be considered demonstrated yet. This concerns in particular the weldment of the collar ring to the containment penetration. This is mainly due to the fact that the events considered as initiators for loads to the pipelines, as presented, are not yet complete. Events of potential importance, such as large leakage from the primary to the secondary circuit or the reference aircraft impact, have apparently not been included so far.
- Taking into consideration the limitations identified above, the full assessment of the behaviour of the primary coolant system and the reactor core under the conditions of multiple steam line breaks in the compartment at the 28,8 m level would be of particular importance.

Preliminary Result of the Monitoring

Since the identification of the HELBs issue several years back, the detailed examinations and the actions taken up to the most recent Comprehensive Safety Case Revisit demonstrate a comprehensive process directed towards improvement. When considering the concerns expressed in the Austrian Technical Position Paper the comparison with the current state also indicates a number of areas of improvement.

It has to be noted, however, that the Specialist's Team presently cannot follow some views and expectations upheld by the Czech side on the applicability of the break exclusion concept.

Based on the recognition that the pertinent Czech-Austrian Bilateral Agreement is the appropriate framework giving the opportunity for further discussion and sharing additional information on these issues, the Specialist's Team would appreciate if the major findings could be revisited in the further monitoring process of HELB.

The Monitoring process so far helped to clarify a number of VLIs. The following areas were identified as those where additional information would be most valuable to consolidate the Monitoring result: The further Monitoring process can thus be restricted to three major items still requiring attention:

1. With regard to the **materials** used for the secondary High Energy Lines:

   The materials properties' requirements and verification of adequate properties of the materials used for the High-Energy Lines at the 28,8 m elevation should be supported by sufficiently qualified evidence.

   The comprehensive specification of the materials properties - on which the acceptance of the stress analyses, the break exclusion verification and the determination of crack propagation to break at the pipe whip restraints' locations is based - should be made accessible. The databases as well as the standards, rules and regulations used to define the materials properties should be included into this information.

   Monitoring should focus on the extent to which values for material properties are based on mandatory standards, rules and regulations and to which these values are used in the component acceptance process.

2. With regard to the **break exclusion concept** verification:

   The specific and extensive use of the break exclusion assumptions and the associated deterministic break location definition should be supported by conclusive probabilistic acceptability results.

   The results of probabilistic analyses should be accessible for Monitoring. Probabilistic analyses should include the failure probabilities of the entire piping ducts up to the first isolation valves. Moreover results from probabilistic fracture mechanics analyses for the duct exposed to maximum loadings should also be made accessible for Monitoring.

   For the particular arrangement of the pipe ducts at the 28,8 m level specific break frequencies were assumed and In-Service-Inspection-Plans were adapted. Monitoring should also aim at a comparision of these assumtions and plans with industry experience.

3. With regard to **accident consequences**:

   The nuclear power plant behaviour under severe accident conditions caused by High-Energy Line Breaks requires extensive analyses of various severe accident sequences to understand options for the mitigation of consequences.

   One exemplary severe accident scenario should be investigated: High Energy Line Breaks occur at full power at the Temelin NPP, and the reactor cannot be shut down successfully. For comparison, results of analyses of a High-Energy Line Break event of one main secondary line with the reactor core at full power and failure to successfully shut down the reactor with one of the control rods stuck in top position should be made accessible.

   The Monitoring should focus on identifying the extent to which accidents with consequences to the reactor core are likely to evolve into radioactive release events.

The Specialists' Team is looking forward to following up the above questions in these three areas in the further Monitoring process of HELBs.

Note that the assessment of technical adequacy is closely related to a number of other "Roadmap" items. Consequently, a final evaluation will only be possible by the end of the Monitoring process on the technical level, as set out in the Roadmap, taking into account the results of other Roadmap events as well as additional information which might be available, inter alia in the framework of the pertinent Czech-Austrian Information Agreement.

ZUSAMMENFASSUNG

Die Republik Österreich und die Tschechische Republik haben mit Unterstützung des Mitglieds der Kommission Verheugen am 29. November 2001 eine Übereinstimmung über die „Schlussfolgerungen des Melker Prozesses und das Follow-up“ erzielt. Um eine wirksame Umsetzung der Ergebnisse des Melker Prozesses im Bereich der nuklearen Sicherheit zu ermöglichen, enthält der Anhang I dieses „Brüsseler Abkommens“ Details zu spezifischen Maßnahmen, die als Follow-up zum „Trialog“ des Melker Prozesses im Rahmen des betreffenden bilateralen tschechisch-österreichischen Abkommens durchzuführen sind.

Weiters legte die Kommission zur Prüfung der Umweltverträglichkeit des KKWs Temelin, die auf Grund einer Resolution der Regierung der Tschechischen Republik eingesetzt wurde, einen Bericht vor und schlug in ihrer Stellungnahme die Umsetzung einundzwanzig konkreter Maßnahmen vor (Anhang II des „Brüsseler Abkommens“).

Zur Überwachung auf technischer Ebene im Rahmen des diesbezüglichen tschechisch-österreichischen bilateralen Abkommens wurde, wie im „Brüsseler Abkommen“ vorgesehen, eine „Roadmap“ („Fahrplan“) ausgearbeitet und am 10. Dezember 2001 vom stellvertretenden Premierminister und Außenminister der Tschechischen Republik sowie vom Bundesminister für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft der Republik Österreich vereinbart.

Das österreichische Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft beauftragte das Umweltbundesamt mit der Gesamtkoordination der Umsetzung der „Roadmap“. Jeder Eintrag in der „Roadmap“ entspricht einem spezifischen technischen Projekt.

Punkt Nr. 1 „Hochenergetische Rohrleitungen auf der 28,8 m Bühne“ im Anhang I des „Brüsseler Abkommens“ behandelt die Integrität der Frischdampf- und Speisewasserleitungen auf der 28,8 m Bühne des Reaktorgebäudes von Temelin – wo die Leitungen von den jeweiligen Durchdringungen des Containments (Sicherheitshülle) in die Turbinenhalle übergeführt werden. Dieser Themenbereich wird üblicherweise als „High Energy Line Breaks“ (HELBs = Brüche von hochenergieführenden Rohrleitungen) bezeichnet. Wie im Anhang I des Brüsseler Abkommens aufgezeigt, lautet das unter diesem Punkt angeführte Ziel: *„Sicherstellung, dass der Sicherheitsnachweis, der einen adäquaten Schutz gegen den Bruch hochenergetischer Leitungen und daraus resultierende Versagen der Dampf- und Speisewasserleitungen zeigt, den Anforderungen und der Praxis, wie sie innerhalb der EU breit angewendet werden, entspricht und eine adäquate Kombination von Maßnahmen besteht.“*

Die „Roadmap“ sah für die zweite Hälfte des Jahres 2002 einen Experten-Workshop in Prag zur Erörterung dieser Thematik vor.

Der Ansatz von tschechischer Seite

Ein wesentliches Ereignis im Überprüfungsprozess („Monitoring Process“) war der Experten-Workshop zu den Punkten Nr. 1 („HELB“) und Nr. 2 („Qualifikation der Ventile“ (PN3)) der „Roadmap“, das am 7. und 8. November 2002 in Prag im Rahmen eines zusätzlichen Expertentreffens gemäß Artikel 7 (4) des bilateralen Abkommens über den Austausch von Informationen über die nukleare Sicherheit abgehalten wurde. Angesichts des Zusammenhangs zwischen den beiden Themenbereichen hielten es die tschechischen Gastgeber für angebracht, beide Punkte in ein- und demselben Workshop zu behandeln. Die Auswertung der dort zur Verfügung gestellten Informationen dient als Grundlage für den vorliegenden vorläufigen Überprüfungsbericht (Preliminary Monitoring Report) des Expertenteams.

Anhand einer Reihe von Präsentationen wurden Lösungsansätze für den HELB-Themenkreis umrissen und die Art und Weise, wie die Genehmigungsbehörde solche Lösungen akzeptiert hatte, von den tschechischen Experten beschrieben.

Die Aspekte, die von tschechischer Seite anhand der Präsentationen anlässlich des Experten-Workshops erläutert wurden, bezogen sich auf den breiten Ansatz des „Comprehensive Safety Case Revisit“ (Umfassende Neubewertung des Sicherheitsproblemfalles Bruchereignisse hochenergieführender Rohrleitungen), der von SÚJB initiiert und als ursprüngliche Entscheidung der Aufsichtsbehörde bestätigend angenommen wurde. Es wurden Informationen zu folgenden Bereichen vorgebracht und erörtert:

- Auslegung
    - Verwendete Codes, Standards, Vorschriften und Regelungen sowie deren Vergleich mit jenen in der EU
    - Belastungsdefinition: Qualifizierung der Entlastungsventile BRU-A und Sicherheitsventile SGSV für Wasserdampfgemisch
    - Rohrbruchwahrscheinlichkeit, Übersicht über probabilistische Bruchmechanik
    - Übersicht über die Anwendung des „Superpipe“-Konzepts auf Dampf- und Speisewasserleitungen
- Thermohydraulik
    - Übersicht über die thermohydraulische Analyse und dynamische Berechnungen, Wasserschlag und Wasserüberfüllung.
    - Übersicht über Schockbelastung unter Temperatur und Druck.
- Werkstoffe
    - Werkstoffeigenschaften
    - Übersicht über durchflussbeschleunigte Korrosion
- Wiederholungsprüfungen
    - Messungen der Verschiebungen (von Rohrleitungskomponenten) beim Anlagenbetrieb
    - Zerstörungsfreie Prüfung: Ultraschallprüfung, Modifikationen, Qualifikation, Abläufe und Ergebnisse

Der Ansatz von CEZ a.s. zur Lösung des Sicherheitsproblems „Folgen sekundären Rohrversagens auf der 28,8 m Bühne“ des KKWs Temelin (wie von SÚJB akzeptiert) besteht darin, ein Gebrechen an den Frischdampf- und Speisewasserleitungen (für den Abschnitt von den Durchdringungen durch das Containment bis zu den Isolierventilen) auszuschließen.

Die Ausführungen gaben zwar Aufschluss über den verwendeten Ansatz, erlaubten jedoch auf Grund der überblicksartigen Darstellung nur einen begrenzten Einblick in die Ergebnisse und wie diese erzielt wurden. Eine Reihe von Fragen, die das Expertenteam stellte, wurde von tschechischer Seite als zu sehr ins Detail oder über den Rahmen der Aufgaben des Roadmap-Workshops hinaus gehend erachtet. In der Folge kamen beide Seiten überein, dass das betreffende bilaterale Abkommen zwischen Tschechien und Österreich den geeigneten Rahmen für weitere Diskussionen und Informationsaustausch zu diesen Themenbereichen darstelle.

Die Präsentationen gewährten einen Einblick in die umfangreichen Arbeiten, die der Betreiber der Anlage und die Technischen Support Organisationen zur Konsolidierung der Sicherheitsfragen im Rahmen des „Comprehensive Safety Case Revisit“ (CSCR) für die Genehmigungsbehörde geleistet hatten.

Der Ansatz des österreichischen Expertenteams

Ein Expertenteam von 15 internationalen Experten wurde vom Umweltbundesamt - im Auftrag der österreichischen Regierung – mit dem technischen Support zur Überwachung der Implementierung der HELB-Thematik auf technischer Ebene (wie im Anhang I der Schlussfolgerungen des Melker Prozesses und des Follow-up aufgezeigt) beauftragt. Dieses spezifische technische Projekt wird als Projekt PN2 bezeichnet, welches insgesamt sieben vorgegebene „Projektmeilensteine“ (PM) umfasst.

Um den vorbereitenden Arbeiten des österreichischen Expertenteams eine Ausrichtung zu geben und die österreichische Delegation durch den Experten-Workshop zu führen, aber auch um eine geeignete Vorbereitung des Experten-Workshop auf bilateraler Ebene zu ermöglichen, wurde als **erster Schritt** (Projektmeilenstein 1 (PM1) das Sicherheitsziel in „Überprüfbare Teilaspekte“ („Verifiable Line Items“ (VLIs) aufgegliedert (siehe ANNEX A). Diese wurden auf der Grundlage des „Defence-in-Depth-Prinzips“, einem Konzept zur Aufrechterhaltung der Betriebssicherheit einschließlich eines mehrstufigen Systems von Rückhaltebarrieren, erstellt und zur Beurteilung herangezogen, inwieweit die Sicherheitsmerkmale des KKWs Temelin mit diesem Konzept in Einklang stehen.

In einem **zweiten Schritt** wurde vom Expertenteam eine Dokumentenliste (PM2) „Specific Information Request – SIR“ erstellt, von der anzunehmen ist, dass sie eine Auflistung jener Informationen enthält, die zur ausführlichen Beantwortung der in den VLIs enthaltenen Fragen erforderlich ist (siehe ANNEX D).

Zum **dritten Schritt** der vorbereitenden Arbeiten für den Workshop gehörte auch eine Erhebung der innerhalb der EU-Mitgliedstaaten (Frankreich und Deutschland) bezüglich der HELB-Thematik zugrunde gelegten Normen und Praktiken. Die Praxis in Frankreich und in den USA stellte hier einen besonderen Schwerpunkt dar, da sich der Betreiber von ETE auf deren Regelwerke, Richtlinien und Vorschriften berufen hat. Im Briefing der österreichischen Delegation (PM3) wurden den Teilnehmerinnen und Teilnehmern der Mission diese Elemente des „Monitoring“ vorgestellt.

Im Rahmen des am 7. und 8. November 2002 in Prag abgehaltenen Workshop über HELB und Ventilqualifikation gaben Experten der Betreibergesellschaft der Anlage, Experten von Organisationen zur technischen Unterstützung (Technical Support Organisation, TSO) und Experten der Genehmigungsbehörde 15 gut aufbereitete Videoprojektor-Präsentationen, die nach tschechischer Aussage zusammengestellt wurden, um einen Überblick zu geben. Bis auf einige – wie oben angeführte - Einschränkungen wurden die meisten Fragen des Expertenteams während des Workshops beantwortet.

Nach dem Workshop folgte als **vierter Schritt** (PM4) ein Rückblick auf den Experten-Workshop und die Mitglieder des Expertenteams lieferten Beiträge für den „Preliminary Monitoring Report“. Auf Grund derzeit zur Verfügung stehender Informationen identifizierte das Expertenteam einige der deutlich gewordenen Ergebnisse wie folgt:

Die Anwendung des französischen Tronçons Protegés-Konzepts (Konzept für geschützte Rohrdurchdringungsabschnitte) fordert kurze Rohrleitungsabschnitte ohne Schweißnähte. Das auf Temelin angewandte Bruchausschluss-Konzept betrifft lange Rohrleitungsabschnitte mit vielen Schweißnähten. Ein weiterer „Monitoring Process“ sollte sich daher näher mit dem Weg zur Akzeptanz zu dieser neuen Vorgangsweise und den Anforderungen an die Nachweise befassen, die dazu in einem Einzelgenehmigungsverfahren zu erbringen sind.

Darüber hinaus ist festzustellen, dass die gegenwärtig üblichen deutschen und französischen Genehmigungsansätze die Akzeptanz eines Bruchausschlussnachweises nur dann vorsehen, wenn eine räumliche Trennung gegeben ist (jede einzelne Dampf- oder Speisewasserleitung wird bis zur ersten Durchdringungsarmatur in ihrem eigenen Einschluss oder räumlich getrennt geführt). In den Vorträgen beim Experten-Workshop berichtete die Tschechische Seite über Ergebnisse ihrer Bewertung einer Trennwand, die den Bereich auf der 28,8 m-Bühne in zwei Hälften teilen würde. Während die Errichtung als technisch machbar eingeschätzt worden war, erwuchsen Bedenken hinsichtlich der nachteiligen Auswirkungen, die eine derartige Trennwand auf die Instandhaltung und die Wiederholungsprüfungen der in unmittelbarer Nähe befindlichen Komponenten und Ausrüstungsgegenstände hätte. Den übermittelten Informationen zufolge scheint auch die Errichtung anderer Ausbildungsformen physischer Trennung bei der in Temelin vorgegebenen Anordnung schwierig zu sein. Die Errichtung einer solchen Trennwand ist seitens des Anlagenbetreibers derzeit nicht geplant.

Das Expertenteam wäre daran interessiert, die Grundlagen zu erfahren, auf der die Genehmigungsbehörde diesen einzigartigen Lösungsansatz akzeptiert hat. In diesem Zusammenhang sind folgende Punkte von besonderem Interesse:

- Hinsichtlich der im Falle von Temelin vorliegenden Leitungsführung scheint die Anwendung des Bruchausschluss-Konzeptes, ohne die Auswirkungen anzunehmender Brucherereignisse von hochenergetischen Rohrleitungen auf sicherheitsrelevante Anlagekomponenten zu berücksichtigen, nicht mit der gegenwärtigen Genehmigungspraxis in Deutschland oder Frankreich in Einklang zu stehen.
- Bruchausschluss erfordert eine 100 %ige Prüfung, welche die Oberfläche und das Volumen aller Schweißnähte in der Bruchausschlusszone erfasst (die Anforderungen der amerikanischen Genehmigungsbehörde (US Nuclear Regulatory Commission, US-NRC) lassen in dieser Hinsicht keinerlei Ausnahmen zu).
- Der Ansatz zur zerstörungsfreien Werkstoffprüfung ist in der Form, wie er von den Experten der Betreibergesellschaft beim Workshop dargestellt worden ist, derzeit nicht geeignet, allen im Zuge der Prüfungen der Schweißnähte an den Dampf- und Speisewasserleitungen auftretenden Schwierigkeiten zu begegnen.
- Die Anwendungen des Bruchausschlusses (z.B. entsprechend den Regeln des deutschen Kerntechnischen Ausschusses (KTA) und den Anforderungen des französischen Tronçons Protégés-Konzepts) erfordern nach Schweißnahtlegung eine Wärmenachbehandlung und eine Nachbehandlung der Schweißnahtoberfläche. Das Expertenteam wurde beim Workshop darüber informiert, dass bis dato keine der beiden Behandlungsformen an den Schweißnähten der Bruchausschlusszone in Temelin durchgeführt worden ist. Es sollte daher in Zukunft besonders Bedacht darauf genommen werden, dass der Behandlungszustand der Schweißnähte den Bruchausschluss-Anforderungen entspricht.
- Die Werkstoffdaten hinsichtlich Zugfestigkeitseigenschaften, die zum Nachweis der Erfüllung mechanischer Spannungskriterien herangezogen werden, sind weder die der Auslegungsvorschrift zugrunde liegenden Nennwerte, noch die vom Hersteller für den tatsächlich eingesetzten Rohrleitungswerkstoff gewährleisteten Minimalwerte. Würde einer dieser beiden Werkstoffkennwerte herangezogen, so wären die Bruchausschlusskriterien nicht erfüllt. Stattdessen werden die Kennwerte für die Werkstoffeigenschaften von Proben abgeleitet, deren Übereinstimmung mit dem tatsächlich zum Einsatz gekommenen Rohrleitungswerkstoff allerdings nicht nachgewiesen wurde. Eine genaue Untersuchung der zur Verfügung stehenden Quellen für Werkstoffdaten sollte in Betracht gezogen werden. Sobald weitere Daten verfügbar sind, sollte ihre Tauglichkeit für eine Verbreiterung der Datenbasis betreffend Werkstoffeigenschaften geprüft werden.
- Auf der Grundlage der beim Workshop vorgestellten Informationen kann die volle Funktionstüchtigkeit der Ausschlagsicherungen noch nicht als nachgewiesen angesehen werden. Dies trifft insbesondere auf die Schweißnähte für die Ringbefestigung an den Durchdringungen des Sicherheitseinschlusses zu. Das ist hauptsächlich darauf zurückzuführen, dass jene Ereignisse, die als wesentliche Auslöser für Belastungen der Rohrleitungen ein-

gestuft worden sind, noch nicht lückenlos aufgearbeitet sind. Ereignisse von möglicherweise folgenschwerer Bedeutung, wie große Leckage vom Primär- zum Sekundärkreislauf oder der Referenz-Flugzeugaufprall, sind augenscheinlich bis dato noch nicht einbezogen worden.

- Unter Berücksichtigung der oben festgestellten Einschränkungen wäre die gesamthafte Einschätzung der Verhaltensweise des Primärkühlkreislaufes und des Reaktorkerns unter jenen Bedingungen von besonderer Bedeutung, die mehrfachen Dampfleitungsabrissen innerhalb des Gebäudeabschnittes auf der 28,8 m Bühne folgen würden.

Bisheriges Ergebnis des Monitoringprozesses

Seit der Problemkreis um die Bruchereignisse von hochenergieführenden Rohrleitungen vor einigen Jahren erkannt wurde, wird in umfassender Weise auf Verbesserungen hingearbeitet. Die Arbeiten reichen von detaillierten Überprüfungen bis hin zu den im Zuge des jüngsten "Comprehensive Safety Case Revisit" getroffenen Maßnahmen. Bezugnehmend auf die im Austrian Technical Position Paper (ATTP) festgehaltenen Bedenken ergibt der Vergleich mit dem heutigen Stand, dass in einigen Bereichen Verbesserungen erzielt worden sind.

An dieser Stelle soll jedoch angemerkt werden, dass das Expertenteam derzeit einigen Sichtweisen und Erwartungshaltungen nicht folgen kann, die die tschechische Seite in Bezug auf die Anwendbarkeit des Bruchausschlusskonzeptes aufrecht erhält.

Im Bewusstsein, dass das einschlägige Tschechisch-Österreichische Bilaterale Nuklearinformationsabkommen einen geeigneten Rahmen für weitere Diskussion und zusätzlichen Informationsaustausch darstellt, würde es das Expertenteam begrüßen, seine wesentlichen Erkenntnisse im weiteren Verlauf des HELB-Monitoringprozesses in diesem Rahmen erörtern zu können.

Der bisherige Verlauf des „Monitoring Process“ ermöglichte es, bereits eine Reihe von VLIs abzuklären, wie die Gegenüberstellung der Ergebnisse des Workshops und der VLIs zeigt. Prioritäten wären nun dort zu setzen, wo zusätzliche Informationen einem fundierten Ergebnis des „Monitoring Process“ am förderlichsten wären. Demnach kann das weitere Monitoring auf drei wesentliche Sachfragenkomplexe eingegrenzt werden, die noch einer näheren Behandlung bedürfen:

1. Zu den **Werkstoffen,** die sekundärseitig für die hochenergieführenden Leitungen verwendet wurden:

   Die Anforderungen an die Werkstoffeigenschaften und die Prüfung der entsprechenden Eigenschaften der für die hochenergieführenden Leitungen auf der 28,8 m-Bühne verwendeten Werkstoffe sollten durch hinreichend qualifizierte Nachweise belegt werden.

   Die umfassende Spezifikation der Werkstoffeigenschaften, die für den Spannungssicherheitsnachweis, den Bruchausschlussnachweis und die Bestimmung der Rissausbreitung bis zum Bruch an jenen Stellen, wo Ausschlagsicherungen angebracht sind, verwendet wird, sollte zugänglich gemacht werden. Die betreffenden Unterlagen sollten ebenfalls die für die Festlegung der Werkstoffeigenschaften herangezogene Datenbasis sowie angewandte Normen, Regeln und Vorschriften enthalten.

Das Monitoring sollte sich darauf konzentrieren, inwieweit nach zwingenden Normen, Regeln und Vorschriften Kennwerte für die Werkstoffeigenschaften verwendet werden und welche Bedeutung diesen Kennwerten beim Zulassungsvorgang für Bauteile und Baugruppen zukommt.

2. Zur **Überprüfung des Bruchausschlusskonzeptes**:

Die Zulässigkeit der besonderen Anwendung von Bruchausschlussannahmen und deren großzügigen Auslegung, sowie der damit verbundenen Bestimmung der Bruchlagen sollte durch schlüssige Resultate aus Wahrscheinlichkeitsüberlegungen unterstützt werden.

Die Ergebnisse der Wahrscheinlichkeitsanalysen sollten für das Monitoring zugänglich sein. Die Wahrscheinlichkeitsanalysen sollten die Versagenswahrscheinlichkeiten der gesamten Leitungsführung bis zu den ersten Durchdringungsarmaturen einbeziehen. Darüber hinaus sollten auch Ergebnisse aus bruchmechanischen Wahrscheinlichkeitsanalysen für jene Leitungsführung, die den maximalen Belastungen ausgesetzt ist, zugänglich sein.

Für die besondere Anordnung der Leitungsführung auf der 28,8 m-Bühne sind bestimmte Bruchhäufigkeitsannahmen üblich sowie bestimmte Wiederholungsprüfungen vorgesehen. Der Monitoringprozess sollte zu beiden auf Vergleiche mit der Industriepraxis abzielen.

3. Zu den **Unfallfolgen**:

Das Verhalten des Kernkraftwerkes unter Unfallbedingungen, die durch Brüche hochenergieführender Leitungen hervorgerufen würden, erfordert umfangreiche Analysen verschiedenartiger Unfallverläufe, um Möglichkeiten der Verminderung von Unfallfolgen verstehen zu können.

Ein exemplarisches Unfallszenario sollte für das KKW Temelin untersucht werden: Unter Volllast treten Brüche an hochenergetischen Leitungen auf, und die Reaktorschnellabschaltung ist nicht erfolgreich. Zum Vergleich sollten Ergebnisse aus Untersuchungen des Reaktorkerns bei Vollleistung, eines Bruches einer Hauptsekundärleitung und des Versagens der Reaktorschnellabschaltung, bei dem einer der Regelstäbe in ausgefahrener Stellung stecken geblieben ist, zugänglich gemacht werden.

Das Monitoring sollte sich darauf konzentrieren, in welchem Ausmaß sich Unfälle mit Folgewirkung auf den Reaktorkern zu Ereignissen entwickeln, bei denen vermutlich Radioaktivität freigesetzt wird.

Das Expertenteam sieht der Diskussion der für den weiteren Monitoringprozess in den oben angeführten drei Bereichen verbleibenden Fragestellungen zu Brucherereignissen an hochenergieführenden Leitungen mit Interesse entgegen.

Es wäre anzumerken, dass die Einschätzung technischer Angemessenheit eng mit einer Anzahl anderer „Roadmap“-Punkte verbunden ist. Deshalb wird eine abschließende Beurteilung erst am Ende des Monitoring-Prozesses auf technischer Ebene, wie er in der „Roadmap“ festgelegt wurde, möglich sein, wenn Ergebnisse anderer „Roadmap“-Ereignisse wie auch zusätzlicher Informationen, die unter anderem im Rahmen des einschlägigen Tschechisch-Österreichischen Informationsabkommens zugänglich werden könnten, einbezogen werden.

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1 INTRODUCTION

The Republic of Austria and the Czech Republic have, using the good offices of Commissioner Verheugen, reached an accord on the "Conclusions of the Melk Process and Follow-up" on 29 November 2001. In order to enable an effective use of the "Melk Process" achievements in the area of nuclear safety, the Annex I of this "Brussels Agreement" contains details on specific actions to be taken as a follow-up to the "trialogue" of the "Melk Process" in the framework of the pertinent Czech-Austrian Bilateral Agreement.

To enable an effective "trialogue" follow-up in the framework of the pertinent Czech-Austrian Bilateral Agreement, a seven-item structure given in Annex I of the "Brussels Agreement" has been adopted. Individual items are linked to:

- Specific objectives set in licensing case for NPP Temelin units;
- Description of present status and future actions foreseen by the licensee and SÚJB respectively.

Each item under discussion will be pursued according to the work plan agreed at the Annual Meeting organised under the pertinent Czech-Austrian Bilateral Agreement.

Furthermore, the Commission on the Assessment of Environmental Impact of the Temelín NPP - set up based on a resolution of the Government of the Czech Republic - presented a report and recommended in its Position the implementation of twenty-one concrete measures (Annex II of the "Brussels Agreement).

The signatories agreed that the implementation of the said measures would also be regularly monitored jointly by Czech and Austrian experts within the Czech-Austrian Bilateral Agreement.

A "Roadmap" regarding the monitoring on the technical level in the framework of the pertinent Czech-Austrian Bilateral Agreement as foreseen in the "Brussels Agreement" has been elaborated and agreed by the Deputy Prime Minister and Minister of Foreign Affairs of the Czech Republic and the Minister of Agriculture and Forestry, Environment and Water Management of the Republic of Austria on 10 December 2001.

This „Roadmap" is based on the following principles:

- *The implementation of activities enumerated in Annex I and II of the "Brussels Agreement" will be continued to ensure that comprehensive material is available for the monitoring activities set out below.*
- *Having in mind the peer review procedure foreseen by the EU to monitor the implementation of the recommendations of the AQG/WPNS Report on Nuclear Safety in the Context of Enlargement, the Czech and Austrian sides agree that this peer review should serve as another important tool to handle remaining nuclear safety issues.*
- *As a general rule the regular annual meetings according to Art. 7(1) of the bilateral Agreement between the Government of Austria and the Government of the Czech Republic on Issues of Common Interest in the Field of Nuclear Safety and Radiation Protection will serve to monitor the implementation of those measures referred to in Chapter V of the Conclusions and to address questions regarding nuclear safety in general, in particular those issues which – according to Chapter IV of the Conclusions - have been found, due to the nature of the respective topics, suitable to be followed-up in the framework of this Bilateral Agreement.*
- *In addition, specialists' workshops and topical meetings will take place, organised as additional meetings according to Art. 7(4) of the bilateral Agreement between the Government of Austria and the Government of the Czech Republic on Issues of Common Interest in the Field of Nuclear Safety and Radiation Protection, as set out in the "Roadmap".*

The Federal Ministry of Agriculture, Forestry, Environment and Water Management entrusted the Umweltbundesamt (Federal Environment Agency Ltd. with the general management of the implementation of the "Roadmap". Each entry to the "Roadmap" corresponds to a specific technical project.

Item No.1 "High Energy Pipe Lines at the 28.8 m Level" of Annex 1 of the "Brussels Agreement" covers the integrity of the main steam and feed water piping at the 28,8 meter level of the Temelín reactor buildings, where this piping transits from the respective containment penetrations to the turbine hall. This issue is frequently referred to as "High Energy Line Breaks" or HELBs. The objective regarding this item as stated in Annex I of the "Brussels Agreement" is to "*ensure that the safety case demonstrating appropriate protection against high energy pipe breaks and consequential failures of the steam and feed water lines, complies with requirements and practices widely applied within the EU and that an appropriate combination of measures are in place".*

Annex I of the "Brussels Agreement" further specified the "Present Status and Specific Actions Planned" as follows:

"The issue of protection against high energy pipe breaks and consequential failures of the steam and feed water lines is included in the existing licensing case of Temelin unit No.1. To solve the difference in opinions of experts with regard to this issue, the Regulatory Authority initiated revisit of the safety case documentation in order to re-evaluate its compliance with requirements and practices widely applied in the EU. Alternative methods of assessment are being applied for this purpose as well as data collected during unit No. 1 commissioning tests. The result of these efforts will be made available to the Regulatory Authority till the end of September 2002 for final decision. Depending on the result, schedule for implementation of additional safety measures may be included into the above - mentioned regulatory submittal[1]. The signatories understand that additional safety measures for both units will be considered by the Regulatory Authority and if needed included into the above mentioned regulatory decision in order to meet the objective of this item."

The "Roadmap" specified that a Specialists' Workshop would be held in Prague in the 2nd half of 2002 to discuss this issue.

A Specialists' Team of 16 international experts was committed by the Environmental Agency Ltd. on behalf of the Austrian Government to give technical support for the monitoring on the technical level of the implementation of the HELB Issue as listed in Annex I of the Conclusions of the Melk Process and Follow-up. This specific technical project is referred to as project PN2 comprising altogether seven predefined "project milestones" (PM).

To focus preparatory work of the Austrian Specialists' Team and to guide the Austrian Delegation through the Specialists' Workshop but also to enable proper preparation of the Specialists' Workshop on the bilateral level, in a **first step** Project Milestone 1 (PM1) the safety objective was broken down to Verifiable Line Items (VLIs) (see ANNEX A). They were based on the Defence in Depth principle applied to qualify Temelin NPP's safety features consistency.

In a **second step** the Specialists' Team prepared a list of documents (PM2) the Specific Information Request – SIR, considered to contain the kind of information required to provide for profound answers to the VLIs (see ANNEX D)[2].

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[1] For details see Sixth Additional Information to the Position Paper on Chapter 14 "Energy" submitted to the EC in September 2001

[2] The SIR, as updated after the Prague Specialists' Workshop is listed in Annex C

The **third step** in the preparatory work for the Workshop also included identification of standards and practices applied within the European Union Member States for the HELB issue (France and Germany). The focus was placed on practices in Belgium, Finland, France, Germany, Spain and Sweden (since these EU Member States have several operating pressurised water reactors), with less emphasis on practices in the Netherlands and the United Kingdom (since each of these EU Member States have only one operating PWR). In addition, practice in the US has been considered extensively, since the operator of ETE applied US-codes, rules and regulations. In the Briefing to the Austrian Delegation (PM3) these elements of the monitoring were presented to the mission participants.

Prior to the week before the Specialists Workshop, little new information had become available since July 2001 the delivery date of the Austrian Technical Position Paper [ATPP 2001], containing the Austrian conclusions at the end of the tripartite process.

The Temelín Roadmap Specialists' Workshop on HELB and Valve Qualification (another issue defined by the Roadmap that is closely interrelated with the HELB issue PN 3 "Qualification of Valves") took place in Prague on 7 – 8 November 2002.

Electronic copies of most of the presentations (listed in ANNEX B) were made available a few days prior to the Workshop, and the representative of the Czech licensing authority provided copies of his presentation at the workshop.

Experts from ČEZ a.s., the Nuclear Research Institute Řež plc, the Institute of Applied Mechanics Brno, Ltd., and from the SÚJB made fifteen well-prepared slide beamer presentations, characterised by one presenter as being of an overview nature. Following the presentations, time was provided for questions from the Specialists' Team.

A number of questions posed by the Specialists' Team were considered to exceed the level of detail or the scope of the Roadmap Workshop activities by the Czech side. Discussion on these questions was limited to side conversations. No additional background documents were supplied to the Specialists' Team up to now.

Following the Workshop in this **fourth step** (PM4), the Specialists' Team reviewed the Specialists' Workshop and the Specialists' Team members provided contributions to the Preliminary Monitoring Report (PMR). Based on information currently available, the Specialists' Team has compiled several results that have become evident.

This Preliminary Monitoring Report is based on evaluations by the Specialists' Team of the presentations and discussions during the Specialists' Workshop: the findings of the specialists were exchanged and discussed after the workshop and the Preliminary Monitoring Report (PMR) was reviewed in an internal workshop of the Specialists' Team held on 8 and 9 December 2002 in Vienna.

The evaluations in the PMR address three different levels of the process by commenting

(a) on the adequacy of the information available in view of the monitoring task (i.e. the presentations) and

(b) on the adequacy of the technical approach as such

(c) on issues directed towards a resolution of the safety issue addressed and on its interrelation to the projects PN 3 "Qualification of Valves" and PN 4 "Qualification of Safety Classified Components" Items.

Note that the assessment of technical adequacy is closely related to a number of other "Roadmap" items. Consequently, a final evaluation will only be possible by the end of the Monitoring process on the technical level, as set out in the Roadmap, taking into account the results of other Roadmap events as well as additional information which might be available, inter alia in the framework of the pertinent Czech-Austrian Information Agreement.

2 ISSUE SPECIFICATION AND CZECH RESPONSE

2.1 Specification

In the VVER-1000 design adopted at the Temelín 28,8 m level (see Figure 2 and Figure 3), there are four main steam pipes and four main feed water pipes.

The steam pipes travel in pairs on opposite sides of the containment, penetrating the containment wall, and following a number of bends until they reach the main steam isolation valves (MSIVs) in pairs on opposite sides of the front of the 28,8 meter elevation of the reactor building. The steam pipes are arranged such that in case rupture of one pipe occurs, the consequential failure of any second adjacent line is not precluded. However, due to the geometric location of the MSIVs, the coinciding rupture of three or four steam pipes between the containment penetration and the isolation valves is very unlikely. (External events are not within the scope of this report).

Three piping loops, referred to as "bubliks" (see Figure 3), are connected to each main steam pipe, each with a T-joint and a valve. One of the valves is a main steam relief valve (BRU-A), and two of the valves are main steam safety valves (MSSVs).

The feed water pipes are likewise arranged in pairs on opposite sides of the containment, underneath the steam lines. The feed water lines travel from the containment penetrations, and follow a number of bends until they reach the feed water isolation valves. The feed water isolation valves are located in a row at the very front of the 28,8 meter level, and in this area it is in principle possible to rupture more than two feed water pipes.

In the Technical Position Paper issued near the conclusion of the Melk Process, the Austrian position on the HELB issue was set forth as follows [ATPP 2001]:

> *In case of a rupture of one or more of these lines damage of adjacent lines as well as other safety-relevant equipment cannot be excluded as a consequence of pipe whip and/or jet impingement effects by discharged material. This could trigger an accident sequence causing large radioactive releases. This issue has not been sufficiently addressed.*
>
> *The main objective of adequate re-assessment and reconstruction of the 28.8 m level must be to physically exclude multiple steam line breaks and consequential component and equipment failures that cannot be compensated by the safety systems and thus could result in severe accidents with potential large release of radioactivity.*

As part of the accession process of the Czech Republic to the European Union, the Atomic Questions Group (AQG) of the Council of the European Union and its ad-hoc Working Party on Nuclear Safety (WPNS) were mandated to examine the nuclear safety status, inter alia, of the Temelin NPP in the Czech Republic. In a country-specific recommendation, the AQG/WPNS recommended [WPNS 200]:

> *Ensure that the safety case demonstrating appropriate protection against high energy pipe breaks and consequential failures of the steam and feed water lines, complies with requirements and practices widely applied within the EU and that an appropriate combination of measures are in place.*

The safety issue of concern therefore is, that a rupture of a high energy line (HEL) at the 28,8 m level (see Figure 1) can induce consequential failures. These failures can cause the event to exceed Design Basis Accident conditions, as assumed for the accident analyses of the Pre-Operational Safety Analysis Report [POSAR] and the accident consequences can eventually lead to unacceptable environmental effects.

2.2 Response to the HELB issue

How to deal with this safety issue is clearly indicated, as an example, in the U.S. NRC Standard Review Plan [NUREG 0800], Section 3.6.1, where guidance is given to the regulator on how to review the plant design for protection against piping failures outside containment. European requirements and practices are very similar and sometimes even more stringent.

> The plant design is reviewed *"to assure that such failures would not cause the loss of needed functions of safety related systems and to assure that the plant could be safely shut down in the event of such failures"* [NUREG 0800] and subsequently kept in stable and safe shut down condition.

The acceptability of the plant design against these postulated pipe breaks is based on the U.S. General Design Criterion 4 of [10 CFR 50] Appendix A, requesting structures, systems and components "important to safety" to be designed to accommodate the dynamic effects of a postulated pipe rupture, including the effects of pipe whip and discharging fluids. Rupture locations and dynamic effects associated with the postulated rupture are determined in Section 3.6.2 of the Standard Review Plan and in the associated Branch Technical Positions.

In finally assessing the Safety Issue the State Office for Nuclear Safety initiated, what it refers to as a "Comprehensive Safety Case Revisit" (CSCR) of the HELB issue by requesting ČEZ, a.s. to "produce safety documentation enabling SÚJB to settle the discrepancy *in opinions of experts on above mentioned issues in a way standard for regulatory practices - by reassessment of existing safety case taking into account newly available information and technical arguments*" [WPNS 200].

The bases for SÚJB approval of the main steam and feed water piping design at the ETE 28,8 m elevation in the initial licensing stage were as follows (as cited in the presentation by the representative of the licensing authority):

- Implementation of a quality assurance system (including non-destructive testing plan) for design, manufacture and installation of the high-energy pipes in order to decrease the possibility of any sudden pipe break
- Postulation of locations where a break is possible in reality (according to the US Nuclear Regulatory Commission's Standard Review Plan [USNRC SRP] Section 3.6.2) and subsequent installation of whip restraints at these locations to eliminate the possibility of consequential failures of the main steam lines and main feed water lines
- Re-routing of the emergency feed water system piping out of the critical area at the 28,8 meter elevation

In the CSCR, ČEZ a.s. has settled on an approach known as "break exclusion" — that is to exclude the possibility of a break of the piping between the containment wall and the first isolation valves in the main steam and main feed water system (see Figure 2) by reducing break likelihood to such a low value that pipe rupture consequences need not be subject to further design measures.

As part of the CSCR, ČEZ, a.s. has identified a combination of three out of four investigated steps, when applying break exclusion to the main steam and feed water piping at ETE in order to resolve the HELBs issue [SWSPR 2002]:

- Confirmation of correct location and design of pipe whip restraints, with circumferential welds covered by the pipe whip restraints inspected by qualified ultrasonic testing (UT) procedures in accordance with the European Network on Inspection Qualification (ENIQ).

- Application of the break exclusion principle to the pipelines from the containment penetration to the first isolation valves outside containment, including a requirement for 100 % volumetric qualified UT examinations for all welds in the high energy piping system from the containment penetrations to the first isolation valves (see Figure 3).
- Implementation of main steam and feed water line monitoring (pipe wall thinning predictive calculations with follow-up wall thickness measurements), management of chemical composition of feed water, and pipe displacement measurements during commissioning tests and refuelling outages (as needed).
- After considering the positive and negative aspects of a possible separation wall (which was found to be feasible to be installed between the two pairs of main steam lines and main feed water lines), the SÚJB decided not to require installation of the separation wall. This decision was based on negative influences of the wall on in-service inspections of the main steam and feed water piping, and on benefits of the combination of pipe whip restraints, application of break exclusion, and periodic piping system monitoring.

The essentially new element to be considered was introduced by the plant operator, ČEZ a.s., under the acronym “Superpipe Concept” as a sound demonstration of the break exclusion based upon European Code (in this case French) requirements. For this purpose the requirements imposed according to the French rules [RCC-P and RCC-M] had to be adapted to the licensing requirements environment of Temelín NPP (e.g. by rules and/or regulations adopted by the Czech Association of Mechanical Engineers (AME)).

The licensing authority SÚJB has approved the above approach, and the Council of the European Union has been informed of this decision by a note submitted by the Czech Government in October 2002 [AQG CZ 2002].

In the Prague Workshop on 7 and 8 November 2002 the approach to cope with this safety issue has been explained to the Specialists’ Team in a series of presentations: it is mainly based on the HEL break exclusion approach and relies on improved in-service inspection procedures. A variety of interrelated problems, such as material quality, erosion-corrosion effects, Non Destructive Evaluation and pipe break probability quantification were also addressed in the presentations.

3 EVALUATION OF THE SPECIALISTS' WORKSHOP PRESENTATIONS AND IDENTIFICATION OF OPEN ISSUES BY THE SPECIALISTS' TEAM

This evaluation is made following the presentations during the Workshop. It groups the Monitoring results, comments, observations and annotations according to technological categories they might be attributed to, in order to provide more insight into the topics treated.

The results presented here (Chapter 3) are used to obtain preliminary Monitoring results regarding the VLIs (Chapter 4) as well as summary conclusions (Chapter 5).

3.1 Overall evaluation of the approach in resolving the issue

The overall monitoring process preparation followed the "defence-in-depth"[3] principle of preventive, protective and mitigative safety measures on which the plant design is based. The application of this principle is reviewed.

The Specialists Team broke the safety objectives down into a set of 18 "monitoring items" that are logically interrelated[4], but manageable separately as VLIs, derived from Section 3.6.1 of the Standard Review Plan and plant design experience.

Monitoring is done to verify whether the operator's response to the HELB issue can be interpreted as a consistent, comprehensive and sustainable application of the "Defense in Depth" concept (DID) according to the 18 Verifiable Line Items (VLIs).

For this verification all of the following 18 "monitoring items" need to be carefully pursued for comprehensive and thorough monitoring of the implementation of the solution to the HELB safety issue.

1	Monitoring of piping design approach and piping stress analysis methodology, considering piping and components qualifications, service levels, load combinations (including expected and unexpected steam/water hammer effects)
2	Monitoring of the criteria used to select pipe break locations and orientations
3	Monitoring of the postulated "aggressive" HELB points assumed in the analysis ("aggressive" means: "which can damage structures, systems or components important to safety sufficiently to impair safety functions to an unacceptable level")
4	Monitoring of pipe internal dynamic fluid forces effects as a consequence of the postulated HELB (including geometry effects and blowdown characteristics)
5	Monitoring of the non-linear mechanical analysis to determine the whipping pipes dynamic response
6	Monitoring of the evaluation of jet impingement shapes, temperatures, pressures, directions and loads, insofar as to find out whether jet forces impulse to HEL or walls or components are likely to cause consequential failures

[3] The DID concept has been confirmed by the operator to be one of the governing principles of the nuclear safety concepts' implementation at ETE. [NRNSC2001under 13.1.3 p. 100]

[4] see ANNEX A The MONITORING scope of the project PN2

7	Monitoring of the proposed measures to protect safety related equipment from pipe whip, blowdown jets and reaction forces, and separation of redundant features (requirements, material properties & sizing of pipe whip restraints and separating shields)
8	Monitoring of the methodology and analyses of compartment pressurisation and environmental conditions following a postulated HELB
9	Monitoring of the structural design loads including pressure & temperature transients and dynamic reactions as consequences from HELB
10	Monitoring of the methodology for evaluation of structural adequacy of Seismic Category I structures (those civil structures required to fulfil safety functions)
11	Monitoring of the structural analysis evaluation including local loads on the concrete Category I structures and non-safety structures whose damage may impair the safety of the plant
12	Monitoring of the structural failures, environmental conditions and potential flooding that might result in loss of safety functions including Monitoring of main control room habitability
13	Monitoring of the adequacy of the safety class components environmental qualification. This should be addressed in PN4. Only identification of candidate components requested
14	Monitoring of the analysis methodologies to evaluate the plant response to MS & MFW HELB outside containment
15	Monitoring, based on plant safety analysis, for performances of mitigating systems, radiological consequences calculations and Monitoring of adequacy of emergency procedures to mitigate MS & MFW HELB outside containment and their extension into SAMGs
16	Monitoring of adequacy of MS & MFW piping outside containment in-service inspections programs
17	Monitoring of event frequency evaluation of HELB and of consequential failures
18	Monitoring of requirements for materials used and for material degradation to be taken into account

In essence, the results of the Workshop should have provided answers related to all these VLIs. Note that the presentations during this workshop did not explicitly follow the 18 “monitoring items” or the DID concept applied.

3.1.1 Adequacy of the information in view of the monitoring task

There is a clear consensus amongst the Specialists’ Team that the presentations by ČEZ a.s. and SÚJB were informative, but at a very general level. The full report versions of the Comprehensive Safety Case Revisit (CSCR) as submitted by ČEZ a.s. to the SÚJB, and of the formal SÚJB decision on the CSCR could have been made available. This fact limits conclusions that can be drawn in this report directed to the Austrian government. The Specific Information Request (SIR) indicates the areas where additional information would have been an asset to the monitoring results.

3.1.2 Adequacy of the technical solutions presented

The demonstrated applicability of a break exclusion concept requires that a comprehensive combination of preventive, protective and mitigative measures be developed, implemented and sustained during operation of a NPP. The Specialists‘ Team investigated how the DID concept is upheld under the prevailing special conditions, and monitored the quality of this process based on the information provided by the Czech side. In doing so the Specialists' Team arrived at the following views:

- Correct positioning and design of pipe whip restraints, comprehensive NDT, and extensive periodic pipe monitoring (e.g., wall thickness measurements) are part and parcel of the break exclusion concept as intended by properly applying the provisions of the code chosen [STD-MATL]. These factors are generally not considered "independent" levels of protection or “safety layers” as asserted by the experts of the plant operator, the licensing authority and the representative of the TSO. Indeed, these factors are safety related precautionary measures and part and parcel of whatever approach is taken to secondary piping integrity, and are not unique to break exclusion. Furthermore, application of break exclusion without fully qualified application of pipe whip restraints, comprehensive NDT and extensive periodic pipe monitoring would not be acceptable according to up-to-date European codes of practice.
- The protection implemented against HELB at Temelín is based on the application of a break exclusion assumption. In contrast with defence-in-depth (which recognises the supporting and integrated roles of prevention, protection, qualification, and mitigation), the approach employs prevention and mitigation only. The presenters from the plant operator, the licensing authority and the TSO confirmed this fact.
- The basis for changing the defence-in-depth (DID) concept in this specific instance was not put forward by the Czech side. The break exclusion approach applied can only be considered as being part of the solution to the item of concern.
- Another part, the analyses and evaluation of the consequences of breaks on structures, systems and components relevant to safety, that in any case must be postulated (e.g. at the terminal ends or along the “bubliks”), has not been addressed in the Specialists' Workshop nor in other documentation accessible by the Specialists' Team up to now.
- The proposed solution is a “first of its kind“ solution to the best knowledge of the Specialists' Team. While this does not mean that it cannot be accepted by the licensing authority, once in possession of the complete evidence provided by the operator, the Specialists' Team finds it difficult to envision licensability in EU countries or in the US based on the information currently available. Application of the break exclusion approach to piping of such an extent requires adequate justification and applicability demonstration, which has to be backed up by consistently qualifying the approach to the highest standards' requirements and should be supported properly with adequate technological evidence. Demonstrated admissibility of multiple HELBs implies acceptance of CCF/CMF and must be argued in the licensing process.
- From the presentations, it was unclear to what extent the accepted HELB solution follows either the USNRC Standard Review Plan or the ANSI/ANS requirements for postulation of high energy line break locations. The Specialists' Team considers it unlikely that the solution complies either with the US-NRC Standard Review Plan (to which the Czech side pointed, both ČEZ a.s. and the SÚJB) or with the ANSI/ANS requirements. AME[5] requirements were not presented and documentation about the standards applied which could justify this extended scope of application was not available.
- The codes, standards, rules and regulations applied could not be identified from the available presentations. No evidence was given on how the gaps between the original design code, standard, rules and regulations and those used for HELB solution, qualification and requalification have been bridged by the plant operators' approach. The procedures adopted to mingle different code and standards requirements while introducing the so-called Superpipe Concept were only touched upon on several occasions in the presentations.

5 The Czech Association of Mechanical Engineers was cited to have played a key role in the “Superpipe” Concept development. The definition of and obligations related to this work were not explained.

- Given the existing piping layout in place at Temelín, break exclusion application, without considering the consequences of the postulated HELBs on the equipment related to safety, would not conform to current French and German practice. There was no evidence that the so-called "aggressive" break points were identified as required by the applied French codes. Analyses of consequential failures due to dynamic effects, jet impingement, pipe whip, etc. were not performed taking into account the break exclusion concept as applied here. This might be the reason why the protection of safety-related structures, systems and components located in the area was not addressed at all by the presentations.
- A proposal of physical separation of Main Steam and Main Feed Water lines with a wall at 28,8 m level, in accordance with Western recommendations, was made and submitted by the plant operator as a protective safety feature. It was disregarded by SÚJB because of the “significant restriction of maintenance and in-service inspection” caused by its presence in the area. A comparison with the break exclusion approach as defined by the U.S. Standard Review Plan (see ANNEX C), indicates that such a position is rather unlikely to be supported in the licensing process.
- Prevention and – if applicable - protection measures are not clearly distinguished, and defence in depth principles are apparently not realised to the full extent in the adopted solution. The operator should remain vigilant about the potential implications on safety culture.

3.2 Specific technical evaluations

In the following chapters, ten specific monitoring areas are addressed by the Specialists' Team; these relate to the:

- Break exclusion concept for the high energy lines at the 28,8 m level,
- Water hammer loadings to the high energy lines during transient and accident conditions,
- Pipe wall thickness measurements to monitor erosion/corrosion,
- PTS Methodology & Harmonisation with EU Practice in the context of multiple steam line breaks,
- Materials Database extension due to lack of abundant archive original material,
- Qualification of UT NDE for the welds of the high energy line piping,
- Operational Displacement Measurements for high energy lines structure,
- High energy lines Pipe Break Probability Calculations,
- Thermal Hydraulic Analysis (TH) of the reactor system in response to a multiple steam line break,
- Comprehensive Safety Case Revisit (SÚJB Position).

History and background of the break exclusion approach as adopted by ČEZ:

Exclusion of any break along large portions of the HELs was the original and first approach of the operator to cope with the problem of the adjacent high energy lines at the 28,8 m level. The erosion/corrosion degradation effects during operation are considered to be the prime cause for failure. A more adequate water chemistry operation regime in the feed water lines was one of the justifications to support this original approach.

The operator replaced this original approach after non-applicability was determined by a second approach, one, which considered breaks but only at selected locations of the pipelines. These breaks were postulated according USNRC rules only for pipe sections where calculated stresses exceed the maximum allowable stress applicable for the individual pipe sections (at the containment penetrations and at the pipe whip restraints located close to the turbine hall separation wall).

This second approach turned out to be unsatisfactory as well. This is clearly documented by the WPNS country report [WPNS 200] for the Czech Republic and the response by the Czech authority indicating a revisit of the “safety case” at the 28,8 m level.

The result of this revisit is the ex-post demonstration of compliance with the so-called Superpipe Concept performed by the operator and accepted by the licensing authority. The “Superpipe Concept” as applied here is an extension of the original Tronçons Protégés, according to e.g. RCC-P 1400 Troisieme Partie Regles d’Interface 3.1 Régles d’Installation ref. 3.13.6.3 [RCC-P] in combination with the material usage limits applicable according to [RCC-M], paragraph C 3650 etc. [see RCC-P]. The French concept is one European variant of the original US-NRC break exclusion design concept, defining the application conditions with respect to special design requirements, material quality, manufacturing quality, in service inspection, operation conditions monitoring, etc.

This concept can be applied for portions of straight pipes and bends in case all associated requirements are fulfilled.

However, after reviewing the related presentations of the Czech side, the Specialists’ Team has reservations concerning the fulfilment of these requirements. The following items address the roots of these reservations.

3.2.1 Break Exclusion ("Superpipe")

The “Superpipe” Concept as developed for the Temelin case has not been presented to the full extent, perhaps because it is said to have been derived from the French Tronçons Protégés RCC code provisions [RCC-P] and [RCC-M]. Nevertheless, it is important to note that the “Superpipe” Concept as such is a novel approach going far beyond previous applications. Therefore, it needs to be coherently composed as a comprehensive concept. In particular, the verification of its integration into the codes, rules and regulations originally applied to ETE before implementation would have deserved special attention. Furthermore, compliance with the requirements imposed by two specifications derived from two different codes has not been presented.

- The EU as well as the US licensing practice in applying the break exclusion concept to secondary piping is to demonstrate exclusion of breaks only for short straight pipe sections. In the case of the main steam and feed water Temelín piping layout ETE applies break exclusion for the first time in Europe for a layout with several welds over a distance of tens of meters (see Figure 3) including 90 degree bends. At the same time the “bubliks” piping loops connected via T-joints to the main steam and feed water lines and leading to the relief valves and safety valves are excluded from this break exclusion demonstration, although the piping diameter is close to the main piping these loops are connected to. Considering rules and regulations and widely accepted requirements in the EU the design features as implemented represent a deviation from standard practice. The Specialists are therefore of the opinion that the standard justification is not sufficient and that more extensive evidence (see ANNEX A) would be required.
- The operator has strictly limited the application of the break exclusion concept to the main steam and feed water piping.
  The main steam piping in each of the four main steam lines has three branch sections "bubliks" connected via T-joints (see Figure 3), which are piping segments from the main steam line to the BRU-A and MSSVs. These “bubliks”, as stated by the presenters, are not part of the break exclusion concept and have not undergone structure analysis.

This should have been done for the following reasons:
The “bubliks” and the piping connecting the “bubliks” to the main steam line are - in case of primary to secondary leak - part of the containment boundary, the ultimate radioactive effluents retention boundary. It is EU practice (in Germany, for example [KTA 3211]), to fully consider integrity of the piping from the T-joint to the relief or safety valve.
The operator’s approach does not comply with this practice, and does not in the view of the Specialists‘ Team recognise adequately the significance of the “bubliks” as parts of the containment boundary.
Without performing required stress analyses and postulating ruptures in the “bubliks”, the Specialists’ Team considers this approach as not being in compliance with the HELB requirements designed to prevent consequences on equipment relevant to safety in the proximity of the lines.

- Considering the components, some aspects of the presentation on the “Superpipe Concept” do not appear to be strict applications of the NUREG-Standard Review Plan [NUREG 0800] or French Code [RCC-P] concepts, e.g., the use of actual material properties for break exclusion area piping stress verification.

  With this approach the allowable safety margins of piping load-bearing capabilities are changed. (The piping analyses are usually performed by checking the maximum stress encountered against the nominal material properties values multiplied by a safety factor according to the Code applied, in order to keep the additional margin against the actual material properties as a nominally not consumed safety asset).

3.2.2 Water Hammer

- Several water hammer load cases for transient and accident conditions must be considered for the HELs at the 28,8 m level. The related presentation and the discussion did not reveal whether important load cases have received sufficient attention. These include:
  - Opening and closing of one or both MSSVs,
  - Blow down of steam water mixture followed by water,
  - Closing of the turbine stop valve in the turbine hall followed by closing of the main steam isolation valve,
  - Pipe break at the "bublik" T-joint, feed water line break in the turbine hall,
  - Feed water pump failure with closing of the isolation valve, and
  - Switching of the feed water pumps.
- The suitability of the Operating Base Earthquake (OBE) loading consequences - Service level B event - to envelope all water/steam hammer effects, as repeatedly stated, is questioned by the Specialists’ Team. In fact, based on the low magnitude of the seismic event apparently assumed for ETE (deduced from the fact that no special seismic supports or shock absorbers have been installed), it seems to be difficult to demonstrate that the OBE event could envelope dynamic loading effects. There are usually quite significant water hammer effects especially on the FW lines, which can serve as an example. More evidence should therefore be presented to substantiate the above assumption. (According to US SRP [NUREG 0800] only the Normal and Abnormal Events (Service Levels A, B) shall be considered in order to obtain the piping state of stress for setting up the baseline for postulated HELBs).

3.2.3 Pipe Wall Thickness (Flow-Accelerated Corrosion, Erosion/Corrosion)

As far as known to the Specialists‘ Team, Feedwater-lines operate, usually, at a significant state of stress and have experienced serious troubles in the past, both in conventional and nuclear power plants. At the same time the degradation effects of erosion/corrosion on FW lines are well known all over the world. The repeated statement that the stress-state of FW lines is very low and that huge safety margins exist was not supported with sufficient evidence.

- The flow-accelerated corrosion, which in general affects the inner surface layers of pipes resulting from the water/steam-water fluid specific chemistry operation regime (FAC, or erosion/corrosion) causes wall thickness reduction. This might induce risk of pipe leak or rupture. Continuous wall thickness monitoring is therefore a mandatory in-service inspection procedure. The presentation on this topic shows feed water system piping wall thickness dimensions that are at or close to the critical dimensions. Further reduction to below the critical wall thickness due to FAC results in failure of the pipe.
  Pipe wall thickness dimensions from some of the actual measurements are at or less than the minimum design value required.
- There was insufficient explanation by the operators experts why the new definition of the “nominal thickness“ versus the actual measured values is acceptable in suggested compliance with the specification of the original Russian project of the Temelín VVER 1000.
- From the presentations it appears that pre-operational wall thickness measurement, as required by the Russian Code [RUS-ISI] (and European practice), was not performed. The information available to the Specialists‘ Team is that the first measurements were performed only after start of the test operation. For this pipe wall the thickness verification may not have been conducted as required by the break exclusion approach.
- Insufficient detail was presented concerning the periodicity of planned wall thickness measurements for the main feed water system, and concerning the number and locations of thickness measurements planned and the basis for their selection.
- The implementation of wall thickness measurement procedures into the ISI program cannot be considered an “independent safety layer” (as declared by the representative of the licensing authority).
- Frequent outages during the plant start-up and test operation phases as well as non-steady state operation conditions do not allow the secondary side water chemistry to be kept within the narrow pH-levels bandwidth required for proper corrosion control and limitation.
- Despite the already redefined “nominal” wall thickness, the related presentations reported CHECWORKS™ lifetime predictions for only 16 years. Note that predictions of the widely used CHECMATE™/ CHECWORKS™ program can considerably under-estimate the wear rate if the pipeline is not properly modelled – as happened in connection with several accidents reported in [NRC-Bulletins]. Thus the existence of “huge safety margins” on FW lines as seen by the presenters was not plausible to the Specialists’ team.
- Characterisation of the current status, evolving changes prediction and therefore well-documented histories of all the elements of the HEL is mandatory for confirming the bases of re-qualification of the HEL according to break exclusion requirements. The procedures adopted have not been described or presented and monitoring of their adequacy was therefore not performed.

3.2.4 PTS[6] Methodology & Harmonisation with EU Practice

The PTS analysis presented by the Czech side for the Temelín VVER 1000 (presentation by an expert of the plant operator) consisted of only a general approach. Even the PTS analysis for rupture of two main steam lines is indicated as "practically done" but not yet complete or presented in detail. PTS analyses for other events (small LOCA, opening of the pressurizer relief or safety valve, primary to secondary leaks and other events) are not set for completion until 2003-2004. The PTS issue will be the subject of another Workshop in 2004 according to the Roadmap.

Accordingly, no conclusions can be drawn at this time on the adequacy of the approach or on the adequacy of implementation of the PTS calculations, despite the fact that rupture of two main steam lines could result in vessel overcooling and potentially result in PTS conditions.

3.2.5 Materials Database

The adequacy of the Materials Database compilation process as well as the uses made of the materials properties to demonstrate fulfilment of various requirements within the “Safety Case” are discussed below.

- It should be clarified which sections of the MFW and MS lines are made of heat resistant steel material ST 20 and which of 16GS.
- The Materials Database as presented seems to be insufficient: some evidence was given, but the results are not consistent because the test results used were produced using three categories of materials:

1) "archival material" (eds. rem. [archive]) (here consisting of samples for the weldment properties documentation),
2) "plant specific material" (from experimental welds made in Russia) and
3) "industry base material" (specific for VVER 440 - and said to have been selected as material equivalent to the one used)

It was not demonstrated that differences in the results amongst the three categories were insignificant. The test results could also be interpreted to suggest that the three materials tested do not exhibit comparable properties (e.g. in terms of ductility or fracture toughness). In addition, the reported small number of validated results from experiments is not suitable to derive consolidated material properties for pipes, elbows and welds.

- According to applicable standards, more work must be performed to provide evidence, that the MFW and MS lines actual material properties are better than the minimum allowable properties according to the code applicable and applied. The Specialists‘ Team sees no justification to exclude the certified material characteristics (component passport data) from the database used.

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6 **P**ressurized **T**hermal **S**hock (PTS) can be the most serious intermediate consequence of – in between other initiating events – main secondary coolant pipe failure events. This type of event is likely to activate emergency core cooling. As a consequence cold emergency core cooling water enters the **R**eactor **P**ressure **V**essel (RPV) at certain flow rates over time. The PTS sequence results from cold water “tongues” when formed from the RPV inlet down the RPV wall causing a rapid temperature drop in this wall. These temperatures drop causes deformation stresses due to temperature differences in the RPV wall. Deficiencies originally of negligible influence on the load-bearing capacity of the RPV can result in stress concentrations with crack stress relief areas, relieving unbearable loads via crack propagation and eventually causing catastrophic failure of the RPV. PTS occurs also when the reactor vessel has been severely overcooled, and then subjected to re-pressurisation (for example, due to actuation of high pressure injection or even the higher pressure pumps in the emergency boration system). If the vessel is cooled below its nil ductility transition temperature and then re-pressurised, the resulting stresses from pressure and temperature gradients can cause brittle fracture of the vessel.

- The tensile characteristics used within the “Superpipe Concept” do not appear to be representative because the origin of the material used for the specimen is not known, the number of experimental results is too low, and the certified values from the component passports are not taken into account.
- Some areas of evidence about establishing material properties quantification were provided, but results are not consistent. The claim, that the minimum material properties values required were met with a probability of 97,75 %, was not demonstrated.
- The "as used" material properties derived from the database are not admissible, because in the “Superpipe” application case, the use of materials minimum properties values is required by the Standards applied [STD-MATL]. (The stress criteria of the “Superpipe” concept are not met for the main steam line system, if – as required by the code applicable – the minimum material properties values for yield strength and ultimate strength are used. The stress criteria are also not met if the certified material properties values from the component passports are used.)
- Regarding steel type ST20 properties, there appears to be a lack of experimental data for the lower temperature range and the weld material as well. The use of the piping material 12022.1 specimens’ results to add additional information to the ST20 properties database raises questions about these data sets being representative for this database. (Using material from Dukovany NPP also raises questions about differences in material properties because the raw material has undergone different transformation processes to serve the substantially different design and operation conditions.)
  Additional technical information - like the reports mentioned in the references of presentation number 2 (as listed in ANNEX D) – would be essential to fully identify the activity performed and the results validation.
  In addition, the specific probabilistic model chosen to fit the data merely on the basis of a Chi-square-test is not justified unless further substantiated.
- Regarding Charpy-V-Notch test results reported by the Czech side, indicating the materials ductility properties (used e.g.- for LBB demonstration cases), the following appears to apply:
  The requirements to be fulfilled were not specified. Fracture toughness properties of the steels used are rather low (properties in some cases considerably lower than k_{CV} = 51 J/cm^2 would be unacceptable if one applies KTA Rules as an exemplary European standard [KTA 3211]).
- The ageing results presented at the Specialists‘ Workshop have not been obtained by testing VVER-1000 secondary piping material as used for the MFWL and MSL (ST20, 16GS). This means that the information available on the ageing behaviour is not VVER-1000 specific and therefore not applicable for ETE.
- European practice regarding break exclusion applications (e.g., German KTA and French Tronçons Protégés) require post-weld heat treatment and post-weld surface treatment. The experts told the Specialists’ Team at the Workshop that neither of these treatments was performed for welds in the break exclusion zone at Temelín. Therefore it is recommended to demonstrate that the state of the welds does conform to break exclusion requirements as they have been widely adopted in Europe.

3.2.6 Qualification of UT NDE

The adequacy of the UT-NDE procedures as well as the uses made of the NDT methods to demonstrate applicability of the break exclusion concept's various requirements within the "Safety Case" are discussed:

- To qualify ultrasonic testing (UT) methods in the context of ISI of the HELs at the 28,8 m level, the plant operator applied ensembles of weld shapes and defect orientations which do not represent worst case defects.
  It was not presented how the "false calls" problem due to geometrical indications can be dealt with (i.e., misinterpreting a weld defect as a non-defect geometry indication). The few examples of obtained defect images as presented indicate a kind of ultrasonic probe movement that makes it nearly impossible to discriminate between geometry and root defects.
  There seems to be no proof that the test block defects are representative and provide for readings comparable to those causing the real difficulties encountered in interpreting UT NDT indications and comparable to real defect in the weld root, the most critical case.
- The inspections of the circumferential welds of the HELs need to be performed with a probe movement parallel to the weld axis. In addition, X-ray frames' evaluation should be available to the UT inspectors to enhance decision making in the case of geometric indications.
- While the Czech side acknowledges the importance of NDT, the practical implementation lags behind. This may be true also for the inspection intervals and the last finger print inspections on the welds foreseen for 2006; the Specialists' Team would consider an earlier date much more preferable. According to the French code Tronçons Protégés document (termed "Superpipe" here) intensified 100 % volumetric inspection is required for all welds. The expert from ETE indicated a remarkably reduced NDT application for ISI. An explanation by the Czech side on how the reduced programme is justified would be helpful.
- During the workshop differences in the interpretation between ČEZ a.s. and Nuclear Research Institute Řež were voiced about the inspection frequency and whether 100 % in-service inspection (ISI) of all welds is required. To completely rely on break exclusion, as adopted by the Czech side, 100 % surface and volumetric inspection of all welds in the break exclusion area is required.
- The inspection procedures for the "Superpipe" break exclusion strategy include their application frequency for material integrity and/or material degradation verification. This has not been described in the comprehensiveness required for monitoring. The 100 % in-service inspection (ISI) requirement is evidently still at stake. USNRC requirements are also set up for 100 % volumetric ISI inspection for the entire break exclusion area, without any exceptions. Unfortunately, the time schedule for NDE measures could not be discussed due to time restrictions at the Specialists' Workshop.

Nonetheless, some comments can be made:

- The related slides presented by the plant operator indicate a considerable reduction of the in-service inspection scope.
- The Specialtists' Team recommends the use of state of the art detection probabilities below 100 % for weld flaws, since possible misperception bears high-risk consequences potential.

3.2.7 Displacement Measurements at the 28,8 m level

- The displacement measurements - as described by the operator in detail when presenting the instrumentation installed - are an interesting start-up exercise detail. The testing and results, if they confirm acceptable movements, are a precondition for operation under normal conditions. In that these measurements are said to have confirmed PIPESTRESS simulation results for both units, they provide for confidence about the stress calculations for normal operation and can serve as good bases for stress calculations under adverse conditions.
- No indication was given on how these operational displacement measurements will be used for load cycles and furthermore for cyclic load pattern identification, accumulation quantification and effects verification as usually applied in the LBB application context. The more stringent break exclusion concept's requirements could make use of it as an additional source of information.

3.2.8 Pipe Break Probability Calculations

- The probabilistic analysis considers only the welds between the containment penetration and the isolation valves. Neither failure of the piping itself, nor failure of the valves was considered. As such, the analysis appears to be incomplete. The results were put forward without considering the uncertainties of the estimates.
- The probabilistic analysis based on the PRAISE code was apparently performed without specific relation to the actual data of the plant, e.g. to the results of the NDE qualification. A description of the input data, the assumptions, and the modelling approach were not included in the presentation. This might make the analysis useful for the monitoring exercise.
- The proper choice of probabilistic models for the input data was not argued in the presentation (evidence should not only be based upon assumptions, since e.g. the present technology application does not provide for 100 % flaw detectability). An assessment of some parameters' statistical behaviour is considered necessary in order to avoid misinterpretations (e.g. application of the normal distribution might not be justified in some instances).
- Probabilistic analysis of pipe break frequency should take into account all contributors and all uncertainties involved. Not all information on statistical uncertainties concerning material properties, geometry, loading, corrosion, reliability of non-destructive testing and examination, initial cracks (location, orientation, size, depth), in-service inspection strategy, environmental conditions, etc. has been addressed in the analysis yet.
- The overall results with a small leak frequency for normal operating conditions (NOC) of 10^{-5} [events/y], a large leak frequency for NOC of 10^{-6} to 10^{-8} [events/y], and a rupture frequency (Double Ended Guillotine Breaks) of less than 10^{-10} [events/y] are not in line with industry experience (8,000 reactor-years of commercial NPP experience), which indicates corresponding values of $2{,}25 \times 10^{-3}$ [events/y] for small leaks, $2{,}7 \times 10^{-2}$ [events/y] for large leaks, and $9{,}5 \times 10^{-3}$ [events/y] for ruptures [LYDELL 2000]. In the absence of a more detailed presentation and of the opportunity to review the underlying detailed report(s), the results cannot be considered to be plausible.
- The presentation included an estimate of the failure frequency of the piping resulting from design basis earthquakes. Accordingly, the design basis earthquake has an assumed frequency of 10^{-4} [events/y], and the conditional probability of failure of the piping at the conditions of the design basis earthquake is 10^{-4} [events/y], yielding a failure frequency of 10^{-8} [events/y]. However, this is not the piping failure frequency comprising <u>all</u> earthquakes. Much larger earthquakes are possible below 10^{-4} [events/y], which have larger conditional probabilities of failure, for which the absolute frequency of failure contribution could exceed

10^{-8} [events/y]. The 10^{-8} [events/y] value cited in the presentation by the expert of the plant operator is not a *summation of all* earthquake-caused contributions to failure, but rather only a point estimate for one ground acceleration value. (Frequencies of 10^{-8} [events/y] are encountered with extraordinary ground acceleration patterns from events such as comet and asteroid impacts. This comparison may serve to illustrate that such extremely low estimated frequencies of pipe failure as the 10^{-10} result estimated appear problematic.)

No seismic hazard analysis was presented. The basis for the adopted frequency of 0,1 g peak ground-acceleration is not clarified. Although the seismic analysis will be the subject of another workshop, at least some basis for the value presented would have been helpful (e.g., presentation of the seismic hazard curve).

- Surprisingly, SÚJB, in its submission to the EC in October 2002 [CR 2002], cites the extraordinarily low frequency numbers denoted in the above. Even though frequencies below 10^{-8} [events/y] can only be supported with difficulty by current PSA methods, they generally lack plausibility compared with the industry experience that numerous steam line and feed water line ruptures have actually occurred. (This is in contrast to the situation with primary system piping, for which in more than 8 000 reactor-years of experience there have been zero large pipe ruptures, and for which regulatory acceptance of failure frequencies of 10^{-6} [events/y] and lower is relatively common.)

3.2.9 Thermal Hydraulic Analysis (TH)

The purpose of TH analyses is to demonstrate that the safety principles of the Temelín NPP will be respected in case of multiple steamlines breaks at the 28,8 m level. In this context the reactivity transients caused by steamlines breaks which result in considerable rapid cool down of the primary coolant system are of particular interest. The duration and magnitude of the associated reactivity disturbances determine the resulting primary system pressure / temperature transients.

Application specification

Four different topics are covered in the Thermal Hydraulics (TH) presentation:

(1) Fuel integrity

(2) Maximum primary circuit pressure

(3) PTS-analysis input data

(4) Radioactive effluents release.

Evidence and demonstration

The Czech side gave an overview of their efforts related to the four topics named above. However, the calculations carried out and the results obtained need to be described in more detail to form a sound judgement on them. Without information about the input data decks, representation, boundary conditions and assumptions, the results presented cannot be monitored, to the contrary the introduction into the topics (2) - (4) as presented implies comprehensiveness of the analyses. A full power analysis as input for the discussion of topic (1) was not made available. The thermohydraulic results presented for topic (3) are only part of the input deck for simulating the PTS issue. Local thermohydraulic information including heat transfer behaviour would be needed for appropriate monitoring of potential HELB related PTS events. The results of topic (4) are input for radioactivity release calculations, but no radioactivity source term has been disclosed.

Fuel integrity

- The SIR (Specific Information Request) describes the kind and amount of information which would be necessary to adequately assess the calculations made and the results obtained. Based on the information provided, such an assessment cannot be made. While the applicability requirements for the codes DYN3D, ATHLET and VIPRE are well known to the Specialists‘ Team, information on the calculation procedures themselves (e.g. DNBR analyses and code coupling) was not made accessible.
- The code DYN3D-ATHLET itself contains several correlations for the determination of DNBR behaviour (Departure from Nucleate Boiling Ratio, an indicator for rapid transition to reduced fuel cooling) developed especially for VVER-fuel elements. The use of such correlations would further simplify the evaluation.
- Information about important parameters during the analyses (especially the reactivity status in the core, the power behaviour, the core inlet temperatures and mass flow rates and the primary circuit pressure) would be necessary to fully appreciate the presentations provided by the operator.

Primary circuit integrity

The following information would be needed to monitor the effects of HELBs on the primary system:

- Full set of initial and boundary conditions
- Deviations from the Input deck used in Fuel Integrity (1)
- Time dependencies of important parameters
- Details about the modelling of the secondary side
- Information about the reactivity status of the core
- Reactor core damage assessment.

3.2.10 Comprehensive Safety Case Revisit (SÚJB Position)

The presentations during the workshop yielded only limited information on the interaction between the licensee, the regulatory authority and the management of the safety issues by SÚJB in regulating the safety of Temelín NPP. There was little evidence about such licensing process elements as:

- Evaluation of proposals from the licensee,
- Identification of all related safety aspects,
- Compliance with requirements and practices widely applied within the EU,
- Definition of requirements and conditions, findings, comments and requests set up by SÚJB and replies from the operator,
- Independent review from sources contracted by the regulator,
- Inspection activities performed by SÚJB staff.

The reasoning and the position of the Czech Safety Authority SÚJB therefore remain unclear.

The presentation about SÚJB activities provided no evidence about the licensing strategies followed within the “Licensing Case” approval merely stated: “licensed according to Standard Review Plans” – and no evidence about the conformance of the Comprehensive Safety Case Revisit (CSCR) activities with it. A more detailed presentation would be needed to understand, for instance, the two important issues related to “the change of chemical regime to minimise the erosion-corrosion” and “the change of the emergency feed water routing” that were not addressed in the Workshop presentations.

4 EVALUATION OF THE MONITORING PROCESS ACCORDING TO THE VLIs

The demonstrated applicability of a break exclusion concept requires a comprehensive combination of preventive, protective and mitigative measures to be developed implemented and sustained during operation of a NPP. The Specialists' Team monitors how the DID concept is upheld under the special boundary conditions imposed by the existing HELs and their environment. Furthermore, the team monitors the adequacy of the requalification process based on the information provided by the Czech side.

The Specialists' Team arrived at the following views about attributing its findings to the Verifiable Line Items defined for the monitoring process.

The contribution to the individual VLIs - after being weighed against the verification scope - is summarised as the conclusive Preliminary Monitoring results.

In addition, the following broader context of Safety Culture implications was defined by the Specialists' Team to collect the Monitoring findings on the interaction in the licensing process.

Monitoring of the interaction of the operator, the manufacturer, the technical support organisations and the licensing authority with respect to HELBs solution implementation.
The Specialists' Team deplored the limitations in evidence about the respective roles and the interaction of the operator, the manufacturer, the technical support organisations and the licensing authority in the qualification process, in the requalification process, in the Comprehensive Safety Case Revisit and subsequently during the persisting operational verification procedures. The presentations and comments during the workshop suggest that requirements and compliance determination play a dominant role in the living safety culture established. The monitoring process' progress and result could be enhanced considerably by providing evidence about the related procedures and specifications.

The Monitoring regarding the HELBs technology evaluation adhered to the 18 defined Verifiable Line Items presented below (see chapter 3.1), each followed by the preliminary monitoring result compiled from the Specialists' Team's Monitoring findings:

1	**Monitoring of piping design approach and piping stress analysis methodology, considering piping and components qualifications, service levels, load combinations (including expected and unexpected steam/water hammer effects)**
	The Specialists' Team welcomed the overview provided for the Comprehensive Safety Case Review: the logic of the design criteria, the design process and conclusive statements of compliance, however, were not provided. Similarly, the introduced so-called "Superpipe Concept" was not demonstrated to be embedded into the original design criteria, and evidence of code compatibility examination for the various codes, standards, rules and regulations was not provided. The Specialists' Team observed deviations from the defense-in-depth concept: an integrated approach of prevention, protection, qualification and mitigation measures was followed only partially.

	Justification for excluding large portions of the HEL piping from the “Superpipe Concept” re-qualification was also not included in the presentations. The Specialists Team would appreciate obtaining a listing of the various codes, standards, rules and regulations applied in the HELB issue in order to properly monitor the compliance with the requirements. The Specialists’ Team is prepared to monitor in particular the “Superpipe Concept” specification for HEL piping and components and how its application relates to the French RCC code requirements. A presentation of the logic of the design process and criteria – starting with the premises and ending with conclusions formulated as clear statements of compliance with specific rules – would be helpful. Accessibility of related documentation to fill in gaps in the presentations would be a substantial asset.
2	**Monitoring of the criteria used to select pipe break locations and orientations**
	The Specialists’ Team received only some indications on how candidate selections of pipe break locations and the break’s orientation have been accepted or eliminated. The selection procedure document would render the process transparent for also monitoring the decisions’ basis to disregard break locations or larger pipe sections eligible, like the “bubliks”. For the Specialists’ Team a thorough structure analysis of the entire piping up to the first valves after the containment penetration would provide for the necessary insight to determine breaks and secondary failure defence-in-depth requirements.
3	**Monitoring of the postulated “aggressive” HELB points assumed in the analysis (“aggressive” means: “which can damage structures, systems or components important to safety sufficiently to impair safety functions to an unacceptable level”)**
	The evidence that “aggressive” HELB points were identified, subsequently postulated, and analysed up to possible consequences could not be extracted by the Specialists’ Team from the provided information. It is not certain that loadings induced to the break exclusion zone from breaks outside this zone (i.e. in the containment or in the turbine hall) have been considered for maximum stress determination. Consequential failure induced effects would provide also information about the investigated occurrences severity. Information of this kind was not available for monitoring.
4	**Monitoring of pipe internal dynamic fluid forces effects as a consequence of the postulated HELB (including geometry effects and blowdown characteristics)**
	The Specialists’ Team was interested in Water Hammer load cases that were supposed to be examined for both the steam lines and the water lines and for various operational and accident transient conditions. The Specialists’ Team could not detect evidence that the Operation Base Earthquake loading consequences exceed all other dynamic loadings and would therefore be bounding load cases. Investigations of dynamic loads are also indicated in all cases of operational loads when combined with degraded piping components.

5	**Monitoring of the non-linear mechanical analysis to determine the whipping pipes dynamic response**
	The restrictions applied to the assumed break locations resulted in no recognised need for non-linear mechanical analyses. Jet forces and reaction forces on the pipe whip restraints were briefly touched upon at the Workshop. The Specialists' Team determined that any reconsideration of the Verifiable Line Item #1 will also add to the knowledge required here.
6	**Monitoring of the evaluation of jet impingement shapes, temperatures, pressures, directions and loads, insofar as to find out whether jet forces impulse to HEL or walls or components are likely to cause consequential failures**
	The restrictions applied to the assumed break locations resulted in no need for estimates of dynamic pipe whip response. Jet forces and reaction forces on the pipe whip restraints were briefly touched upon at the Workshop. Any reconsideration of the Verifiable Line Item #1 will also add to the knowledge required here. Simulation results used for the preliminary design of a separation wall were not made available. The Specialists' Team obtained rather limited information on this subject.
7	**Monitoring of the proposed measures to protect safety related equipment from pipe whip, blowdown jets and reaction forces and separation of redundant features (requirements, material properties & sizing of pipe whip restraints and separating shields)**
	The provisions made to protect safety-related equipment as part of defence in depth concept application were not presented. Even for those protective features that are in place (separation wall, supports etc.), no technological information was made available to the Specialists' Team. The current status of the line item could not be verified.
8	**Monitoring of the methodology and analyses of compartment pressurisation and environmental conditions following a postulated HELB**
	The Specialists' Team recognises the environmental conditions specification as being a prerequisite for project PN 4 "Qualification of Safety Classified Components". Within the scope of this project PN2 the Specialists' Team learned, that secondary failure and the resulting environmental conditions should serve to determine how the components could stand these loadings. Additional information might be important for the Monitoring of environmental conditions at the 28,8 m level, including also information that is not available from project PN4.
9	**Monitoring of the structural design loads including pressure & temperature transients and dynamic reactions as consequences from HELB**
	In the presentations, the design loads required to be quantified for protection of safety related equipment as part of defence in depth concept application were identified for single events only and, for these cases, only qualitatively. Pipeline dynamics were treated based on a very theoretical simulation only. There is no need to intensify information exchange about theoretical aspects of this topic. The thermal-hydraulic simulations also performed for the POSAR support the Specialists' Teams view on accident management questions. Further information would be desirable.

10	**Monitoring of the methodology for evaluation of structural adequacy of Seismic Category I structures (those civil structures required to fulfil safety functions)**
	The provisions made to protect safety-related equipment from failure due to consequences from seismic loadings should be part of defence in depth concept application; information about such provisions was not presented. Nothing was reported on this subject. The seismicity issue will be treated in project PN 6 “Site Seismicity”.
11	**Monitoring of the structural analysis evaluation including local loads on the concrete Category I structures and non-safety structures whose damage may impair the safety of the plant**
	The load bearing capacity of 28,8 m steel girder support and concrete structures to protect safety related equipment from indirect damage is part of the defence in depth concept application. Results to this need were not presented. This subject was not addressed at all in the presentations!
12	**Monitoring of the structural failures, environmental conditions and potential flooding that might result in loss of safety functions including Monitoring of main control room habitability**
	The provisions made to preserve vital safety functions and safety equipment as part of defence in depth concept application were not presented. The environmental qualification of electrical equipment should be examined in PN 4 “Qualification of Safety Classified Components”
13	**Monitoring of the adequacy of the safety class components environmental qualification. This should be addressed in PN4 (monitored in PN 4 “Qualification of Safety Classified Components”). Only identification of candidate components requested**
	The listing of candidate components requiring environmental qualification (monitored in PN 4 “Qualification of Safety Classified Components”) as part of the defence in depth concept application was not yet available. To the knowledge of the Specialists’ Team the identification and exemplary verification was not yet performed during project PN4.
14	**Monitoring of the analyses methodologies to evaluate the plant response to MS & MFW HELB outside containment**
	The elements necessary to monitor analyses and evaluations of plant response to High Energy Lines Breaks in order to provide for the safety of plant and the proper safety systems functions as part of defence in depth concept application were presented as overview information. The monitoring related to the Pressurised Thermal Shock vulnerability would take place in the context of project PN 9 “Reactor Pressure Vessel Integrity and Pressurised Thermal Shock”. More detail would be required to enable the Specialists’ Team to consolidate a positive monitoring result.

15	**Monitoring, based on plant safety analysis, for performances of mitigating systems, radiological consequences calculations and Monitoring of adequacy of emergency procedures to mitigate MS & MFW HELB outside containment and their extension into SAMGs**
	Those elements of the safety analyses providing the basis for consequences mitigation options and evaluations of plant response and the adequate safety systems functions as part of defence in depth concept application were presented in an overview information. The monitoring of the Pressurised Thermal Shock mitigation procedures will be completed in 2004 only and treated in the context of project PN 9 "Reactor Pressure Vessel Integrity and Pressurised Thermal Shock". Fuel Integrity during bounding accident sequences was not discussed quantitatively but in some instances qualitatively. More detail would be required to enable the Specialists' Team to consolidate a positive monitoring result.
16	**Monitoring of adequacy of MS & MFW piping outside containment in-service inspections programs**
	In Service Inspection to establish and sustain protection against High Energy Lines Breaks as part of defence in depth concept application was addressed in the context of periodic wall thickness history evaluation and Non-destructive Testing and Evaluation procedures implementation descriptions. The Specialists' Team identified areas of improvement and at the same time the need for more detailed description of the procedures set up and implementation as well as of quality assurance. The 100 % volumetric examination requirement should be followed. The Specialists' Team could not conclude whether the Czech side has reached a defined position on this matter.
17	**Monitoring of event frequency evaluation of HELB and of consequential failures**
	The Specialists' Team concluded that break exclusion applicability demonstration for very extended High-Energy Pipe ducts with large diameters could not be justified based solely on deterministic break location selection. Probabilistic fracture mechanics evaluation, in combination with probabilistic evaluation of NDE based flaw detectability, should provide break incidence frequency estimates regarding the defined break exclusion areas. The small leak and break frequency estimates supplied in the Workshop presentations do not relate well to industry experience and are therefore questioned by the Specialists' Team. Additional evidence should be produced and provided in order to promote the monitoring on this Verifiable Line Item.
18	**Monitoring of requirements for materials used and for material degradation to be taken into account**
	The Specialists' Team in monitoring the Materials Database development and materials properties definition process identified several areas for clarification: the selection procedures of "comparable" material for test specimen manufacturing could not be monitored conclusively.

> Its has not become evident to the Specialists' Team that the material properties used for qualification of the stress analysis results are in line with the requirements imposed by the codes standards rules and regulation defined to be applicable.
>
> The Specialists' Team could not interrelate the materials properties requirements for the two pipe materials used, as applicable for the "Superpipe Concept's" break exclusion requalification and the materials properties requirements defined for the High-Energy Lines in the design process, with the properties of the material "in place". Additional evidence about comparable and acceptable properties would be of use.

The VLIs Preliminary Monitoring result indicates a considerable number of distinct areas where sufficient information has been gained enabling conclusions to be drawn.

These results can be regrouped and associated to areas needing further investigation and provide an outline for the future Monitoring focus.

CONCLUSION

Based on the recognition that the pertinent Czech-Austrian Bilateral Agreement is the appropriate framework giving the opportunity for further discussion and sharing additional information on these issues, the Specialist's Team would appreciate if the major findings could be resolved in the further monitoring process of HELB.

The Monitoring scope was accomplished as defined in a series of Verifiable Line Items (VLIs), and the Workshop's results were checked against those VLIs. After an attempt to prioritise where additional information would be most valuable to consolidate of the Monitoring result, the following areas have been defined:

1. With regard to the **materials** used for the secondary High Energy Lines:

   The materials properties' requirements and verification of adequate properties of the materials used for the High-Energy Lines at the 28,8 m elevation should be supported by sufficiently qualified evidence.

   The comprehensive specification of the materials properties - on which the acceptance of the stress analyses, the break exclusion verification and the determination of crack propagation to break at the pipe whip restraints' locations is based - should be made accessible. The databases as well as the standards, rules and regulations used to define the materials properties should be included into this information.

   Monitoring should focus on the extent to which values for material properties are based on mandatory standards, rules and regulations and to which these values are used in the component acceptance process.

2. With regard to the **break exclusion concept** verification:

   The specific and extensive use of the break exclusion assumptions and the associated deterministic break location definition should be supported by conclusive probabilistic acceptability results.

   The results of probabilistic analyses should be accessible for Monitoring. Probabilistic analyses should include the failure probabilities of the entire piping ducts up to the first isolation valves. Moreover results from probabilistic fracture mechanics analyses for the duct exposed to maximum loadings should also be made accessible for Monitoring.

   For the particular arrangement of the pipe ducts at the 28,8 m level specific break frequencies were assumed and In-Service-Inspection-Plans were adapted. Monitoring should also aim at a comparision of these assumtions and plans with industry experience.

3. With regard to **accident consequences**:

   The nuclear power plant behaviour under severe accident conditions caused by High-Energy Line Breaks requires extensive analyses of various severe accident sequences to understand options for the mitigation of consequences.

   One exemplary severe accident scenario should be investigated: High Energy Line Breaks occur at full power at the Temelin NPP, and the reactor cannot be shut down successfully. For comparison, results of analyses of a High-Energy Line Break event of one main secondary line with the reactor core at full power and failure to successfully shut down the reactor with one of the control rods stuck in top position should be made accessible.

The Monitoring should focus on identifying the extent to which accidents with consequences to the reactor core are likely to evolve into radioactive release events.

The remaining questions in these three areas should be resolved in the further Monitoring process of HELBs.

During this Monitoring phase, special attention will be paid to the defense in depth protection needs, protection requirements recognised and provisions implemented to cope with Common Mode Failure/Common Cause Failure occurrence.

LIST OF REFERENCES

ATPP 2001	Austrian Technical Position Paper, http://www.ubavie.gv.at/umweltsituation/radio/akw_temelin/melk1/trialog/toc.htm
Melk 2001	Conclusions of the Melk Process ad Follow-up, Annex I, Brussels, 29.11.2001
PMR-PN3	PRELIMINARY MONITORING REPORT PN3: BRU-A AND MAIN STEAM SAFETY VALVE QUALIFICATION FOR WATER AND TWO-PHASE FLOW, Institute of Risk Research - Austrian Research Centers Seibersdorf, Vienna, Austria, 10 February 2003
WPNS 2001	http://www.ubavie.gv.at/umweltsituation/radio/akw_temelin/melk1/wpns/WPNS1.pdf http://www.ubavie.gv.at/umweltsituation/radio/akw_temelin/melk1/wpns/Appendix_WPNS_report_2001.pdf http://www.ubavie.gv.at/umweltsituation/radio/akw_temelin/melk1/wpns/Corrigendum_WPNS_Report_2001.pdf
AQG CZ 2002	SÚJB approval decision as submitted by the Czech Government in a note to the Council of the European in October 2002 http://www.sujb.cz/soubory/AQGrevrec.pdf/
POSAR	Pre-operation Safety Analysis Report, (declared confidential in 2002 by ETE)
10 CFR 50	U.S. Code of Federal Regulations [Code of Federal Regulations] TITLE 10 ENERGY PART 50 DOMESTIC LICENSING OF PRODUCTION AND UTILIZATION FACILITIES, US Government Printing Office, Washington D.C.
USNRC SRP	U.S. Nuclear Regulatory Commission Standard Review Plan, (here especially USNRC SRP 3.6.2, BTP MEB 3-1), U.S. Nuclear Regulatory Commission, Washington, DC 20555 (equiv. to NUREG 0800)
SWSPR 2002	Specialists' Workshop Presentation (see ANNEX B) made by the Czech side, Prague, November 7th and 8th, 2002,
NRNSC 2001	National Report for the purpose of the Nuclear Safety Convention, Ref. 10366/2.0/2001, http://www.sujb.cz/national_report/index1.htm
RCC-P	RÈGLES FONDAMENTALES DE SÛRETÉ RELATIVES AUX RÉACTEURS À EAU SOUS PRESSION Règles de conception et de construction des centrales nucléaires PWR. Recueil de règles relatives aux procédés tranches de 900 MWe (réf.: code RCC-P) tranches de 1400 MWe (réf.: code RCC-P) RÈGLE SIN N°3130/84 du 13 juin 1984
RCC-M	RÈGLES FONDAMENTALES DE SÛRETÉ RELATIVES AUX RÉACTEURS À EAU SOUS PRESSION Règles générales applicables à la réalisation des matériels mécaniques (réf.: code RCC-M), (8 avril 1981); révision 1 (12 juin 1986).
NUREG 0800	NUREG-0800 USNRC Standard Review Plan U.S. Nuclear Regulatory Commission Office of Nuclear Reactor Regulation, Washington, DC 20555
RCODE Pipes	GOST 8731-74, 8732-78, 1050-88 (close to API 5L, grade B, ASTM A106/A53)

NRC-Bulletins Nuclear Regulatory Commission Bulletin - Bulletin Board System
United States Office of Nuclear Reactor Regulation
Washington, D.C. 20555-0001

STD-MATL RÈGLES FONDAMENTALES DE SÛRETÉ RELATIVES AUX RÉACTEURS À EAU SOUS PRESSION
RFS-V.2.c. Règles générales applicables à la réalisation des matériels mécaniques (réf.: code RCC-M), (8 avril 1981) ; révision 1 (12 juin 1986).

KTA 3211 KTA 3211.1
Druck- und aktivitätsführende Komponenten von Systemen außerhalb des Primärkreises Teil 1: Werkstoffe 4.2
Sicherheitstechnische Regel des KTA

CR 2002 Safety Evaluation Summary
NPP Temelín Comprehensive Safety Case Revisit subjected to High-Energy Steam and Feed Water Pipelines At the 28.8m Level and Safety and Relieve Valves Qualification
Revision adapted for purpose of informing the European Council in frame of the EU enlargement process, SÚJB, Prague - October 2002

LYDELL 2000 B. Lydell, *Pipe Failure Probability - the Thomas Paper Revisited*, in Reliability Engineering and System Safety 68 (2000) 207-21)

KTA 3211. 1 to 4Druck- und aktivitätsführende Komponenten von Systemen außerhalb des Primärkreises, Sicherheitstechnische Regel des KTA, Juni 1991

RUS-ISI Standard program of in-service inspection of the material state for base materials and welds for components and piping in NPPs of the type VVER-1000, ATPE-9-96, Moscow 1997

CHECKMATE™
CHECWORKS™ software packages focus on corrosion-related issues in the balance of plant portions of nuclear power plants, and to support the development and implementation of tools and software to assist nuclear operators in addressing corrosion issues throughout a plant's piping, vessels and the components of other systems. EPRIsolutions Business Development, Headquarters, 3412 Hillview Avenue, Palo Alto, California 94304, U.S.A.

PIPESTRESS™ (formerly called PS+CAEPIPE) is a library of interrelated software modules for static and dynamic analyses of nuclear and non-nuclear piping systems. It provides unmatched dynamic analysis power to handle complicated problems. SST Systems, Inc. U.S.A.

PRAISE™ Computer code PRAISE-C for Double-Ended Guillotine Break (DEGB) Breaks from Weld Cracks in Light-Water Reactor Piping Systems, OECD-NEA NESC Databank

ANNEX A

The MONITORING scope of the project PN2:

Defined and accepted by the Specialists' Team

Revision 2, issued 2002 11 07

Interpretation of a consistent, comprehensive and sustainable application of the “Defense in Depth” concept (DID) in the form of 18 Verifiable Line Items.

VERIFIABLE LINE ITEMs (VLIs)	
1	Monitoring of piping design approach and piping stress analysis methodology, considering piping and components qualifications, service levels, load combinations (including expected and unexpected steam/water hammer effects)
2	Monitoring of the criteria used to select pipe break locations and orientations
3	Monitoring of the postulated “aggressive” HELB points assumed in the analysis (“aggressive” means: “which can damage structures, systems or components important to safety sufficiently to impair safety functions to an unacceptable level”)
4	Monitoring of pipe internal dynamic fluid forces effects as a consequence of the postulated HELB (including geometry effects and blowdown characteristics)
5	Monitoring of the non-linear mechanical analysis to determine the whipping pipes dynamic response
6	Monitoring of the evaluation of jet impingement shapes, temperatures, pressures, directions and loads, insofar as to find out whether jet forces impulse to HEL or walls or components are likely to cause consequential failures
7	Monitoring of the proposed measures to protect safety related equipment from pipe whip, blowdown jets and reaction forces and separation of redundant features (requirements, material properties & sizing of pipe whip restraints and separating shields)
8	Monitoring of the methodology and analyses of compartment pressurisation and environmental conditions following a postulated HELB
9	Monitoring of the structural design loads including pressure & temperature transients and dynamic reactions as consequences from HELB
10	Monitoring of the methodology for evaluation of structural adequacy of Seismic Category I structures (those civil structures required to fulfil safety functions)
11	Monitoring of the structural analysis evaluation including local loads on the concrete Category I structures and non-safety structures whose damage may impair the safety of the plant
12	Monitoring of the structural failures, environmental conditions and potential flooding that might result in loss of safety functions including Monitoring of main control room habitability
13	Monitoring of the adequacy of the safety class components environmental qualification. This should be addressed in PN4. Only identification of candidate components requested
14	Monitoring of the analysis methodologies to evaluate the plant response to MS & MFW HELB outside containment
15	Monitoring, based on plant safety analysis, for performances of mitigating systems, radiological consequences calculations and Monitoring of adequacy of emergency procedures to mitigate MS & MFW HELB outside containment and their extension into SAMGs
16	Monitoring of adequacy of MS & MFW piping outside containment in-service inspections programs
17	Monitoring of event frequency evaluation of HELB and of consequential failures
18	Monitoring of requirements for materials used and for material degradation to be taken into account

ANNEX B

Workshop Programme
on
High Energy Piping at 28,8 m Level

Revision 1, issued 2002 11 07

Workshop Programme on High Energy Piping at 28,8 m Level

Date: 7-8 November, 2002 **Place: SÚJB Prague**

	Thursday November 7, 2002			
	Workshop opening.	Krs (SÚJB)	-----	
1.	**Temelín NPP position on high energy piping at 28,8m level**	**Holán (ETE)**	**7.1**	
2.	**Comprehensive safety case overview.**	**Žďárek (NRI)**	**7.2.1**	
3.	**Dynamic calculations results due to the steam water hammer and water overfill overview.**	**Pečínka (NRI)**	**7.2.2**	
4.	**Flow accelerated corrosion assessment.**	**Pečínka (NRI)**	**7.2.3**	
	Coffee Break (11^{15}-11^{45})		**-----**	
5.	**PTS methodology/harmonisation with EU practice.**	**Pištora (NRI)**	**7.2.4**	
	Lunch Break (12^{45} – 14^{00})		**-----**	
6.	**Material Database Summary.**	**Ondrouch**	**7.2.5**	
7.	Qualification Dossiers for S-W Mixture of BRU-A and SGSV including EQ of BRU-A actuator.	Fridrich (NRI)	7.2.6	
	Coffee Break (15^{00}-15^{30})		-----	
8.	**Qualification of UT NDE**	**Horáček (NRI)**	**7.2.7**	
9.	**Displacement measurement results.**	**Junek (ÚAM)**	**7.2.8**	
10	**Pipe break probability calculation overview**	**Pečínka (NRI)**	**7.2.9**	
	Friday November 8, 2002			
1.	**UT NDE testing and results**	**Horáček (NRI)**	**7.2.7**	
2.	**Summary of TH analysis.**	**Macek (NRI)**	**7.2.10**	
3.	**Superpipe concept application on steam and feed water lines**	**Žďárek (NRI)**	**7.2.1**	
	Coffee Break (10^{30}-11^{00})		**-----**	
4.	**Time schedule and modifications required for 100 % UT NDE.**	**Holan (ETE)**	**7.2.7**	
5.	**SUJB preliminary asessment of the Safety Case results.**	**Krs (SÚJB)**	**7.1**	
	Lunch Break (12^{00} – 13^{30})			
	Discussion on Safety Case Status (13^{30} – open end)	Included in comments	-----------------	

ANNEX C

Comparison of the ETE solution with U.S. Standard Review Plan

In view of SÚJB's rejection of a physical separation of Main Steam and Main Feed Water lines

The Regulatory Authority has shown satisfaction over the approach and the solution of the safety issue. The proposal of physical separation of Main Steam and Main Feed Water lines with a wall at 28,8 m level, in accordance with Western recommendations, was submitted as an additional safety feature by the plant operator. It was rejected because of the "significant restriction of maintenance and in-service inspection" caused by its presence in the area.

This position should be further examined for the following reasons:

The break exclusion approach as defined by the U.S. Standard Review Plan - Sect. 3.6.2 BTP MEB 3-1, B 1b - (and by French [RCC-P]) is an exception to break postulation, in the so-called "Containment Penetrations Areas" or "Break exclusion zones" [7] only, provided that a set of specific requirements are met. This position is in agreement with General Design Criterion 4 of 10CFR 50 Appendix A. The statement there is: *"dynamic effects with postulated pipe ruptures may be excluded from the design basis, when analyses demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis of the piping"*.

Here in the following there are some excerpts on the criteria that must be met according to the above-mentioned SRP and the actual situation of the HEL at the 28,8 m elevation in the Temelín NPP:

Sect. B.1b (1): *"the following design stress and fatigue limits should not be exceed: for ASME Code Section III, Class 2 piping"* – the Temelín MS and MFW lines were produced to similar design requirements: *"The stress ranges calculated by the sum of equations (9) and (10) of § NC 3652 of ASME code, Section III, are smaller than 0.8 (1.2 Sh+Sa) for the normal or abnormal operation of the reactor; the maximum stress intensity calculated by equation (9) of § NC 3652 is below 1.8 Sh."* Sh and Sa are allowable stresses at maximum temperature, and allowable stress ranges for thermal expansion, *"as defined in article NC3600 of the ASME Code", that means "the minimum Code material properties"*

Material tensile properties data used at ETE for the demonstration of the fulfilment of the stress criteria are neither the code-based nominal values nor the minimum certified values from the manufacturer for the piping material as installed. If either one of these values were used, the break exclusion stress criteria would not have been met. Instead, values used are derived from test samples for which evidence of reliability for the original piping material has not been provided.

Sect. B.1b (2): *"Welded attachments, for pipe supports or other purposes, to these portions of piping should be avoided except where detailed stress analyses, or tests, are performed to demonstrate compliance with the limits of B.1 (1)"*.

Along the HEL at 28,8 m level there are several weld-on attachments (e.g. pipe whip restraints reinforcing plates are welded to the main pipes). This solution is not allowed by German rules (KTA).

Sect. B.1b (3): *"The number of circumferential piping welds and branch connections should be minimised.*

Along the HEL at 28,8 m level there are several circumferential piping welds (elbows) and branch connections (three T joints connecting each steam line to the so-called "bubliks").

Sect. B.1b (4): *"The length of these portions of piping should be reduced to the minimum length practical".*

[7] The "*break exclusion zone"* is in Western NPPs the area of the piping between the Reactor Building containment penetration outboard weld and the upstream weld of Auxiliary Building anchor point beyond the isolation valves, including Main Steam safety valves and connecting branch piping.

The length of steam and feed water lines from the containment piping penetration to the isolation valves is in the order of tens of meters.

Sect. B.1b (5): *"The design of pipe anchors or restraints … should not require welding directly to the outer surface of the piping ...".*

This is the case with the pipe whip restraints fixtures (see also in the above).

The current ETE solution is not in full compliance with the principles of the above requirements and at the same time exceptions are adopted from each requirement.

ANNEX D

Specific Information Request

Revision 4, issued 2002 11 27

Specific Information Request (SIR) in the context of

“ Item No.1 High Energy Pipe Lines at the 28.8 m Level (AQG/WPNS country specific recommendation)”

Information about the use of the following tables:

The SIR asks for documentation and information about all **Activities** undertaken to resolve the “Safety Case”, which are treated in the Comprehensive Safety Case Revisit (CSCR).

1. These **Activities are denoted** in the “ 6th Additional Information to the Decision Paper on Chapter 14 „Energy“ “ (Document. CONF-CZ-50/01, Brussels, 2001 09 17, **hereinafter in the APPENDIX I document**). It contains only aspects linked to the HELB issue that need to be treated (according to Conf-CZ 50/01).
   The Activities have been numbered individually **in columns 1 and 2** of the Table in APPENDIX I (page 73).
2. The **requested Specific Information** (see the following table) is organised according to areas of interest for monitoring. **In column 7 on page 62 ff it indicates the Activities** the document requested is thought to be related to.
3. The ***WORKSHOP*** *has indicated some of the* ***documentation*** *available and these titles have been added** and the Activities they are associated with in column 7 (on page 69).

Since most of the documentation is known neither by exact title and author, nor by document number or identification code, the expected content is outlined in the following tables by an English short title, indicating the main topic(s) of interest. Based on this information, the organisational technology units at CEZ/ETE, the supplier(s) and/or the licensing authority should be able to identify the relevant documentation.

Information contained in the documentation would be needed as one supplement to create answers to the Verifiable Line Items. A positive answer to the Verifiable Line Items supports assumptions about an adequate, consistent and sustainable implementation of the Defense in Depth concept.

The Ranking I to III (introduced in column 2,3,4) of the SIRs applied in the following tables is only intended to indicate priorities for access to the related information. It does not indicate that some of this information would be less supportive to the monitoring process.

*) *It would be particularly beneficial if key documentation as it is cited in the individual WORKSHOP presentations would be available in the MONITORING Process under way.*

Area	I	II	III	No	High Energy Pipe Lines at the 28,8 m Level – Specific Information Request	Related Activities see APPENDIX I col 1,2 ↓
1	2	3	4	5	6	7
Codes and Regulations	x			1	Czech Codes and other codes & rules that were applied in the primary and secondary systems. Special attention should be given to the:	
	x				• piping integrity requirements	2.
	x				• design loads	2.
	x				• load combinations and structural parts	2.
	x				• mechanical, structural and ISI requirements for break exclusion demonstration	2.
	x			2	Specification of rules and regulations governing the application procedures of the simulation codes (used in stress analyses, pipe break loads and impact, water hammer, corrosion, probabilistic fracture mechanics …)	2.
	x			3	Safety evaluation and plant start-up tests evaluation report(s) issued by the SÚJB concerning Temelín insofar as the report(s) address(es) HELB issues	2.6.
	x			4	Safety Analysis Report (Chapters related to the topic in question, most recent revision)	1.
Material and Coolant Fluid	x			5	Data base for Fractures and Mechanical Properties Including Corrosion for Temelín NPP, ÚJV, Report 10294, October 1994 (as well as subsequent updates and replacements for this report)	3.3.
		x		6	Documentation of erosion/corrosion verification and mitigation programs applicable to the main steam and main feed water lines	2.
	x			7	Report on the determination of mechanical and fracture mechanical characteristics for all materials of the main steam and main feed water lines (ETE-1 and ETE-2)	2.
		x		9	Chemical composition and material properties for all main steam & main feed water (including welds, piping restraints, penetrations, and valves)	2.
		x		10	System specification of water chemistry and water treatment for main coolant pipes and secondary pipes (MS & MFW) and diagnostic parameter evaluation procedures (such as pH-value control in various operation regimes, concentration of oxygen ammonia, etc)	2.

Design		x		11	Determination specification and design of pipe whip restraint requirements/material properties	2.1, 2.2.
	x			12	Specification of break exclusion requirements, including the design basis and in-service inspection provisions to ensure that the design basis continues to be met	2.5., 3.1.
	x			13	Specification of pipe whip restraints requirements, including the design basis and in-service inspection provisions to ensure that the design basis continues to be met	6., 2.
	x			14	Static and seismic analysis specification document, results evaluation and validation for the secondary coolant loops	2.
	x			15	Seismic design parameters for Temelín and floor response spectra used for the piping stress analysis for the main steam and main feed water lines (including penetrations, pipes, valves, welds, and pipe restraints)	2.
Loads	x			16	Design loads (such as water-steam hammer, design transients, seismic level, etc.) and load combinations specification (as used for ETE1 and ETE2)	2.
	x			17	Water hammer analysis specification and results documentation for the main steam lines and main feed water lines	3.2.
	x			18	Local loads on concrete structures and integrity evaluation of floors and walls for the main steam lines and main feed water lines	2.
		x		19	Beyond design basis accidents and the related load definition for high energy line breaks	2.
	x			20	Comprehensive loads and damage mechanisms specification for feed water and main steam lines, for the entire plant life	2.
Safety Provisions	x			21	Specification and documentation of modifications to the current plant Emergency Operating Procedures (EOPs) and severe accident management guidance planned to assist the plant staff in responding to HELB initiating events and consequential failures (probabilistic aspect)	2.4.
	x			22	Emergency Operating Procedures (EOPs) related to HELB initiating events (and consequential failures) response and management (probabilistic aspect)	2.4.
	x			23	Guidelines for severe accident management of severe accidents involving high energy line break initiating events and consequential failures (probabilistic aspect)	2.4.
Stress and Failure	x			24	Specification of criteria and methodology used for main steam line and main feed water line piping stress analysis and pipe rupture approach	2.

Analysis	x			25	Piping stress analysis of main steam lines and main feed water lines (loops 1 through 4) including the containment penetration and the piping extending from the penetration to the turbine building wall	2.
	x			26	Sensitivity Study of Stress Response of Steam Piping & Feed water Line after Hanger Failures, ÙJV, 10238, June 1994 (as well as any subsequent updates and replacements for this document)	2.
	x			28	Report evaluating the pipe break locations postulated for the main steam lines and main feed water lines (loops 1 through 4)	2.
Failure Consequences	x			29	Report by the Regulatory Authority SÚJB evaluating multiple consequential pipeline failures resulting from HELB initiating events	1.
Analysis	x			30	Multiple pipe breaks analyses specification documenting exclusion of multiple main steam line and main feed water line breaks for demonstration for internal events and external events	2.
				31	Specification and documentation for modifications planned to reduce the likelihood of consequences of HELB initiating events and consequential failures	2.4.
		x		32	Assessment documents quantifying the likelihood of steam generator tube leakage or rupture as a consequence of main steam line rupture	2.4.
		x		33	Core neutronics/return to power analysis documentation (which underlies the PSA's assessment of accident progression analysis for HELB initiating events and consequential failures). Calculations and assessment covering multiple steam line, multiple feed water line, and mixed cases involving steam and feed water line ruptures should be provided as available	4.1.
Preventive Measures	x			34	Layout of existing design solution and proposed design solution for main steam line and main feed water lines from the containment penetration to the turbine building wall, with supports and restraints locations (if any) – "as-built" documentation	2.
and related Components	x			35	Pipe whip restraint and containment penetration restraint drawings for the main steam lines and main feed water lines (loops 1 through 4)	2.1, 2.2.
	x			36	Pipe whip sizing assessment and related reports for the main steam line and main feed water lines	2.1., 2.2.
	x			37	Proposal for Design Changes for Feed water lines ETE, Unit 1, ÚJV 10245 T, July 1994 (as well as any subsequent updates and replacements for this report)	1., 2.
	x			38	Design and arrangement of the main steam safety valves, main steam relief valves (BRU-A), and main steam isolation valves, including opening and closure behaviour description in accident conditions (delay, characteristics)	1., 2., 7.

	x			39	Component passports (especially valve data) for the main steam lines and the feed water lines (ETE-1 and ETE-2, loops 1 through 4 in both units))	7., 2.
			x	40	LBB Handbook covering the main steam lines and main feed water lines (if LBB is applied for this case by Czech side)	3.
			x	41	Leak before break (LBB) concept specifications and LBB calculations reports for the main steam lines and main feed water lines (loops 1 through 4, ETE1 and ETE2)	3.
			x	42	Specification of leak detection systems for feed water and main steam lines surveillance	3.4.
			x	43	Evaluation report of jet impingement including temperatures/pressures response for the main steam lines and main feed water lines	2.3.
			x	44	Evaluation report of jet impingement shape including jet direction and loads for the main steam lines and main feed water lines	2.3.
		x		45	Specification of equipment used for the prevention of jet impingement effects on safety related equipment (protective jacket)	2.3.
		x		46	Jet shields drawings and sizing report for the main steam lines and main feed water lines (loops 1 through 4, ETE1 and ETE2)	2.3.
		x		47	Evaluation document of the postulated pipe break locations in relation to safety related equipment in the vicinity of pipe breaks	1., 2.
PSA and PFM	x			48	Internal events (IE) probabilistic safety assessment (PSA) for Temelín (updated circa 2002) (including the main report, attachments, and appendices to the main report, computerised plant model, PSA-software specification)	2.4.
	x			49	Most recent external events (EE) probabilistic safety assessment (PSA) for Temelín for which HELB is possible as a result of the initiating event (most recent issue thereof); main report, attachments, appendices to the main report, computerised plant model, PSA-software specification. Relevant initiating events may include, for example, aircraft crash or seismic events. (main steam lines and main feed water lines from the isolation valves to containment wall)	2.4.
		x		50	Reports analysing accident progression using the MELCOR (or other severe accident progression codes) for accident sequences initiated by HELB of the main steam lines and feed water lines from the containment penetration to the turbine building wall (loops 1 through 4, ETE1 and ETE2)	4.3.
	x			51	Most recent level 2 PSA for Temelín which provides the containment event tree, accident progression analysis, and source term analysis relevant to severe accident sequences involving HELB initiators and consequential HELB sequences (including the main report, attachments, appendices to the main report, computerised plant model, PSA-software specification)	2.4.

	x			52	Quantification of the initiating event frequencies for HELB in the main steam lines and main feed water lines (loops 1 through 4, ETE1 and ETE2) which provides the basis for the values used in the revised internal events PSA	2.4.
	x			53	Quantification of conditional probability of consequential high energy line break following a HELB initiating event in the main steam lines and main feed water lines (loops 1 through 4, ETE1 and ETE2)	2.4.
	x			54	Documentation of quantitative basis of top events which appear in PSA sequence cut sets for which HELB is an initiating event or a consequential failure (system notebooks, human reliability analysis, or documents of comparable content for the quantitative basis for the top event)	2.4.
		x		55	Report about failure cases considered in the assessment of secondary failures resulting from HELB in the main steam lines and main feed water lines (loops 1 through 4, ETE1 and ETE2)	2.4.
	x			56	Probabilistic fracture mechanics (PFM) analyses documentation for the main steam lines and main feed water lines at Temelín NPP	2.4.
		x		57	Documentation on piping and instrumentation diagrams (P&ID) for the main steam and main feed water systems, including the instrumentation and control systems used for HELB events response and management in the emergency operating procedures and severe accident management guid-ance	1., 2.
Integrity verification	x			58	Specifications of in-service inspection (ISI) program(s) and related procedures applicable to the main steam lines and feed water lines including the immediate containment wall vicinity	6.
	x			59	Specifications of non-destructive testing (NDT) program(s) and related procedures applicable to the main steam lines and feed water lines including the immediate containment wall vicinity	6.
	x			60	Specifications of the NDT program for the main steam lines and main feed water lines (loops 1 through 4, ETE1 and ETE2), including a description of the methodology and a summary of NDT results before start-up, and the ISI procedures and results	6.
	x			61	NDT of circumferential welds and fillet welds of fixation plates in the areas covered by the pipe whip restraints for main steam and feed water lines:	6.
	x				• – as built drawings of the set-up	1., 2.
	x				• – test specifications and procedures	6.
	x				• – results of qualification tests on reference specimens	6.

		x			• – NDT equipment specification	6.
		x			• – NDT records	6.
Operation		x		62	Plant operation data (if comparable or generic) suitable to demonstrate that corrosion (IGCC, stress corrosion, etc.) is assumed to be not a problem for the secondary system of the VVER 1000 NPPs and Temelín units 1 and 2	3.3
		x		63	Plant operation data (if comparable or generic) suitable to demonstrate that erosion (flow velocity layout components, etc.) is not a problem for the secondary system of the VVER 1000 NPPs	3.3
	x			64	Report or database of historical HELB events used or established as part of the process of estimating the initiating event frequency for HELB	2.4.
Accident Scenarios and Accident Analyses	x			65	Description of the code(s) used for the HELB thermohydraulic plant (including qualification for VVER type reactors, modelling of the horizontal steam generator, degree of modelling, numerical description applied, critical (discharge) flow models, entrainment model(s), coolant mixing models and assumptions)	4, 4,1. 4.2
	x			66	Description of the code(s) used for the HELB thermohydraulic core analyses (including verification and validation basis)	4, 4,1. 4.2
	x			67	Description of the code(s) used for the HELB neutron-kinetic core analyses (including neutron-kinetic core model with approximations for steady-state and transient neutron flux distribution, code-qualification for calculation of hexagonal fuel elements, code verification and validation basis)	4, 4,1. 4.2
	x			68	Description of the coupling of the core and the plant models (including coupling of different codes used, proof of non-affecting the results in case of de-coupled analysis)	4, 4.1, 4.2
	x			69	Information about the degree of modelling the core, modelling of single components and about implementation of control and safety systems (including modelling of essential plant components like loops, steam-generator primary and secondary side, relevant primary and secondary side pumps, thermohydraulic and neutron-kinetic axial/radial nodalisation, macroscopic cross section library for reactor core)	4, 4,1. 4.2
	x			70	Description of the HELB scenario selected (including break location, size and number of affected loops, neutron-physical and thermohydraulic initial and boundary conditions, stuck open control rod position, availability of control and safety systems and actions during the transient)	4, 4,1. 4.2
	x			71	Assessment of the HELB scenario selected (i.e. a bounding scenario regarding core cooling/heat removal, fuel rod integrity, return to power after scram, including models/assumptions for primary coolant mixing in down-comer, lower and upper plenum and in the core)	4, 4,1. 4.2

	x			72	Description of the HELB transient calculations (including description of analysis performed, time-history of sequence of events concerning activation/de-activation of relevant control and safety systems, transients of core inlet temperature and of steam generator water level)	4, 4,1. 4.2
	x			73	Results of steady-state and transient calculations concerning reactor core (including control rod movement, transients of reactor power, of reactivity, of fluid temperatures/pressures at core inlet and outlet, of core mass flow, maximum temperatures of fuel/cladding/coolant, of 3D power distribution at minimal DNB locations, DNBR analysis results)	4, 4,1. 4.2
	x			74	Results of steady-state and transient calculations concerning primary circuit model (including time history of coolant temperatures in hot/cold legs and mass flow rates in loops, pressure in upper plenum and pressurizer, water level in pressurizer)	4, 4,1. 4.2
	x			75	Results of steady-state and transient calculations concerning secondary circuit model (total/liquid/steam discharge mass flow rate through break opening, discharge coefficients, steam generator pressure and water level, steam line and safety/relief valves mass flow rates, feed water mass flow rates and temperatures for normal, auxiliary and emergency feeding of every single steam generator)	4, 4,1. 4.2
	x			76	Discussion of the results of the HELB transient thermohydraulic calculations performed (including information about sensitivity of results to specific parameters and modelling features)	4, 4,1. 4.2
1	2	3	4		6	
Area	I	II	III	No	**High Energy Pipe Lines at the 28,8 m Level –** Specific Information Request	**Related Activities see APPENDIX I Col 1,2 ↑**

Additional WORKSHOP documents*)						
RANKING	I	II	III		Document	Related Activities see APPENDIX I col 1,2↓
1	2	3	4		6	7
Procedure assessment	x				Comparative study on regulatory requirements of the US NRC, CEA (France) and RSK – BMI (Germany) on pipe break postulations. Report DITI, May 2002	***3.1***
	x				LBB concept modification based on comprehensive study with the Break Preclusion Concept. Report DITI, May 2002	***3***
	x				“Superpipe” concept application according to the RCC-P on the steam lines. Report DITI, June 2002	***(3 new)***
Pipe Whip restraints	x				Pipe whip restraint[s] design for steam feed water piping outside hermetic zone. Report UAM, March 2001	***2.1***
Stress and	x				Project for strain gage measurement on steam and feed water lines. Report UAM, July 2001	***3.4***
displacement measurements	x				Displacement measurement on steam and feed water lines at A820 for Units No. 1 and 2. Report UAM, July 2002	***2.6***
Thermal Hydraulic Assessment	x				Thermal-hydraulic analysis of 2 MSL breaks for Safety Case 28.8 m at NPP Temelín. Report DITI, July 2002	***4***
Dynamic Forces Assessment	x				Dynamic response of steam and feed water lines on steam and feed water hammer. Report DITI 300/113, June 2001	***3.2***
	x				Integrity Assessment of Steam Lines on Primary to Secondary leak. Report DITI, August 2002	***2.3***
	x				Probability calculation of steam and feed water lines failure for NOC, ANOC and seismic loading conditions. Report DITI June 2002	***2.4***
	x				Steam line response on opening and closing BRU-A. Report DITI August 2002	***3.2***
	x				Steam Generator relief valve (BRU-A) discharge piping assessment for NOC and ANOC loading conditions. Report DITI, September 2002	***3.2***

	x				Qualification of impulse line connecting steam lines, SG impulse safety and safety valves for two phase [and] water loads. Report DITI, September 2002	***3.2***
Separation Wall Study	x				Determination of maximum forces due to pipe breaks on steam and feed water lines acting on separation wall. Report DITI May 2002	***5***
Material Database	x				Refinement of the materials database-mechanical and fracture mechanics properties for secondary circuit materials. Report DITI, July 2002	***2***
Containment Pipe Penetrations	x				Pipe whip restraint[s] effect assessment on containment pipe penetrations hermetic sealing ability due to postulated pipe break on steam and feed water lines. Report DITI, December 2001	***2.1***
PTS Methodology	x				Methodology of the structural Part of the PTS Assessment for the NPP Temelín. Report DITI, July 2002	***4.2***
	x				Initiation events summaries for the PTS assessment. Report DITI, February 2002	***4.2***
UT NDE Qualification	x				Inspection procedure for UT NDE of fillet welds with fixation plates for pipe whip restraints. Report DITI, June 2002	***6***
	x				Inspection procedure for mechanised UT NDE of circumferential steam and feed water welds. Report DITI, June 2002	***6***
1	2	3	4		6	
RANKING	I	II	III		Document	**Activities see APPENDIX I col 1,2 ↑**

APPENDIX I

References in the SIR

are related **to the following Activities** as announced in Document
“ Sixth Additional Information to the Decision Paper on Chapter 14 ‘Energy’“
(Document. CONF-CZ-50/01, Brussels, 2001 09 17).

Activity No. in SIR column 7		#	Activity description	Status	Time schedule
1	2	3	4	5	6
1.		1	Preparation of Comprehensive Safety Case on Temelín NPP high energy piping layout at 820 and 826/1 BRU-A and SGSV steam-water mixture qualification (the report will comprise results of steps 2 – 7)	Started 30.1.2001	30.09.2001 1st Progress 30.10.2001 2nd Progress Rep. 30.03.2002 3rd Progress Rep. 30.06.2002 Final Report 30.09.2002 Regulatory Submittal
2		2	Stress state calculation and measurement including:		
	1	3	pipe whip restraint reassessment	Finished	10.03.2001
	2	4	pipe penetrations reassessment	Finished	15.08.2001
	3	5	integrity reassessment of steam piping due to water overfill	Started	30.10.2001
	4	6	probability calculation according to PRISE methodology	Started	30.10.2001
	5	7	(US NRC) in comparison with LBP Pipe (SKI Methodology		
	6	8	stress state measurements projects	Started	till 2003
3		9	LBB concept application assessment including:		
	1	10	comparison with Break Preclusion Concept	Started	30.10.2001
	2	11	dynamic loading calculations due to steam water hammer	Finished	15.08.2001
	3	12	E-C assessment	Started	15.09.2001
	4	13	LBB concept application according to the US NRC SRP 3.6.3.	Started	30.04.2002
4		14	TH analysis of multiple steam and feed water lines breaks in respect:		
	1	15	core cooling and final performance	Started	15.10.2001
	2	16	PTS situation		15.10.2001
	3	17	radiological consequences		15.10.2001

5		18	Feasibility study on separation of steam and feed water lines by qualified separation walls design	Started	30.06.2002
6		19	UT Qualification of method, equipment and personnel according to ENIQ methodology for circumferential welds and pipe whip restraint fixation elements, UT testing and assessment of results	Started	30.11.2001 and during outage
7		20	Qualification file development for the BRU-A valve and the SG SV (IPU-Valves) for steam-water mixture performance	Started	30.06.2002
1	2	3	4	5	6
Activity No. in SIR column 7		**#**	**Activity description**	**Status**	**Time schedule**

APPENDIX II

Figures and Schemes

Revision 4, issued 2003 01 12

Origin of the Figures

Figures	Title	Source
Figure 1	Scheme and Plant lay-out for a generic VVER	http://www.nucleartourist.com/type/vver.htm
Figure 1	Scheme and Plant lay-out for a generic VVER	http://www.insc.anl.gov/sov_des/npfsubib.php
Figure 2	TEMELÍN NPP mock-up in between other exhibiting the 28,8m level area and two main secondary feedwater lines	http://www.insc.anl.gov/sov_des/
Figure 3	WWER-1000 main steam and feed water lines inside and outside the containment (at 28,8 m level)	WWER-1000 specific schematic

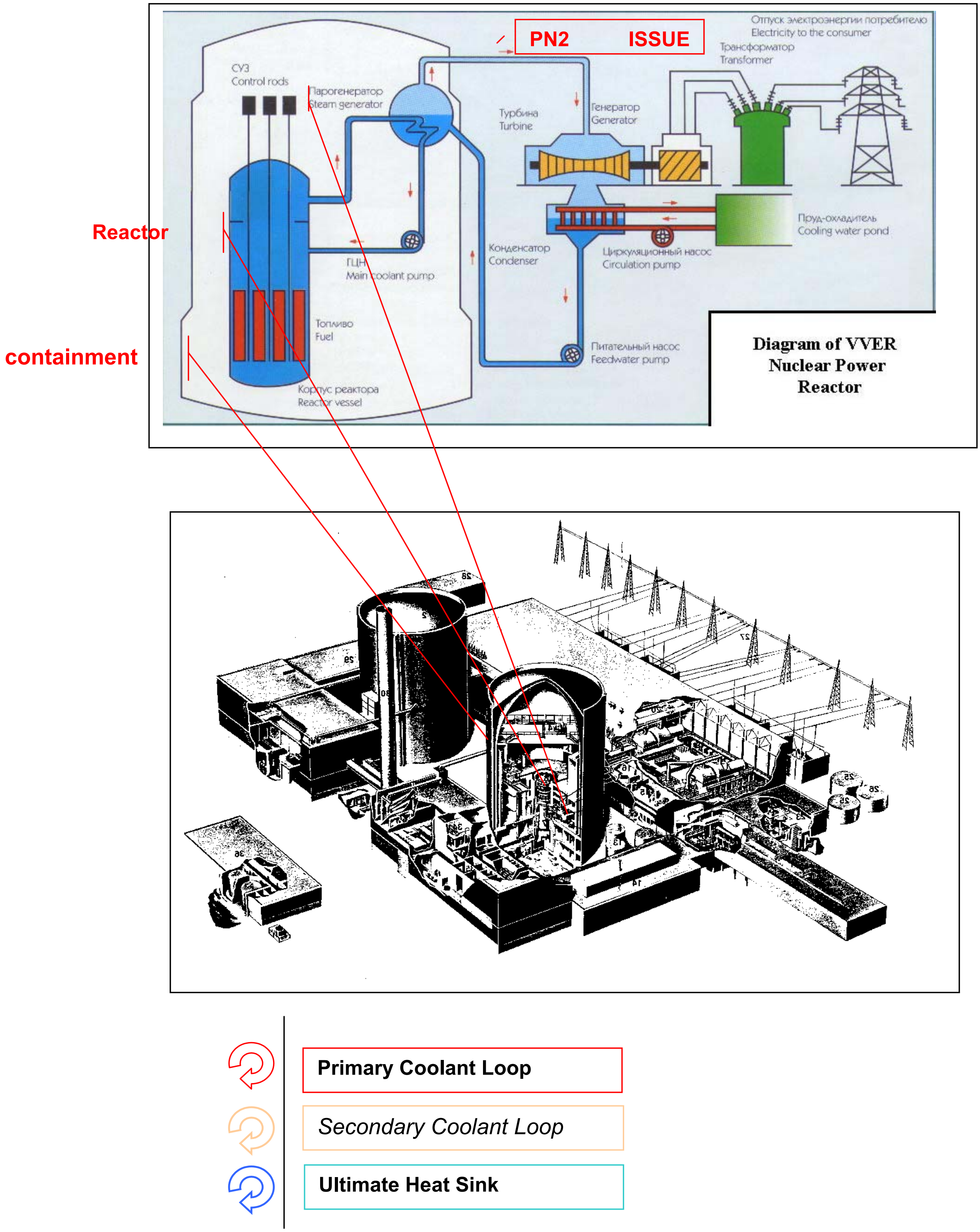

Figure 1 Scheme and Plant lay-out for a generic VVER

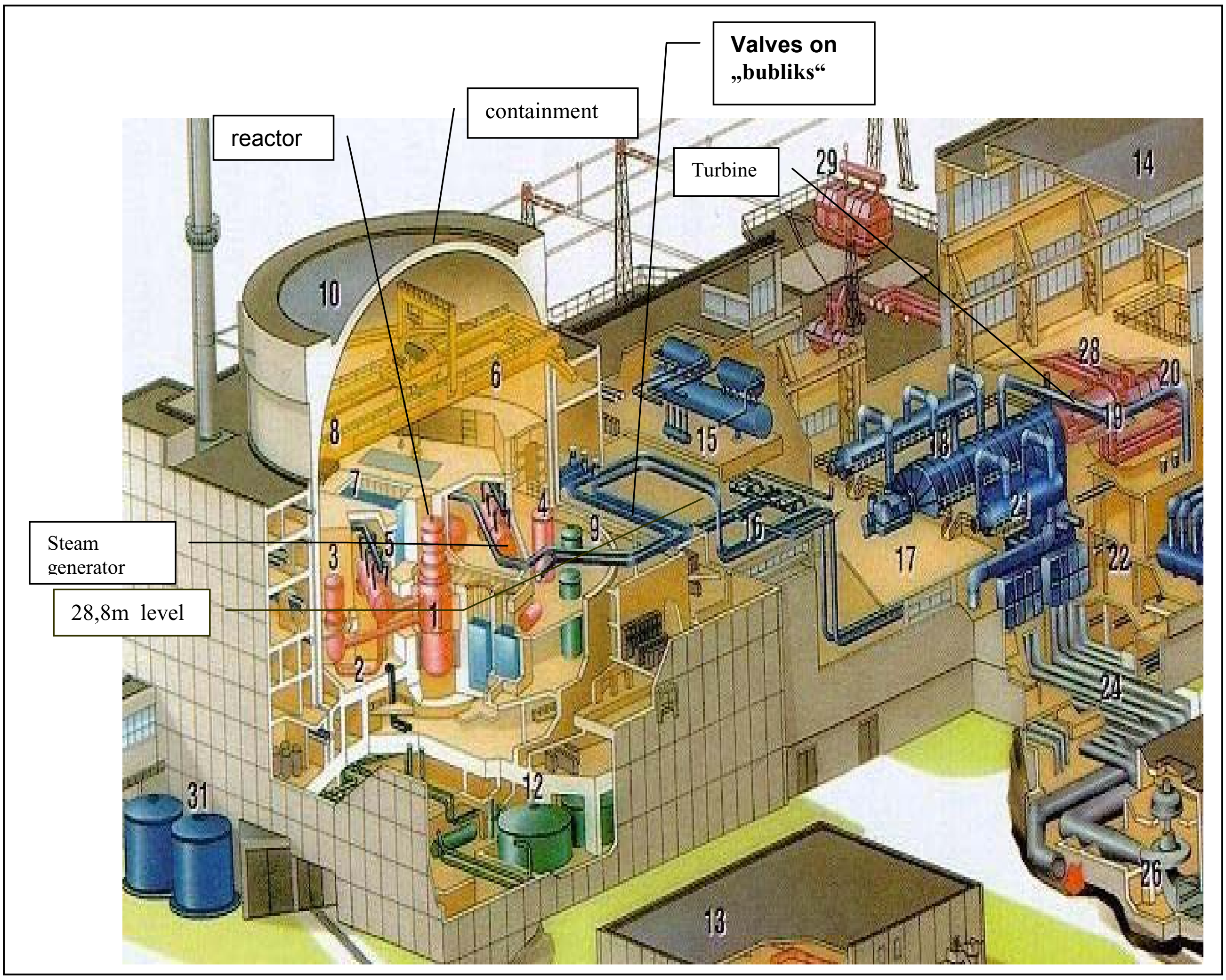

Figure 2 Temelin NPP - mock-up in between other exhibiting the 28,8m level area and two main secondary feed water lines

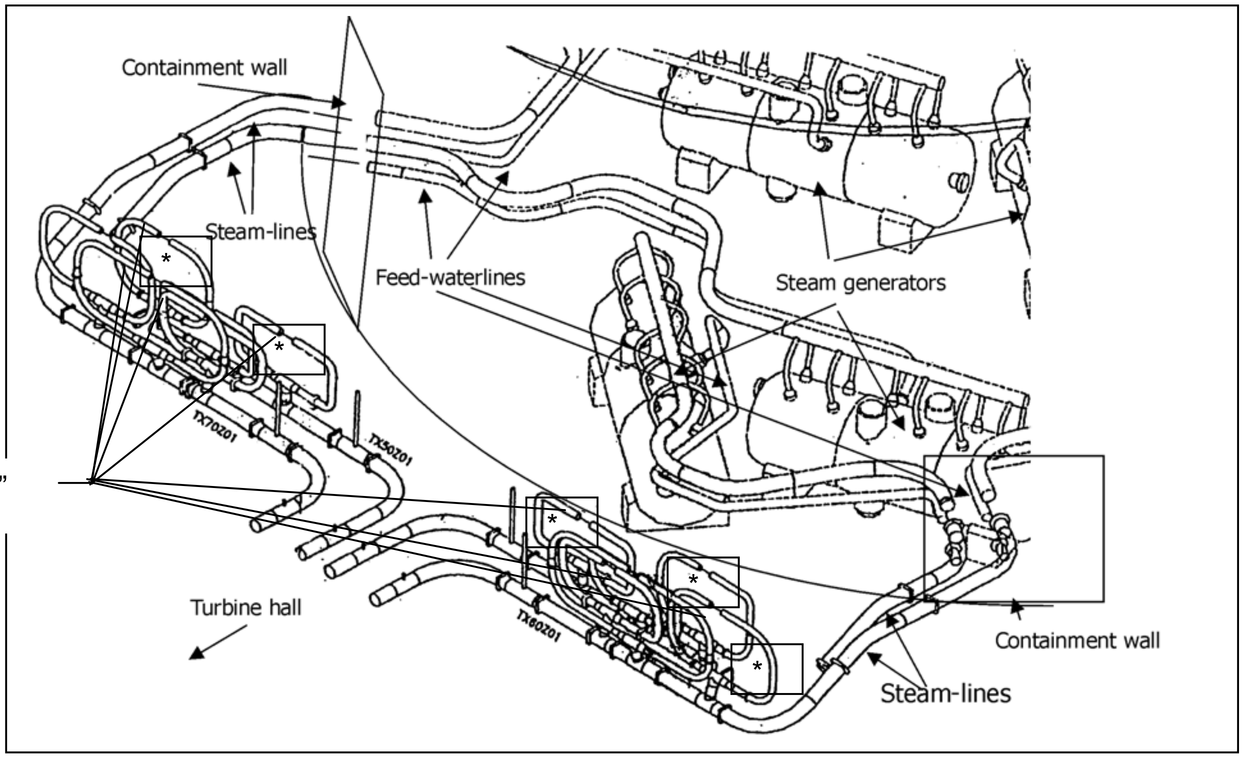

Figure 3 WWER-1000 main steam and feed water lines inside and outside the containment (at 28,8 m level)

APPENDIX III

Règles Applicables aux Procedés des Centrales Nucléaires A Eau Légère sous Pression de 1400 MWe (authors EdF and Framatome)

REGLES DE CONCEPTION ET DE CONSTRUCTION DES CENTRALES NUCLÉAIRES REP

REGLES APPLICABLES AUX PROCEDES DES CENTRALES NUCLÉAIRES A EAU LÉGÈRE SOUS PRESSION DE 1400 MWe

RCC-P1400

Document préparé par EDF et FRAMATOME

Révision 1 - Octobre 1991

RCC-P 1400
Révision 1
Octobre 1991

AVERTISSEMENT

Le [RCC-P] est destiné aux organismes chargés de la conception et de l'installation de systèmes des centrales nucléaires à eau sous pression et peut être utilisé dans le cadre de relations contractuelles entre le client (propriétaire-exploitant de la centrale) et le constructeur de la chaudière ou de l'îlot nucléaire, ainsi que dans celui de relations avec des Autorités de Sûreté.

Il traduit les règles de conception adoptées pour les tranches du palier N4, dont la centrale tête de série est CHOOZ.

Il est susceptible d'évoluer pour suivre les progrès techniques réalisés.

Ce document est établi et édité conjointement par ELECTRICITE DE FRANCE et FRAMATOME. Il ne peut être diffusé sans leur accord écrit.

En aucune façon l'usage qui en est fait ne pourra engager la responsabilité des auteurs.

RCC-P 1400 **1/2**
Révision 1
Octobre 1991

SOMMAIRE GENERAL

RCC-P 1400 **2/2**
Révision 1
Octobre 1991

QUATRIEME PARTIE

REGLES APPLICABLES AUX ETUDES DE FONCTIONNEMENT

CINQUIEME PARTIE

REGLES APPLICABLES A LA PROTECTION DES PERSONNES CONTRE LES RAYONNEMENTS IONISANTS

RCC-P 1400 3.1 - 12/30
Révision 1
Octobre 1991

Dans les règles suivantes, les calculs des contraintes et du facteur d'usage sont effectués en considérant le chargement faisant intervenir le séisme correspondant au demi-spectre de dimensionnement (voir chapitre 4.2) et les situations correspondant aux conditions de fonctionnement normal ou aux incidents de fréquence modérée (conditions 1 et 2)

3.1.3.6.1 Tuyauteries haute énergie

a) Circuit primaire principal (niveau 1 du RCC-M)

On retient 11 types de ruptures sur le circuit primaire principal, définis comme suit :

- boucles
  - 6 ruptures guillotine (aux entrées et sorties des composants: cuve, générateur de vapeur, pompe) ;
  - 1 rupture guillotine au milieu de la branche intermédiaire reliant le générateur de vapeur à la pompe ;
  - 1 rupture longitudinale à l'intrados du coude situé à l'entrée du générateur de vapeur ;
- piquages
  - 3 ruptures guillotine aux piquages de plus grand diamètre: circuit de refroidissement du réacteur à l'arrêt, accumulateurs et ligne d'expansion du pressuriseur.

b) Tuyauteries auxiliaires étudiées suivant les règles de niveau 1 RCC-M

On fait l'hypothèse de rupture aux points suivants :

- aux extrémités de la tuyauterie ;
- aux points intermédiaires où l’on a, à la fois, le facteur d'usage supérieur à 0,1 et l'amplitude de variation de la somme des contraintes primaires et secondaires entre deux états du système (calculée par l'équation (10) du paragraphe B 3653 du RCC-M), supérieure à 2,4 S_m ;

- aux points intermédiaires où l'on a, à la fois, le facteur d'usage inférieur à 0,1, l'amplitude de variation de la somme des contraintes primaires et secondaires définie précédemment supérieure à 3 Sm, et les amplitudes de variations pour les contraintes d'expansion thermique, d'une part, pour la somme des contraintes primaires plus secondaires de membrane et de flexion (hors flexion thermique et expansion thermique) d'autre part, (respectivement équations (12) et (13) du paragraphe B 3653 du RCC-M), supérieures à 2,4 S_m.

Si aucun point intermédiaire ne peut être retenu de cette façon (ou s'il n'y en a qu'un), il en est choisi deux, sur la base des contraintes les plus élevées, présentant entre eux un écart d'au moins 10 % sur le niveau des contraintes ou, si l'écart est inférieur à 10 %, séparés par au moins un coude. Il peut n'en être choisi qu'un seul, au point où les contraintes sont les plus élevées, si la tuyauterie est droite, sans singularité et si toutes les contraintes sont en-dessous du niveau admissible.

c) Tuyauteries de niveaux 2 et 3 RCC-M

On fait l'hypothèse de rupture aux points suivants

- aux extrémités de la tuyauterie ;

- aux points intermédiaires où le taux de contraintes calculé par la somme des équations (10) et (7) des paragraphes C ou D 3650 du RCC-M dépasse 0,8 (1,2 S_h+ S_A), si l'analyse de contrainte est disponible.

Si aucun point intermédiaire ne peut être retenu de cette façon (ou s'il n'y en a qu'un), il en est choisi deux, sur la base des contraintes les plus élevées, présentant entre eux un écart d'au moins 10 % sur le niveau des contraintes ou, si l'écart est inférieur à 10 %, séparés par au moins un coude. Il peut n'en être choisi qu'un seul, au point où les contraintes sont les plus élevées, si la tuyauterie est droite, sans singularité et si toutes les contraintes sont en-dessous du niveau admissible.

Si l'analyse de contrainte n'est pas disponible, on fait l'hypothèse de rupture aux singularités de la tuyauterie (emplacements où le coefficient d'amplification de contrainte défini au paragraphe C3680 du RCC-M est supérieur ou égal à 2).

RCC-P 1400 3.1 - 14/30
Révision 1
Octobre 1991

d) Tuyauteries non classées - RCC-M

On utilise les règles de l'alinéa précédent.

3.1.3.6.2 Tuyauterie à moyenne énergie

On fait l'hypothèse de fissure traversante aux points où le taux de contraintes, calculé selon les équations (10) et (7) des paragraphes C ou D 3650 du RCC-M, est supérieur ou égal à 0,4 ($1{,}2\ S_h + S_A$).

Si l'analyse des contraintes n'est pas disponible, la localisation des fissures traversantes s'effectue selon les critères définis à l'alinéa d précédent du paragraphe 3.1.3.6.1.c.

3.1.3.6.3 Tronçons protégés

On ne postule pas de rupture ni de fissure traversante sur les tuyauteries haute énergie étudiées suivant les règles de niveau 2 du RCC-M lorsque toutes les exigences suivantes sont réalisées (critères de conception des tronçons protégés) :

- la longueur de ces tronçons est réduite autant que possible ;

- le taux de contraintes calculé par la somme des équations (10) et (7) du paragraphe C 3650 du RCC-M n'excède pas 0,8 ($1{,}2\ S_h + S_A$) ;

- les contraintes maximales calculées par l'équation (10) paragraphe C 3650 du RCC-M, sous les chargements résultant de la rupture de tuyauterie au-delà de la zone de traversée, ne dépassent pas 1,8 S_h (les chargements considérés sont le poids, la pression et les conséquences de la rupture).

- aucune soudure n'est réalisée sur la surface externe de ces tuyauteries à moins qu'elle ne puisse être contrôlée en volume à 100 % et qu'une analyse de contraintes détaillée ne montre que les contraintes ne dépassent pas les valeurs de l'alinéa 3.1.3.6.1 c ;

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- le nombre des soudures circulaires ou longitudinales est limité. Si des fourreaux sont utilisés, il n'y a aucune soudure longitudinale, sauf si des accès sont prévus pour permettre leur contrôle volumique périodique ; les tronçons droits de tuyauteries sont réalisés à partir de tubes sans soudures ;

- les discontinuités géométriques, telles que les changements de section aux raccords tuyauteries-vannes, aux noeuds de tuyauteries, aux changements d'épaisseur de tuyauterie, sont conçues pour que les concentrations de contraintes soient minimisées ;

- l'ensemble des soudures est soumis à une inspection renforcée précisée dans le programme correspondant.

Ceci n'est mis en oeuvre que pour les tronçons de tuyauterie eau et vapeur compris entre la traversée proprement dite et le point fixe extérieur.

3.1.3.7 Ruptures ou fissures traversantes postulées

Cette sous-section ne s'applique qu'aux tuyauteries hors circuit primaire principal pour lequel le paragraphe 3.1.3.6.1 est d'application et hors tronçon protégé (voir paragraphe 3.1.3.6.3).

Pour les tuyauteries de diamètre nominal inférieur ou égal à 25mm, on nt considère aucune rupture ni fissure traversante de tuyauterie pour ce qui concerne les conséquences mécaniques (jet, fouettement).

Il convient toutefois de vérifier que la rupture d'une ligne d'instrumentation du système de protection raccordé au circuit primaire ne conduit pas à des agressions provoquant :

Remark:

In addition to this Code and Regulation the following rules should be consulted whether applicable or not for the "Superpipe" approach:

RCC-M	paragraph
	C 3650
	D 3650
	B 3653
	C 3680

ABBREVIATIONS

Symbols		
	[°C]	degree centigrade
	[g]	Gram
	[km]	Kilometre
	[m]	Meter
	16GS	pipe mild steel type
	3D	3-dimensional
A		
	A820	28,8 m level
	ANOC	Abnormal Operation Condition
	ANSI/ANS	American National Standards Institute/American Nuclear Society
	APP	Application
	AQG/WPNS	Atomic Question Group/Working Party on Nuclear Safety
	archival	archive (material stored away for later use)
	ARCS	Consultant: Austrian Research Centers seibersdorf research
	ASME	American Society of Mechanical Engineers
	ASME Code QME	American Society of Mechanical Engineers Code
	ASME QME-1-1994	American Society of Mechanical Engineers Code
	ATHLET	Advanced Thermal Hydraulics Code developed by GRS
B		
	BAM	Bundesanstalt für Materialprüfung
	BMI	Bundesministerium des Inneren
	BRU-A	secondary system relief valves
C		
	CCF	Common Cause Failure
	CCF/CMF	Combined Common Cause/Common Mode Failure deliberations
	CEA	Commissariat à l'Energie Atomique
	CERVUS	Working Group CERVUS
	České Budějovice	City close to Temelín
	ČEZ	České energetické závody - the Czech Electricity Generating Company
	ČEZ a.s.	Energetická společnost ČEZ, as
	ČEZ/ETE	Nuclearna Electrarna Temelín
	Charpy-V-Notch Test	fracture toughness test using special specimen
	CHECMATE™/ CHECWORKS™	corrosion wear prediction software developed by EPRI
	CHECWORKS™	corrosion wear prediction software developed by EPRI
	Chekhov	Checkov Company (joint venture with Siemens) producer of valves

	chi square	uncertainty quantification method
	cladding	metal skin of nuclear fuel or the RPV inner surface
	CMF	Common Mode Failure
	Code	consistent package of rules and regulations
	Code-Case	Individually treated application of a Code setting requirements
	Commissioning	Licensing Process
	CONF	Czech Conference Paper Series (documentation)
	CSCR	Comprehensive Safety Case Revisit
	CUMULUS	valves test facility of EdF
	ČZ	Czech Republic
D		
	DIMNP	Dipartimento di Ingegneria Meccanica, Nucleare e della Produzione
	DID	Defense in Depth
	DITI	Publication Series source not identifiable
	diversity	identical function provided by applying different means
	DNB	Departure from Nucleate Boiling
	DNBR	Departure from Nucleate Boiling Rate
	Doket	Document
	ductility	material property providing for deformation capability before rupture
	duplicate	reproduce test
	DYN3D	3D Code
E		
	EC	European Community
	EdF	Électricité de France
	EE	External Event
	ENIQ	European Network for Inspection Qualification
	EOPs	Emergency Operation Procedures
	EPRI	Electrical Power Research Institute
	EQ	Environmental Qualification
	ETE	Temelín NPP
	ETE1	Temelín NPP Unit 1
	ETE2	Temelín NPP Unit 2
	EU	European Union
F		
	FAC	Flow-Accelerated Corrosion
	Final Report	Final Monitoring Report
	FW	feed-water
G		
	GbR	Consultant: Innovativer Werkstoffeinsatz GbR
	GRS	Gesellschaft für Reaktorsicherheit
	Guidelines	Non-mandatory recommendations for an identified purpose
	guillotine	Break type perpendicular to the axis of the main component body

H		
	Hanger	pipeline vertical support
	Harmonisation	develop a coherent view or solution
	HEL	High Energy Lines
	HELB	High Energy Line Break
	hexagonal	six edged cross-section shape of the ETE fuel element
I		
	IAEA	International Atomic Energy Agency
	IGCC	Intergranular Corrosion Cracking
	IPU	SG Safety Valves (IPU-Valves)
	IRR	Consultant: Institute for Risk Research
	ISI	In-service Inspection
	Isometric	drawing projection method for engineering designs
J		
	jacket	here: equipment used for the prevention of jet impingement
	jet	high speed flow
	JETE	
	judgement	result of factual and documented results assessed
K		
	k_{CV}	material fracture toughness quantification
	KTA	Kerntechnischer Ausschuss, German Nuclear Standards Board
L		
	LBB	Leak Before Break Method proving leak detectability before break
	LBP	Low Break Probability Concept of SKI (Sweden)
	LOCA	Loss of Coolant Accident
	Ltd	Limited
M		
	MELCOR	Core degradation simulation code
	Melk	City in Austria where the A - CZ "Melk Agreement" was signed
	MFW	Main Feed-Water
	MFWL	Main Feed-Water Line
	Mochovce	EMO Nuclearna Electrarna Mochovce in Slovakia
	mock-ups	physical representation of relevant component properties for testing
	MONITORING	Austrian oversight process along the Temelín Roadmap (see page 16)
	MS	Main Steam
	MSIV	Main Steam Isolation Valve separating the steam generator from the turbine
	MSL	Main Steam Line
	MSS	Main Steam System
	MSSV	Main Steam Safety Valve

N		
	NDE	Non Destructive Evaluation
	NDT	Non Destructive Testing
	NOC	Normal Operation Condition
	NPP	Nuclear Power Plant
	NRI-Řež	Nuclear Research Institute in Řež
	NUREG	Nuclear Code of Regulations
O		
	OBE	Operation Bases Earthquake
	OPB	Russian Code for Nuclear Installations
P		
	P&ID	Piping and instrumentation diagrams
	Passport	Certified materials properties document according to OPB requirements
	PFM	Probabilistic Fracture Mechanics
	pH	Negative hydrogen ion concentration indicating acid or basic fluid properties
	PIPESTRESS	stress evaluation code for pipelines
	plc	Public Legal Company
	PM3	Project Milestone 3
	PN2	Project Number 2 “High Energy Pipe Lines at the 28.8 m Level”
	PN3	Project Number 3 “Qualification of Valves”
	PN….	Project of the Roadmap (see page **101** ff)
	PRAISE	Probabilistic Fracture Mechanics Code
	PRISE	Primary to Secondary Leak Event
	Procedure	Qualified and approved sequence of actions serving a specified purpose
	Project Milestone	subdivision of IRR/ARCS Project
	PSA	Probabilistic Safety Assessment
	PTS	Pressurised Thermal Shock
	PTSA	Pressurised Thermal Shock Analyses
	PWR	Pressurised Water Reactor
Q		
	QME	Quality of active Mechanical Equipment
	QVC	Extension of Qualification from Parent to Candidate Valves
	QVP	Qualification for Parent Valves
R		
	RANKING	Importance of document requested
	RCC	Règlements Code du Construction
	redundancies	system portions providing for independent identical functions
	Reference material	Material with well established properties
	Roadmap	Elaborated and agreed steps to be followed in the

	RPV	Reactor Pressure Vessel
	RSK	Reaktorsicherheitskommission
S		
	SAMG	Severe Accident Management Guideline
	Scenario	Sequence of events
	SG	Steam Generator
	SGSV	Steam Generator Safety Valve
	Similarity	Comparable operation properties of two components different in size
	SIR	Specific Information Request
	SKI	Statens Kernenergi Inspectorate the Swedish Licensing Authority
	Specialists	Experts Appointed for the Roadmap Process
	SRP	Standard Review Plan of the US-NRC
	ST 20	Piping mild steel type used at ETE
	SÚJB	Státní Úřad Pro Jadernou Bezpečnost - Czech Licensing and Supervisory Body
	SUPERPIPE	Indigenous "Safety Case" demonstration composed by the Czech partners
	Surveillance	Properties development verification process
	SV	Safety Valve
T		
	TH	Thermal-Hydraulic
	TOR	Terms of Reference
	toughness	resistance to fracture, ductility of materials
	Tronçons Protégés	Break exclusion procedure according to the French RCC
	TSO	Technical Support Organisation
U		
	ÚAM	Ústav Aplikované Mechaniky, BRNO, spol. s.r.o. Supplier SGs
	UBA	Umweltbundesamt (Federal Environment Agency) (Main Contracting Party)
	ÚJV	Ústav jaderného výzkumu Řež (ÚJV), Research Institute Řež
	US	United States
	USA	United States of America
	US-NRC	United States Nuclear Regulatory Commission
	UT	Ultrasonic Testing
V		
	validated	Qualified for use in a validation procedure
	VERLIFE	Lifetime assessment of components piping in VVERs
	VIPRE	Electric Power Research Institute's thermal-hydraulic licensing analysis code of the nuclear utilities
	VLI	Verifiable Line Item
	volumetric	Encompassing the entire material volume of interest
	VVER	WWER synonym (Water-cooled Water-moderated Energetic Reactor = VVER is an acronym for Vodo-Vodyannoy Energeticheskiy Reactor

W		
	WORKSHOP	PM3 event in Prague
	WPNS	Working Party on Nuclear Safety of the EU
	WWER	PWR as the former East-Block Version

APPENDIX IV

AUSTRIAN PROJECTS IDENTIFICATION

PN 1	Severe Accidents Related Issues – [Item No. 7a] *
PN 2	High Energy Pipe Lines at the 28.8 m Level (AQG/WPNS country specific recommendation) [Item No.1] *
PN 3	Qualification of Valves (AQG/WPNS country specific recommendation) [Item No.2] *
PN 4	Qualification of Safety Classified Components [Item No. 5] *
PN 5	Regular bilateral Meeting 2002
PN 6	Site Seismicity [Item No. 6] *
PN 7	Severe Accidents Related Issues – [Item No. 7b] *
PN 8	Regular bilateral Meeting 2003
PN 9	Reactor Pressure Vessel Integrity and Pressurised Thermal Shock [Item No. 3] *
PN 10	Integrity of Primary Loop Components – Non Destructive Testing (NDT) [Item No. 4] *
PN 11	Regular bilateral Meeting 2004

* *The Items are related to Annex I of the Conclusions of the Melk Process and Follow up*

APPENDIX V

The Austrian Specialists' Team

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Quality Assurance was assigned to all partners as an integral part of the document review during its development!

MISSION STATEMENT
as adopted by the Specialists' Team

MONITORING MISSION STATEMENT

The independent Specialist Team agreed on a "Mission Statement" to define the monitoring process co-ordinated by IRR/ARCS.

"Monitoring" is a process performed in a predefined frame addressing selected issues defined in the "Conclusions of the Melk Process" as well as in the "Roadmap" and the solutions to these issues adopted by the Czech side.

Issues and their solutions are monitored on the basis of reference safety criteria and requirements coherent with Safety Approaches accepted in Western Europe. The requirements are checked against the generally applied Defense in Depth Concept.

The Monitoring has the objective to obtain evidence that adequate solutions have been submitted by the licensee to the licensing authority and that these solutions have been appropriately evaluated and approved by the regulator. Monitoring aims at performing an evaluation of the quality and adequacy of an overall process and the implementation results.

The Czech side has offered documentation and discussion opportunities.

The Monitor, in order to form a consistent opinion should be provided with the opportunity to ask for additional information and evidence or request supporting assessments to understand the evidence presented.

Reports of the Specialists' Team therefore include monitoring results of

- what has been done,
- how the applicable requirements have been addressed,
- how the safety objectives' and requirements' compliance was analysed and justified for the proposed solutions, and
- how were evaluated the solutions in the frame of the licensing process and considered in the related regulatory process

The Monitors were not tasked with performing a licensing review of Temelín NPP, and nothing in their reports may be construed to represent any such review. The responsibility for the safety and licensing of Temelín remains with ČEZ a.s. as the owner of the facility, and with the SÚJB, as the designated nuclear licensing and regulatory authority under Czech law.