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ETE Road Map

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

Summary Monitoring Report

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

Vienna, June 2005

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The present report is financed by the Federal Ministry of Agriculture, Forestry, Environment and Water Management of Austria.

Masthead

Editor: Federal Environment Agency Ltd.
Spittelauer Lände 5, 1090 Vienna, Austria

In-house reproduction

ISBN 3-85457-791-5

Note to the Reader

The report is published on the Temelín homepage provided by the Federal Environment Agency at http://www.umweltbundesamt.at.

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EXECUTIVE SUMMARY

I. The Framework

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 ("Brussels Agreement", see ANNEX A of this report). 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 Czech-Austrian bilateral "Nuclear Information 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 implementation of the said measures would also be regularly monitored jointly by Czech and Austrian Experts within the bilateral "Nuclear Information Agreement."[1]

A "Roadmap" regarding the monitoring on the technical level in the framework of the bilateral "Nuclear Information 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 (see ANNEX B of this report).

The Federal Ministry of Agriculture, Forestry, Environment and Water Management entrusted the Umweltbundesamt (Federal Environment Agency) with the general management of the implementation of the "Roadmap" on the Austrian side.

II. Monitoring on a Technical Level – Austrian Technical Projects

The monitoring on the technical level followed the sequence introduced by the "Roadmap". Each item relevant to safety and addressed in ANNEX I of the "Brussels Agreement" (further on ITEM), as well as ANNEX II of this agreement, corresponds to a specific technical project (see ANNEX C of this report).

Referring to Chapter IV of the "Brussels Agreement" and the principles of the "Roadmap", a number of issues identified in the "Trialogue" of the "Melk Process" were found suitable to be followed-up in the framework of the bilateral "Nuclear Information Agreement". Those issues, where appropriate, were also covered by the corresponding technical projects (see ANNEX D of this report).

For each of the projects an international experts' team was committed by the Umweltbundesamt (Federal Environment Agency) on behalf of the Austrian Government to provide technical support for the monitoring on technical level. In total, 35 organisation and other contractors from 10 countries were involved in the monitoring process on the Austrian side.

The specific technical projects are referred to as project PN1 – PN10 comprising altogether seven predefined "project milestones" (PMs).

[1] 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.

To focus preparatory work of the Austrian Experts' Team and to guide the Austrian Delegation through the Experts' Workshop, in a first step (Project Milestone 1), the safety objective was broken down to **Verifiable Line Items** (VLIs)

In a second step (Project Milestone 2) the Experts' Team prepared the so-called **Specific Information Request** (SIR), a listing considered to contain the kind of information required to provide for profound answers in the VLIs.

The third step (Project Milestone 3) included the Specialists´ **Workshops** with all the preparatory activities comprising also the briefing session for the Austrian delegations to these workshops.

The analysis of the information made available at the Specialists' Workshops played a decisive role in the development of the basis for the Preliminary and Final Monitoring Reports.

In a fourth step (Project Milestone 4), following the Specialists´ Workshops, the Austrian Experts' Teams reviewed the information and data received at the Workshops, benchmarked the information/documents handed out by the Czech delegations against the state of the art consolidated practice and prepared the **Preliminary Monitoring Report** (PMR). This report also highlighted issues recommended to be paid further attention to.

The Preliminary Monitoring Reports of each project have been presented at the regular **Annual Bilateral Meetings** under the bilateral "Nuclear Information Agreement" in 2002, 2003 and 2004, respectively, in a fifth step (Project Milestone 5).

The sixth step (Project Milestone 6) concentrated on the consolidation of findings and their presentation in one final report for each project. In case the Czech side provided additional project specific information after the related Specialists' Workshop, the related relevant monitoring steps and conclusions were included in the assessment contained in the **Final Monitoring Report** (FMR).

The Preliminary Monitoring Reports have been published on the website of the Umweltbundesamt (www.umweltbundesamt.at) between May 2003 and September 2004 (except for projects PN5, PN9 and PN10, which were the last to be completed). The Final Monitoring Reports will also be published there.

The present **Summary Monitoring Report** (SMR) summarizes in a seventh step (Project Milestone 7) the entire monitoring process and the monitoring results of all technical projects. Based on the Final Monitoring Reports, it intends to summarize those issues, which are recommended to be in the focus of further attention.

The Austrian Experts' Teams wish to recall that several aspects of the ITEMS considered in the Monitoring Process concluded here, are linked to other ITEMS within the scope of this Monitoring Process. When pursuing overall safety aspects in future bilateral information exchange, the interrelations between safety ITEMS should be taken into account, thus ensuring a full coverage of all relevant issues.

Nevertheless, given the complexity and details of the monitoring results indicated in the SMR, it should be noted that the complete considerations can be found only in the Final Monitoring Reports of each Austrian Technical Project. The summaries of these Final Monitoring Reports are presented in Section 2 of this Summary Monitoring Report.

III. Main Findings and Issues of Further Interest

For each ITEM identified, ANNEX I of the “Brussels Agreement” lists its objective, its status as of November 2001 and the specific actions planned at that time.

In this section the SMR summarizes the essence of the evaluation results of the Austrian Experts’ Teams for each ITEM. For each ITEM, the main findings are presented, as well as the issues recommended to be paid future attention.

The implementation of the “Roadmap” constituted, as described, an intensive process of expert work over several years. In the course of this process, the Austrian Experts’ Teams acquired detailed knowledge about the nuclear power plant Temelín, which served, inter alia, as the basis for various suggestions and proposals for improvements. Although some aspects deserve further discussion, the process as such – as presented in detail below – can be assessed as a positive contribution to the safety culture of the NPP Temelín. Furthermore, it has to be assumed that many of those points also apply to other nuclear power plants of the same or similar type – namely, to WWER-1000 plants, and partly also to other pressurized water reactors. A systematic analysis of the applicability of the results to other plants, however, is beyond the scope of the project presented here.

III.1 ITEM 1 – High Energy Pipelines at the 28,8 m Level

The information received from the Czech side provided an insight into the extensive work which was accomplished by the plant operators and their technical support organisations to consolidate the safety case in the framework of the “Comprehensive Safety Case Revisit”. When considering the concerns expressed in the Austrian Technical Position Paper (July 2001), the comparison with the current state also indicates a number of areas where improvements have been achieved and implemented.

An integrated approach of prevention, protection, qualification and mitigation measures (Defence-in-Depth concept), however, was followed only partially so far for the high energy pipelines at the 28,8 m level of the NPP Temelín. For sections of the pipes, with elbows and “bubliks”[2], the safety case relies on break exclusion only. Reliable compensation of this circumstance according to western practice was not yet demonstrated.

Therefore, a number of issues remains to be clarified:

- It remains to be clarified to which extent the material database as used and applied for the stress analyses results’ acceptance (SUPERPIPE concept) is adequately consolidated to justify break exclusion for the HELs at the 28,8 m level.
- A special weld construction (weld-on-patches) and the accessability of some circumferential welds requires strong NDT efforts for the applicability of the SUPERPIPE Concept. The establishment of an adequate NDT strategy for those efforts did not yet become evident in the presentations.
- The Czech experts have postulated that the loads resulting from a seismic design basis accidents envelop the loads resulting from fluid dynamics. However, according to a pilot study performed by the Austrian Experts’ Team it does not appear certain yet that it is possible to envelop, by seismic loads, all the dynamic loads, which have to be assumed for the HELs. Furthermore, leak and break estimates, which are the basis of break exclusion applicability, including assumptions concerning break locations, should be examined.

[2] Twofold pipe sections leading from the main steam line to the two entry nozzles of the steam-relief valves, forming a doughnut (in Czech: bublik) shaped piping arrangement linked to the steam line via a double T-joint.

- According to a pilot study by the Austrian Experts' Team, in case of multiple steam line breaks the reactor is likely to become re-critical after scram under certain conditions. (Re-criticality as such, however, does not necessarily mean that there is danger to fuel integrity or to the core.)

Furthermore, to fully honour the safety case, more detailed information would be useful – for example:

- Demonstration of embedding of the SUPERPIPE Concept into the original design criteria, and selection of pipe break locations and orientations for the analysis,
- influence of loads from outside the 28,8 m level area on maximum stress for the HELs within this area; loads due to water hammer or jet forces on pipe whip restraints; conclusive solutions for the water hammer loads on "bubliks"; proof, that the loads from the design basis earthquake are enveloping with respect to all other dynamic loads,
- provisions to protect safety-related equipment as part of the Defence-in-Depth concept; consequential damage from pipe whip and related assumptions concerning the support structures; analyses of the plant response to high energy line breaks; as well as results of the design analyses for the installation of a separation wall.

Consequently, the future exchange of information on HELs should above all cover the following issues:

- With regard to the materials used for the secondary High Energy Lines and their characterization, identification of the procedures used for the characterization of materials' properties and the use of these properties in the component acceptance process (SUPERPIPE application);
- With regard to the break exclusion concept verification, comparison with industry experience concerning break frequencies' assumptions specific to the particular arrangement of the pipelines, and comparison with industry experience of the in-service-inspection procedures adapted for pipe ducts at the 28,8 m level;
- With regard to the analysis of accident consequences which could result from HELBs, the analysis of immediate accident consequences with regard to bounding cases for dynamic loadings. Regarding intermediate accident consequences, the identification of the evolution of accident sequences from effects to the reactor core into events causing radioactive releases. For both the immediate and intermediate accident aspects, it appears to be essential to be able to know the magnitudes and the frequencies of the related accident scenarios.

III.2 ITEM 2 – Qualification of Valves

The Czech presentation and the discussion indicated positive achievements within the frame of the Comprehensive Safety Case Revisit (CSCR). These activities appear to have already increased the functional reliability of the main steam relief valves (BRU-A) and of Safety Valves (MSSV) in general. (They relate to the replacement of electrical actuators of the BRU-A valves and of pilot valves of the MSSVs on both units.)

Furthermore, the functional qualification of the main steam relief and safety valves of Temelín NPP for two-phase and water flow appears feasible, applying the ASME-QME-1994 requirements (similarity-approach) for functional qualification of valves.

Currently, however, those requirements are only partly met up to now. Adequate analyses for compensation of this, according to the state of the art, have not been demonstrated yet as having been performed.

Thus, the approach taken is not yet sufficient to definitely clarify to which extent the main steam safety and relief valves of Temelín NPP are functionally qualified for dynamic two-phase flow and pressurized sub-cooled water flow conditions.

Consequently, the future exchange of information on the main steam relief and safety valves should above all cover the following issues:

- Additional information about the basis on which the Czech regulatory authority accepted the valves' functional qualification;
- Demonstration of the functional qualification of the main steam safety and relief valves of Temelín NPP by additional tests and comprehensive analyses, including access to representative qualification documents.

III.3 ITEM 3 – Reactor Pressure Vessel Integrity and Pressurized Thermal Shock

The Czech approach for pressurized thermal shock (PTS) analyses, as presented, is in accordance with the state of science and technology, with respect to the concept, the methodology and the applied computer codes. The most severe transients analysed are well comparable to those regarded as representative for WWER-1000 plants according to current knowledge. All accident groups important in a PTS analysis were considered.

The surveillance program which is monitoring embrittlement progress represents a considerable improvement compared to other WWER-1000s, in particular regarding the location of the samples.

The demonstration of RPVI (reactor pressure vessel integrity) throughout service life was performed, for Temelín NPP, using the VERLIFE methodology. From a comparison to the Russian Code and the IAEA Guidelines, the Austrian Experts' Team has found that the VERLIFE methodology, as applied to the Temelín RPVs, seems to make use of reduced safety margins (i.e. reduction of the postulated crack size, elimination/reduction of safety factors, less conservative warm pre-stressing effect criterion, non-conservative assumptions for the fracture mechanics analyses). In combination with other uncertainties concerning material and embrittlement properties and with the observation that it cannot be excluded that there are reductions of conservatisms in several respects (see below), the resulting global safety margin for the Temelín reactors might not be sufficient.

Therefore, a number of important issues remains to be treated further:

- Although all accident groups important in a PTSA were analysed, in some cases the time frame of the simulation might not have caught critical loads to the reactor pressure vessel, since simulation results were available only for the phase ending just before repressurization would take place. Within accident groups, the transients analysed in some cases cannot be considered as the most critical ones. For individual transients it is assumed that emergency operating procedures are performed within a narrow time window to avoid brittle failure of the RPV.
- It seems that there are reductions of conservatisms. VERLIFE criteria seem to be weaker than those required by the IAEA Guidelines. Applying the values (concerning postulated crack sizes, safety factors and warm pre-stressing effect criterion) as required by the IAEA Guidelines would not result in a demonstration of RPVI requirements' fulfillment throughout lifetime.
- Further critical points remaining for clarification concern, for example: TH transient models, mixing behaviour models, embrittlement behaviour of the RPV materials as well as thematerials' initial critical brittleness temperature, fluence determination and the introduction of measures for fluence minimization, as well as areas of in-service-inspection, where qualification has not yet been achieved.

- Conservatism is reduced by including the intact cladding zone as structural reinforcement into the Finite Element model, in particular without adequate NDT reconfirmation, including non-conservative assumptions for fracture mechanics analyses at the cladding/ferritic steel interface (as confirmed by a pilot study of the Austrian Experts' Team). Accordingly, not all types of underclad cracks required for licensing of comparable RPVs in Western European countries might have been evaluated yet.

Consequently, the future exchange of information on RPVI and PTS should above all cover the following issues:

- Regarding PTS analyses, the consequences of additional critical conditions, and of an extended time frame for some of the sequences calculated, as well as the consideration of all crack sizes and crack positions of relevance in fracture mechanics (including stability considerations);
- The progression of embrittlement and the remedies taken. (This includes surveillance results for both units of the Temelín NPP, in particular the results of samples with higher initial critical brittleness temperatures, irradiated in Unit 2.);
- The comparison of materials' characteristics determined within the qualification tests, the extended acceptance tests and the lifetime evaluation programme with the surveillance programme data, in order to evaluate the scatter of materials' properties;
- Embrittlement mitigations measures, in particular core configuration, refuelling pattern and enrichment changes.

III.4 ITEM 4 – Integrity of Primary Loop Components–Non Destructive Testing

In-service-inspection (ISI) and non destructive testing (NDT) for the primary circuit of Temelín NPP are based on requirements as adopted by Western European countries and are in most respects comparable to the western practices. Some open issues remain. However, ISI and NDT should not be seen as important open safety issues.

- Acceptance of indications is based on analytical thresholds and an analytical procedure. The criteria used at the end of this procedure have not been clearly presented so far.
- Regarding worst case defects and test conditions, the Czech practice is not yet in full agreement with Western European standards.
- A maximum crack depth of 20 mm is assumed for PTS analyses. Half the PTS-relevant crack depth (i. e. 10 mm under-clad crack) is taken at Temelín NPP as defect depth which must and can be detected with 100% reliability – in accordance with VERLIFE methodology. This goal appears achievable. Site-feedback from practical ISI carried out, however, is still required for confirmation. Also, the discrimination between under-clad cracks and cracks within the cladding in the RPV wall has not been thoroughly proven yet.
- Qualification procedures are similar to those in Western Europe. However, the Qualification Body is established by the plant utility, and a representative of the power plant is a member of this body, which raises the question of independence. Furthermore, there is no national steering committee for inspection qualification, unlike in most countries.

Consequently, the future exchange of information on ISI and NDT should above all cover the following issues:

- Progress towards the establishment of a written working policy for the Qualification Body and national working instructions for the qualification, as well as the experiences with the national Czech ISI code which is at present being introduced; the further development of the Qualification Body regarding independence;
- The exact procedures to be followed in case of a detected flaw;

- The collection of data on defects found and their statistical evaluation, as well of further developments of NDT techniques and their application during inspections at Temelín NPP;
- RPV inspection trials for the differentiation between under-clad cracks and through-cladding cracks, which are, potentially, particularly hazardous and the feedback from site inspections regarding the detectability of 10 mm under-clad cracks, particularly in connection with RPVI;
- Refinement of the qualification procedures, particularly regarding the use of artificial defects for training that are more similar to those expected to be found during the real ISI. Such defects include worst case defects for ultrasonic testing of RPV welds, and defects in discarded tubes which originated in operation for eddy current testing.

III.5 ITEM 5 – Qualification of Safety Classified Components

The evaluation shows that the equipment qualification (EQ) in Temelín NPP today is comparable with the western approaches regarding principles, methods used and results achieved. The regulatory requirements and the technical basis for the EQ are comparable to western requirements and approaches, the implementation of the EQ follows prudent practices and the EQ documentation is comparable to that of western plants. The methods used and the acceptance criteria appear broadly similar to western practices.

There are still safety-classified components for which equipment qualification is not finalized. The plans to complete EQ have been evaluated as realistically achievable. For some of the components where the EQ is not completed, compensatory measures have been introduced.

Consequently, the future exchange of information on EQ should above all cover the following issues:

- The completion of the equipment qualification on all equipment which is scheduled for 2006 (For 5 equipment groups, general EQ is yet incomplete; for 14 equipment groups, ageing qualification is incomplete as of December 2004);
- Significant findings of regulatory inspections related to equipment qualification that could influence successful completion of the EQ programme;
- Localized effects on selected components outside the containment, which have not been considered so far.

III.6 ITEM 6 – Site Seismicity

Considerable efforts have been undertaken by Czech experts to clarify questions forwarded by IAEA review teams concerning seismic hazard assessment. However, there are topics where questions remain open, including the intensity of the earthquake, which has to be assumed as design basis at the Temelín site.

In this context, it is also relevant that there has been considerable change recently in the engineering approach towards the seismic evaluation of nuclear facilities. This is not a trend relevant for Temelín NPP alone; it concerns many plants, in particular those at sites previously assessed as “quiet”, and is supported worldwide, going towards the consideration of longer return periods and the consideration of site-specific effects.

- Not all faults in the near region of Temelín were studied. Mapping and data collection was partly insufficient. Also, important geomorphological features apparently might not have been taken into account yet.

- The deterministic method of seismic hazard assessment used by the Czech experts is based on an expert system[3] which is not internationally verified. The data constituting the basis for the near site hazard calculation should be re-examined.
- A safety margin of at least 1° of intensity as measured by the MSK-scale instead of 0,5° would be appropriate and in better accord with the international practice.
- The consideration of longer return periods for the historical earthquakes would have been desirable. Paleoseismical methods – as recommended by IAEA – were not used by the Czech experts until now.
- The probabilistic methods used up to now should be revised, particularly regarding the attenuation relation and the spread of the data. The correlation between MSK intensity and peak ground acceleration does not reflect the globally applied procedure and therefore, in all likelihood, is not conservative.

Consequently, the future exchange of information on site seismicity should above all cover the following issues:

- Further efforts to establish a GIS-based geological database, merging all available data from the near region;
- Further investigations concerning the assessment of the near-regional faults, in particular the Hluboká fault;
- Integration of geodetic data and data from digital elevation models, in order to gain more information on the possible uplift of the Temelín area;
- Investigation of the consequences of an assumed maximum horizontal peak ground acceleration of 0,23 g, as assumed for comparable sites (for the safe shut-down earthquake, 0,1 g has been assumed); carrying out of a probabilistic seismic hazard analysis study, using the most up-to-date methods – in particular, the analysis of long return periods;
- Improvement of the localisation of the microseismicity occurring near Temelín NPP, by upgrading of the existing monitoring system by three to four additional seismic stations at distances of about 30 – 50 km from the NPP.

III.7 ITEM “Seismic Design”

In Temelín NPP, seismic design is based on traditional approaches. The seismic design re-evaluation performed at the NPP conforms to the existing standards and recommendations.

The Czech experts demonstrated that they made efforts to fulfil the requirements specified in the IAEA guidelines concerning seismic design. However, the international seismic design practice has made considerable progress in the last years, based on information derived from recent seismic events. This resulted in considerable changes in the approach as well as in related codes and standards.

- The traditional approach to seismic design as employed by the Czech experts is limited to structures. Not all important seismic effects are included, such as the interactions between adjacent structures, differential local movements at vital interfaces as well as the performance and eventual collapse of non-structural components.

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[3] A computer-based system of artificial intelligence, which analyses information in order to improve the quality of data banks for particular applications.

Consequently, the future exchange of information on seismic design should above all cover the following issues:

- A probabilistic seismic safety analysis, corresponding to recent IAEA recommendations and the current best practice in Western Europe;
- Seismic qualification of civil structures, interfaces and components in the context of the 10 year periodic safety review;
- Improving the monitoring system and enhancing the use of actual data in the evaluation process, including an improvement of the existing database.

III.8 ITEM 7a – Severe Accidents' Related Issues – Working Group on Comparison of Calculations Regarding the Radiological Consequences of Beyond Design Basis Accidents

A basis for mutual understanding of procedures and codes used in emergency situations in the Czech Republic and Austria was created by the activities regarding this ITEM. The results of the Czech-Austrian Working Group are summarized in a Joint Summary Report and were jointly presented at the International Symposium on Off-site Nuclear Emergency Management, Salzburg 2003. The intensive information exchange has already had a very positive impact on the emergency preparedness in both countries. Furthermore, the results and the experience gained could be a basis for further harmonisation in the field of emergency management in both countries. The extended bilateral exchange of information and co-operation in the field of emergency management could serve as good example for the bilateral co-operation in the field of radiation protection between neighbouring countries.

Regarding this ITEM, follow-up activities are already under way. A programme for future bilateral and regional cooperation in the field of emergency management is being developed. These common future activities include an intensified data and information exchange and co-operation between both Crisis Centres.

Conditions, under which results and specific input data of the Czech and Austrian prognosis systems (ESTE and TAMOS) will be transmitted, have already been agreed under the bilateral "Nuclear Information Agreement". The following data are expected to be exchanged in case of an emergency: Observed weather conditions at the point of radionuclide release, meteorological forecasts for dispersion calculations, radionuclide air concentration and depositions forecasts based on weather models obtained by both parties, forecasts of the course of the accident and source terms. The ESTE system has been installed at BMLFUW in Austria for assessing the possible radiological consequences based on observed weather data as well as on weather predictions. The bilateral "Nuclear Information Agreement" guarantees that both sides will have the same information relevant for off-site emergency management.

Furthermore, both countries are co-operating regarding relevant topics included in the European Union's 6th Research Framework Programme, such as joint demonstration activities and exercises with the RODOS system. Last but not least, the exchange of emergency planning experts in the Crisis Centres of both countries and joint exercises to test the emergency preparedness are part of the co-operation.

III.9 ITEM 7b – Severe Accidents' Related Issues – SAMG

The development and implementation of the Temelín severe accident management (SAM) programme have not been finalized; however, they are reported as well advanced. The overall concept and the approach to the development and implementation of the severe accident management guidelines (SAMG) packet reflect current good practice. The programm is supported by severe accident analyses and a plant specific probabilistic safety assessment (PSA).

Regarding the technical measures available at the NPP Temelín for severe accident management, the hazards of primary to secondary leakages are well recognized, the appropriate strategies developed and the technical means provided. The hazards of containment failure due to direct heating or long-term increase of pressure have been evaluated by the Austrian Experts' Team as rather low. The measures and strategies to reduce fission product releases will be in compliance with international practice once they are introduced.

However, several issues remain:

- There are questions of consistency in assumptions and analyses in general related to the interfaces between severe accident analyses on the one hand, and PSA and severe accident management strategies on the other.
- In case of the station blackout, the battery backed-power supply availability is questioned due to a limited capacity of existing batteries. Load shedding procedures should be implemented if appropriate, to preserve battery life.
- Although releases would be considerably smaller than in case of early containment failure, basemat melt-through appears to constitute the most critical problem in connection with severe accidents. In this case, containment failure could occur relatively swiftly during an accident sequence. As of now, the stopping of the corium erosion progress cannot yet be clearly demonstrated. Additional mitigative measures are under consideration.
- The formation of a detonable cloud of hydrogen cannot be entirely excluded, as determined by the analysis of a small-break loss-of-coolant accident sequence. Although the probability of a detonation leading to containment failure appears rather small, consequences of such an event would be likely to lead to a large source term. The possibility of local accumulation of hydrogen should be further investigated and – if found relevant – counteracted by appropriate measures (e.g. ventilation of critical rooms), including adequate provisions within SAMGs.
- Failure of depressurization of the reactor cooling system could lead to high-pressure ejection of corium from the RPV, with subsequent damage to the containment liner and consequential leakage from the containment. However, in view of the available information, this hazard can be considered as unlikely.
- Molten corium spreading within the cavity and beyond, coolability, as well as ways to further improve the corium coolability.

Consequently, the future exchange of information on severe accidents (SAMG) should above all cover the following issues:

- Supporting severe accident analyses and PSA as well as their use in the verification of SAM strategies and the related procedures;
- SAMG implementation activities including procedural framework, SAMG validation, and SAM-related staff training;
- Establishment of tolerable non-uniformities in the hydrogen distribution in the containment atmosphere;
- Implementation of planned changes to enhance the technical measures credited for in the SAMGs;

- Regarding specific calculations using severe accidents code packages, the capabilitiy of power operated relief valves (PORVs), the effectiveness of hydrogen control and possible uses of existing filtered venting for contaiment pressure reduction in long term accident sequences, the operational capabilities of the emergency gas removal system in severe accident conditions as well as analyses of basemat melt-through failure are of interest.

III.10 Chapter V – Environmental Impact Assessment

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 Paper” the implementation of twenty-one concrete measures.

The signatories of the “Conclusions of the Melk Process and Follow-up” agreed that the implementation of the said measures would be regularly monitored jointly by Czech and Austrian experts within the bilateral ”Nuclear Information Agreement”.

Following the information exchange at the annual bilateral meetings 2002, 2003 and 2004 and at an additional meeting of the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management and the Umweltbundesamt with representatives of SÚJB and the EIA-Commission in February 2005, the following aspects can be summarized:

- An overview has been given by the EIA-Commission and SÚJB on the status of implementation of the said measures, their scope and the organizations in charge.
- Most of the activities for the implementation of the said measures are still ongoing, partly for the entire service life of Temelín NPP.
- The bilateral “Nuclear Information Agreement” is seen as the appropriate framework for further joint monitoring of the ongoing process of the implementation of the measures.
- It is of particular interest how the implementation of the measures for which the corresponding research projects come to an end will be continued, and how they will be integrated into standard programmes of the authorities in charge.
- Furthermore, in case the functionality of the EIA-Commission web-page as an information platform is changed, the information of the wider public needs further attention in the bilateral information exchange.

III.11 Summarizing Overview on Important Interrelations of ITEMS

There are numerous interrelations between the ITEMS according to ANNEX I of the “Brussels Agreement” (i.e. the ITEMS discussed in sections III.1 to III.9).

ITEMS can be closely linked, if they are concerned with different aspects of the same component (like ITEMS 3 and 4, dealing with pressurized thermal shock of the reactor pressure vessel, and non-destructive examinations of this vessel) or if they concern different aspects of the same event (like ITEM 6 and ITEM “Seismic Design”, both dealing with seismic issues).

Furthermore, there are cases of one ITEM having potential influence on another, but not vice versa. For example, ITEM 2 (qualification of valves) could influence ITEM 7b (Severe Accidents – SAMG). If failure of those valves in “open” position would have to be assumed, this could lead to acceleration of accident sequences. Another example is that ITEM 6 (Site Seismicity) has potential influence on ITEM 5 (equipment qualification). Should the ground acceleration for the safe-shutdown earthquake have to be revised upwards, seismic re-evaluation of specific safety classified equipment might become necessary.

There are many more links between ITEMS, direct and indirect, important and of lower significance. The overview presented here is limited to the essential points, the direct and important interrelations, which are potentially relevant also for future information exchange.

The table on the following page is to provide an overview over those interrelations.

In the table, a grey field indicates a close connection between two ITEMS, implying mutual influence. An arrow indicates that one ITEM has potential influence on the other, but not vice versa.

Table 1: Overview of interrelations and influences among the ITEMS according to ANNEX I of the "Brussels Agreement", resulting from links between their respective subject matters
Grey field: Close connection between two ITEMS, signifying mutual influence
(for example, ITEMS 3 and 4 are closely connected)
Arrow: Potential, one-sided influence of one ITEM on another
(for example, ITEM 6 has potential influence on ITEM 1, but not vice versa)

	Projects	ITEMS	1	2	3	4	5	6	SD	7a	7b
High Energy Pipelines	PN2	1	○		▲		▲				▲
Qualification of Valves	PN3	2	▲	○							▲
Reactor Pressure Vessel Integrity	PN9	3			○	░					▲
Integrity of Primary Loop Components	PN10	4	▲		░	○					
Qualification of Components	PN4	5					○				▲
Site Seismicity	PN6	6	▲				▲	○	░		▲
Seismic Design	PN8	SD	▲				▲	░	○		▲
Severe Accidents – Rad. Consequences	PN1	7a								○	
Severe Accidents – SAMG	PN7	7b								▲	○

III.12 Clusters of Safety Issues for Further Interest

The results of the monitoring process constitute a very complex compilation, covering many different issues, which are interrelated in various ways, as shown in section III.11.

Aware of the risk of simplification, all findings and open questions from the Monitoring Process on Temelín NPP have been concentrated and condensed, and the result has been subdivided into the following five clusters of issues relevant to safety, identified for further information exchange between experts of the Czech and the Austrian sides.

For their treatment, a prioritization of the clusters is proposed according to their importance (safety relevance) as well as to the urgency of this further treatment.

Safety relevance of a cluster is seen as **"primary"** if it concerns a problem, which can directly lead to the initiation of an accident (as opposed to problems which only become relevant once an accident sequence has started), and if several other safety issues are potentially influenced by it.

Safety relevance is rated as **“secondary”** in cases where the impact on safety is of an indirect nature. This designates lower priority in comparison with primary-importance clusters but by no means implies low importance or low interest.

“Short-term” treatment of a cluster is considered appropriate, if the potential safety consequences do not depend on long lasting processes, investigations, data collections, surveillance or developments like ageing; and if new and more appropriate insights can be expected soon.

“Long-term” treatment of the cluster should be considered in cases where safety consequences depend on processes over longer periods of time, like ageing, data collection etc.

The treatment of the clusters should respect the characteristics of the safety issues and their need for clarification concerning the following differentiation:

- Start-up and early operation requirements;
- Recurrent, persisting, and plant-life related requirements.

The clusters identified as particularly important for further information exchange are:

1. **High Energy Line Breaks at the 28,8 m Level**, including localized effects relevant for Equipment Qualification:

   This cluster is of **primary safety relevance** and should be treated in the **short term**.

2. **Severe Accidents’ Related Issues – SAMG:**

   This cluster is of **secondary safety relevance** (the corresponding issues are relevant after an accident has been initiated) and can be treated in the **short term**.

3. **Qualification of Valves:**

   This cluster is of **secondary safety relevance** (issues are relevant after an accident has been initiated) and can be treated in the **short term**.

4. **Reactor Pressure Vessel Integrity**, including Non Destructive Testing for PTS-relevant under-clad cracks:

   This cluster is of **primary safety relevance** and to be treated in the **long term**. The first results from surveillance samples, important for following material embrittlement development, will be available 2005, and further surveillance results will follow during the next years.

5. **Seismic Issues:** This cluster includes the issues to be pursued from ITEM 6 (Site Seismicity) as well as ITEM “Seismic Design”:

   It is of **primary safety relevance** and to be treated in the **long term**, since data are still being collected through the seismicity monitoring system. Furthermore, the 10 year periodic safety review is supposed to address issues of seismic design.

Based on the recognition that the bilateral “Nuclear Information Agreement” is the appropriate framework giving the opportunity for further discussion and for the sharing of additional information on these issues, these five clusters are recommended as a basis for a future in-depth exchange of information between experts of the Czech and the Austrian side.

ZUSAMMENFASSUNG

I. Rahmenbedingungen

Die Republik Österreich und die Tschechische Republik haben mit Unterstützung des Kommissionsmitglieds Verheugen am 29. November 2001 eine Übereinstimmung über die Schlussfolgerungen aus dem Melker Prozess und das „Follow-up" („Vereinbarung von Brüssel") erzielt (siehe ANHANG A des vorliegenden Berichtes). Um eine wirksame Umsetzung der Ergebnisse des Melker Prozesses im Bereich der nuklearen Sicherheit zu ermöglichen, enthält der ANHANG I dieser „Vereinbarung von Brüssel" Details zu spezifischen Maßnahmen, die als Follow-up zum „Trialog" des „Melker Prozesses" im Rahmen des tschechisch-österreichischen bilateralen „Nuklearinformationsabkommens"[4] durchzuführen sind.

Weiters legte die Kommission zur Prüfung der Umweltverträglichkeit des KKWs Temelín, die auf Grund einer Resolution der Regierung der Tschechischen Republik eingesetzt wurde, einen Bericht vor und schlug in ihrer Stellungnahme die Umsetzung von einundzwanzig konkreten Maßnahmen vor (ANHANG II der „Vereinbarung von Brüssel").

Die Unterzeichner kamen überein, die Umsetzung der genannten Maßnahmen gemeinsam von tschechischen und österreichischen ExpertInnen im Rahmen des bilateralen „Nuklearinformationsabkommens" regelmäßig zu überwachen.

Zur Überwachung auf technischer Ebene im Rahmen des bilateralen „Nuklearinformationsabkommen" wurde, wie in der „Vereinbarung von Brüssel" 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 (siehe ANHANG B des vorliegenden Berichtes).

Das Österreichische Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasser wirtschaft beauftragte das Umweltbundesamt mit der Gesamtkoordination der Umsetzung der „Roadmap" auf österreichischer Seite.

II. Monitoring auf technischer Ebene – Österreichische Technische Projekte

Das Monitoring auf technischer Ebene wurde in der von der „Roadmap" festgelegten Reihenfolge durchgeführt. Jeder Punkt, der Bedeutung für die Sicherheit hat und im ANHANG I der „Vereinbarung von Brüssel" angesprochen wird, sowie der ANHANG II dieser Vereinbarung, entspricht je einem spezifischen technischen Projekt (siehe ANHANG C des vorliegenden Berichtes). (Sicherheitsrelevante Punkte gemäß ANHANG I werden in der Folge als PUNKTE bezeichnet.)

Im Kapitel IV der "Vereinbarung von Brüssel" sowie in den Prinzipien der "Roadmap" werden eine Reihe von Problemkreisen, die im "Trialog" des "Melker Prozesses" bearbeitet wurden, als verfolgungswürdig im Rahmen des bilateralen „Nuklearinformationsabkommens erachtet. Jene Problemkreise wurden, wo zutreffend, von den entsprechenden technischen Projekten mitbehandelt (siehe ANHANG D des vorliegenden Berichtes).

[4] Abkommen zwischen der Regierung der Republik Österreich und der Regierung der Tschechischen Republik zur Regelung von Fragen gemeinsamen Interesses im Zusammenhang mit der nuklearen Sicherheit und dem Strahlenschutz.

Im Namen der Österreichischen Regierung hat das Umweltbundesamt für jedes dieser Projekte ein internationales ExpertInnen-Team mit dem technischen Support des Monitoringprozesses auf technischer Ebene beauftragt. Insgesamt waren 35 Organisationen und andere Projektnehmer aus 10 Ländern auf österreichischer Seite in den Monitoring Prozess involviert.

Die spezifischen technischen Projekte werden als Projekte PN1 – PN10 bezeichnet und umfassen insgesamt sieben vordefinierte Projektmeilensteine (PMs).

Um die Vorbereitungsarbeit des österreichischen ExpertInnen-Teams zu bündeln und die österreichische Delegation durch den ExpertInnen-Workshop zu leiten, wurde in einem ersten Schritt (Projektmeilenstein 1), das Sicherheitsziel in **nachprüfbare Einzelaspekte (Verifiable Line Items, VLI)** unterteilt.

In einem zweiten Schritt (Projektmeilenstein 2) bereitete das ExpertInnen-Team den sogenannten **„Specific Information Request“** (SIR) vor, eine Liste, die jene Information enthält, von der angenommen wurde, dass sie für eine fundierte Beantwortung der VLIs erforderlich ist.

Der dritte Schritt (Projektmeilenstein 3) beinhaltete den ExpertInnen-**Workshop** mit allen vorbereitenden Aktivitäten, was auch eine „Briefing Session“ für die österreichischen Delegationen zu diesen Workshops einschloss.

Die Analyse der bei den ExpertInnen-Treffen (Workshops) zur Verfügung gestellten Informationen spielte eine entscheidende Rolle für die Entwicklung der Grundlagen für die Vorläufigen Monitoringberichte (Preliminary Monitoring Reports) und die Endberichte (Final Monitoring Reports).

In einem vierten Schritt (Projektmeilenstein 4), nach dem Workshop, überprüfte das ExpertInnen-Team rückblickend die Information und Unterlagen, die beim Workshop erhältlich waren, wertete die Informationen und Dokumente, die die tschechischen Delegationen übergeben hatten, anhand des Standes der gefestigten Praxis aus und verfasste den **Vorläufigen Monitoring-Bericht (Preliminary Monitoring Report, PMR)**. Dieser Bericht hatte auch zum Ziel, Themen zur weiteren Beachtung hervorzuheben.

Diese vorläufigen Monitoring-Berichte für jedes Projekt wurden bei den **Regulären Bilateralen Treffen** gemäß dem bilateralen „Nuklearinformationsabkommen“ 2002, 2003 bzw. 2004 in einem fünften Schritt (Projektmeilenstein 5) präsentiert.

Der sechste Schritt (Projektmeilenstein 6) konzentrierte sich auf die Konsolidierung der Ergebnisse und ihrer Darstellung in einem **Endbericht (Final Monitoring Report, FMR)** für jedes einzelne Projekt. Im Fall, dass von tschechischer Seite nach dem entsprechenden ExpertInnen-Workshop zusätzliche projektspezifische Information zur Verfügung gestellt wurde, wurden die dazu gehörigen Überprüfungsschritte und Schlußfolgerungen in die Bewertung im Endbericht mit einbezogen.

Die Vorläufigen Monitoringberichte wurden auf der Web-Seite des Umweltbundesamtes (www.umweltbundesamt.at) im Zeitraum von Mai 2003 – September 2004 veröffentlicht (ausgenommen jene der Projekte PN5, PN9 und PN10, die als letzte abgeschlossen wurden). Die Endberichte werden ebenfalls dort veröffentlicht werden.

Der vorliegende **Abschlussbericht (Summary Monitoring Report, SMR)** fasst in einem siebenten Schritt (Projektmeilenstein 7) den gesamten Monitoring-Prozess und die Monitoring-Ergebnisse aller technischen Projekte zusammen. Aufbauend auf die Endberichte (Final Monitoring Reports) hat er zum Ziel, jene Fragestellungen zusammenzufassen, die im Brennpunkt künftiger Aufmerksamkeit stehen sollten.

Die österreichischen ExpertInnen-Teams möchten in Erinnerung rufen, dass verschiedene Aspekte der PUNKTE, die in dem hier abgeschlossenen Monitoring-Prozess untersucht wurden, mit anderen im Rahmen dieses Prozesses behandelten PUNKTEN verbunden sind. Bei der Behandlung von allgemeinen Sicherheitsfragen im Rahmen des künftigen bilateralen Informationsaustausches sollten die Wechselbeziehungen zwischen sicherheitsrelevanten

PUNKTEN berücksichtigt werden, so dass eine abdeckende Behandlung aller relevanten Themen gewährleistet ist.

Nichtsdestotrotz gilt es angesichts der Komplexität und des Detailreichtums der Monitoring-Ergebnisse, wie sie im vorliegenden Abschlußbericht (Summary Monitoring Report) zusammengefasst sind, zu beachten, dass die vollständigen Überlegungen nur in den jeweiligen Endberichten (Final Monitoring Reports) für jedes österreichische technische Projekt zu finden sind, deren Zusammenfassungen in Abschnitt 2 dieses SMR präsentiert werden.

III. Wichtigste Ergebnisse und Fragestellungen von bestehendem Interesse

Für jeden PUNKT, der identifiziert wurde, listet der ANHANG I der "Vereinbarung von Brüssel" die Zielsetzung, den Stand im November 2001 und die zu dieser Zeit geplanten spezifischen Maßnahmen auf.

Dieser Abschnitt des „Summary Monitoring Report" fasst den Kern der Auswertungsergebnisse der österreichischen ExpertInnen-Teams für jeden PUNKT zusammen. Für jeden PUNKT werden die wesentlichen Ergebnisse sowie jene Themen dargestellt, die auch in Zukunft Aufmerksamkeit verdienen sollten.

Die Umsetzung der „Roadmap" stellte, wie beschrieben, einen mehrjährigen, intensiven fachlichen Prozess dar. Während dieses Prozesses eigneten sich die österreichischen ExpertInnen-Teams detailliertes Wissen über das Kernkraftwerk Temelín an, das u. a. die Basis für verschiedene Anregungen und Vorschläge von Verbesserungsmöglichkeiten darstellt. Wiewohl einzelne Fragen einer weiteren Erörterung bedürfen, kann der Prozess – wie im Folgenden näher ausgeführt – insgesamt als positiver Beitrag zur effektiven Verbesserung der Sicherheitskultur des Kernkraftwerks Temelín bewertet werden. Es ist ferner davon auszugehen, dass viele der erörterten Punkte auch auf andere Kernkraftwerke gleicher oder ähnlicher Bauart zutreffen – also auf WWER-1000 Anlagen, und teilweise auch auf Druckwasserreaktoren anderen Typs. Eine systematische Analyse der Übertragbarkeit der Ergebnisse auf andere Anlagen übersteigt jedoch den Rahmen des gegenständlichen Projektes.

III.1 PUNKT 1 – Hochenergetische Rohrleitungen auf der 28,8 m Bühne

Die Informationen, die von der tschechischen Seite erhalten wurden, gaben einen Einblick in die umfassenden Arbeiten, die von den Anlagenbetreibern und ihren technischen Experten-Organisationen durchgeführt wurden, um den Sicherheitsnachweis im Rahmen der „Umfassenden Neuüberprüfung des Sicherheitsnachweises" („Comprehensive Safety Case Revisit") zu konsolidieren. Eine Betrachtung der Bedenken, die im „Austrian Technical Position Paper" (Juli 2001) ausgedrückt worden waren, zeigt im Vergleich mit dem gegenwärtigen Status ebenfalls eine Reihe von Bereichen, in denen Verbesserungen erzielt und eingeführt wurden.

Eine integrierte Herangehensweise, bestehend aus Maßnahmen zur Vermeidung, zum Schutz, zur Qualifizierung und zur Abschwächung der Folgen (Konzept der gestaffelten Verteidigung – „Defence-in-Depth") wurde bei den hochenergetischen Rohrleitungen auf der 28,8 m-Bühne des KKW Temelín bisher allerdings nur teilweise verfolgt. So beruht der Sicherheitsnachweis für Abschnitte der Rohrleitungen, mit Biegungen und „bubliks"[5], lediglich auf Bruchausschluss. Eine zuverlässige Kompensation dieses Umstands, entsprechend der westlichen Praxis, wurde bisher nicht demonstriert.

[5] Zweifache Rohrabschnitte, die von der Frischdampfleitung zu den beiden Eingangsstutzen der Dampf-Entlastungsventile führen, in Form eines Torus, der mit einer doppelten T-Verbindung an der Dampfleitung hängt.

Daher gibt es einige Fagen, die noch zu klären sind:

- Es ist zu fragen, wieweit die Werkstoff-Datenbasis, die für die Akzeptanz der Ergebnisse der Spannungsanalysen (SUPERPIPE Konzept) benützt und angewandt wird, angemessen konsolidiert ist, um Bruchausschluss für die hochenergetischen Rohrleitungen auf der 28,8 m Bühne zu rechtfertigen.
- Die besondere Schweiß-Konzeption (Anschweißungen im Bereich von Ausschlagsicherungen) sowie die Zugänglichkeit mancher Rundnähte erfordern erhebliche Anstrengungen bei den zerstörungsfreien Prüfungen (NDT), um die Anwendbarkeit des SUPERPIPE-Konzeptes zu gewährleisten. Es wurde bei den Präsentationen noch nicht klargestellt, dass für diese Anstrengungen eine NDT-Strategie eingerichtet worden ist.
- Die tschechischen ExpertInnen haben postuliert, dass die Lasten, die aus einem seismischen Auslegungsstörfall resultieren, die fluid-dynamischen Lasten abdecken. Eine Pilot-Studie des österreichischen ExpertInnenteams zeigt jedoch, dass es noch nicht als gesichert anzusehen ist, alle dynamischen Lasten, die für die hochenergetischen Rohrleitungen angenommen werden müssen, durch seismische Lasten abdecken zu können. Auch die Abschätzungen für Lecks und Brüche, auf denen die Anwendbarkeit des Bruchausschlusses beruht, einschließlich der Annahmen zu den Orten der Brüche, sollten überprüft werden.
- Im Falle mehrfacher Frischdampfleitungsbrüche ist es – ebenfalls gemäß einer Pilotstudie des österreichischen ExpertInnenteams – wahrscheinlich, dass der Reaktor unter bestimmten Bedingungen nach der Schnellabschaltung wieder kritisch wird. (Re-Kritikalität als solche bedeutet aber nicht zwangsläufig, dass die Integrität des Brennstoffes oder der Reaktorkern gefährdet sind.)

Weiterhin wären, um den Sicherheitsnachweis in vollem Umfang würdigen zu können, detailliertere Informationen von Nutzen – zum Beispiel:

- Demonstration der Einbettung des SUPERPIPE Konzeptes in die ursprünglichen Auslegungs-Kriterien, und Auswahl der für die Analyse ausgewählten Orte und Orientierungen der Leitungsbrüche,
- Einfluss von Lasten von außerhalb des Bereiches der 28,8 m-Bühne auf die maximale Spannung in den hochenergetischen Rohrleitungen innerhalb dieses Bereiches; Lastwirkungen auf die Ausschlagsicherungen durch Wasserschlag oder Strahlkräfte; schlüssige Lösungen für die Lasten durch Wasserschlag auf die „Bubliks“; Nachweise, dass die Lasten des Auslegungserdbebens alle anderen dynamischen Lasten abdecken,
- Vorkehrungen, um, als Teil des Konzeptes der gestaffelten Verteidigung, sicherheitstechnische Ausrüstung zu schützen; Folgeschäden durch das Ausschlagen von Rohrleitungen und damit zusammenhängende Annahmen zu den stützenden Strukturen; Analysen der Reaktion der Anlage auf den Bruch hochenergetischer Rohrleitungen; sowie auch Ergebnisse der Auslegungs-Analysen für den Einbau einer Trennwand.

Dementsprechend sollte der künftige Austausch von Informationen zu den hochenergetischen Rohrleitungen in erster Linie die folgenden Punkte betreffen:

- Im Hinblick auf die Werkstoffe, die für die sekundär-seitigen hochenergetischen Rohrleitungen verwendet werden, die Prozeduren für die Charakterisierung der Werkstoffeigenschaften und ihr Einsatz beim Abnahmeprozess der Komponenten (Anwendung des SUPERPIPE-Konzeptes);
- Im Hinblick auf die Verifizierung des Bruchausschluss-Konzeptes, Vergleiche mit Industrie-Erfahrungen betreffend die Annahmen über die Häufigkeit von Brüchen bei Rohrleitungen der entsprechenden Anordnung, sowie Vergleiche der Vorgehensweise bei den wiederkehrenden Prüfungen, so wie sie den Rohrleitungen der 28,8 m Bühne angepasst wurden, Industrie-Erfahrungen;

- Im Hinblick auf die Untersuchung von Unfallfolgen, die aus dem Bruch hochenergetischer Rohrleitungen resultieren könnten, die Analyse unmittelbarer Folgen auf der Grundlage von abdeckenden Fällen dynamischer Lasten. Bei den mittelfristigen Unfallfolgen, die Identifizierung der Entwicklung von Unfallabläufen von Auswirkungen auf den Reaktorkern hin zu Ereignissen mit radioaktiven Freisetzungen. Sowohl für die unmittelbaren, als auch die mittelfristigen Gesichtspunkte der Unfallabläufe erscheint es wesentlich, Ausmaß und Häufigkeit der entsprechenden Unfallszenarien kennen zu können.

III.2 PUNKT 2 – Qualifikation der Ventile

Die tschechische Präsentation und die Diskussion deuteten auf positive Errungenschaften im Rahmen der „Umfassenden Neuüberprüfung des Sicherheitsnachweises“ („Comprehensive Safety Case Revisit“) hin. Diese Aktivitäten scheinen die allgemeine funktionelle Zuverlässigkeit der Frischdampfentlastungsventile (BRU-A) und der Sicherheitsventile (MSSV) bereits erhöht zu haben. (Die Aktivitäten beziehen sich auf den Ersatz der elektrischen Auslöser der BRU-A Ventile sowie der Vorsteuerventile der MSSV, bei beiden Blöcken.)

Darüber hinaus erscheint die Qualifikation der Funktionstüchtigkeit der Frischdampfentlastungs- und Sicherheitsventile des KKW Temelín für Zweiphasen- und Wasserdurchströmung grundsätzlich unter Anwendung der Anforderungen von ASME-QME-1994 (Ähnlichkeits-Ansatz) für die funktionelle Qualifikation von Ventilen durchführbar.

Zur Zeit werden diese Anforderungen allerdings erst teilweise erfüllt. Die Durchführung von angemessenen Analysen, um dies entsprechend dem Stand der Technik zu kompensieren, wurde bisher noch nicht demonstriert.

Somit reicht die gewählte Vorgehensweise bisher noch nicht aus, um endgültig zu klären, wieweit die Frischdampfentlastungs und –sicherheitsventile des KKW Temelín funktionell für die Bedingungen dynamischer Zweiphasen-Strömungen und Strömungen von unter Druck stehendem, unterkühltem Wasser qualifiziert sind.

Dementsprechend sollte der künftige Austausch von Informationen zu den Frischdampfentlastungs- und sicherheitsventilen in erster Linie die folgenden Punkte betreffen:

- Zusätzliche Informationen über die Basis, auf der die tschechische Genehmigungsbehörde die Ventil-Qualifikation akzeptiert hat;
- Demonstration der Qualifikation der Funktionstüchtigkeit der Frischdampfentlastungs- und Sicherheitsventile des KKW Temelín durch zusätzliche Tests und umfassende Analysen, einschließlich des Zugangs zu repräsentativen Qualifikations-Unterlagen.

III.3 PUNKT 3 – Reaktordruckbehälterintegrität und Schockbelastung unter Temperatur und Druck

Die tschechische Vorgehensweise stimmt bei der Analyse von Schockbelastung unter Temperatur und Druck (pressurized thermal shock, PTS) – so wie sie präsentiert wurde – im Hinblick auf das Konzept, die Methodik und die angewandten Computer-Codes mit dem Stand der Technik überein. Die schwersten Störfallabläufe, die analysiert wurden, sind gut vergleichbar mit jenen, die nach heutigem Wissensstand für WWER-1000 Anlagen als repräsentativ angesehen werden. Alle Gruppen von Unfällen, die für eine PTS-Analyse wichtig sind, wurden betrachtet.

Das Überwachungsprogramm, mit dem das Fortschreiten der Versprödung verfolgt wird, stellt im Vergleich zu anderen WWER-1000 Anlagen eine deutliche Verbesserung dar, insbesondere im Hinblick auf die Platzierung der Bestrahlungsproben.

Die Demonstration der Integrität des Reaktordruckbehälters (reactor pressure vessel integrity, RPVI) während seiner Lebensdauer wurde für das KKW Temelín mittels der VERLIFE-Methodik durchgeführt. Anhand eines Vergleiches mit dem Russischen Regelwerk und den IAEA-Richtlinien stellte das österreichische ExpertInnenteam fest, dass die VERLIFE-Methodik, wie bei den Reaktordruckbehältern in Temelín angewandt, reduzierte Sicherheitsreserven zu benützen scheint (d. h. Reduzierung der postulierten Rissgröße, Eliminierung/ Reduzierung von Sicherheitsfaktoren, ein weniger konservatives Kriterium für den Warm-Vorspannungs- (warm prestress, WPS) Effekt, nicht konservative bruchmechanische Annahmen). In Kombination mit anderen Unsicherheiten betreffend die Material- bzw. Versprödungseigenschaften und angesichts der nicht auszuschließenden Reduzierungen der Konservativität in mehrfacher Hinsicht (siehe unten) könnte die resultierende Gesamt-Sicherheitsreserve bei den Reaktoren von Temelín nicht ausreichend sein.

Daher gibt es einige wichtige Fragen, die weiter zu behandeln sind:

- Obgleich alle Gruppen von Unfällen, die für eine PTS-Analyse wichtig sind, untersucht wurden, hat der Zeitrahmen der Simulation in manchen Fällen möglicherweise die kritischen Belastungen des Reaktordruckbehälters nicht erfasst, da die Resultate von Simulationen nur für jene Phase verfügbar waren, die unmittelbar vor einem erneuten Druckanstieg endet. Innerhalb der Unfall-Gruppen können die betrachteten Abläufe in manchen Fällen nicht als die kritischsten angesehen werden. Bei einzelnen Unfallabläufen wird davon ausgegangen, dass Maßnahmen gemäß den Störfall-Betriebsanleitungen (emergency operating procedures) innerhalb eines engen Zeitfensters durchgeführt werden, um sprödes Versagen des Reaktordruckbehälters zu vermeiden.
- Es scheint, dass Konservativitäten reduziert wurden. Die VERLIFE-Kriterien scheinen schwächer als jene zu sein, die von den IAEA-Richtlinien gefordert werden. Die Anwendung jener Werte (im Hinblick auf postulierte Rissgrößen, Sicherheitsfaktoren und das Kriterium für den Warm-Vorspannungs- (warm prestress, WPS) Effekt), die die IAEA-Richtlinien verlangen, würde nicht zu einer Demonstration der Erfüllung der RPVI-Anforderungen für die Lebensdauer führen.
- Weitere Punkte, die noch der Klärung bedürfen, betreffen beispielsweise: Die thermo-hydraulische Modellierung von Unfallabläufen, die Modellierung von Mischungsverhalten, das Versprödungsverhalten sowie auch die ursprüngliche kritische Versprödungs-Temperatur der Druckbehälter-Werkstoffe, die Bestimmung von Fluenzen sowie die Einführung von Maßnahmen zur Fluenzminderung sowie Bereiche bei den wiederkehrenden Prüfungen, bei denen die Qualifikation bisher nicht erreicht wurde.
- Konservativität wird durch die Modellierung der intakten Plattierungs-Zone als strukturelle Verstärkung im Finite-Element-Modell reduziert, insbesondere ohne angemessene Bestätigung durch NDT, was nicht-konservative Annahmen für die bruchmechanischen Analysen an der Grenzfläche zwischen Platierung und ferritschen Stahl einschließt (bestätigt durch eine Pilot-Studie des österreichischen ExpertInnenteams). Dementsprechend wurden möglicherweise noch nicht alle Arten von Unterplattierungs-Rissen, die für die Genehmigung vergleichbarer RDBs in Westeurpoa gefordert werden, bewertet.

Dementsprechend sollte der künftige Austausch von Informationen zu RPVI und PTS in erster Linie die folgenden Punkte betreffen:

- Im Hinblick auf PTS-Analysen, die Konsequenzen zusätzlicher kritischer Bedingungen, sowie eines erweiterten Zeitrahmens für manche der berechneten Abläufe, ebenso die Betrachtung aller Rissgrößen und Risspositionen, die für die Bruchmechanik relevant sind (einschl. von Stabilitätsbetrachtungen);
- Das Fortschreiten der Versprödung und die ergriffenen Gegenmaßnahmen (Dies schließt Ergebnisse von Bestrahlungsproben für beide Blöcke ein, insbesondere die Ergebnisse von Proben mit höheren ursprünglichen Sprödbruchübergangs-Temperaturen, die in Block 2 bestrahlt wurden.);

- Der Vergleich der Werkstoffeigenschaften, die bei den Qualifikations-Tests, den erweiterten Abnahme-Tests sowie dem Lebensdauer-Auswertungsprogramm bestimmt wurden, mit den Daten aus dem Bestrahlungsprogramm, um die Streuung der Materialeigenschaften zu bewerten;
- Maßnahmen zur Abschwächung des Versprödungsfortschrittes, insbesondere Konfiguration des Reaktorkerns, Strategie des Brennelementwechsels und Änderungen der Anreicherung.

III.4 PUNKT 4 – Integrität der Primärkreislaufkomponenten – zerstörungsfreie Prüfung (NDT)

Wiederkehrende Prüfungen (in-service-inspection, ISI) und zerstörungsfreie Prüfungen (non-destructive testing, NDT) des Primärkreislaufes im KKW Temelín werden auf der Grundlage von Anforderungen wie den in Westeuropäischen Ländern gültigen durchgeführt und sind überwiegend vergleichbar mit der westlichen Praxis. Einige Fragen bleiben offen; ISI und NDT sollten insgesamt jedoch nicht als wichtige offene Sicherheitsfragen angesehen werden.

- Die Akzeptanz von Indikationen beruht auf einem analytischen Schwellenwert und einer analytischen Vorgehensweise. Die Kriterien, die beim Abschluss dieser Vorgehensweise angewandt werden, wurden noch nicht ausreichend deutlich gemacht.
- Im Hinblick auf worst-case Fehler und Testbedingungen stimmt die tschechische Praxis noch nicht völlig mit Westeuropäischen Standards überein.
- Eine maximale Risstiefe von 20 mm wird für PTS-Analysen angenommen. Die Hälfte dieser PTS-relevanten Risstiefe (d. h. ein 10 mm Unterplattierungs-Riss) wird im Kernkraftwerk Temelín als jene Fehlertiefe angenommen, die mit 100%iger Zuverlässigkeit nachgewiesen werden kann und muss – in Übereinstimmung mit der VERLIFE-Methodik. Dieses Ziel erscheint erreichbar. Eine Rückkoppelung der Ergebnisse aus der Anlage (site-feedback), von praktisch durchgeführten ISI, ist zur Bestätigung allerdings noch erforderlich. Ebenso ist die Unterscheidung zwischen Unterplattierungs-Rissen und Rissen innerhalb der Plattierung der Reaktordruckbehälterwand noch nicht gründlich nachgewiesen worden.
- Das Vorgehen bei der Qualifikation ist ähnlich wie in Westeuropa. Das Qualifikationsgremium wurde allerdings vom Eigner der Anlage eingerichtet, und ein Vertreter des Kernkraftwerkes ist Mitglied dieses Gremiums. Dies könnte die Frage der Unabhängigkeit aufwerfen. Weiterhin gibt es, im Gegensatz zu den meisten Ländern, keinen nationalen Lenkungsausschuss für die Qualifikation der Inspektionen.

Dementsprechend sollte der künftiger Austausch von Informationen zu ISI und NDT in erster Linie die folgenden Punkte betreffen:

- Fortschritte bei der Erstellung einer schriftlich festgehaltenen Verfahrensweise für die Arbeit der Qualifikationsbehörde und von nationalen Anleitungen für das Vorgehen bei der Qualifikation, ebenso wie die Erfahrungen mit dem nationalen tschechischen ISI-Regelwerk, das zur Zeit eingeführt wird. Die weitere Entwicklung der Qualifikationsbehörde im Hinblick auf ihre Unabhängigkeit;
- Die genaue Vorgehensweise, der im Falle des Nachweises eines Fehlers gefolgt werden soll;
- Die Sammlung von Daten über aufgefundene Fehler und deren statistische Auswertung, ebenso weitere Entwicklungen von NDT-Verfahren und ihrer Anwendung bei Prüfungen im Kernkraftwerk Temelín;
- Versuchsweise Prüfungen des Reaktordruckbehälters zum Zwecke der Unterscheidung zwischen Unterplattierungs-Rissen und Rissen, die durch die Plattierung gehen und somit möglicherweise besonders gefährlich sind und die Rückkoppelung von Prüfungen in der Anlage im Hinblick auf die Nachweisbarkeit von 10 mm Unterplattierungs-Rissen, besonders im Zusammenhang mit RPVI;

- Die Verbesserung des Vorgehens bei der Qualifikation, insbesondere im Hinblick auf die Verwendung von künstlich hergestellten Fehlern zu Ausbildungszwecken, die jenen ähnlicher sind, deren Auffindung bei real durchgeführten wiederkehrenden Prüfungen zu erwarten wären. Derartige Fehler schließen worst-case Fehler für die Ultraschall-Prüfungen der Schweißnähte des Reaktordruckbehälters ein, sowie Fehler in ausgebauten Heizrohren, die im Betrieb entstanden sind, für die Wirbelstromtests.

III.5 PUNKT 5 – Qualifikation von sicherheitsrelevanten Komponenten

Die Bewertung zeigt, dass die Qualifikation von Komponenten (equipment qualification, EQ) im Kernkraftwerk Temelín heute mit westlichen Vorgehensweisen vergleichbar ist, und zwar im Hinblick auf die Grundsätze, die eingesetzten Methoden und die erreichten Ergebnisse. Die Genehmigungs-Anforderungen und die technische Basis für die EQ sind mit westlichen Anforderungen bzw. westlichem Vorgehen vergleichbar, die Anwendung der EQ erfolgt im Rahmen einer bedachtsamen Praxis und die Dokumentation der EQ ist jener von westlichen Anlagen vergleichbar. Die eingesetzten Methoden und die Annahmekriterien erscheinen allgemein ähnlich den westlichen Praktiken.

Es gibt noch sicherheitsrelevante Komponenten, für die die Qualifikation noch nicht abgeschlossen ist. Die Pläne zur Vervollständigung der EQ wurden als realistisch erreichbar bewertet. Bei manchen der Komponenten, bei denen die EQ nicht abgeschlossen ist, wurden kompensatorische Maßnahmen eingeführt.

Dementsprechend sollte der künftige Austausch von Informationen zur EQ in erster Linie die folgenden Punkte betreffen:

- Die Vervollständigung der Qualifikation für alle Komponenten, die für 2006 vorgesehen ist (Für 5 Komponenten-Gruppen ist die allgemeine EQ noch unvollständig; für 14 Komponenten-Gruppen ist die Alterungs-Qualifikation unvollständig (Stand: Dezember 2004));
- Signifikante Ergebnisse von Inspektionen der Aufsichtsbehörde im Zusammenhang der Qualifikation von Komponenten, die den erfolgreichen Abschluss des EQ-Programmes beeinflussen könnten;
- Lokalisierte Effekte auf ausgewählte Komponenten außerhalb des Containment, die bisher nicht betrachtet wurden.

III.6 PUNKT 6 – Erdbebengefährdung des Standortes

Beträchtliche Anstrengungen wurden von tschechischen ExpertInnen unternommen, um Fragen zu klären, die von Überprüfungsteams der IAEO im Zusammenhang mit der Ermittlung der seismischen Gefährdung aufgeworfen wurden. Dennoch gibt es noch Themen, zu denen Fragen offen bleiben, einschließlich der Intensität des Erdbebens, das als Auslegungsbasis am Standort Temelín anzunehmen ist.

In diesem Zusammenhang ist von Bedeutung, dass es in der technischen Herangehensweise bei der seismischen Bewertung von Nuklearanlagen in letzter Zeit beachtliche Veränderungen gegeben hat. Dies ist kein Trend, der nur für das Kernkraftwerk Temelín relevant wäre. Dieser Trend betrifft viele Anlagen, insbesondere jene, die sich an bisher als „ruhig“ eingeschätzten Standorten befinden, und wird weltweit wahrgenommen. Er geht in Richtung der Berücksichtigung erheblich längerer Wiederkehrintervalle und der Berücksichtigung von standortspezifischen Effekten.

- Nicht alle Störungen in der näheren Umgebung von Temelín wurden untersucht. Kartierung und Datensammlung waren teilweise nicht ausreichend. Möglicherweise wurden wichtige geomorphologische Erscheinungen noch nicht berücksichtigt.

- Die deterministische Methode der seismischen Gefahrenabschätzung, die von den tschechischen ExpertInnen angewandt wurde, beruht auf einem Expertensystem[6], das nicht international verifiziert ist. Die Daten, auf denen die Gefahrenabschätzung für die nähere Umgebung des Standortes beruht, sollten überprüft werden.
- Eine Sicherheitsbandbreite von mindestens 1 ° der Intensität gemäß MSK-Skala – anstatt 0,5 °– erschiene als angemessen und besser im Einklang mit der internationalen Praxis.
- Bei den historischen Erdbeben wäre die Berücksichtigung längerer Wiederkehrintervalle wünschenswert. Paläoseismische Methoden – wie von der IAEO empfohlen – wurden von den tschechischen ExpertInnen bisher noch nicht angewandt.
- Die bisher angewandten probabilistischen Methoden sollten überarbeitet werden, insbes. im Hinblick auf Abminderungsverhältnis und Datenstreuung. Die Korrelation zwischen MSK-Intensität und maximaler Bodenbeschleunigung entspricht nicht dem weltweit angewandten Vorgehen und ist daher aller Wahrscheinlichkeit nach nicht konservativ.

Dementsprechend sollte der künftige Austausch von Informationen zur Erdbebengefährdung des Standortes in erster Linie die folgenden Punkte betreffen:

- Weitere Bemühungen zum Aufbau einer GIS-basierten geologischen Datenbasis, die sämtliche verfügbaren Daten der näheren Umgebung zusammenfasst;
- Weitere Untersuchungen zur Bewertung der Störungen in der näheren Umgebung, insbesondere im Hinblick auf die Hluboká Störung;
- Integration von geodätischen Daten und Daten von digitalen Höhenmodellen, um weitere Informationen über mögliche Aufwärtsbewegungen im Raum Temelín zu gewinnen;
- Die Konsequenzen einer angenommenen maximalen horizontalen Bodenbeschleunigung von 0,23 g, wie an vergleichbaren Standorten zugrunde gelegt (für das Sicherheitserdbeben wurden 0,1 g angenommen); Durchführung einer Studie zur probabilistischen seismischen Gefahrenabschätzung, wobei die neuesten Methoden angewandt werden sollten – insbesondere die Analyse langer Wiederkehrintervalle;
- Verbesserung der Lokalisierung der Mikroseismik, die sich in der näheren Umgebung des Kernkraftwerkes Temelín ereignet, durch eine Erweiterung des existierenden Überwachungssystems um drei bis vier seismische Stationen in Abständen von etwa 30 – 50 km vom Kernkraftwerk.

III.7 PUNKT “Seismische Auslegung”

Die seismische Auslegung im Kernkraftwerk Temelín beruht auf traditionellen Vorgehensweisen. Die Neubewertung der seismischen Auslegung, die bei dem Kernkraftwerk durchgeführt wurde, entspricht den bestehenden Vorschriften und Empfehlungen.

Die tschechischen ExpertInnen haben demonstriert, dass sie Anstrengungen unternommen haben, um die die seismische Auslegung betreffenden Anforderungen der IAEA-Richtlinien zu erfüllen. Die internationale Praxis bei der seismischen Auslegung hat in den letzten Jahren jedoch beträchtliche Fortschritte erzielt, die aus seismischen Ereignissen in jüngster Zeit gewonnen wurden. Daraus ergaben sich beträchtliche Änderungen in der Herangehensweise ebenso wie in damit zusammenhängenden Vorschriften und Standards.

- Die traditionelle Vorgehensweise bei der seismischen Auslegung, wie von den tschechischen ExpertInnen angewandt, beschränkt sich auf Baukörper. Sie schließt nicht alle wichtigen seismischen Effekte ein, wie die Wechselwirkungen zwischen benachbarten

[6] Ein rechnergestütztes System künstlicher Intelligenz, das Informationen analysiert, um die Qualität von Datenbanken für bestimmte Anwendungen zu verbessern.

Baukörpern, unterschiedliche lokale Bewegungen an wichtigen Berührungsflächen, sowie auch das Verhalten und schließlich das Versagen von nicht-tragenden Komponenten.

Dementsprechend sollte der weitere Austausch von Informationen zur seismischen Auslegung in erster Linie folgende Punkte betreffen:

- Eine probabilistische Sicherheitsanalyse, entsprechend jüngsten Empfehlungen der IAEO und der gegenwärtigen besten Praxis in Westeuropa;
- Seismischen Qualifizierung der Bauwerke, Übergänge und Komponenten, im Rahmen der zehnjährigen periodischen Sicherheitsüberprüfung;
- Die Verbesserung des Überwachungssystems und die Einbeziehung aktueller Messwerte in den Evaluierungsprozess inkl. der Verbesserung der existierenden Datenbank.

III.8 PUNKT 7a – Fragen im Zusammenhang mit Schweren Unfällen – Arbeitsgruppe zum Vergleich von Berechnungen hinsichtlich der radiologischen Folgen von auslegungsüberschreitenden Unfällen

Durch die Aktivitäten zu diesem PUNKT wurde eine Basis für das gegenseitige Verständnis von Vorgehensweisen und Rechenprogrammen, die in Notfall-Situationen in der tschechischen Republik und in Österreich angewandt werden, hergestellt. Die Ergebnisse der Tschechisch-Österreichischen Arbeitsgruppe sind in einem Gemeinsamen Zusammenfassenden Bericht (Joint Summary Report) zusammengefasst und wurden auf dem Internationalen Symposium über Nukleare Notfall-Maßnahmen außerhalb des Anlagengeländes in Salzburg, 2003, gemeinsam vorgestellt. Der intensive Austausch von Informationen hatte bereits eine sehr positive Auswirkung auf die Notfall-Vorsorge in beiden Ländern. Weiterhin könnten die Ergebnisse und Erfahrungen, die gewonnen wurden, eine Basis für eine weitere Harmonisierung auf dem Gebiet des Notfallschutzes in beiden Ländern darstellen. Der ausgedehnte bilaterale Austausch von Informationen, und die ausgedehnte Zusammenarbeit, auf dem Gebiet des Notfallschutzes könnten als ein gutes Beispiel für die bilaterale Zusammenarbeit beim Strahlenschutz zwischen benachbarten Ländern dienen.

Im Hinblick auf diesem PUNKT haben Folgeaktivitäten bereits begonnen. Ein Programm für zukünftige bilaterale und regionale Kooperation auf dem Gebiet des Notfallschutzes wird gerade entwickelt. Diese gemeinsamen, zukünftigen Aktivitäten schließen einen intensivierten Austausch von Daten und Informationen ein, ebenso wie Kooperation zwischen beiden Krisen-Zentren.

Im Rahmen des bilateralen “Nuklearinformationsabkommens“ wurde bereits eine Einigung über die Bedingungen erzielt, unter denen Resultate und spezifische Eingangsdaten der tschechischen und österreichischen Prognose-Systeme (ESTE und TAMOS) übertragen werden sollten. Der Austausch der folgenden Daten wird erwartet, wenn ein Notfall eintritt: Aktuelle Wetterbedingungen am Ort einer Radionuklid-Freisetzung, meteorologische Prognosen für Ausbreitungsrechnungen, Konzentrationen von Radionukliden in der Luft sowie Vorhersagen zur Ablagerung, die auf Wettermodellen beruhen, die beiden Seiten zur Verfügung stehen, Vorhersagen des Unfallverlaufes und von Quelltermen. Beim BMLFUW in Österreich wurde das ESTE System installiert, um die möglichen radiologischen Konsequenzen, beruhend auf aktuellen Wetterdaten wie auch auf Wettervorhersagen, zu bewerten. Das bilaterale „Nuklearinformationsabkommen“ gewährleistet, dass beide Seiten die gleichen, für den Notfallschutz relevanten Informationen haben.

Weiterhin arbeiten beide Ländern im Hinblick auf wichtige Themen zusammen, die im 6. Forschungs-Rahmenprogramm der Europäischen Union enthalten sind. Dies betrifft etwa gemeinsame Aktivitäten zur Vorführung des RODOS-Systems, und Übungen mit diesem System. Nicht zuletzt sind der Austausch von ExpertInnen der Notfallvorsorge in den Krisen-Zentren beider Länder sowie gemeinsame Übungen zum Testen der Bereitschaft für Notfälle Teil der Zusammenarbeit.

III.9 PUNKT 7b – Fragen im Zusammenhang mit schweren Unfällen – SAMG

Die Entwicklung und Einführung des Programmes für den internen Notfallschutz (severe accident management, SAM) sind in Temelín noch nicht abgeschlossen; allerdings wird berichtet, dass sie bereits weit fortgeschritten sind. Das Gesamt-Konzept und die Vorgehensweise bei der Entwicklung und Einführung des Richtlinienpaktes für den internen Notfallschutz (severe accident management guidelines, SAMG) spiegelt gegenwärtige gute Praxis wider. Das Programm wird durch Analysen schwerer Unfälle sowie durch eine anlagenspezifische probabilistische Sicherheitsanalyse (PSA) gestützt.

Im Rahmen der technischen Maßnahmen, die im KKW Temelín für den anlageninternen Notfallschutz verfügbar sind, wurden die Gefahren von Leckagen aus dem Primär- in den Sekundärkreislauf gut erkannt, die angemessenen Strategien entwickelt und die technischen Mittel bereit gestellt. Die Gefahren eines Containment-Versagens durch direkte Erwärmung oder langfristigen Druckanstieg wurden vom österreichischen ExpertInnen-Team als ziemlich niedrig bewertet. Die Maßnahmen und Strategien zur Verringerung der Freisetzung von Spaltprodukten werden der internationalen Praxis entsprechen, sobald sie eingeführt sind.

Dennoch verbleiben einige Fragen:

- Es bestehen Fragen zur Konsistenz in den Annahmen und den Analysen allgemein in Bezug auf die Schnittstellen zwischen den Analysen schwerer Unfälle einerseits, und der PSA sowie den Strategien des anlageninternen Notfallschutzes andererseits.
- Im Falle eines totalen Stromausfalles (station blackout) erscheint die Verfügbarkeit der batteriegepufferten unterbrechungslosen Notstromversorgung aufgrund der begrenzten Kapazität der vorhandenen Batterien fraglich. Betriebsanleitungen zum Lastabwurf sollten bei Bedarf implementiert werden, um die Versorgungszeitdauer der Batterien zu erhalten.
- Obgleich Freisetzungen erheblich kleiner wären, als im Falle eines frühzeitigen Containment-Versagens, scheint das Durchschmelzen der Bodenplatte im Zusammenhang mit schweren Unfällen das kritischste Problem zu sein. Das Versagen des Containments könnte in diesem Falle relativ rasch während eines Unfallablaufes eintreten. Zur Zeit kann noch nicht eindeutig demonstriert werden, dass das Fortschreiten der Erosion durch Corium gestoppt werden kann. Zusätzliche Maßnahmen zur Verringerung der Unfallfolgen werden erwogen.
- Die Bildung einer detonationsfähigen Wasserstoff-Wolke kann nicht zur Gänze ausgeschlossen werden, wie die Analyse eines Kühlmittelverlustunfalles mit kleinem Leck zeigt. Obwohl die Wahrscheinlichkeit einer Detonation, die zu einem Versagen des Containment führt, ziemlich gering erscheint, würden die Konsequenzen eines solchen Unfallablaufes wahrscheinlich einen großen Quellterm nach sich ziehen. Die Möglichkeit lokaler Ansammlung von Wasserstoff sollte weiter untersucht werden und, falls erforderlich, sollte ihr mit geeigneten Maßnahmen entgegengesteuert werden (z. B. durch die Belüftung kritischer Räume), inklusive einer adequaten Berücksichtigung in den SAMGs.
- Ein Versagen der Druckentlastung des Reaktorkühlsystems könnte zum Ausstoß von Corium aus dem Reaktordruckbehälter, unter hohem Druck, führen. Beschädigung der Dichthaut (liner) des Containments und darauffolgende Leckagen aus dem Containment wären die Folge. Angesichts der verfügbaren Information kann diese Gefahr jedoch als unwahrscheinlich angesehen werden.

- Ausbreitung der Kernschmelze innerhalb der Reaktorgrube und darüber hinaus, Kühlbarkeit der Kernschmelze, sowie Möglichkeiten, die Kühlbarkeit weiter zu verbessern.

Dementsprechend sollte der weitere Austausch von Informationen zu den schweren Unfällen (SAMG) in erster Linie folgende Punkte betreffen:

- Unterstützende Analysen schwerer Unfälle sowie probabilistische Sicherheitsanalysen, einschließlich ihrer Verwendung bei der Verifikation von SAM-Strategien und damit zusammenhängenden Verfahrensweisen;
- Aktivitäten zur Einführung von SAMG, einschließlich des prozeduralen Rahmens, der Validierung der SAMG und des Trainings von Personal im Zusammenhang mit SAMG;
- Festlegung von tolerierbaren Ungleichmäßigkeiten der Wasserstoff-Verteilung in der Containment-Atmosphäre;
- Umsetzung von geplanten Veränderungen, die auf eine Verbesserung der in den SAMGs berücksichtigen technischen Maßnahmen hinzielen;
- Im Hinblick auf spezifische Rechnungen mit Programmpaketen für schwere Unfälle, die Kapazitäten der motorgetriebenen Entlastungsventile (power operated relief valves, PORV), die Effektivität der Wasserstoffkontrolle sowie Einsatzmöglichkeiten des gefilterten Abblasens zur Verringerung des Druckes im Containment während lang andauernder Unfallabläufe, die Leistungsfähigkeit des Notfall-Entgasungssystems (emergency gas removal system) unter den Bedingungen eines schweren Unfalls sowie Analysen zum Versagen der Bodenplatte durch Durchschmelzen.

III.10 Kapitel V – Umweltverträglichkeitsprüfung

Die Kommission zur Prüfung der Umweltverträglichkeit des Kernkraftwerks Temelín (UVP-Kommission) – eingesetzt auf der Grundlage einer Resolution der Regierung der Tschechischen Republik – legte einen Bericht vor und empfahl in ihren Schlussfolgerungen die Umsetzung von einundzwanzig konkreten Maßnahmen (ANHANG II der „Vereinbarung von Brüssel“).

Die Unterzeichner der "Vereinbarung von Brüssel" kamen überein, dass die Umsetzung der beschriebenen Maßnahmen in regelmäßigen Abständen von österreichischen und tschechischen ExpertInnen im Rahmen des bilateralen “Nuklearinformationsabkommens“ untersucht werden würde.

In der Folge des Informationsaustausches bei den jährlichen Bilateralen Treffen 2002, 2003 und 2004 sowie bei einem zusätzlichen Treffen des Österreichischen Bundesministeriums für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft und des Umweltbundesamtes mit Vertretern von SÚJB und der UVP-Kommission im Februar 2005 kann der gegenwärtige Stand wie folgt zusammengefasst werden:

- Die UVP-Kommission und SÚJB haben einen Überblick über den Stand der Umsetzung der genannten Maßnahmen, ihren Umfang und die verantwortlichen Organisationen gegeben.
- Die meisten Aktivitäten zur Umsetzung der genannten Maßnahmen sind noch im Gange, teilweise für die gesamte Betriebsdauer des KKW Temelín.
- Das bilaterale “Nuklearinformationsabkommen“ wird als der angemessene Rahmen für eine weitere gemeinsame Überprüfung des laufenden Prozesses der Umsetzung der Maßnahmen angesehen.
- Es ist von besonderem Interesse, wie die Umsetzung jener Maßnahmen, für die die entsprechenden Forschungsprojekte zum Ende kommen, weitergeführt wird und wie sie in reguläre Programme der zuständigen Behörden integriert werden.

- Darüber hinaus wird für den Fall, dass es Änderungen bei der Funktionsfähigkeit der Web-Seite der UVP-Kommission als Informationsplattform geben sollte, die Gewährleistung der Information der breiten Öffentlichkeit zusätzliche Aufmerksamkeit beim künftigen bilateralen Informationsaustausch erfordern.

III.11 Zusammenfassender Überblick über wichtige Wechselbeziehungen zwischen PUNKTEN

Es gibt zahlreiche Wechselbeziehungen zwischen den PUNKTEN gemäß ANHANG I der „Vereinbarung von Brüssel“ (d. s. die in Abschnitten III.1 bis III.9 diskutierten PUNKTE).

PUNKTE können eng zusammenhängen, wenn sie verschiedene Aspekte der gleichen Komponente betreffen (wie die PUNKTE 3 und 4, die die Schockbelastung unter Temperatur und Druck des Reaktordruckbehälters, bzw. die zerstörungsfreien Prüfungen dieses Behälters behandeln), oder verschiedene Aspekte des gleichen Ereignisses (wie der PUNKT 6 und der PUNKT „Seismische Auslegung“, die beide seismische Fragen behandeln).

Darüber hinaus gibt es Fälle, in denen ein PUNKT potenziellen Einfluss auf einen anderen hat, aber nicht umgekehrt. Beispielsweise könnte PUNKT 2 (Qualifikation von Ventilen) potenziell PUNKT 7b (Schwere Unfälle – SAMG) beeinflussen. Sollte ein Versagen dieser Ventile in Offenstellung angenommen werden müssen, könnten Unfallabläufe dadurch beschleunigt werden. Ein anderes Beispiel ist, dass PUNKT 6 (Erdbebengefährdung des Standortes) potenziellen Einfluss auf PUNKT 5 (Qualifikation von Komponenten) ausüben kann. Falls die Bodenbeschleunigung für das Sicherheitserdbeben höher angesetzt werden müsste als bisher, könnte die seismische Neubewertung von bestimmten sicherheitsrelevanten Komponenten erforderlich werden.

Es gibt sehr viele weitere Verbindungen zwischen PUNKTEN, direkte und indirekte, wichtige und solche von geringerer Bedeutung. Der hier präsentierte Überblick beschränkt sich auf die wesentlichen Punkte, auf die direkten und wichtigen Wechselbeziehungen, die auch für einen künftigen Informationsaustausch potenziell relevant sind.

Die Tabelle auf der nächsten Seite soll einen Überblick über diese Zusammenhänge geben.

In der Tabelle zeigt ein graues Feld eine enge Verbindung zwischen zwei PUNKTEN an, was gegenseitige Beeinflussung impliziert. Ein Pfeil bedeutet, dass ein PUNKT potenziellen Einfluss auf einen anderen hat, aber nicht umgekehrt.

Tabelle 1: Überblick über Wechselbeziehungen und Einflüsse zwischen den PUNKTEN gemäß ANHANG I der „Vereinbarung von Brüssel“, die sich aus Verbindungen zwischen den jeweiligen fachlichen Themen ergeben
Graues Feld: Enger Zusammenhang zwischen zwei PUNKTEN, der gegenseitige Beeinflussung bedeutet (beispielsweise hängen PUNKTE 3 und 4 eng zusammen)
Pfeil: Potenzieller, einseitiger Einfluß eines PUNKTES auf einen anderen (beispielsweise hat PUNKT 6 potenziellen Einfluß auf PUNKT 1, aber nicht umgekehrt)

	Projekte	**PUNKTE**	**1**	**2**	**3**	**4**	**5**	**6**	**SD**	**7a**	**7b**
Hochenergetische Rohrleitungen	PN2	1	○		▲		▲				▲
Qualifikation von Ventilen	PN3	2	▲	○							▲
Reaktordruck-behälterintegrität	PN9	3			○						▲
Integrität der Primärkreislaufkomp.	PN10	4	▲			○					
Qualifikation von Komponenten	PN4	5					○				▲
Erdbebengefährung des Standortes	PN6	6	▲				▲	○			▲
Seismische Auslegung	PN8	SD	▲				▲		○		▲
Schwere Unfälle – Rad. Folgen	PN1	7a								○	
Schwere Unfälle – SAMG	PN7	7b								▲	○

III.12 Gruppen von sicherheitsrelevanten Themen für künftigen Austausch

Die Ergebnisse des Monitoring-Prozesses sind sehr komplex und vielschichtig. Sie umfassen viele verschiedene Themen, die in vielfältiger Form miteinander verbunden sind, wie in Abschnitt III.11 gezeigt.

Im Bewusstsein des Risikos der Vereinfachung wurden alle Ergebnisse und offenen Fragen aus dem Monitoring Prozess für das KKW Temelín zusammengeführt und kondensiert. Das Resultat wurde in die folgenden fünf Gruppen von sicherheitsrelevanten Themen unterteilt, die für einen weiteren Informationsaustausch zwischen tschechischen und österreichischen ExpertInnen identifiziert wurden.

Für ihre weitere Behandlung wird eine Bewertung der Gruppen nach Prioritäten vorgeschlagen, entsprechend ihrer Bedeutung (Relevanz für die Sicherheit) sowie auch der Dringlichkeit dieser weiteren Behandlung.

Die **Sicherheits-Relevanz** einer Gruppe wird als **„primär“** angesehen, wenn sie ein Problem betrifft, das direkt zur Auslösung eines Unfalles führen kann (im Gegensatz zu Problemen, die erst relevant werden, nachdem ein Unfallablauf begonnen hat), und wenn mehrere andere sicherheitsrelevante Themen von ihr potenziell beeinflusst werden.

Die **Sicherheits-Relevanz** einer Gruppe wird als **„sekundär“** eingestuft, wenn ihr Einfluss auf die Sicherheit indirekter Natur ist. Dadurch wird niedrigere Priorität im Vergleich mit den Gruppen mit primärer Priorität ausgedrückt, aber keineswegs eine niedrige Bedeutung oder geringes Interesse schlechthin.

“Kurzfristige“ Behandlung einer Gruppe wird als angemessen angesehen, wenn die potenziellen sicherheitsmäßigen Konsequenzen nicht von länger andauernden Prozessen, Untersuchungen, Datensammlungen, Kontrollen oder Entwicklungen wie Alterung abhängig sind, und wenn neue, weiter gehende Einsichten bald erwartet werden können.

„Langfristige“ Behandlung einer Gruppe sollte in jenen Fällen erwogen werden, in denen sicherheitsmäßige Konsequenzen von Prozessen abhängen, die sich über längere Zeiträume erstrecken – wie Alterung, Datensammlungen usw.

Die Behandlung der Gruppen sollte den Charakter der sicherheitsrelevanten Themen sowie den bestehenden Klärungsbedarf im Hinblick auf folgende Unterscheidung berücksichtigen:

- Anforderungen bei der Inbetriebnahme und der frühen Betriebsphase;
- Wiederkehrende und fortdauernde Anforderungen, sowie solche, die mit der Lebensdauer der Anlage zusammenhängen.

Die Gruppen, die als besonders wichtig für einen weiteren Informationsaustausch identifiziert wurden, sind folgende:

1. **Brüche hochenergetischer Rohrleitungen auf der 28,8 m Bühne**, einschließlich lokalisierter Effekte, die für die Klassifikation von Komponenten relevant sind:
   Diese Gruppe ist von **primärer Sicherheits-Relevanz** und sollte **kurzfristig** behandelt werden.
2. **Fragen im Zusammenhang mit schweren Unfällen – SAMG:**
   Diese Gruppe ist von **sekundärer Sicherheits-Relevanz** (sie wird relevant, nachdem ein Unfall ausgelöst wurde) und kann **kurzfristig** behandelt werden.
3. **Qualifikation von Ventilen:**
   Diese Gruppe ist von **sekundärer Sicherheits-Relevanz** (sie wird relevant, nachdem ein Unfall ausgelöst wurde) und kann **kurzfristig** behandelt werden
4. **Reaktordruckbehälterintegrität**, einschließlich zerstörungsfreier Prüfungen auf PTS-relevante Unterplattierungs-Risse:
   Diese Gruppe ist von **primärer Sicherheits-Relevanz** und soll **langfristig** behandelt werden. Die ersten Ergebnisse von Voreil-Bestrahlungsproben, die für die Überwachung der Versprödung wichtig sind, werden 2005 verfügbar sein, und weitere Überwachungsergebnisse werden in den nächsten Jahren folgen.
5. **Seismische Fragen:** Diese Gruppe schließt jene Themen ein, die aus PUNKT 6 (Erdbebengefährdung des Standortes) weiter verfolgt werden sollen, sowie jene aus dem PUNKT „Seismische Auslegung“:
   Sie ist von **primärer Sicherheits-Relevanz** und soll **langfristig** behandelt werden, da noch Daten mit dem mikroseismischen Überwachungssystem gesammelt werden. Außerdem sollen anlässlich der zehnjährigen periodischen Sicherheitsüberprüfung Fragen der seismischen Auslegung wieder aufgegriffen werden.

Im Bewusstsein, dass das bilaterale „Nuklearinformationsabkommen“ einen geeigneten Rahmen für weitere Diskussion und einen weiteren Informationsausstausch darstellt, werden diese fünf Gruppen als eine Basis für einen zukünftigen, eingehenden Informationsaustausch zwischen ExpertInnen der tschechischen und österreichischen Seite empfohlen.

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1 INTRODUCTION

1.1 The Framework

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 (see ANNEX A). 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 Temelín 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 (see ANNEX B).

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 [in the “Roadmap”] .*
- *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 below [in the “Roadmap”].*

The Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) entrusted the Umweltbundesamt (Federal Environment Agency) with the general management of the implementation of the "Roadmap".

1.2 Monitoring on technical level – Austrian Technical Projects

Each entry to the "Roadmap" corresponds to a specific technical project [see ANNEX C]. For each of the projects an international experts' team was committed by the Umweltbundesamt (Federal Environment Agency) on behalf of the Austrian Government to provide technical support for the monitoring on technical level. In total, 35 organisation and contractors from 10 countries were involved in the monitoring process.

The specific technical projects are referred to as project PN1 – PN10 comprising altogether seven predefined "project milestones" (PMs).

Referring to Chapter IV of the "Brussels Agreement" and the principles of the "Roadmap", a number of issues identified in the "trialogue" of the Melk Process were found suitable to be followed-up in the framework of the Bilateral Agreement. Those issues, where appropriate, were also covered by the corresponding technical projects.

For each project a Specialists' Workshop was forseen and specified in the Roadmap. In addition to this schedule, further meetings or presentation were agreed for Item 7a, Item 3 and Item 6 during the bilateral discussions.

For Item 7a, persued as PN1, the first topical meeting served to establish a Czech-Austrian working group on comparison of calculations regarding the radiological consequences of beyond design basis accidents (BDBA) with a view to harmonise the basis for emergency preparedness. The working group elaborated a detailed working programme and discussed the calculation results in additional 3 workshops. The results of the working group are summarized in a Joint Summary Report and were jointly presented by the Czech and Austrian Authorities at the International Symposium on Off-site Nuclear Emergency Management, Salzburg 2003.

During the discussion within the Roadmap Item 6 (PN6, "Site seismicity") the Czech side offered an additional presentation about the issue re-evaluation/seismic design at the Bilateral Meeting 2003. For the preparation of the Austrian delegation on this subject, an additional item and a correponding project PN8 "Seismic Design" were created.

Furthermore, as a result of the discussion within the Specialists' Workshop of Item 3 (PM9, "Reactor Pressure Vessel Integrity and Pressurised Thermal Shock") the developments regarding the NPP Temelín PTS issue since May 2004 were presented in an additional meeting in October 2004.

The analysis of information made available at the Specialists' Workshops played a significant role in the development of the basis for the Preliminary and Final Monitoring Report of each project.

The Preliminary Monitoring Reports have been published on the website of the Umweltbundesamt (www.umweltbundesamt.at) between May 2003 und September 2004 (except for projects PN5, PN9 and PN10, which were the last to be completed). The Final Monitoring Reports will also be published there.

Furthermore, the preliminary monitoring results of each project have been presented by the Austrian Experts' Teams at the regular Annual Meetings under the Czech-Austrian Bilateral Agreement in 2002, 2003 and 2004.

The following table gives an overview on the monitoring process, the specific Austrian technical projects and the corresponding Roadmap items.

Table 2: Overview on the monitoring process, the specific Austrian technical projects and the corresponding Roadmap items

Technical Project	Roadmap Item	Technical Project Management	Meeting	Date
2002				
PN1	WG on Comparison of Calculations Regarding the Radiological Consequences of BDBA	BMLFUW and Umweltbundesamt	Workshop 1	14th-15th May 2002, Vienna
PN1	WG on Comparison of Calculations Regarding the Radiological Consequences of BDBA	BMLFUW and Umweltbundesamt	Workshop 2	10th-11th September 2002, Prague
PN2	Item1: High Energy Pipe Lines at the 28,8 m Level	ARCS, IRF	Workshop	7th-8th November 2002, Prague
PN3	Item2: Qualification of Valves	ARCS, IRF	Workshop	7th-8th November 2002, Prague
PN4	Item5: Qualification of Safety Classified Components	ENCONET	Workshop	9th-10th December 2002, Prague
	Presentation of Preliminary Monitoring Results of PN1		Bilateral Meeting 2002	11th December 2002, Prague
PN5	Chapter V – Environmental Impact Assessment	Umweltbundesamt	Bilateral Meeting 2002	11th December 2002, Prague
2003				
PN1	WG on Comparison of Calculations Regarding the Radiological Consequences of BDBA	BMLFUW and Umweltbundesamt	Workshop 3	28th-29th April 2003, Vienna
PN6	Site Seismicity	VCE	Workshop	27th-28th March 2003, Prague
PN7	Item 7b: Severe Accidents Related Issues	ARCS, ENCONET, IRF	Workshop	17th-18th June 2003, Prague
PN1	WG on Comparison of Calculations Regarding the Radiological Consequences of BDBA	BMLFUW and Umweltbundesamt	Workshop 4	9th October 2003, Prague
	Presentation of Final Monitoring Results of PN1 and Austrian Preliminary Monitoring Results of PN2, PN3, PN4, PN6		Bilateral Meeting 2003	17th-18th December 2003, Vienna
PN8	Seismic Design	VCE	Additional CZ Presentation at the Bilateral Meeting 2003	17th-18th December 2003, Vienna
PN5	Chapter V – Environmental Impact Assessment	Umweltbundesamt	Bilateral Meeting 2003	17th-18th December 2003, Vienna

2004				
PN9	Item 3: Reactor Pressure Vessel Integrity and Pressurised Thermal Shock	ARCS, IRF	Workshop	24th-25th May 2004, Prague
PN9	Item 3: Reactor Pressure Vessel Integrity and Pressurised Thermal Shock	ARCS, IRF	Additional CZ Presentation on PTS-Update	7th October 2004, Řež
PN10	Item 4: Integrity of Primary Loop Components – Non Destructive Testing (NDT)	ENCONET	Workshop	7th-8th October 2004, Řež
	Presentation of Austrian Preliminary Monitoring Results of PN7, PN8, PN9, PN10, Monitoring of Chapter V (PN5)		Bilateral Meeting 2004	29th-30th November, Dolní Dunajovice
PN5	Chapter V – Environmental Impact Assessment	Umweltbundesamt	Bilateral Meeting 2004	29th-30th November, Dolní Dunajovice

The Monitoring on the technical level within each technical project followed a seven milestone structure:

To focus preparatory work of the Austrian Experts' Team and to guide the Austrian Delegation through the Experts' Workshop, but also to enable proper preparation of the Experts' Workshop on the bilateral level, in a first step (Project Milestone 1), the safety objective was broken down to Verifiable Line Items (VLIs)

In a second step the Experts' Team prepared the Specific Information Request (SIR), considered to contain the kind of information required to provide for profound answers in the VLIs.

The third step (Project Milestone 3) was intended to complete all the preparatory activities for the workshop (PM 3). This included also the benchmarking of information/documents provided by the Czech side during the workshop against the state-of-the-art consolidated practice. VLIs formulated in the first step were used for this purpose. The scope of this milestone also included the development of briefing material and preparation of the briefing session for the Austrian delegation.

Following the Workshop in a fourth step, the Experts' Team reviewed the information and data received at the Workshop and prepared the Preliminary Monitoring Report (PMR). This report also intended to highlight issues recommended to the Austrian Government to pay further attention to.

These preliminary monitoring results have been presented at the following regular bilateral meeting 2002, 2003 or 2004 in a fifth step.

The sixth step concentrated on the consolidation of findings and their presentation in the form of a final report. In case additional information was provided by the Czech side, this was included in the assessment contained in the Final Monitoring Report (FMR).

The present Summary Monitoring Report (SMR) summarizes in a seventh step the entire monitoring process and the monitoring results of all technical projects. Based on the Final Monitoring Reports, it intends to summarize those issues which are recommended to the Austrian Government to be in the focus of further attention.

Nevertheless, it should be kept in mind that the monitoring results in their full complexity can only be found in the Final Monitoring Reports for each item, summaries of which are presented in section 2.

The full reference for sources which are quoted in the summaries in section 2 can also be found in the corresponding Final Monitoring Report.

2 MONITORING FINDINGS

2.1 Item No. 1 – High Energy Pipe Lines at the 28,8 m Level

Technical Project Management	Mario Brandani (Ansaldo Energia, Nuclear Division – Italy) Wolfgang Kromp (Institute of Risk Research, University of Vienna – Austria) Emmerich Seidelberger (Institute of Risk Research, University of Vienna – Austria) Geert Weimann (ARCS Seibersdorf Research – Austria)
Technical Expertise from	Francesco D'Auria (Department of Mechanical, Nuclear and Production Engineering, University of Pisa – Italy) Mario Brandani (Ansaldo Energia, Nuclear Division – Italy) Werner Erath (Kerntechnik Entwicklung Dynamik – Germany) Helmut Hirsch (Consultant – Austria/Germany) Helmut Karwat (Consultant – Germany) Gueorgui Kastschiev (Institute of Risk Research, University of Vienna – Austria) Sören Kliem (Forschungszentrum Rossendorf – Germany) Roman Lahodynsky (Institute of Risk Research, University of Vienna – Austria) Antonio Madonna (Consultant – Italy) Norbert Meyer (Innovativer Werkstoffeinsatz GbR – Germany) Bernd Nowotny (Kerntechnik Entwicklung Dynamik – Germany) Petko Petkov (Bulgarian Academy of Sciences – Bulgaria) Gerhard Schuëller (Institute of Engineering Mechanics, University of Innsbruck – Austria) Steven Sholly (Institute of Risk Research, University of Vienna, Austria) Ilse Tweer (Consultant – Germany) Hermann Wüstenberg (Consultant – Germany) Piero Zanaboni (Ansaldo Energia, Nuclear Division, Italy)

2.1.1 Basis and background of the project

The Republic of Austria and the Czech Republic, using the good offices of Commissioner Verheugen, had 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 – had 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 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" had 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 Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management has entrusted the Umweltbundesamt (Federal Environment Agency) 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 of the Roadmap process covered by 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."*

On behalf of the Austrian Government the Umweltbundesamt (Federal Environment Agency) has committed an Austrian Experts' Team composed of national and international experts to provide technical support for the monitoring of the implementation on the technical level of the +28,8 meter level Issue as listed in ANNEX I of the "Brussels Agreement". This specific technical project is referred to as project PN2 comprising altogether seven predefined "project milestones" (PMs).

The technical support for the monitoring on the technical level of the implementation of the "Conclusions of the Melk Process and Follow-up" regarding the item High Energy Pipe Lines at the 28,8 m Level Issues was aimed at focussing on the evaluation of how the Czech Side (operator as well as regulatory body) has dealt with the issue in a methodological way for implementation. In particular, it was intended to focus on HELB assessment and consequential failures mitigation, comprehensive PSA analyses and the implementation of ISI programmes, all to be checked against requirements and practices governed by valid interpretations of the ALARA principle and widely applied within the EU and of new developments in WWER-reactor specific knowledge, both on the technical and regulatory level.

2.1.2 The approach and objectives of the Czech side

The Temelín NPP, originally of Soviet design, and later upgraded to include elements of western safety concepts and western equipment, has addressed integrity of the High Energy Lines at the 28,8 m Level late in the construction phase. During the Specialists' meetings in the frame of the Melk process it appeared that the process of a Comprehensive Safety Case Revisit of this topic at Temelín was not adequately completed. The availability of information on the details of the approach adopted at the Temelín NPP was insufficient. Therefore, HELs integrity on the 28,8 m level remained one of the items to be addressed during the follow up to the Melk process. This established the basis and defined the scope of the proposed project.

The NPP Temelín has to be considered as a very specific case: Design and construction were performed in the former Soviet Union, the manufacture occurred at least partially in the former Czechoslovakia under Russian supervision. After the political re-organisation of Eastern Europe the construction was completed including Western technology from Westinghouse under the responsibility of the plant owner. Licensing happened within the legal frame of the Czech Republic.

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" (PN3) 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 workshop was the key element in the monitoring process for the analysis by the Austrian Experts' Team before and after the Specialists' Workshop. Additional information has been collected at the two Bilateral Meetings following the Specialists' Workshop. The analysis of the information made available at the three occasions is the basis for the present Final Monitoring Report of the Austrian Experts' Team.

In a series of presentations the outline of the solution for the HELB item was described by Czech experts at the Specialists' Workshop, 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 as 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 in the EU
  - Load Definition: Steam-Water Mixture of BRU-A and SGSV Qualification
  - 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
  - Flow Accelerated Material Corrosion Overview
- In-Service Inspection
  - Measurement of Operational Displacement (of piping sections)
  - 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 m 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 extending over up to 30m each, including elbows from the containment penetration to the isolation valves.

The descriptions at the Specialists´ Workshop did provide information about the approach taken. However, due to the overview type of the presentations only limited insight was possible into the results and how these were obtained. Several questions remained open. As a consequence, 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 at the Specialists´ Workshop in Prague provided an insight into the extensive work accomplished by the plant operator and its technical support organisations in trying to consolidate the safety case in the framework of the "Comprehensive Safety Case Revisit" (CSCR) for judgement by the licensing authority.

2.1.3 The approach by the Austrian Experts' Team

An Austrian Experts' Team of 15 national and international experts was committed by the Umweltbundesamt on behalf of the Government of Austria 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 "Brussels Agreement".

The project PN2 is composed of two complementary segments (horizontal and vertical), the horizontal segment depicting an assessment of principles, standards and practices, the vertical segment providing an analysis of HELB bounding cases and of the materials database established and used for the Temelín NPP.

The monitoring process conducted by the Austrian Experts' Team was concentrated on the engineering approach taken by ČEZ to have the Temelín HELs licensed by the SÚJB (State Office for Nuclear Safety).

In applying current safety philosophy, the consideration of HELB usually includes the precautions taken to identify HEL material and integrity degradation in time and sequences, which are likely to cause excessive loads on the HEL.

Both segments – the horizontal and vertical one – were related to the collection of information on the Temelín HEL behaviour during transients and over service life, as well as the HEL material history and usage and their vulnerability.

This specific technical project comprises altogether seven predefined "project milestones" (PM). The PMs requested by the contracting party, the Austrian Umweltbundesamt, represented the main tasks to be accomplished by the Austrian Experts' Team. Several preparatory tasks had to be performed to support and accomplish the main tasks. These preparatory tasks are also addressed in this report.

For the different tasks within the HELB assessment the state of science and technology was reviewed for comparison with the findings of the evaluation of the Czech approach and the Comprehensive Safety Case Revisit, which included the following issues:

- HEL quality with respect to design, construction/manufacture
- HEL analysis
- HEL surveillance
- ISI programme
- HELB related modifications
- HELB related EOPs and SAMGs

At the time of the NPP Temelín construction the actual HEL concept did not take into consideration the need for secondary coolant circuit failures mitigation to the extent needed. Therefore the WWER-1000 analyses were only conducted under the assumption, that subsequent failure of the secondary main coolant piping is too unlikely to occur.

With better knowledge of the materials behaviour and ISI results from a number of installations indicating ageing effects important to integrity, the secondary failure as a consequence of a rupture of one of the secondary main steam or feedwater lines outside the containment became subject of extensive investigations. The widely accepted practice to provide for physical protection of endangered components, structures and equipment introduced against common cause failure was not applied at the Temelín plant. Instead, an extensive program was started to demonstrate sustainable integrity of the secondary HEL in the first place and limitations to the consequential failures of HELs also.

To focus preparatory work of the Austrian Experts' 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). They were based on the Defense-in-Depth principle applied to qualify Temelín NPP's safety features consistency.

In a **second step** the Austrian Experts' 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 G of the FMR for Item1).

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

The principles of HELB analyses requirements and the related work conducted within the Comprehensive Safety Case Revisit, the implementation at the plant including known modifications compared to former WWER-1000 related HEL programmes, the compliance and differences with the state of science and technology and currently accepted practices as identified were described and commented in the Briefing Material with respect to their safety significance.

At the Specialists' 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.

The Workshop in Prague 2002 concentrated on the performance of the HELB analyses and HEL related operational precautions. Other topics related to HELB were not treated in detail at the Workshop, such as, multiple line failures, line penetration failures, the 28,8 m level support structure load bearing, HELB consequences to the primary coolant system and core cooling as well as reactivity control.

Within the limitations spelled out above, questions from the Austrian Experts' Team were mostly answered during the workshop.

Following the Specialists´ Workshop in this **fourth step (PM4)**, the Austrian Experts' Team reviewed the Specialists' Workshop presentations and the Austrian Experts' Team members provided contributions to the later issued **Preliminary Monitoring Report (PMR)**. Based on information available at the time, the Austrian Experts' Team had characterised several results in the PMR.

The evaluations in the PMR addressed four different levels of the process by commenting:

- on the adequacy of the information available from the presentations in view of the monitoring task and
- on the adequacy of the technical approach as such
- on the state of science and technology in Western Europe and its compliance with the situation identified at Temelín NPP
- on issues directed towards a resolution of the safety issue addressed and on its interrelation to the items of projects PN3: "Qualification of Valves" and PN4 "Qualification of Safety Classified Components."

As one of the results of the PMR the Austrian Experts' Team performed analyses for three issues identified as open in order, to assess the Czech statements related to those issues for this Final Monitoring Report (FMR).

These issues are:

- Recriticality of the reactor initiated by a HELB,
- Design loads for the HELs at the 28,8 m level and
- The material database.

The PMR focused on the application of the French Tronçons Protégés concept in the HEL case. The concept standard application requires short, weld-free pipe segments. The Temelín break exclusion application however comprises lengthy pipes with many welds. Further considerations should 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 break exclusion demonstration acceptance only in addition to physical separation (e.g. with each steam-line or feedwater-line in its own compartment or with spatial separation up to the main isolation valves).

During the presentation at the Specialists' Workshop the Czech side reported the results of their evaluation on a separation wall splitting the +28,8 m 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 Austrian Experts' Team stated already in the PMR, that it would be interested in receiving information about the bases on which the Regulatory Authority accepted this unique approach for the break exclusion. 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 and 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 Specialists´ 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 Austrian Experts' Team was told at the Specialists´ Workshop that neither of these treatments has been performed for welds in the break exclusion area at Temelín until now. Therefore consideration should be given 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 available samples, yet 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 Specialists´ Workshop, the full functionality of the pipe whip restraints cannot be considered demonstrated up to now. This concerns in particular the weldment of the collar ring to the containment penetration.
- This is mainly because those events, which have been presented as initiators considered for **loads to the pipelines** 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 up to now.
- 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.

In the PMR the Austrian Experts' Team had grouped already its major findings, in view of the indicated progress regarding the plants safety and the information, expected from other, future Roadmap Workshops to complete the view obtained from the Comprehensive Safety Case Revisit.

In a **fifth step (PM5)** the Austrian side presented a **summary of the HELB issue monitoring** and the related main findings at the Bilateral Meeting on December 18, 2003. The discussion provided no new facts at this stage.

At the Bilateral Meeting November 28 and 29, 2004 two short lists of questions were delivered to the Czech partners resulting in valuable information to the Austrian Experts´ Team additional analyses which were finished in December 2004.

The **sixth and final step (PM6)** in the monitoring process of PN2 'High Energy Line Breaks' was to set up the **Final Monitoring Report (FMR), which is presented herewith**.

As suggested by the Austrian Experts' Team the Technical Project Management ordered additional analyses for the FMR (PM6) related to the three selected topics addressed above in context of the PMR issues list. For these three issues additional substantial work has been performed in the frame of PM6 to support the final assessments. The three issues are:

(1) 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 and the suspected recriticality of the reactor,

(2) **Design loads for the HELs at the 28,8 m level** according to European practice (e.g. water hammer caused) compared with design seismic loads applied declared bounding by the Czech side

(3) **Qualification of the material properties data for the database** to be used in the break exclusion attempt, the HEL design verification and operational wear and ageing evaluation.

The main findings of these additional Austrian Experts' analyses are denoted in Chapter 2.1.4.

Since the results and the recent additional information presented by the Czech side were valuable but not sufficient to clarify these three issues, (1., 2. and 3.), it is recommended to follow also these issues beyond the end of the current Monitoring Process.

2.1.4 Summary of Main findings

The evaluation of the presentations held at the Specialists´ Workshop by Czech experts is discussed in the FMR in relation to the international practice and the Czech requirements including the legal framework.

The results of the bounding case calculations performed in support of the monitoring effort are respected implicitly in the argumentation. [ANNEX F of the specific Final Monitoring Report]

All additional information collected during the work on the other Items, which have lasted from 2002 until late 2004, after the Bilateral Meeting on November 29 /30, 2004, has been duly taken into consideration, when transforming the original Preliminary Monitoring Report (created and issued as the result of PM4 in early 2003) into this Final Monitoring Report.

2.1.4.1 Findings about the CSCR

About the interaction of the operator, the manufacturer, the technical support organisations and the licensing authority with respect to HELBs solution implementation:

The presentations and comments during the Specialists´ Workshop suggest that the determination of requirements and the subsequent compliance verification should play the dominant role in the living safety culture for the realisation of the Defense-in-Depth concept established.

2.1.4.2 Findings about the 28,8 m Level

The Monitoring regarding the HELBs technology evaluation adhered to the 18 defined Verifiable Line Items (see Chapter 4 of the FMR for Item 1) presented below, each followed by the monitoring result compiled from the findings:

- **With respect to the 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)

  For the Comprehensive Safety Case Review: the logic of the design criteria, the design process and conclusive statements of compliance were discussed only in brief in the Czech experts' presentations at the Specialists´ Workshop. Similarly, the introduced so-called "Superpipe Concept" was not demonstrated embedded into the original design criteria, without evidence of code compatibility examination for the various codes, standards, rules and regulations.

  An integrated approach of prevention, protection, qualification and mitigation measures was followed only partially, thus deviating in part from the Defense-in-Depth concept.

  Justification for excluding large portions of the HEL piping from the "Superpipe Concept" re-qualification was also not included in the presentations.

  Accessibility of related documentation to fill in gaps in the presentations would be a substantial asset.

- **Regarding the criteria used to select pipe break locations and orientations:**

  Only some indications were received on how pipe break locations candidates were selected and on how the breaks' orientations have been accepted or eliminated.

- **Regarding the postulated "aggressive" HELB points assumed in the analysis:**

  From the provided information "aggressive" HELB points identification of the subsequently postulated, and analysed breaks up to possible consequences could not be followed. 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 field determination. Consequential failure induced effects would provide also information about the investigated occurrences severity. Issues of this kind would deserve more in-depth attention.

- Results of explorative work by experts of the Austrian Experts´ Team for a generic WWER 1000 set-up for the Design Loads for the HELs at the 28,8 m Level:

  Experts of the Austrian Experts' Team performed calculations according to state of science and technology. The results indicate that the extent to which "aggressive" HELB points were identified and considered for the Temelín NPP in the design review fell short at least with regard to the so-called Bubliks.

- **With respect to pipe internal dynamic fluid forces effects as a consequence of the postulated HELB (including geometry effects and blowdown characteristics):**

  Water Hammer load cases, supposed to be examined for both, the steam lines and the water lines and for various operational and accident transient conditions would have to be performed. Evidence that the Operation Base Earthquake loading consequences would be bounding to all other dynamic loadings fell short in the demonstration.

  - Results of explorative work by experts of the Austrian Experts´ Team for a generic WWER 1000 set-up for the Design Loads for the HELs at the 28,8 m Level:

    The results indicate that design loads for the HELs at Temelín NPP appear not to be enveloped by the seismic loads, an assumption made and confirmed by the Czech side.

  Investigations of dynamic loads are also indicated in all cases of operational loads when combined with degraded piping components.

- **The non-linear mechanical analysis to determine the whipping pipes dynamic response indicated:**

  Non-linear mechanical analyses were phased out due to the restrictions applied to the assumed break locations. Jet forces and reaction forces on the pipe whip restraints were briefly presented at the Specialists' Workshop

  - Results of explorative work by experts of the Austrian Experts´ Team Team for a generic WWER 1000 set-up for the Design Loads for the HELs at the 28,8 m Level:

    The results indicate that design loads for the HELs resulting from jet forces and reaction forces considered together with the dynamic response of whipping pipes require non-linear mechanical analyses.

- **About 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. Simulation results used for the preliminary design of a separation wall were not made available.

- **With respect to 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 Defense-in-Depth concept's 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 Austrian Experts' Team.

- **In the context of methodology and analyses of compartment pressurisation and environmental conditions following a postulated HELB:**

  The environmental conditions specification is a prerequisite for project PN4 "Qualification of Safety Classified Components". Specific Information made available can be found in the related FMR.

On the context of 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 Defense-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.

- **In treating 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 Defense-in-Depth concept's application; information about such provisions was not presented. Nothing was reported on this subject. The seismicity issue was treated in project PN6."Site Seismicity".

  The Austrian Experts' Team, when monitoring the actual status of the "Bubliks" sections evaluation for compliance with Defense-in-Depth requirements in the Specialists´ Workshop follow-up, had to find out that a conclusive solution to the water hammer loading has not been presented. The Czech Technical Support organization has indicated in a statement provided recently, that analyses to this open issue has been started already and is supposed to be conducted during 2005.

  To some extent, pipe whip consequential damage has been analyzed evidently by the Czech experts. At the Specialists' Workshop, the assumptions about the pipes' supporting structure, and in particular of the pipe supports intended to limit the movement of broken pipes, have been only mentioned qualitatively.

  - Results of explorative work by experts of the Austrian Experts´ Team for a generic WWER 1000 setup has lead to questions about the applicability of the results presented for Temelin to describe rupture events and pipe whip, that could damage the adjacent wall and impair the integrity of the HELs at the 28,8 m level.

- **As regards 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 the 28,8 m steel girder support and concrete structures to protect safety related equipment from indirect damage is part of the Defense-in-Depth concept application. Results to this need were not presented.

  - Results of explorative work by experts of the Austrian Experts´ Team for a generic WWER 1000 setup for the Design Loads for the HELs at the 28,8 m Level:

    Steam or feedwater line pipe whip in the vertical section after the 28,8 m level might endanger not only the adjacent turbine hall wall and the HELs in this area but also the HELs at the 28,8 m level in case the fix point near by at the turbine hall wall is not capable to take the resulting loads.

- **With respect to the structural failures, environmental conditions and potential flooding that might result in loss of safety functions and habitability of the main control room:**

  The provisions made to preserve vital safety functions as well as safety equipment, part of the Defense-in-Depth concept application, have not been presented.

- **Treating the aspect of adequacy of the safety class components environmental qualification, – candidate equipment selection:**

  The aspect addressed was generally part of the project PN4 "Qualification of Safety Classified Components". However no specific listing became available of candidate components at the 28,8 m level requiring environmental qualification.

- **Regarding 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 Defense-in-Depth concept application were presented as overview information.

  - Results of explorative work by experts of the Austrian Experts´ Team for a generic WWER 1000 set-up lead to question, whether in case of a stuck rod scenario connected with a MSLB the Temelín NSSS remains in a controlled non-critical condition.

  The monitoring related to the Pressurised Thermal Shock vulnerability has taken place in the context of project PN9."Reactor Pressure Vessel Integrity and Pressurised Thermal Shock".

- **With respect to 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 Defense-in-Depth concept application were presented as an overview information. This is also the context for events related to project PN9."Reactor Pressure Vessel Integrity and Pressurised Thermal Shock".

  - Results of explorative work by experts of the Austrian Team for a generic WWER 1000 set-up lead to questions about the behaviour of the Primary Coolant System and the Reactor Core:

    In a pilot study by experts of the Austrian Experts' Team the behaviour of the reactor core after a multiple lines break of the main steam piping has been analysed. According to the results, a WWER 1000 reactor like Temelín is likely to become critical after the scram with the most effective rod stuck in top position after a multiple steam line break.

    The results from calculations accomplished show that the effectiveness of the scram system is reduced by 20% if the most effective CRA is stuck in top position. The relative power contribution of individual assemblies in the surroundings of the stuck CRA is by a factor of two to three orders of magnitude higher when comparing it with the assemblies from the diametric opposite region of the core. Results for the end of the first cycle show that reactor will be critical again if the temperature drops below 200 to 197 °C.

  Based on these results the Austrian Experts´ Team concludes that re-criticality in case of a stuck rod scenario connected with a MSLB remains still an open question, very important for clarification. For answers to be fully satisfying the required comprehensive analyses would have to be performed.

  Fuel Elements' Integrity in relation to bounding accident sequences was not discussed quantitatively, but in some instances qualitatively.

- **With regard to the adequacy of in-service inspections programs of MS & MFW piping outside containment:**

  In Service Inspection was addressed in the context of periodic wall thickness history evaluation and Non-destructive Testing and Evaluation procedures implementation descriptions. The need was identified for more detailed description of the procedures as set up and implementation as well as of quality assurance.

  The general introduction into NDE practice at the TSO in Řež provided valuable indications about this topic.

- **In identifying the event frequency evaluation of HELB and of consequential failures:**

  Break exclusion applicability demonstration for very extended High-Energy Pipe ducts was accomplished with assuming the low leak and break frequency estimates supplied in the Specialists´ Workshop presentations, which do not relate well to European and worldwide industry experience and are therefore questioned.

- **Regarding requirements for the materials used and material properties degradation to be taken into account:**
  - Results of explorative work by experts of the Austrian Team for Materials Databases used as the basis for NPP's component materials and manufacturing specifications::

    The Austrian Experts´ Team performed a review of the information available about the material database used to support the evaluation regarding the Superpipe Concept applied by the Czech side for the HELs integrity verification at the 28,8 m level. The outcome of this review gives reason in several contexts to raise doubts whether the material database is adequately consolidated for break exclusion confirmation of the HELs at the 28,8 m level.

  The Materials Database development and materials properties definition process leads to the identification of several areas for clarification: the selection procedures of "comparable" material for test specimen manufacturing allowed no conclusion. The material properties used for qualification of the stress analysis results and the requirements imposed by the codes, standards, rules and regulations defined to be applicable could not be seen as in line.

  The materials properties requirements for the two pipe materials used could not be interrelated, as applicable for the "Superpipe Concept's" break exclusion re-qualification. The materials properties requirements defined for the High-Energy Lines at the design stage do not correspond with the properties of the material "in place". Therefore the acceptance criteria for the appropriate material properties would be of interest and the compliance demonstration documentation as well.

  Furthermore, the material properties as defined at the design stage of the HEL could not be related to the material properties of the pipe sections installed.

2.1.4.3 SÚJB position

The SÚJB has acknowledged, accepted and approved the ETE approach for the 28,8 m-level HEL integrity demonstration and the associated accident scenario evaluation, including the consequential failure arguments, in particular also those conclusions drawn as a consequence of the Comprehensive Safety Case Revisit. The SÚJB has not asked for additional proof and did not impose additional requirements, besides a discussion of the ISI frequency that has not been closed yet.

2.1.5 Conclusions

The global approach as indicated in the presentations at the Specialists' Workshop provided for the following conclusions, which have been determined by the Austrian Experts' Team:

Since the identification of the HELBs issue several years ago, improvements are addressed in a comprehensive manner. The actions taken range from detailed examinations up to the measures implemented in the context of the "Comprehensive Safety Case Revisit" demonstrate a comprehensive process directed towards improvement. When considering the concerns expressed in the Austrian Technical Position Paper [ATPP 2001, see Reference List of the FMR for Item 1], the comparison with the current state also indicates a number of areas where improvements have been achieved and implemented.

The Austrian Experts' Team denotes, that it did not find reason to follow the views and expectations, expressed as a result of the Comprehensive Safety Case Revisit, upheld by the Czech side on the applicability of the break exclusion concept.

In this respect the following consolidated results were determined:

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

  The comprehensive specification of the materials properties – as used and applied for the stress analyses results acceptance, for the break exclusion verification and for crack propagation to break at the pipe whip restraints' locations – should be an issue of in-depth exchange of information and expert discussion. The databases used for the materials properties' definition and the standards, rules and regulations applicable for defining the materials properties should be included therewith.

  Checking should be focused on the way material characteristics according to mandatory standards, rules and regulations are used and what is the significance of such characteristics in the licensing of components and assembled sections.

  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.

- **With regard to the break exclusion concept verification:**

  The results of probabilistic analyses should also be an issue of in-depth exchange of information and expert discussion. 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 discussed.

  With regard to the special piping arrangement at the 28,8 m level concrete breaks' incidence rate assumptions are usually applied and certain In-Service-Inspection procedures are introduced. Comparisons for both issues with general industrial practice should be performed.

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

- **With regard to the break consequences:**

  The loads resulting from water hammer effects can be compared with regard to nature and consequences only in a limited way with earthquake loads as estimated.

  Due to water hammer, the pipes may experience loads significantly higher than those acting on them as a consequence of the earthquake specified.

  The pipe whip after rupture of the vertical section of a HEL must be assumed to act on the HEL at the 28,8 m level in such a way, that the pipe whip loading to the turbine hall wall is likely to have an effect on the HELs integrity at the 28,8 m level also, let alone secondary effects on the piping there.

- **With regard to accident consequences:**

  Exemplary severe High Energy Line Breaks' accident scenarios should be investigated with the following key elements: High Energy Line Break with the reactor at full power and control rods remaining stuck in top position, inhibiting a successful shut-down.
  The treatment should focus on the extent, to which accidents with consequences to the reactor core could evolve into events where releases of radioactive effluents are likely to take place.

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

2.1.6 28,8 m Level Issues for future information exhange and expert discussions

The Austrian Experts' Team recommends pursuing further the issue of HELB as a major priority in the framework of the pertinent bilateral Agreement between the Federal Republic of Austria and the Czech Republic. This recommendation concerns the implementation and results from the HEL In-Service-Inspection programs as well as revisiting the major findings enumerated above. It is recommeded in particular to continue work on the mitigation of breaks of the HEL.

Items with high priority, where expert discussions based on additional and new information would be most valuable, are:

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

   Identification of the procedures used to determine material properties characterisation and their use in the component acceptance process according to mandatory standards, rules and regulations.

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

   Comparison with industry experience of break frequencies' assumptions specific to the particular arrangement of pipelines, and comparison with industry experience of the In-Service-Inspection adapted to the pipe ducts at the 28,8 m level.

   The state of science and technology in codes and standards as followed in terms of consistency requirements in Western European practice.

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

   Analysis of immediate accident consequences with regard to bounding cases determined for maximum dynamic loadings. Precautionary consequences should be drawn from confirmed bounding conditions only.

   The intermediate accident consequences' analyses should focus on identifying the extent to which consequences to the reactor core, arising from accidents, are likely to evolve into events causing radioactive releases.

   It appears to be essential for both accident aspects to know the magnitudes and the frequencies of related accident scenarios.

2.2 Item No. 2 – Qualification of Valves (AQG/WPNS country specific recommendation)

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2.2.1 Basis and background of the project

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) with the general management of the implementation of the "Roadmap". Each entry to the "Roadmap" corresponds to a specific technical project (see ANNEX IV of the FMR for Item 2). For each project an own international experts team was ordered by the Umweltbundesamt to accomplish the related work. For the project considered the Institute of Risk Rresearch at the University of Vienna and the Austrian Research Center Seibersdorf were selected as leaders of this expert team.

Item No. 2 "Qualification of Valves" of ANNEX I of the "Brussels Agreement" covers the functional qualification for Two-Phase and Water-Flow of the main steam relief (BRU-A) and safety valves (MSSV or SGSV) at the + 28,8 meter level of the intermediate building of the Temelín NPP. The objective regarding this item as stated in ANNEX I of the "Brussels

Agreement" is the "Demonstration of reliable function of key steam safety and relief valves under dynamic load with mixed steam-water flow."

The Specialists' Workshop as specified in "Roadmap" was held in Prague in the 2nd half of 2002 to discuss this issue.

2.2.2 The approach by the Czech Side

The key element in the monitoring process was a joint Specialists' Workshop on the "Roadmap" item No. 1 "HELB" and "Roadmap" item No. 2 "Qualification of Valves" (PN3) conducted in Prague on 7 and 8 November 2002 in the framework of an additional specialist meeting according to Article 7 (4) of the Pertinent 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 in essence the basis for the present Final Monitoring Report of the Austrian Experts' Team.

The main steam relief and safety valves functional qualification was addressed by the Czech Technical Support Organisation and the Regulatory Authority SÚJB at the Specialists' Workshop and in the framework of the information provided during the pipe integrity related presentations (see project PN2) within the broad scope of the "Comprehensive Safety Case Revisit" (CSCR). The Regulatory Authority SÚJB has for the time being accepted the results of the valves functional qualification preliminarily. With some equipment replacements and based on "new qualification files", the results of the CSCR are accepted as confirming and endorsing the original decisions of the regulatory authority.

Information about the following main areas was presented by the Czech TSO and the Regulator and discussed at the Specialists' Workshop:

- Parent Valves: BRU-A and MSSV Functional Qualification for Water and Steam-Water Mixture
- Extension of the Functional Qualification of Parent Valves to Temelín Candidate BRU-A and MSS Valves applying ASME-QME-1-1994, QVC valves-similarity approach
- Environmental Qualification of BRU-A Actuator
- Replacement of MSSV Pilot Valves and of Electric Motor Drives of BRU-A Valves

The approach ČEZ a.s. as operator of Temelín has taken to resolve the safety issue "Qualification of main steam relief and safety valves" (as approved by SÚJB) is the application of the ASME Code procedure ASME QME-1-1994, QVC. This procedure is based on the similarity of functionally tested "parent" valves and the "candidate" valves. According to this procedure those valves used in the Temelín NPP are to be considered as "candidate" valves. Their functional qualification was intended to be achieved by extension of the qualification procedure of similar "parent" valves to the "candidate" valves of Temelín. These "parent" valves should have already passed a functional qualification test successfully and should have been designed by the same Company. SÚJB has accepted this specific approach taken by ČEZ a.s and its TSO as an application of the ASME Code procedure mentioned above, used for the qualification for water and two-phase flow (steam and water at the same time).

The descriptions at the workshop did provide information about the approach taken. However, due to the overview type presentation only limited insight into the results and how these were obtained was possible. Several questions remained open. As a consequence, 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.

2.2.3 The approach of the Austrian Specialists' Team

An Austrian Experts' Team of five international experts was committed by the Umweltbundesamt (Federal Environmental Agency) on behalf of the Austrian Government to give technical support for the monitoring on the technical level of the implementation of the Valves Issue as listed in ANNEX I of the Conclusions of the Melk Process and Follow-up. This specific technical project is referred as project PN3 comprising altogether seven predefined "project milestones" (PM).

In a **first step** (Project Milestone 1 – PM1), the safety objective was broken down to Verifiable Line Items (VLIs), in order to focus preparatory work of the Austrian Experts' 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 (see ANNEX A of the FMR for Item 2). The VLIs were based already on the ASME similarity concept[7], because the Czech approach was principally known from preceding discourses.

In a **second step** (PM2) the Austrian Experts' 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 C of the FMR for Item 2).

The **third step** in the preparatory work for the Workshop also included identification of Standards and practices applied for the Valves' issue within the European Union Member States. A special focus was the practice in Germany, since it has devoted considerable resources to analyse valves' behaviour. In the Briefing to the Austrian Delegation (PM3) these elements of the monitoring were presented to the mission participants.

At the Specialists' Workshop on HELB and Qualification of Valves 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, one of which was particularly devoted to the Qualification of Valves PN3 issue, characterised by one Czech presenter as being of overview nature. Within the limitations spelled out above most questions by the Austrian Specialists' Team were answered during the Specialists' Workshop.

Following the Workshop in the **fourth step** (PM4), the Austrian Experts' Team reviewed the Specialists' Workshop and the Team members provided contributions to the Preliminary Monitoring Report (PMR).

The contributions of the Austrian Experts' Team members have been merged by the Technical Project Management to provide the technical basis for the Preliminary Monitoring Report (PMR, project milestone PM4). This technical basis was reviewed and commonly agreed in an internal workshop of the Austrian Specialists' Team held on 8 to 9 December 2002 in Vienna.

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

- on the adequacy of the information available from the presentations in view of the monitoring task and
- on the adequacy of the technical approach as such
- on issues directed towards a resolution of the safety issue addressed and on its interrelation to the items of projects PN2: "High Energy Pipe Lines at the 28,8 m Level" and PN4: "Qualification of Safety Classified Components" .

[7] If at least two valves of different dimensions but of the same family (valves having the same configuration) are functionally qualified by physical testing, then another valve of a family deduced from the parent family, but in principle of identical configuration can also be assumed to be functionally qualified under specific requirements without the physical testing prescribed.

In a **fifth step** the Austrian side presented to the Czech side a summary of the valves´ issue monitoring and the related main findings at the Bilateral Meeting on December 18, 2003. The discussion with the Czech partner resulted in no new information.

The **sixth step** in the monitoring process of PN3 "Valves´Qualification" was to set up the Final Monitoring Report (FMR), which is presented herewith.

2.2.4 Monitoring Process Results

The Monitoring process so far helped to clarify a number of VLIs. Based on the information currently available, the Austrian Experts' Team formulates its view on the Status of functional qualification of main steam safety and relief valves in the following way:

Since the identification of the Valves 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 (ATTP) the comparison with the current status also indicates a number of areas of improvement.

The Czech presentation and the discussion indicated several positive activities within the frame of the Comprehensive Safety Case Revisit (CSCR); these appear to increase functional reliability of the main steam relief valves (BRU-A) and of Safety Valves (MSSV) in general. They relate to the replacement of electrical actuators of the BRU-A valves and of pilot valves of the MSSVs on both units.

The Czech operator's and TSO's approach to functionally qualify the main steam and relief valves for two-phase and water flow applying the ASME-QME-1994 similarity approach appears feasible only in case the related requirements are followed. Should compliance with requirements only be possible for specific steps in the qualification procedure, then situations of non-compliance should be compensated by performing well developed, adequate state of the art analyses, as e.g. in Germany.

Up to now, however, ASME-QME-1994 qualification requirements have only partly been met. Adequate analyses for compensation according the state of the art have not been demonstrated as having been performed.

In the opinion of the Austrian Experts' Team the Czech approach is therefore not yet sufficient to demonstrate that the main steam relief and safety valves are qualified for the dynamics of two-phase flow and pressurised sub-cooled water flow conditions. The basis on which the Regulatory Authority has accepted the above solutions did not become evident to the Austrian Experts' Team.

The Austrian Experts' Team therefore recommends the completion of the functional qualification of the main steam safety and relief valves by tests and by comprehensive analyses.

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 Austrian Experts' Team would appreciate if the above major findings could be revisited in a further bilateral information exchange related to the Qualification of Valves.

Note that the assessment of technical adequacy is closely related to a number of other "Roadmap" items. Consequently, the final evaluation at the now ending Monitoring process on the technical level of the Item No. 2 "Qualification of Valves", as set out in the Roadmap, has taken into account also the results of other Roadmap events as well as additional information which was made available by the Czech side.

2.3 Item No. 3 – Reactor Pressure Vessel Integrity and Pressurised Thermal Shock

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2.3.1 Basis and the background for the project

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"*).

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

The Roadmap project treated here is focused on the exchange of information related to:

Item No.3: Reactor Pressure Vessel Integrity and Pressurised Thermal Shock (Workshop scheduled for the first half of the year 2004): *"This topical meeting will serve to address the status of the PTS (Pressurized Thermal Shock) analysis."*

The objective of the Roadmap process covered by this Roadmap Item as stated in ANNEX I of the “Brussels Agreement” is:

“The reactor pressure vessel (RPV) integrity under pressurized thermal shock (PTS) conditions shall be maintained with sufficient safety margin against brittle fracture throughout the NPPs service life.”

In addition ANNEX I provides the following statements regarding the “present status and specific actions planned”:

“The NPP Temelín is commissioned and operated respecting pressure-thermal (PT) curves calculations developed according to Westinghouse methodology. These calculations will be expanded with set of further PTS analysis for both units using a step-by-step approach with full respect of the IAEA Guidelines for the PTS analysis. The PTS analysis will be finished in accordance with approved project work plan for this item.”

On behalf of the Austrian Government the Umweltbundesamt (Federal Environment Agency) committed an Experts' Team composed of international experts to provide technical support for the monitoring of the implementation on the technical level of the RPVI – PTS 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 PN9 comprising altogether seven predefined “project milestones” (PMs).

A Specialists' Workshop on the Roadmap Item No. 3 “Reactor Pressure Vessel Integrity and Pressurised Thermal Shock“ was conducted in Prague on May 24 and 25, 2004 according to Article 7 (4) of the Bilateral Agreement of the Exchange of Information on Nuclear Safety. The workshop information was supplemented later, on October 7, 2004, by presentations given at Řež, which provided additional detailed information and answers to questions. These workshops were key elements in the monitoring process. The analysis by the experts and the team of information made available during the workshops played a significant role in the development of the Final Monitoring Report prepared by the Austrian Experts' Team.

The technical support for the monitoring on the technical level of the implementation of the “Conclusions of the Melk Process and Follow-up” regarding the item Reactor Pressure Vessel Integrity and Pressurised Thermal Shock Issues was aimed at focussing on the evaluation of how the Czech Side (operator and regulatory body) has dealt and will deal with the issue in a methodological way for implementation. In particular, it was intended to focus on the implementation of surveillance programmes and comprehensive PTS analysis, all to be checked against the background of requirements and practices widely applied within the EU and of new developments in WWER-reactor specific knowledge, both on the technical and regulatory level.

2.3.2 The approach and objectives of the PN9 project

The Temelín NPP, originally of Soviet design, and later upgraded to include elements of western safety concepts and western equipment, has addressed PTS and RPV integrity late in the construction phase. Russian and Western Codes request a pre-service PTSA. During the Experts' meetings in the frame of the Melk process it appeared that the process of PTS prevention implementation at Temelín was late and still not complete. The availability of information on the details of the approach adopted at the Temelín NPP was insufficient. Therefore, PTS remained one of the items to be addressed during the follow up to the Melk process. This established the basis and defined the scope of the proposed project.

The NPP Temelín has to be considered as a very specific case: Design and construction were performed in the former Soviet Union, the manufacture occurred at least partially in the former Czechoslovakia under Russian supervision. After the political re-organisation of Eastern Europe the construction was completed including Western technology from Westinghouse under the responsibility of the plant owner. Licensing happened within the legal frame of the Czech Republic.

The project PN9 „Reactor Pressure vessel (RPV) Integrity and Pressurised Thermal Shock (PTS)“ deals with the topic of RPV damage especially as a consequence of a possible thermal shock transient. In the case of most critical transients, the primary circuit is under high pressure. This is one of the main concerns within the reactor safety analysis, since the RPV pressure retention and radioactive inventory retention functions are of non-redundant nature by design. A rupture of this component would therefore induce a catastrophic accident.

Consideration of RPV integrity (RPVI) as well as the exclusion of the PTS (pressurized thermal shock) at the Temelín NPP (nuclear power plant) is an essential ingredient of its defence in depth approach and therefore of utmost importance to Austria.

PTS events should have very low frequencies, since they may have significant consequences resulting in failure of at least one entire barrier (the primary coolant system envelope). As PTS has not been explicitly considered in the design of many older nuclear power plants, which are currently in operation, considerable efforts have been devoted already by most of those plants to prevent PTS events during plant operation, but also at zero-power, shutdown and during outages. PTS prevention has been recognised as an important safety issue at large and is consequently addressed in a comprehensive and systematic way.

In applying current safety philosophy, the consideration of PTS and RPV-integrity in NPPs usually includes the precautions taken to avoid excessive embrittlement, RPV material degradation and PTS sequences.

The project PN9 is composed of two complementary segments (horizontal and vertical), the horizontal segment depicting an assessment of principles, standards and practices, the vertical segment providing an analysis of PTS bounding cases.

In the light of the broad scope of PN9 not only the effort, but also the result addresses all the disciplines [ANNEX A of the FMR for Item 3] that were covered in the monitoring and at the Workshop as well.

The monitoring process conducted by the Experts' Team was concentrated on the engineering approach taken by CEZ to have the Temelín RPVs licensed by the SÚJB (State Office for Nuclear Safety).

Both segments are related to the collection of information on the Temelín RPV embrittlement behaviour over time, as well as the vessel's material history and usage and its thermal shock vulnerability.

2.3.3 Preparatory and Main tasks accomplished within the PN9 project

The main tasks to be accomplished by the Experts' Team were those in fulfilling the **Project Milestones (PMs)** ordered by the contracting party, the Umweltbundesamt. Several preparatory tasks had to be performed to support and accomplish the main tasks. These preparatory tasks are also addressed here.

For the different tasks within an RPVI assessment the state-of-the-art practice was reviewed for comparison with the findings of the evaluation of the Czech approach. RPVI includes the following steps:

- RPV quality with respect to design, construction/manufacture
- PTS analysis
- Surveillance programme
- NDT programme
- Core modifications
- EOPs

At the time of the NPP Temelín RPV construction the actual knowledge on radiation embrittlement was that copper and phosphorus impurities were causing the problematic irradiation embrittlement behaviour of the WWER RPV steels. Therefore for the WWER-1000 RPVs the steel was purified with respect to copper and phosphorus. In order to reach better hot work manufacturing properties the content of the alloying element nickel was increased. Only years later, it turned out that it might be this high nickel content that introduced a new kind of embrittlement mechanism. Modern RPV material – to be manufactured according to the state-of-the-art – would be steel optimised for minimum radiation embrittlement susceptibility.

It is therefore problematic to compare the Czech procedures concerning RPVI measures with other regulatory requirements that are based on the presumption of optimized materials. The Czech regulatory concept is being developed for existing NPPs that are not constructed and built fulfilling current state-of-the-art requirements. The basic requirement of state-of-the-art RPV integrity, the use of optimised steels (not radiation-sensitive) is not met for the Temelín RPVs.

During former Workshops with Czech Experts in the frame of the Trialogue and the project PN2 (High Energy Pipe Lines at the 28,8 m Level (AQG/WPNS country specific recommendation) [Item No.1]) information has been compiled concerning:

- Operational pressure-temperature limit curves (calculated in accordance with the Westinghouse methodology)
- First attempts of PTS analyses related to the DEGB (double-ended guillotine break) of the main steam line at the 28,8 m level
- Modifications of the WWER-1000 surveillance programmes related to the elimination of the evident deficiencies of these programmes
- Material properties of the RPV steel and weld material at NPP Temelín
- NDE (non-destructive evaluation) qualification approach

Specialists Workshop (PM3)

The preparatory activities for the workshop included the development of briefing material and the briefing for the Austrian delegation. The principles of PTS analysis requirements, surveillance programme implementation including known modifications compared to the former WWER-1000 surveillance programmes, the compliance and differences with the state-of-the-art practices as identified were described and commented with respect to their safety significance.

The Specialists' Workshop scheduled in the frame of the "Conclusions of the Melk Process and follow-up" for the first half of 2004 took place at SÚJB in Prague during May 24th/25th, 2004.

The Specialists' Workshop in Prague 2004 was concentrated on the performance of the PTS analyses and PTS related operational precautions. Other topics related to RPVI were not touched at the Workshop, such as, main coolant recirculation line penetrations, vessel head control rod penetrations, core instrumentation and other service penetrations, main flanges' tightness, and major environmental and other damage mechanisms contributing to the loss of integrity, like main coolant chemistry, hydrogen diffusion, corrosion, load cycling, severe accident behaviour, as well as integrity preservation and surveillance measures ascertaining LBB applicability and leakage detection instrumentation. During the Workshop the Czech side presented a set of 16 presentations, which are reflected in the respective chapters of the FMR.

In addition to the Workshop presentations Czech Experts delivered a second series of presentations on October 7, 2004 in Řež, in order to complement the information provided at the Workshop. The important clarifications provided there and the results of the discussions that followed the presentations have also contributed to this report.

Preparation of the Preliminary Monitoring Report (PMR) (PM4)

It was intended to publish a Preliminary Monitoring Report evaluating the Czech presentations during the Workshop in relation to the international practice and the Czech legal basis. The results of the bounding case calculations performed in support of the monitoring effort should have consolidated already the argumentation in the PMR [ANNEX D of the FMR for Item 3].

Given the tight schedule on the one hand and the need to consider additional information arising from the October Meeting and the Bilateral Meeting 2004 on the other hand, the Federal Ministry of Agriculture, Environment and Water Management finally decided to forgo the PMR.

Bilateral Meeting (PM5)

The 13th Bilateral Meeting under the 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 took place in Dolni Dunajovice, on 29-30 November 2004 On this occasion the preliminary results of the monitoring were presented to the Czech delegation and the replies were discussed.

An overview of the activities that would follow this Bilateral Meeting was given and further information on the issues associated with RPVI and PTS was envisaged to be treated in future Bilateral Meetings.

Final Monitoring Report (FMR) (PM6)

The evaluation of the additional information provided by the Czech Experts and of additional results of pilot studies conducted was incorporated into this Final Monitoring Report.

2.3.4 Main findings

2.3.4.1 Reactor pressure vessel integrity and PTS analyses

From monitoring Reactor Pressure Vessel Integrity issues of the Temelín NPPs as treated in the Czech Republic the Austrian Experts' Team has made the following findings:

A PTS analysis has to be performed according to Code regulations in any country before the start-up as part of the licensing to demonstrate the structural integrity of the RPV throughout the service life.

The NPP Temelín was started without performing a pre-service PTS analysis. The Regulatory Body accepted the operational limiting p-T curves (according to an analysis performed according the methodology of the Westinghouse concept) as preliminary demonstration of RPVI.

The Austrian Experts' Team did not consider the operational pressure-temperature limits (Westinghouse concept) as an appropriate substitute for a PTS analysis; furthermore the performed analysis was based on non-conservative assumptions[8]. It has to be recalled that – the Roadmap states with respect to the RPVI actions to be performed by the Czech side: "…a step by step approach with full respect of the IAEA Guidelines for the PTS analysis".

The Workshop presentation on first results of PTS analyses within the frame of the project PN2 (Conclusions of the Melk Process and Follow-up: Item No.1: High Energy Pipe-Lines at the 28,8 m Level) provided first information on the concept of PTSA being performed for NPP Temelín.

The state-of-the-art RPV integrity requirement to use optimised steels, that are not radiation embrittlement susceptible, is not met for the Temelín RPVs.

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[8] Please refer to the FMR for Item 3 for details and the Austrian Technical Position Paper [ATPP 2001].

Code regulations and state-of-the-art practice

NPP Temelín construction was started with former Soviet support, according to the Soviet design and manufacturing regulations. Even during the late construction phase under former Czechoslovakian and later Czech Republic authorities the Russian Code regulations were the legal regulatory base.

According to SÚJB (Workshop May 2004) the current Czech ruling on RPVI and PTSA is based on:

- Section IV if the Association of Mechanical Engineers of the Czech Republic Code (ASI Standard): Residual lifetime assessment of WWER nuclear power plants components and piping.
- The instructions and recommendations for lifetime assessment of WWER RPV and reactor internals during NPP operation [SUJB 1998]
- IAEA-Guidelines on PTSA for WWER nuclear power plants [IAEA 1997]
- The Czech Experts have been taking the lead in a EU research program called VERLIFE aiming at the development of the so-called VERLIFE methodology as non-mandatory guideline for the demonstration of WWER-RPVI. The VERLIFE methodology was approved by SÚJB in the beginning of May 2004. It should be noted however, that further development of the VERLIFE methodology is still ongoing. The overall concept of the VERLIFE methodology is in principle comparable to Western practices. Nevertheless, comprehensive documentation on the VERLIFE methodology is not available to the Austrian Experts.

The demonstration of reactor pressure vessel integrity can be performed in probabilistic or deterministic manner in principle. The various national requirements do not call for a particular way of demonstration, however many regulatory authorities have adopted the IAEA Guidelines as the basis.

In different National Codes there are requirements for safety factors to be used within the calculations, either within the fracture mechanical calculations (Russian Code) or with respect to the postulated crack sizes (German Code) or requirements related to specified conditions (French Code)[9].

The possibility to take credit of a possible WPS (warm pre-stress) effect reduces the inherent safety margin. This effect is respected as part of the new Russian Code; it was also applied in Germany. Although included in the ASME Code, it was never used in the U.S., and it is not included in the French Code. The IAEA Guidelines (1997) would allow for applying WPS[10].

Although the IAEA Guidelines on PTSA (1997) are part of the Czech licensing and are cited in the “Conclusions of the Melk Process and follow up” as the basis for the PTS analyses to be performed, the VERLIFE methodology has adopted no safety factors in the Stress Intensity Factors calculations (the IAEA Guidelines, however make use of safety factors in comparable cases). Furthermore, the WPS effect is assumed with 90% of the global maximum of the peak stress intensity factor (as compared to 80% of the peak level as defined in the IAEA Guidelines). This is a considerable reduction of conservatism in comparison with the recommendations of the IAEA Guidelines for PTSA.

[9] Please refer to the FMR for Item 3 for details on codes and their application.

[10] IAEA cautions that the application of WPS ”should be carefully considered since it may not be fully applicable in the highly embrittled materials”.

<u>ETE sponsored activities concerning PTS analyses</u>

The PTSA methodology applied by NRI Řež for the NPP Temelín appears to be in accordance with the recommendations of the IAEA Guidelines and the international state-of-the-art using validated computer codes such as the RELAP5/mod.3.2 code for the general thermal-hydraulics, CATHARE and the engineering model based REMIX/NEWMIX codes for the mixing in the downcomer and the temperature fields at the RPV wall, and SYSTUS for the structural/fracture mechanics analyses. For the calculation of the stress intensity factors both, the application of FEM computer codes or engineering knowledge based analytical approaches may be used. The new Russian code has included analytical approaches based on weight functions.

The application of the named codes was approved by SÚJB.

The Experts' Teams' evaluation of the Czech approach as described in the Workshop presentations takes into account also the results of the monitoring bounding case calculations. The resulting conclusions are summarised in V.1.

The demonstration of the RPV integrity is performed in terms of the safety margin between maximum allowable value of the materials critical brittle fracture temperature T_k^a and actual RPV material specific value T_k. The maximum allowable value of critical brittle fracture temperature is derived from the fracture mechanics calculations of the load paths for each postulated defect in combination with every selected accident transient.

The applicability of the WPS effect is still controversial in the international community due to theoretical and experimental uncertainties. The actual RPV material state is described by the fracture toughness curve where T_k is determined by the formula from the Russian Code using the specified embrittlement coefficient. The experimental data from the surveillance programme are supposed to confirm the conservatism of the embrittlement coefficient.

Even the actual situation with transients used for PTS analyses, which do not include all worst-case conditions and neglecting the safety factors the Czech analyses results for the maximum allowable critical temperature of brittleness T_k^a are extremely close to the EOL values of the T_k for WWER-1000 materials. These reactors experience extreme PTS conditions since they can compensate a Double-End Guillotine Break of the main recirculation line with their increased emergency cooling systems injection capabilities of cold water into the downcomer during emergency operation. This emergency cooling has three consequences important for PTS:

1. Reactor pressure vessel wall inner surface layers are cooled down very rapidly to the temperature range 80 ÷ 20 [°C].
2. The high capability of the emergency cooling systems causes cold plumes in the downcomer and steep temperature gradients over the pressure vessel wall thickness.
3. For small and intermediate breaks the fast compensation of the coolant loss by the high flow rate from the emergency cooling systems causes an early and rapid re-pressurisation of the primary circuit, which adds to the thermal shock load.

In case internationally recommended safety factors would be considered in the Stress Intensity Factors (SIF) calculations for Temelín, the critical embrittlement conditions would occur significantly before the projected End of Life (EOL) of the Temelín NPP. These results confirm the unfavourable situation of WWER-1000 RPV also revealed by PTSA results. Since the most critical transients have not yet been analysed, the situation might be even worse.

In general, the omission of safety factors in RPV design becoming accepted practice would result in a significant reduction of safety margins.

2.3.4.2 Temelín activities concerning material embrittlement monitoring (surveillance programme) and material properties

Surveillance programme

In principle, the material degradation due to neutron irradiation can be predicted based on the knowledge of tests on RPV steel specimens performed over the years during development of the specific type of reactors. The results of this broad experimental background have been used for the definition of material requirements in the National Codes. Besides this in practically all countries the material degradation (embrittlement) of the plant specific RPV materials (except for the very first NPPs) is monitored throughout the operational lifetime by executing the so-called surveillance programmes.

Surveillance programmes require representative samples of the vessel material (representative samples are made using oversize cuts of the ring base material and special welds, manufactured using identical base material and weld electrodes, and identical manufacturing conditions as for the RPV). The irradiation capsules for the surveillance samples have to be located in the RPV so that the neutron flux at the sample location is higher than at the vessel wall in the belt region in order to reach an accelerated irradiation that allows prognostic information on the embrittlement behaviour. The so-called "lead factor" is the ratio of the flux at the surveillance sample position relative to the flux the vessel wall is exposed to in the region of the active core.

This procedure provides an accelerated irradiation condition for each specimen set that allows predictive data on the embrittlement with a need to restrict the lead factor to about 2 to avoid distortion due to high dose rate. The capsules are withdrawn after regular time periods for destructive testing of the material specimens.

The original surveillance programmes for WWER-1000 NPP had severe deficiencies and this fact has been confirmed by two TACIS projects:

"In the framework of these projects, the validity and representatively of WWER-1000 surveillance data and other experimental results have been done. But due to the low fluence value and insufficient number of surveillance specimens the accuracy of radiation embrittlement assessment of RPVs was not high. It was also confirmed that the specimen temperature was possibly higher than the vessel wall temperature. In this case the surveillance results for vessel embrittlement assessment may give non-conservative forecast."
[KRYUKOV 2000 – see Reference List of the FMR for Item 3]

The modification of the surveillance program for WWER-1000 implemented at NPP Temelín has eliminated the obvious deficiencies of the original WWER-1000 surveillance programmes, with respect to irradiation temperature, neutron flux and fluence at the sample location. The embrittlement information of the Temelín irradiated samples will therefore provide the first reliable data on WWER RPV material embrittlement.

Temelín RPV material properties

The Czech determination of the critical temperature of brittleness T_k is defined and performed in according to Russian Code regulations, which are quite close to the Western practice. The shift of this temperature caused by neutron embrittlement is also performed and defined according to Russian Code regulations.

According to the information available to the Austrian specialists the (unirradiated materials') initial critical temperature of brittleness T_{k0} is highest for weld no.4 in both units. Although the neutron flux in weld no.4 is about 80% of the neutron flux at weld no.3, the weld material at the location of the weld no.4 has to be considered leading with respect to neutron embrittlement.

The predictive values for neutron embrittlement in the Russian Code are based on experimental test results on the WWER-1000 steel irradiated 15Ch2MNFAA in materials test reactors at high dose rates; no results with low lead factors are yet available. The irradiation experiments performed in the test reactor Řež using original RPV materials of the NPP Temelín unit-1 have also been realized with high lead factors (about 160 or higher).

This means that the possible dose rate effect (higher embrittlement at lower neutron flux compared to high neutron flux for identical fluence) could have affected the results[11].

The first capsule with irradiated ETE-samples has been withdrawn during May 2004; the evaluated data will be available one year thereafter. Until that time the PTS analysis performed is using the potentially non-conservative predictive values of the Russian Code. The VERLIFE methodology used by the operator does not foresee the use of any safety margin covering these uncertainties. The Russian Code and the IAEA Guidelines require a safety margin of ΔT =10 [K] with respect to the uncertainties of critical temperature of brittleness. The U.S. regulations require the use of a safety margin to cover the uncertainties of the experimental method for the determination of the initial RT_{NDT}[12] and the uncertainties of the determination of ΔT_{RTNDT} (15,5 [K] for welds and 9,5 [K]). However, other National Codes do not provide rules for the use of safety margins to consider the uncertainties.

Despite the fact that the surveillance data will be as reliable as required, it has to be stated, that each removal of capsules will contribute with only one single value to the embrittlement versus fluence (operation time) behaviour representation. Evidence is there, that this surveillance programme during service life cannot establish the statistical basis required for reliable prediction of the embrittlement behaviour. Since many publications indicate that the values of embrittlement for WWER-material specifications as defined in the Russian Code might be non-conservative, these uncertainties should be considered in the discussion of the safety margins against brittle fracture of the RPV material in case of PTS events.

Fracture toughness curve for PTSA

The assessment of the structural integrity or the residual lifetime of an RPV by a PTS analysis includes the comparison of the calculated load path in case of a PTS transient and the actual material state of the RPV steel which degrades mainly due to neutron embrittlement. This material state is described by the fracture toughness as a function of temperature $K_{Ic}(T-T_k)$.

The formula defined within the VERLIFE methodology can be considered to be the most conservative when compared to the Russian Code and the ASME Code[13] (which is identical to the French and the German Code). It should be noted that the formula is equivalent to the fracture toughness curve recommended in the IAEA Guidelines.

However, the static fracture toughness data shown during the Specialists' Workshop in Prague 2004 did not demonstrate that the used fracture toughness curve could be considered to be conservative for irradiated WWER-440 materials. There is also no evidence that the static fracture toughness data from WWER-1000 materials will be described conservatively by the used fracture toughness curve – sort of a master-curve.

[11] A question of the Austrian Experts during the Workshop 2004 on the possible influence of the dose rate effect was answered in the sense that this effect cannot be excluded and will be studied in future research programmes.

[12] Reference temperature for the ductile brittle transition temperature in the Western terminology is comparable to the critical temperature of brittleness in the Russian Code.

[13] Below about 70 [MPa√m] the ASME curve is slightly more conservative.

2.3.4.3 NDT (Non-Destructive Testing) programme

Nuclear reactor pressure vessels are submitted at regular intervals to in-service inspections (ISI) in order to detect and monitor flaws. Since detection methods are improving it is possible to detect fabrication flaws only during in-service inspection, – it is also possible that flaws grow during service reaching a detectable size.

NDT programs have to be qualified using specific test samples that are representative for the components to be inspected.

The qualification procedure at the test sample KB 190 for the RPV-wall inspection at Temelín NPP has obviously only been finalized very recently. This indicates that qualified inspection results available up to now are based only on a limited number of wall inspections that conform to the qualified and accepted procedure.

It is not clear whether a complete zero-NDT map exists. The comparability of any available inspection results with the qualified methods has not been demonstrated yet.

This issue of NDT will be treated in detail in project PN10: Integrity of Primary Loop Components – Non Destructive Testing (NDT) [Item No. 4][14].

2.3.4.4 Core design – fluence management

Fluence estimates calculated at the RPV wall are very sensitive to the calculation procedures. Because of high neutron fluence attenuation between the core and the RPV wall in the core region the calculated RPV fluence is also strongly sensitive to the physical model of the core and RPV internals as well as to the mathematical model for the neutron transport calculations. The accurate determination of the RPV fluence is difficult and comparisons of measured and calculated data show a varying degree of agreement for different WWER designs and different core loading schemes.

In ETE Westinghouse implemented a new core concept replacing the original concept of the Russian designer. It is not known to what extent this concept has been validated. Since it is a sort of prototype assembly – until the construction of ETE there has been no essential core modification with respect to the original Russian design – one should assume that there was an extensive validation process.

2.3.4.5 EOPs

During the Specialists' Workshop in Prague, a presentation was provided on how the Temelín Emergency Operating Procedures (EOPs) address PTS conditions. The state-of-the-art in procedural aspects of pressurized thermal shock (PTS) is to have symptom-based Emergency Operating Procedures (EOPs) in place to identify and manage potential PTS conditions and bring the plant to safe shutdown without reactor coolant system pressure boundary failure, with adequate core cooling at the same time. Should conditions occur nonetheless which give rise to core damage, Severe Accident Management Guidelines (SAMGs) are required to be available to limit core damage and mitigate the consequences of such a core damage. Symptom-based EOPs, the result of a joint CEZ-Westinghouse project, were implemented at Temelín in 1998. Similarly, SAMGs are in the stage of implementation to be completed by the end of 2004. ČEZ has adopted a standard and well-recognized procedural approach to managing PTS events in implementing Westinghouse EOPs and SAMGs.

This issue has been treated in detail within the project PN7 Severe Accidents Related Issues – [Item No. 7b][14].

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[14] The Items are related to Annex I of the "Conclusions of the Melk Process and Follow-up".

2.3.4.6 Training programmes – QA programmes

Implementation of an extended program like RPVI assurance, including the VERLIFE concept, involves many disciplines and TSOs. Therefore extended collateral programs have to be set up for training and quality assurance before and during the time period the program is enacted – in this case the operational life of the plant.

The information about the personnel training program related to PTS events provides for a satisfactory picture. The activities correspond with comparable European situations.

The information concerning the QA program was about some general information concerning QA procedures and acceptance criteria imposed by SÚJB for computational analyses applied at NRI.

2.3.4.7 SÚJB position

Expectations about the involvement of SÚJB were largely clarified during the Workshop. The substance of the decisions bases for e.g. adopting the VERLIFE methodology has not been discussed. The schedule for implementation of PTS related RPVI measures was also not discussed.

At the Specialists` Workshop all the topics of interest were addressed in a general manner and specific information was obtained regarding certain questions. The Experts' Team received insight into the essential topic of external support and independence, which is also addressed in the NRA fundamentals.

The IAEA IRRT Mission to the Czech Republic [IRRT 2000, paragraph 1.7.1] recommended, inter alii, to address external and independent expertise. It stated that SÚJB's personnel capacity and possibilities should be increased by all means appropriate.

Generally and specifically this should be the case with respect to the RPVI and PTS issues at the Temelín NPP in a sufficient and efficient manner.

2.3.5 Conclusions

The demonstration of RPVI (reactor pressure vessel integrity) throughout service life is performed by the Czech Experts, for Temelín NPP, using the VERLIFE methodology. From a comparison to the Russian Code and the IAEA Guidelines, the Austrian Experts' Team has found that the VERLIFE methodology, as applied to the Temelín RPVs, makes use of reduced safety margins (i.e. reduction of the postulated crack size, elimination/reduction of safety factors, non-conservative assumptions for the fracture mechanics analyses). In combination with other uncertainties concerning material/embrittlement properties and apparent reductions of conservatisms in several respects, the Austrian Experts' Team considers the resulting global safety margin for the Temelín RPVs as not being sufficient.

The complete VERLIFE methodology requirements and their application to the Temelín NPP have not been available to the Austrian Expert's Team. For the applied VERLIFE methodology the Austrian Experts' Team had to rely essentially on the information provided during the Specialists´ Workshops.

The Austrian Experts' Team also found that the Czech approach – as presented – for PTS analyses is in accordance with the state of science and technology, with respect to the concept, the methodology and the applied computer codes. The most severe transients analysed are well comparable to those regarded as representative for WWER-1000 installations according to current knowledge. All accident groups important in a PTS analysis were considered.

However, a number of issues remain to be clarified:

- The basis for the analyses appears to be insufficient: Although all accident groups important in a PTSA were analysed, in some cases the time frame of the simulation might not have caught critical loads to the reactor pressure vessel, since simulation results were available only for the phase ending just before repressurization would take place. Within a number of accident groups, the transients analysed in some cases cannot be considered as the most critical ones. For some transients it is necessary that emergency operating procedures be performed within a narrow time window to avoid brittle failure of the RPV.
- There are apparent reductions of conservatisms. Some VERLIFE criteria are weaker than those required by the IAEA Guidelines. Applying the values concerning postulated crack sizes, safety factors, WPS (warm prestressing effect criterion) as required by the IAEA Guidelines would not result in the demonstration of RPVI requirements' fulfilment throughout lifetime.
- Uncertainties – procedural as well as intrinsic – identified regarding the PTS assessment for Temelín NPP concern, for example: TH transient models, mixing behaviour models, embrittlement behaviour of the RPV materials as well as initial materials' brittleness properties, fluence determination and the introduction of measures for fluence minimization, and areas of in-service-inspection (ISI), where qualification has not yet been achieved. These are further critical points remaining for clarification.
- Conservatism is further reduced by including the intact cladding zone as structural reinforcement into the Finite Element model, including non-conservative assumptions for fracture mechanics analyses at the cladding/ferritic steel interface (as confirmed by a pilot study of the Austrian Experts' Team). Accordingly, not all types of underclad cracks have been evaluated.

Regarding the surveillance program, which is monitoring embrittlement progress, in particular the location of the samples, it has to be pointed out, however, that it represents a considerable improvement compared to other WWER-1000s of the same vintage.

Consequently, the future exchange of information on RPVI and PTS should above all cover the following issues:

- Regarding PTS analyses, the consequences of additional critical conditions, and of an extended time frame for some of the sequences calculated, are of interest, as well as the consideration of all crack sizes and crack positions of relevance in fracture mechanics (including stability considerations).
- The progression of embrittlement and the remedies taken should be further observed. This includes surveillance results for both units of the Temelín NPP, in particular the results of samples with higher initial critical temperatures brittleness, irradiated in unit 2.
- The comparison of materials' characteristics determined within the qualification tests, the extended acceptance tests and the lifetime evaluation programme with the surveillance programme data is of interest, in order to evaluate the scatter of materials' properties.
- Embrittlement mitigations measures, in particular core configuration, refuelling pattern and enrichment changes, are of interest.

In the course of further information exchange, the issues listed here could be combined with the issues remaining for information exchange under Item 4 (Non Destructive Testing) of ANNEX I of the "Brussels Agreement", regarding the reliable detection of all PTS relevant defects.

2.3.5.1 Detailed conclusions

Benchmarking the presentations at the Specialists' Workshop against internationally accepted guidance, recommendations and ruling has led the Austrian Experts' Team to the following observations: Many of these observations are also based on generic calculations and investigations that were conducted while preparing the workshop.

- The Austrian Experts appreciate that the Czech side is no more considering the operational pressure-temperature limit curves as appropriate demonstration of avoidance of unacceptable PTS sequences.
- The RPVI concept, as it pertains to the PTS analysis approach, appears to follow the state-of-the-art practice and the IAEA Guidelines with respect to analytical methodology. The IAEA Guidelines safety precautions were significantly reduced the way they are interpreted in the new VERLIFE methodology.
- The presented Czech approach for PTS analyses (part of the VERLIFE) with respect to the concept, the methodology and the applied computer codes are considered to be in accordance with state-of-the-art procedures.
- Evidently all thermal hydraulic calculations work has been performed with state-of-technology computer codes, which were validated for WWER-1000 use. Once completed the RPVI/PTS related TH-analyses can be considered comprehensive. TH-analyses should provide a sound basis for the selection of candidate transients for the mixing and heat transfer calculations to be conducted subsequently. The use of assumptions, which are not conservative for the specific scope and represent therefore an impact on safety, should be reconsidered.
- The most severe transients are by all means comparable to those considered representative for WWER-1000 installations according to current knowledge. In some instances the time frame observed in the simulation might not have caught the essence of the loading to the RPV, since re-pressurization during the up-following accident-sequence might just not have taken place that early (i.e. before ceasing the simulation).

With regard to "Mixing Calculations and Heat Transfer" issues:

- The mixing calculations for the accident transients within the PTS analyses performed appear to be in accordance with the state-of-the-art in international practice and comparable to calculations for other WWER-1000 reactors.

With regard to FEM calculations and Fracture Mechanics evaluation:

- The applied computer codes for the FEM simulation and the consideration of elastic-plastic material behaviour is considered to be in accordance with the actual state-of-the-art. The PTS assessment can be considered a consolidated approach, up to now unprecedented for WWER-1000 reactors.
- The IAEA Guidelines allow the use of postulated crack depths shallower than the normally required ¼ of wall thickness (which is for the WWER-1000 about 50 [mm]) for the case of the NDT-Program enabling the safe detection of the respective small defect sizes. For this case the IAEA Guidelines require the mandatory use of safety factors: Safety factor 2 for the crack depth or safety factor $\sqrt{2}$ for the stress and $\Delta T = 10$ [K] for the embrittlement induced shift of the critical brittle fracture temperature. In accordance with VERLIFE [PISTORA 2004a – see Reference List of the FMR for Item 3] the Czech Experts postulate a crack depth of 20 [mm] only (1/10 wall thickness, which is significantly smaller than ¼ wall thickness) but do not apply any of the safety factors. (e.g. as required according to the IAEA Guidelines).

- The Czech approach is also deviating from the IAEA Guidelines [IAEA 1997] with respect to the missing variations of the crack size and crack geometry. The following investigations have not been presented:
  - The analyses for very shallow cracks (a < 6 [mm]) and
  - Large cracks (a = 20 [mm] up to ¼ of the wall thickness) and
  - The variation of the aspect ratio to a:c = 1:10.
- The approach taken for integrating the cladding zone into the FE modelling introduces furthermore a reduction of conservatism, not only when excluding elliptical under-clad cracks, but also because assuming a Stress Intensity Factor (SIF) levelling out to SIF=0 exactly at the cladding/base-material interface does not correspond to reality. This has been reconfirmed by pilot case simulations conducted during the monitoring process.
- The FEM model represents one half of the reactor pressure vessel. This procedure does not include the stresses from the superposition of the cold plumes, the strain induced distortion of the cylinder and the interaction with the RPV bottom and the RPV head (deformation hindering). It should be noted, that this approach is in accordance with the international practice. The simulation using a mesh covering the complete RPV would represent an outstanding effort.

With respect to the PTSA:

- All accident groups important to be treated in a PTSA were analysed. For WWER-1000 reactors this is the first PTSA with a completeness not achieved up to now.
- The PTS loads for WWER-1000 are extremely high. For a postulated crack depth of only 20 [mm] the resulting T_k^a values are below 70 [°C] in four cases and 3 accident groups, no comparable behaviour is found with any other reactor types, e.g. WWER-440. This is a consequence of the very effective emergency coolant injection systems that are able to compensate large breaks up to ND 850 but induce at the same time a severe thermal shock load at the RPV wall.
- The lowest T_k^a values are found for small to intermediate break sizes, where in addition to the thermal shock load a full or partial re-pressurisation of the primary coolant circuit might occur .
- The operator must perform the appropriate emergency operation procedures (EOPs) at the correct moment in order to cope with several accident transients (PSV41) and at the same time avoid brittle failure of the RPV. However, it is not international practice to require “guaranteed” operational procedures of the personnel; therefore this must be considered a considerable reduction of conservatism in the handling of emergencies.
- Some accidents (PSV43) have not been calculated until to the point of applicability of the 90% WPS-criterion.
- In some cases the definition of the accident transients cannot be considered the most critical one: In the accident group PRZ SV the total loss of off-site power has not been included, although this is required by the IAEA Guidelines. Including total loss of off-site power would induce a re-pressurisation in the primary circuit following the re-closure of the pressuriser safety valve.

With respect to the safety factors required by the IAEA Guidelines it has to be stated:

- The VERLIFE methodology as applied by the Czech Experts for the Temelín NPP uses only postulated crack depths of 20 [mm] ($^1/_{10}$ wall thickness, which is significantly smaller than ¼ wall thickness) and no safety factors, which is not in line with the pertinent IAEA Guidelines.

- The VERLIFE methodology as applied by the Czech Experts for NPP Temelín is applying the 90% WPS criterion although the IAEA Guidelines recommend the 80% level, if applied at all. This modification significantly reduces further conservatism, which violates the need to compensate for uncertainties in embrittlement prediction for radiation-sensitive RPV steels.
- Even though applicability of the WPS effect is still judged controversial in the international community due to theoretical and experimental uncertainties[15] it is applied for the Temelín RPV integrity.
- The consequent application of the IAEA guidelines would lead to a different assessment result than advocated by the operator of Temelín, e.g. in cases where the 80% WPS-criterion, together with the safety factor $\sqrt{2}$ and the required safety factor $\Delta T = 10$ [K] should be applied.

With respect to the surveillance program in the NPP Temelín and ETE RPV material embrittlement:

- The use of optimised steels – not radiation embrittlement susceptible/sensitive – one basic element of state-of-the-art RPV integrity, is not met for the barrier – the Temelín RPVs.
- The modified surveillance program in the NPP Temelín allows the determination of reliable embrittlement data with respect to irradiation temperature and neutron flux/fluence at the samples irradiation location.
- The modified surveillance program causes inaccessibility of RPV wall in the container area and therefore for NDT in regions close to weldment 4, the active core and core zone.
- The evaluation of published surveillance results from WWER-1000 materials taking into account the estimated irradiation temperatures does result in considerable uncertainties about the neutron embrittlement of WWER-1000 steel. It is therefore obvious that the specification in the Russian Code ($A_F = 20$ for welds, 23 for base material) cannot be considered conservative.
- Although the first reliable results ever regarding a WWER-1000 will be available from the Temelín surveillance program, uncertainties about the WWER-1000 RPV steel embrittlement persist: the RPV specific surveillance program cannot provide a reliable statistics background for the prediction of the material degradation, since every set of samples withdrawn and evaluated provides for only one single data point to be added to the irradiation embrittlement versus time correlation.
- The embrittlement coefficients determined so far for Temelín specific materials are based on irradiation in test reactors with high lead factors. The existing dose rate effect might have adversely affected the embrittlement and the coefficients determined, i.e. the embrittlement might in reality be more advanced than the measured values indicate.
- The material properties data in the passports indicate that the initial critical temperature of brittleness T_{k0} can vary by tens of degrees from one weld metal charge to another. It has not been possible to check whether the temperature margin δT_M (10 [K] for the base material and 16 [K] for the weld metals) as defined within the VERLIFE methodology, in order to cover the scatter of the mechanical property values, have been taken into account for T_{k0} assessment.
- This fact and the uncertainties of the specified embrittlement coefficients need to be taken into consideration by using the safety factor ΔT as required by the IAEA Guidelines [IAEA 1997 – see Reference List of the FMR for Item 3].

[15] This is the case especially with respect to the real situation in the component and the temperature/pressure history during a realistic PTS event.

- Weld no.4 in ETE-1 was welded with two different electrode heat charges (Sv12Ch2N2MAA, heat number 17084 and 170007) for both heat numbers surveillance samples were fabricated; the surveillance program of ETE-1 is performed using the samples welded with the same electrode heat than weld no.3 (T_{k0} = -50 [°C]). The other weld metal with T_{k0} = -30 [°C] will be irradiated within the surveillance program of ETE-2. In view of the Austrian specialists this is a shortcoming because the results on irradiation embrittlement for the weld material with the highest T_{k0} of ETE-1 will not be available without significant delay.
- The fracture toughness curve formula used in the VERLIFE methodology can be considered conservative as compared with fracture toughness curves of other National Codes.

With respect to the NDT/ISI program performed in NPP Temelín:

- The ISI using ultrasonic NDT methods for the RPV cylindrical wall has successfully been qualified. The methods can as such be regarded to basically enable detection of all kinds of crack-like defects, which are of special concern for the PTS events and their analyses, e.g. cracks close to the claddings' interface to the base material layer with an a/c aspect-ratio of e.g. 0,3 and with different depth, depending on the PTSA defects as postulated. A semi-elliptical crack seems to be the most critical for NDT, which starts at the cladding interface and extends 8 [mm] deep into the ferritic wall. Although qualification using the RPV wall test block demonstrated the basic potential of the applied UT methods to allow detection of those defects, some problems are not yet finally solved.
- The test block does not contain the cladding condition at the welds and on its vicinity, where one has to take into account a considerably higher noise level and therefore a higher false call rate, as mentioned in the qualification report. This requires special countermeasures, e.g. additional Eddy Current Testing (ECT) in areas with an elevated number of UT indications. This is particularly needed, because the VERLIFE concept requires an intact cladding, especially at locations of near cladding cracks in the ferritic wall. The remaining ligament between the crack tip and the wet inner surface can be proven with properly qualified ECT methods only. The safety evaluation regarding the absence of flaws important to PTS has not been finalized up to now, since neither the qualification of, nor the inspection using the ECT method as required has been carried out yet.
- Two more ISI areas bearing specific PTS concerns are the inner corner of the inlet nozzles and the welds connecting the primary loop to the RPV. For both areas qualification exercises have been announced, but have not been finished yet and presented. Of special interest are the PTS relevant crack sizes within the nozzle corner and the connecting weld, in order to judge the difficulties the NDT techniques will have to guarantee sufficient detectability and a reasonable false call rate.
- In view of the not yet finished remaining NDT activities, but needed to prove the absence of all kind of PTS relevant cracks, one must conclude, that the NDT inspections carried out until today cover only in part all the ISIs required. According to the information given at the PN9 Workshop, completion of the ISI concerning the PTS analysis is in preparation, with several qualification activities ongoing, but will certainly not be reached before the foreseeable next RPV ISI.

With regard to Core Design and Radiation Embrittlement Mitigation:

- The OUT-IN strategy is a well-known early means of embrittlement mitigation; the ETE specific information contained in the presentation did not give a clue to the question, whether introduction is made for irradiation embrittlement mitigation, or just as a side effect of power output optimization. The PTS relevant effects of the RPV fluence reduction management can be derived from the fluence distribution only. Nevertheless, information presented was limited to power distribution sketches.

- The statement during the Specialists' Workshop, that operation will take place well below fluence calculation input, does not per se endorse that embrittlement is managed properly. The RPV fluence reduction management policy is one element to be enacted along with plant operation.
- The Westinghouse core design used in a WWER-1000 reactor is the first of its kind to be validated. Apparently, the core design has not yet been modified aiming to a fluence minimization at the reactor pressure vessel wall in order to reduce the neutron embrittlement of the steel. This improvement is envisaged be implemented at one of the upcoming refuelling outages of the core. Up to now the intended changes have not been presented.

With regard to EOPs and SAMGs transition:

- Extensive feedback from plant analyses was used to more appropriately adapt the EOPs outline and elements to an up-to-date emergency management tool. It can be understood from the overview presentation, that the concept is suitable for proper adaptation. This work is evidently a successfully ongoing process.
- The EOPs as well as the SAMGs and associated measures are well in line with the state of science and technology requirements, given the equipment to be used be qualified or been qualified for the intended use in the respective operational regime.

Conclusions concerning the issue of quality assurance and training:

- Due to the unavailability of detailed information it is not possible to judge the efficiency of quality assurance programmes related to RPVI activities at NPP Temelín. In any case, together with the evaluation of quality assurance the improvements achieved for QA are appreciated.
- Verification and consolidation of a sound understanding of the actual RPV and plant systems situation requires procedures and management structures to be set up. This management should be set up for a process that is supposed to last for the entire plant life. The related prerequisites have been set-up in adequate proportions.
- The training and implementation activities are comprehensive and compare well with activities in other NPPs in Europe. In some instances thoroughness was most probably given precedence before timeliness when implementing EOPs training opportunities.

Conclusions concerning the SÚJB position:

- The SÚJB position on the "PTS requirements" implementation versus the licensee is an indication of their observing position in assuring the RPVI and PTS precautions fulfilment.
- In line with the IAEA IRRT Mission recommendation the Experts' Team considers that it is a valid aim to enhance SÚJB´s "strength". Its personnel capacity and possibilities ought to be increased by all means appropriate and necessary also in the RPVI and PTS context.

2.3.6 PTS – items of further interest

The team of Experts recommends pursuing topics of high priority in the framework of the pertinent Bilateral Agreement between the Federal Republic of Austria and the Czech Republic. This concerns the implementation and results from the RPVI Program, VERLIFE and the related PTSA. In addition, since the ongoing RPVI/PTS information exchange process is supposed to be continued for the entire plant life, it is recommended to follow plant operation by continuous exchange of information.

Since the present RPVI work did not explicitly take into consideration cold over-pressurisation and outage-issues, no comments will be found here on these topics.

These items recommended are as follows:

- The consideration of additional critical conditions, such as total loss of off-site power,
- The time frame of sequences calculated – some transients' simulations have not been conducted up to a time-span sufficiently long, that any over-pressurisation during the left out accident transient could have been captured – and
- The consideration of fracture mechanics regarding all the crack sizes and crack positions of relevance, and stability considerations (smaller cracks might grow and become instable during the up following transient sequences).
- The embrittlement progression as well as the remedies taken and the actual RPVI verification and consequences.
- The comparison of the materials characteristics determined within the qualification tests, the extended acceptance tests and the lifetime evaluation programme cited during the Workshop [BRUMOVSKY 2004a – see Reference List of the FMR for Item 3] with the surveillance programme data in order to evaluate the scatter of materials characteristics.
- The information on the results of the surveillance programme for both units. Special emphasis should be dedicated to the surveillance results of the weld no.4 samples (including the heat affected zone). The first results of the surveillance capsule removed in May 2004 will be available in 2005.
- The information on the results of the surveillance samples irradiated in unit 2 (esp. specimens of weld no.4/unit-1 and weld no.4/unit2, including HAZ) should be included in the future information exchange with special emphasis during the next years. At the same time it would be desirable to obtain information whether specimen of weld number 2 are included in the PTS considerations.
- Continuous information on the experimental assessment evaluation of the neutron embrittlement of ETE materials, using surveillance specimens, in order to confirm the application of temperature margins as defined in the VERLIFE methodology (upper boundary of the radiation induced T_k shifts to be used in the RPV lifetime evaluation).
- The Temelín RPV embrittlement mitigation is of utmost importance for RPVI; therefore fuel-reload as well as reload-pattern changes are envisaged after one of the next campaigns. The information provided up to now is coarse; it stipulates further interest.

Future information exchange should also include:

- Main coolant recirculation line penetrations,
- Vessel head control rod penetrations,
- Core instrumentation and other service penetrations,
- Main flanges' tightness, and
- Major environmental and other damage mechanisms contributing to the loss of integrity, like main coolant chemistry, hydrogen diffusion, corrosion, load cycling, severe accident behaviour, as well as integrity preservation and surveillance measures ascertaining LBB applicability and leakage detection instrumentation,
- The damage progression as well as the remedies taken and the actual RPVI verification and consequences,

since the Workshop did not cover those RPVI relevant issues.

Concluding statement

The Czech Experts make use of the VERLIFE methodology for demonstrating RPVI (reactor pressure vessel integrity) throughout service life of the Temelín RPVs. Compared to the Russian Code and the IAEA Guidelines the VERLIFE methodology has reduced the safety margins, adopted via inherent methodologies like the reduction of the postulated crack size, reduction of safety factors, the non-conservative fracture mechanics assumptions etc.

In combination with other uncertainties, such as modelling of TH transients, mixing behaviour modelling assumptions, material and embrittlement properties, fluence determination, NDE reliability, etc., the resulting global safety margin cannot be considered sufficient. Therefore the Austrian Experts' Team recommends continuing to follow up on those items, relevant for the completion of the VERLIFE methodology:

- Additional PTS analyses and their upgrading
- Surveillance specimen evaluation (of both units)
- Integrity verification dedicated NDE program
- Progress in embrittlement mitigation

The update of the Temelín RPVI demonstration specification based on the VERLIFE methodology would also be of high priority.

2.4 Item No. 4 – Integrity of Primary Loop Components – Non Destructive Testing (NDT)

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The quality of the in-service inspection of the main primary loop components (reactor pressure vessel, main coolant lines, primary side of steam generator, surge line) has been recognized as an important aspect of the safety of NPP Temelín. As the methods originally used for WWER-1000 NPPs are being improved to correspond to the Western safety standards, the issue of in-service inspection and non-destructive methods applied to the integrity of primary system components has been identified as Item No 4 among seven items to be monitored on technical level according to the "Conclusions of the Melk process and follow-up" ("Brussels Agreement"). The aim of monitoring is to evaluate the level of completeness and the appropriateness of in-service inspection and non destructive testing of integrity of primary loop components at Temelín, aimed at assuring their integrity under all normal and accidental conditions envisaged at Temelín plant.

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.

According to the ANNEX I of the "Brussels Agreement", each item to be monitored is linked to:

- Specific objectives set in licensing case for NPP Temelín units
- Description of present status and future actions foreseen by the licensees and State Office for Nuclear Safety (SONS), respectively.

Following the "Roadmap" guidance that a Specialists' Workshop be held in the 2nd half of 2004, the workshop was held in Rez near Prague on October 7-8, 2004 to discuss this issue. Recognizing that the Czech-Austrian Bilateral Agreement is an appropriate framework that provides the opportunity for further discussion and sharing additional information on this issue, it is understood that any findings warranting further attention would be addressed and resolved within the monitoring process as defined by the Bilateral agreement.

ENCONET Consulting was contracted by Umweltbundesamt (Federal Environment Agency) on behalf of the Austrian Government to provide the technical support for the monitoring process related with the ISI and NDT of primary loop components, succinct to the ANNEX I of the Conclusions of the Melk Process and Follow-up. This technical support to the monitoring was defined as a specific project, which is referred to as the "Project PN10: Integrity of Primary Loop Components – Non Destructive Testing (NDT)". The project itself comprises several predefined “project milestones” (PM), each devoted to specific technical aspect and/or interface requirements.

The main aspects of the situation in Temelín NPP considered in the project are related with the in-service-inspection and with non-destructive testing qualifications issues.

Since the introduction of the Atomic Act in 1997 and the accompanying regulations the program of in-service inspection has been required by law and is subject of State Office for Nuclear Safety (SONS) approval. Generally the ISI programme qualification approach is based on the requirements adopted by Western Europe countries in accordance with European Network for Inspection Qualification (ENIQ) methodology for Nondestructive Tests, on EUR 17299 and on IAEA methodology for qualification of ISI systems for WWER NPPs.

State Office for Nuclear Safety (SONS) issued its own safety guide on ISI of Main Primary Circuit Components in WWER Reactors (1998), and it is the basis of ISI/NDT in Temelín NPP. The basic standard for the qualification of the NDE personnel has been also published and it is similar to the European standard EN 473.

SONS provides supervision of all ISI qualification activities, and has determined the rules for performance demonstration which is a part of ISI qualification system. The responsibilities of the plant owner are determined by SONS decrees and the Atomic Act.

The extent and frequency of examinations, the methods and acceptance standards are clearly defined within the ISI programme and in work instructions. Acceptance standards are specified for each NDE method applicable for ISI program. The acceptance criteria for UT inspection have been replaced with analytical thresholds, which means that in the case of indications which exceed the registration level an analytical procedure is applied to judge upon the defect relevance using state-of-the art method. The criteria used at the end of the analytical procedure have not been clearly discussed.

Reactor Pressure Vessel is inspected both from inside and outside. All nozzle to pipe welds, including dissimilar welds are requested to be 100% inspected both from outside and inside. UT techniques are applied to all welds with commonly recommended pulse echo probe arrangements and registration thresholds are comparable with those in western states, e.g. in Germany, UK or USA. For all the different inspection tasks previous qualification trials including performance demonstration had to be performed. Further developments of NDT techniques especially in respect of RPV crack detection should be followed by the plant and applied as appropriate. This should be one of the items of future bilateral information exchange.

Atomic law and decrees prescribe responsibilities for preparation and retention of records and reports. The content is prescribed by the ASI requirements. When the acceptance criteria are exceeded, a submittal of reports to SONS is required.

The Qualification Body is established at CEZ as a permanent institution supported by external experts. Since a representative of Temelín NPP is a member of QB, there is a doubt about the independence of QB. The participation of the plant representative in the QB is not usual but it can be understandable in the case of reactor pressure vessel inspection because the inspection manipulators and mock-ups used in qualification are permanently stored inside the plant area and the qualification trials have to be performed in the plant area. Therefore the participation of plant personnel can be necessary. It was understood that the representative of Temelín NPP has been a non-voting member in the QB and has not the possibility to affect the results of qualification. The qualification process is supervised by SONS. The transparency and independence of the qualification is assured by the participation of APC (Association for Personnel Certification in Czech Republic). The content of qualification procedure is described in SONS document and is similar to the content given in EUR 17299 EN.

Inspection procedures are in general the effect of transferring recommendations of EUR 18117 EN and EUR 18101 EN to the Czech situation in a somewhat modified form.

The calibration block design, calibration, equipment set-up the data collection, interpretation, recording and ways of reporting are included in the ISI programme and described in detail. The surveillance activities of SONS include also during the qualification trials the check of personnel qualification.

It is recognized, that the Czech organizations apply modern eddy current equipment and analysis tools produced by the company ZETEC (USA). This confirms that Czech experts follow common western practices.

Other kinds of inspection like eddy current of collector surfaces and threaded holes, or visual inspections of welded joints, guarantee the confidence to all- embracement of the SG ISI program.

Determination of steam generator tubing plugging criteria represents the typical and correct way how the plugging criteria should be calculated based on performed burst test. Taking in account eddy current tool accuracy, flow growth rate followed by the statistical evaluation, shows that SG ISI experts are competent in this field.

The ideas of technical justification defined in EUR 18099 EN have been taken into consideration, and the qualification trials demonstrated for the ISI at the RPV and at 850 DN piping prove that the TJ philosophy was a starting point for qualification activities at Skoda and NRI. In some aspects however the Czech interpretation is not in agreement with the intentions of EUR 18099, in particular what concerns the use of worst case test defects and test conditions at the test block design.

The cases observed by Austrian experts indicate that the minimal personnel requirements follow the EUR18099 EN. The qualification specimen trials are conducted under SONS supervision in a secure area, the qualification assessment reports and certificates are drawn in accordance with the approach established in Western European countries.

There are some hints from discussions with Czech experts that one should in future carefully observe that they will continue with the positive efforts which have been stated by the Austrian experts during their investigations in order to improve the NDT also at those items where critical remarks have been made within this report. In particular it is recommended to revisit the following issues:

- establishment of a written working policy concerning responsibilities of qualification body and practical actions in qualification, as recommended in European ENIQ methodology
- links of new Czech ISI to US and EUR standards
- independence of qualification procedures
- extension of inspection scope in case of detected flaws
- statistical analysis influence on judgment about the accuracy of results
- detectability of defects perpendicular to the inner surface of the reactor vessel
- upgrading the qualification process by bringing the conditions of artificial defects closer to those which may appear during ISI in the plant components.

Although these items warrant further bilateral information exchange, it should be realized that most of the issues mentioned here are connected with the fast development of NDT techniques and are expected to be resolved with time. The level of achievement so far and consideration of the on-going activities in Temelín NPP is such as to allow the conclusion that the ISI and NDT of integrity of primary loop components at Temelín is comparable with Western European NPPs.

2.5 Item No. 5 – Qualification of Safety Classified Components

Technical Project Management	ENCONET Consulting (Vienna – Austria)
Authors	A. Strupczewski (ENCONET Consulting, Vienna – Austria) A. Madonna (Consultant – Italy) B. Gachot (ENCONET Consulting, Vienna – Austria)

The operability of safety equipment in a nuclear power plant (NPP) shall also be assured under accident conditions, when the temperature, humidity, pressures and radiation fields could be much higher than under normal operating conditions. The equipment is normally designed taking these conditions under considerations. To assure safety of a NPP it is essential to confirm that the equipment was verified to be able to operate under these accident conditions. The process of the preparation and maintenance of evidence to establish that the safety equipment will operate upon demand in the environment that is expected to be present at its respective physical locations is called the equipment qualification (EQ). It constitutes an important part of the safety requirements and defense in depth for each NPP.

The equipment qualification requirements and practices differ among countries operating NPPs. In particular, the EQ requirements which are typical in Western countries have not been standard applied to original Soviet designs. For Temelín NPP, the requirements for the EQ in force during the design and construction phase were much less than the actual requirements for EQ in Western countries.

The EQ, being an important safety element for Temelín NPP, was recognized and addressed as the Safety Issue #19 of the initial phase of the Melk process. Since this safety issue could not be resolved during the Melk process, it was adopted for the monitoring on technical level in the “Conclusions of the Melk Process and Follow-up”, the Agreement between the Czech Republic and Austria of November 2001 (“Brussels Agreement”) as item #5 “Qualification Safety Classified Components”.

ENCONET Consulting was contracted by the Umweltbundesamt (Federal Environment Agency), on behalf of the Austrian Government, to provide the technical support for the monitoring process related with the EQ. This report summarizes the activities undertaken by ENCONET on the monitoring of the status of the EQ on Temelín as performed between August 2002 and December 2004. The evaluation of the status of EQ at Temelín was based on the information obtained from a variety of sources (presentations, IAEA reports, etc) and in particular from the Topical two-day Workshop devoted to the EQ and held in Prague on 9-10 December, 2002, as well as additional contacts and clarifications in October 2004. The Workshop was one of the measures agreed to be implemented in the “Road Map” regarding the “Brussels Agreement”.

The status of the EQ at Temelín was compared with the state of the art of the requirements and the approaches to the EQ in western countries. Using this as the criteria, the conclusions on the adequacy of the EQ at Temelín were established. The findings, criteria and the status at Temelín are all documented in this report.

Temelín EQ program that was introduced in 1999 to fulfill regulatory requirements set forth in the Atomic act of 1997 and Decrees, follows western principles and methods. The EQ was to be completed in 2002 but due to delays, it is now scheduled for the completion in 2006. There is no special regulatory approval of the EQ in the Czech Republic. SUJB however, monitors the implementation of the EQ through periodic regulatory inspections. Large progress in EQ is visible, and the number of open issues has been greatly reduced over the last year. Difficulties with the lack of proper documentation for some equipment necessitated additional analysis and, in some cases, testing of specific components.

The overall conclusion of the evaluation is that the EQ at Temelín is now comparable with the western approaches in principles, methods used and results achieved. The regulatory requirements and the technical basis for the EQ are comparable with western requirements, the implementation of the EQ follows prudent practices and the EQ documentation of the EQ is comparable (or even better) than for some western plants. The methods used in establishing the status of EQ as well as the acceptance criteria appear broadly similar to western practices.

While significant improvement in the number of components for which the EQ is completed is noted, there are still safety components not having the EQ finalized. The plans to complete the EQ on all equipment were presented and evaluated by ENCONET experts as realistically achievable. For some of the components where the EQ is not completed, compensatory measures have been introduced in the form of specific operating instructions. An example confirmed that the compensatory measures were successfully implemented. The full list of equipment where compensatory measures were introduced were not provided.

The following points are of future interest in relation with EQ activities at Temelín:

- The continuation of completion of the EQ on all equipment (for 5 equipment groups general EQ is incomplete and for 14 equipment groups ageing qualification is incomplete as of December 2004), including EQ for ageing phenomena
- Consideration on localized effects on selected components outside the containment of Temelín.
- Significant findings of regulatory inspections related with EQ that could influence successful completion of the EQ program.

Nevertheless, the level of achievement so far and consideration of the on-going activities is supporting the conclusion that the EQ at Temelín is not an open safety issue any more.

2.6 Item No. 6 – Site Seismicity

Technical Project Management	Helmut Wenzel (VCE Holding GmbH, Vienna – Austria) Wolfgang Kromp (Institute of Risk Research, University of Vienna – Austria)
Contributions by	Kurt Decker (Institute of Geology, University of Vienna – Austria) Ralph Hinsch (Institute of Geology, University of Vienna – Austria) Helmut Hirsch (Working Group CERVUS/Consultant – Austria/Germany) Gerhard Jentzsch (Working Group CERVUS/Institute of Applied Geophysics, University of Jena – Germany) Franz Kohlbeck (Institute of Geodesy and Geophysics, Vienna University of Technology – Austria) Roman Lahodynsky (Institute of Risk Research, University of Vienna – Austria) Mustapha Meghraoui (Ecole et Observatoire des Sciences de la Terre (EOST), Strasbourg – France) Roger M.W. Musson (British Geological Survey, Edinburgh – UK) Barbara Theilen-Willige (Büro für Angewandte Geowissenschaftliche Fernerkundung (BAGF), Stockach – Germany)

2.6.1 Framework

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").

The signatories agreed that the implementation of these 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 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 Nr. 6 *"Site Seismicity"* of Annex I of the *"Brussels Agreement"* covers the site selection in relation to the possible seismicity. As shown in Annex I of the *"Brussels Agreement"*, the objective under this issue is: *"Siting of the installation shall take into account seismic as one of the possible external hazards."*

Annex I of the *"Brussels Agreement"* further specified the "Present Status and Specific Action Planned" as follows: *"The NPP Temelín underwent a thorough siting procedure in relation to possible seismic hazards. The Czech standard for this procedure is based on IAEA recommendations. A set of written documentation was released prior and in course of the "Trialogue" giving evidence of this process. Due to the complexity of this issue and in order to foster mutual understanding, a topical workshop will be organised in the frame of the bilateral cooperation."*

The "Roadmap" specified that a Specialists' Workshop would be held in the first half of the year 2003 to discuss this issue. The Workshop was held in Prague in March 27-28, 2003.

VCE Holding GmbH and the Institute of Risk Research of the University of Vienna was committed by the Federal Environment Agency on behalf of the Austrian Government to give technical support for the monitoring on the technical level of the implementation of the conclusions regarding the item Site Seismicity. This technical support focuses on the evaluation of the extent of conformity of the seismic hazard assessment for NPP Temelín with state-of-the-art practice in European Union member states and IAEA guidelines.

This specific technical project is referred to as project PN6 comprising altogether seven predefined "project milestones" (PM).

To focus preparatory work of the Austrian Expert Team and to guide the Austrian Delegation through the Experts' Workshop, but also to enable proper preparation of the Experts' Workshop on the bilateral level, in a first step (Project Milestone 1), the safety objective was broken down to Verifiable Line Items (VLIs). In a second step the Experts' Team prepared a list of documents, the Specific Information Request (SIR), considered to contain the kind of information required to provide for profound answers to the VLIs. Summarizing the VLIs treat the procedures of the seismic assessment, legal issues, risk management and data collection, as well as seismotectonic methods and results, practical implementation and the consequences of an earthquake.

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, it would be appreciated if the major findings could be addressed in the further bilateral information exchange.

2.6.2 The Approach by the Czech Side

The key element in the monitoring process was the Experts' Workshop on the item PN6 "Seismic Hazard Assessment of the Temelín NPP Site" of the roadmap held within the frame of an additional expert meeting following § 7 (4) of the pertinent bilateral agreement on March 27 and 28, 2003.

Information about the following main areas was presented by experts from SÚJB, the State Office for Nuclear Safety, CEZ ETE, S&A-CZ Stevenson and Associates, Energoprůzkum, Institute of Rock Structure and Mechanics of the Academy of Science, the Institute of Physics of the Earth of the Masaryk University Brno and Energoprojekt:

- Site Seismic Licensing Requirements
- Introductory Remarks of the NPP Temelín
- Summary of International Seismic Missions and Audits
    - History of the construction of the Temelín NPP

  - Summary of international seismic missions and audits
- Geological Investigations
  - Regional and near-regional geological data
  - Site vicinity investigations
  - Site area investigations
- Seismological Data – Earthquake Hazard Assessment
  - Historical earthquake data and catalogues
  - Regional seismogenic zones
  - Isoseismal maps and macroseismic observations
  - Intensity attenuation relations
  - Probabilistic hazard assessment
- Microearthquake Monitoring
  - Local seismic network
  - Recorded seismic events and interpretation of results
  - Seismological information display
- Seismotectonic Investigations
  - Regional seismotectonic model, description and criteria
  - Deterministic hazard assessment
- Temelín Seismic Monitoring System
- Supplementary Earthquake Hazard Assessment
- Earthquake Hazard Assessment
- Seismic Design Basis
  - SL1 and SL2 determination
  - Response spectra and accelerograms.

The analysis of the information made available there (SÚJB, ed., 2003: Seismic Hazard Assessment of Temelín NPP Site. Workshop. Abstract Volume and CD-Rom), as well as the report No. rep067-04.ete Revision 0 August 2004 with subject "Answers to the Conclusions of the Melk Process Site Seismicity of the NPP Temelín", which has been received in November 2004 containing information relevant to site seismicity and seismic design, are the basis for the present Final Monitoring Report of the Austrian Expert Team.

2.6.3 The Approach by the Austrian Expert Team

VCE Holding GmbH and the Institute of Risk Research of the University of Vienna, committed by the Federal Environment Agency on behalf of the Austrian Government to give technical support for the monitoring on the technical level, set up a team of ten international experts. The specific technical project is referred to as project PN6.

To focus preparatory work of the Austrian Expert Team and to guide the Austrian Delegation through the Experts' Workshop, but also to enable proper preparation of the Experts' Workshop on the bilateral level, in a **first step** (Project Milestone 1), the safety objective was broken down to Verifiable Line Items (VLIs)

In a **second step** the Experts' Team prepared a list of documents, the Specific Information Request (SIR), considered to contain the kind of information required to provide for profound answers in the VLIs.

The **third step** in the preparatory work for the workshop also included the identification of the IAEA Safety Standards and IAEA Safety Report Series for the Evaluation of the Seismic Hazards for Nuclear Power Plants and a GIS based tectonic investigation of Satellite Data from the Southern part of the Bohemian Massive.

Following the Workshop in a **fourth step**, the Experts' Team reviewed the data received at the Experts' Workshop in Prague and during internal meetings of the Austrian Expert Team. The experts provided contributions to the Preliminary Monitoring Report (PMR).

The preliminary results have been presented by VCE in the regular bilateral meeting in December 2003 in a **fifth step**.

The additional information provided in November 2004 has been assessed in preparation of the final monitoring report in a **sixth step**. The current FMR is based on the PMR and the assessment of additional information and the results of the discussion during the bilateral meeting in December 2003. There have been no essential changes to the technical assessment from PMR to FMR.

2.6.4 Result of the Monitoring

The monitoring process so far helped to clarify a number of VLIs. Based on the information available, the Austrian Expert Team formulates its view on the status of the seismicity and seismic hazard of the Temelín NPP site as follows:

There has been recently a considerable change in the engineering approach towards the seismic evaluation of existing nuclear facilities, particular affecting those plants situated in previously as "quiet" assessed sites. This trend, which is supported actually worldwide, is towards the consideration of longer return periods and the probability of site effects.

There is a clear consensus amongst the Austrian Expert Team that the information and materials received from the Czech experts during the Specialists Workshop at SUJB Praha (March 27 and 28, 2003) and the additional report of November 2004 was very informative. The Czech experts demonstrated that they made efforts to clarify questions put by IAEA review teams concerning seismic hazard assessment that remained open.

Nevertheless there are topics, which should be further investigated to enable a conclusive assessment, namely:

Geology & Tectonics

Until now, only three out of twelve faults in the near region of Temelín were studied in some detail. No high resolution geophysical methods except geoelectrics were applied to locate and map near surface faults and choose the right places for state of the art trenching. The existing data for the most prominent scarp, the Hluboka fault, comprise only one section based on three boreholes and are insufficient to date the youngest fault activity. This has been also highlighted by IAEA-mission in 2003.

The apparent uplift of Quaternary terraces (upward convex topography at the crossing of Vltava River and Hluboka fault) and the increased number of terraces north of Budweis Basin seem to be related to Quaternary tectonics. These geomorphological features are not addressed in the reference report (Simunek, 1995). Apparently, appropriate age data for quaternary sediments are lacking (no biostratigraphic or radiometric data). Nevertheless, segmented fans adjacent to the suspected Hluboka fault scarp may be indicative for active uplift along the scarp. Also published geodetic data (Vyskocil, 1975) indicate an ongoing subsidence of the Budweis Basin.

The proper assessment of active (or non-active) tectonics at the Hluboka Fault is of utmost importance for the Temelín seismic hazard assessment as a whole. This conclusion might be drawn from the analysis of the material provided by the Czech party and two field surveys conducted during the monitoring process. These highlight geological and geomorphological features of the Hluboka Fault, which do indicate young movements along the fault. The previous assessment of the fault should be supplemented by detailed high-resolution geophysical and paleoseismological analyses. The report contains a list of three transects crossing the fault, which should be analysed in order to constrain the seismic potential of the Hluboka Fault convincingly. The proposed investigations are state of the art and they are considered to be necessary to characterize the recent movement on the fault.

Seismicity & Seismic Hazard Assessment

The deterministic method presented by Czech experts is based on an expert system[16] that is not internationally verified. The near site hazard calculation is based on insufficient data and uncertainties are not given. For some zones the maximum credible earthquake (MCE) and also the SL2 (Safety Level 2 according to IAEA requirements, SSE) earthquake is currently based on the relation $I_{mc} = I_0 + 0{,}5\,°$ (I_0 = observed intensity of the largest known earthquake within a region and I_{mc} = maximum credible earthquake of the region). However, standard safety margin would be 1 ° instead of 0,5 ° – see IAEA mission Feb. 2003 – whereas some authors add 1,5 °. For that reason the seismic hazard for Temelín site seems to be underestimated by at least 0,5 ° with that method. From historical reports an observed intensity of I_{mc} = 6,0 ° – 6,5 ° is derived for Southern Bohemia. Based solely on the derivation of the MCE from data of the strongest historical earthquake of the whole region (Neulengbach, 1590) we conclude a conservative value of 7 ° – 7,5 °MSK for SL2. Especially areas of assumed low seismicity should take into account longer return periods of strong earthquakes and investigate the geochronological record to extend the catalogue coverage. More generally, despite recommendations by IAEA (Guidelines and Site safety review mission, 1990) to determine a MCE by dating youngest movements of faults (paleoseismological method) this method was not performed.

The probabilistic method presented by Czech experts uses an attenuation relation derived from an U.S site, which is inappropriate for this specific site. This attenuation relation does not take into account the strong directional variation for attenuations on regional earthquakes felt in Southern Bohemia. Consequently, the study presented by SUJB (2003) uses attenuation for waves from the Mur-Mürz-Leitha Fault that is nearly one degree higher than that relation found by a more profound investigation by Simunek et al. (1995). In addition the probabilistic calculation does not use the correct spread of the data. Instead it uses a predefined unrealistic uncertainty. For that reason this approach is not a stochastic one and does not follow IAEA recommendations. It is expected that a recalculation would give an SL2-level earthquake of at least 7 °MSK.

The demonstrated correlation between intensity I = 7 °MSK and a MHPGA (maximum horizontal peak ground acceleration) of 0,1 g does not reflect the globally applied procedure. French, German and Russian standards correlate intensity levels with higher g values and therefore follow a more conservative approach. The value of 0,1 g accepted in Temelín for the SL2 is equal only to the minimum requirements of the IAEA and does not contain any safety margin. The Czech hazard assessment therefore cannot be considered as conservative.

In the light of the technical subjects discussed in this report and the recently published IAEA safety reports series no. 28 "Seismic Evaluation of existing Nuclear Power Plants it is recommended to study the consequences of an assumed peak ground acceleration of 0,23 g, as performed for comparable sites, and the performance of a seismic probabilistic safety assessment (SPSA) under this assumption. It should be noted that the IAEA report mentioned above is expected to upgraded to the Safety Standard Series (SSS) in the next cycle of SSS revision.

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[16] A software-based artificial intelligence system which analyzes information to upgrade the quality of databases for specified purposes.

2.7 Seismic Design

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2.7.1 Framework

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).

The signatories agreed that the implementation of these 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.

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

During the discussion within the Roadmap item 6 site seismicity the Czech side offered to report about the issue re-evaluation/seismic design during the bilateral meeting 2003. For the preparation of the Austrian delegation on this subject the project PN8 has been created. The subject is related to issue 7 ("Seismic Design and Seismic Hazard Assessment") of the Melk process, whereas here the relation is limited to seismic design. Seismic hazard assessment is subject to project PN6.

VCE Holding GmbH of Vienna was committed by the Umweltbundesamt (Federal Environment Agency) on behalf of the Austrian Government to give technical support for the monitoring on the technical level of the implementation of the conclusions regarding the issue seismic design. This technical support will have to focus on the evaluation of the extent of conformity of the seismic design for NPP Temelín with state of the art practice in European Union member states and IAEA guidelines.

This specific technical project is referred to as project PN8 comprising all together 7 predefined "project milestones" (PM).

To focus the preparatory work of the Austrian expert team and to guide the Austrian delegation through the specialist presentation in the 1st step (Project Milestone 1) the safety objective regarding seismic design was broken down to Verifiable Line Items (VLIs). After the presentation of the Czech side during the bilateral meeting in December 2003 in Vienna, the Austrian Expert team prepared a list of information, the Specific Information Request (SIR), considered to contain the necessary background required to provide for profound answers in the VLIs. The VLIs treat the subjects of legal framework, seismic design input, re-evaluation methodology, identification of critical structures, interfaces and components, and implementation of seismic upgrade measures.

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, it would be appreciated if the major findings could be resolved in a further bilateral information exchange.

2.7.2 The Information provided by the Czech Side

The key information has been provided by the Czech side in the presentation named:

Temelín NPP: Seismic qualification of civil engineering structures, prepared by Mr. Maly of the nuclear research institute, REZ, division Energoproject Praha, which he presented during the bilateral meeting in Vienna on December 18th 2003.

The analysis of the information made available through the power point presentation: Temelín NPP, seismic qualification of civil engineering structures and the inquiries and discussions held with Stevenson and Associates and the Technical University of Praha are the basis for the monitoring report of the Austrian expert team.

In November 2004 the report No. rep067-04.ete Revision 0 August 2004 with subject “Answers to the Conclusions of the Melk Process Site Seismicity of the NPP Temelín” has been received which contained information relevant to seismic design.

2.7.3 The Approach by the Austrian Expert Team

Based on the preliminary monitoring results of project PN6 (site seismicity) the Austrian expert team broke down the safety objective regarding seismic design into Verifiable Line Items (VLIs) in a 1st step. This defined the items of interest and the questions to be answered.

In a 2nd step, after the presentation of the Czech side, a list of required information, the Specific Information Request (SIR), has been compiled considered to contain the necessary background required to provide for profound answers in the VLI’s.

The 3rd step is the compilation of background information and materials necessary to assess the gathered information. It is represented in the preliminary monitoring report (PMR) as separate chapter and comprises the current practice in seismic design.

In meetings with the involved subcontractor of CEZ ETE, Stevenson and Associates, and the Technical University of Praha, Prof. Bidnar, additional information has been collected.

The preliminary results have been presented by VCE in the bilateral meeting on November 30th, 2004.

The current FMR is based on the PMR and the assessment of the results of the discussion during the bilateral meeting in November 2004. There have been no changes to the technical assessment from PMR to FMR.

2.7.4 Final Result of the Monitoring

The monitoring process so far clarified the VLIs. Based on the information available the expert team formulates its view on the status of the seismic design of the Temelín MPP as follows:

The seismic design practice has made considerable progress in the last years based on the experience made and the measurements taken from past events such as Northridge (1994, U.S.A.), Kobe (1995, Japan), Kozaeli (1999. Turkey), and ChiChi (1999, Taiwan). This resulted in considerable changes in the approach as well as related codes and standards. Probabilistic approach and performance based design philosophies are prevailing, analysing the global behaviour of the technical complex systems.

Traditional approaches as represented by national codes and also some of the valid IAEA guidelines do not satisfy the requirements of a realistic assessment of the seismic capacity of structures. New guidelines reflecting the current practice are in the drafting process and are expected to come into force soon.

In Temelín seismic design has been limited to structures, neglecting such important seismic effects as:

- Interaction between adjacent structures
- Differential local movements at vital interfaces
- The performance and eventual collapse of non structural components

There is a clear consensus among the Austria expert team that the information and material provided by the Czech side during the bilateral meeting on December 18th 2003 and the written information in fall 2004, was very informative and conclusive. The Czech experts demonstrated that they made efforts to fulfil the requirements specified in the IAEA guidelines concerning seismic design.

From the Austrian point of view the seismic design re-evaluation conforms to the existing standards and recommendation which on the other hand do not consider the current best engineering practice. The question of interfaces and non structural components has therefore not been addressed in the re-evaluation process.

2.7.5 Recommendations

In order to improve the knowledge on the seismic performance and the possible identification of necessary retrofit measures the Austrian expert team recommends the following:

1. To perform a probabilistic safety analysis (PSA) on the level of the recommendation of IAEA and the current best practice in Western Europe.
2. To open the chapter of seismic qualification of civil structures, interfaces and components again to be incorporated into the 10 year periodic safety review.
3. To actively improve the monitoring system and enhance the use of actual data in the evaluation process including an improvement of the existing database

2.8 Item No. 7 – Severe Accidents Related Issues – a)

Institutions involved in the Working Group on Comparison of Calculations Regarding the Radiological Consequences of BDBA	
Czech Republic	State Office for Nuclear Safety – SÚJB, NPP Temelín (ČEZ), VUJE, Trnava, Inc, ABmerit Engineering Services, Trnava National Radiation Protection Institute – NRPI, Czech Hydrometeorological Institute – CHMI, UTIA Praha Skoda Plzen Nuclear Research Institute Rez, plc. – NRI NRI Rez – Division Energoprojekt Praha
Austria	Federal Ministry of Agriculture, Forestry, Environment and Water Management – BMLFUW Umweltbundesamt – Federal Environment Agency ARCS Seibersdorf Research – ARCS Institute of Meteorology and Physics, University of Natural Resources and Applied Life Sciences, Vienna (IMP) Central Institute of Meteorology and Geodynamics (ZAMG) Austrian Institute of Applied Ecology (ÖI)

2.8.1 Background

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.

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.”

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.

The objective of Item No.7 “Severe Accidents Related Issues“ as stated in ANNEX I of the “Brussels Agreement” is *“Effective prevention and mitigation of consequences of beyond design basis accidents (severe accident).”*

ANNEX I of the “Brussels Agreement” further specifies the “Present Status and Specific Actions Planned” for Item 7 as follows:

> *“A set of preventive and mitigative measures is, at present, applied in NPP Temelín with respect to beyond design basis accidents. These include software and hardware measures, among others, e.g. Symptom Based Emergency Operating Procedures, Technical Support Centre, Post Accident Monitoring System, Emergency Preparedness.*
>
> *For the purpose of emergency preparedness, the PSA was employed with the aim to identify and group events with different initiating occurrences, but with similar end-effects. On the basis of this assessment the relative risk was estimated for specific events in order to select those which will serve for the determination of emergency response activities (pre-planned, reactive).*
>
> *Severe Accidents Management Guidelines (SAMG) as a state-of the-art tool will complete the whole system of mitigation measures with respect to the beyond design basis accident management. The project for SAMG development is scheduled to be finished by end 2002 to be followed by validation.*
>
> *To foster mutual understanding two lines of activities will be followed within the framework of the bilateral agreement:*
>
> *a) A Working Group on comparison of calculations regarding the radiological consequences of BDBA with a view to harmonize the basis for emergency preparedness will be established.*
>
> *b) The exchange of information related to SAMG will include discussion on the analytical basis as well as on corresponding software and hardware measures. “*

The Issue a) corresponds to the specific technical project PN1, whereas Issue b), covering the issue of SAMGs, corresponds to the technical project PN7.

The “Road Map” specified that a topical meeting would be held in the first half of 2002 regarding Item No.7 “Severe Accidents Related Issues - a)”. The objective of this meeting is to establish a Working Group on comparison of calculations regarding the radiological consequences of BDBA (hereinafter “Working Group”), performed by models and codes used in the Czech Republic and in Austria, with a view to harmo-nising the basis for emergency preparedness. The “Road Map” further specified that the “Regular Bilateral Meeting” scheduled for the 2nd half of 2003 would *“include a presentation and discussion on the results of the Working Group on comparison of calculations regarding the radiological consequences of BDBA (Item 7a)”.*

Actually, the first “unscheduled” meeting on the “severe accidents” topic was held in Prague on 6 September 2001. At the meeting, both delegations agreed to establish a Working Group and to organise workshops on comparison of codes for radiological consequences evaluation.

An expert team (ARCS Seibersdorf Research; Austrian Institute of Applied Ecology – ÖI; Central Institute of Meteorology and Geodynamics – ZAMG; Institute of Meteorology and Physics of University of Natural Resources and Applied Life Sciences Vienna) was committed by the Umweltbundesamt (Federal Environment Agency) on behalf of the Austrian Government to provide technical support for the monitoring on the technical level within the Working Group.

All together the Working Group, after its official establishment, met four times, twice in Vienna and twice in Prague.

The result of the Working Group on comparison of calculations regarding the radiological consequences of BDBA are presented in detail in the comprehensive “Joint Summary Report”.

2.8.2 Overview on Working Group Activities

According to an agreed working programme elaborated at the first topical meeting in Vienna in May 2002 for implementation of Item 7a) of the "Road Map" of the Brussels Protocol, three further Working Group (WG) workshops were organised. Presentations were given by both sides, clarifications and in-depth discussions followed each topic. Both delegations provided transparencies and background information in hard copy, on CDs and by a common information platform (CIRCA) developed under the European Commission IDA programme.

In the last WG workshop in October 2003, the WG considered its activities within STEPs I-III to be closed successfully. Summarising the WG activities, the WG agreed that the co-operation of Czech and Austrian experts in assessing the radiological consequences of BDBA was very effective and useful for both sides. Both sides expressed their strong belief that this bilateral co-operation which started so successfully would continue in the future.

2.8.3 First Topical WG Meeting in Vienna, May 14-15th, 2002

In the first topical WG meeting in Vienna, 14-15 May 2002, presentations of models for dispersion and dose calculations (computer codes) in the Czech Republic and in Austria were given and an agreement between the delegations was reached on a draft work programme of model comparisons, as well as a provisional timetable for the next steps of the WG.

Three subgroups were established with the purpose of running the models as agreed in the work programme and to interpret and summarise the results of the comparisons:

- Subgroup 1 with the task of "Benchmarking for radiological consequences"
- Subgroup 2 for "Real-time meteorological long-distance modelling" and
- Subgroup 3 focusing on "Food chain" aspects

Austria suggested setting up a common information platform (CIRCA) developed under the European Commission IDA programme, with access limited to a defined group of persons to exchange information and documents. The delegations agreed to make use of this tool.

2.8.4 WG Programme

The main objective for the WG activities according to the Temelín "Road Map" Item 7a) was the comparison of calculations regarding the radiological consequences of BDBA performed by different models and codes used in the Czech Republic and in Austria with a view to harmonise the basis for emergency preparedness. A draft work programme for realising this objective was set up in the first topical WG meeting.

In STEP I – "Benchmarking for Radiological Consequences," four tasks of subgroup 1 were formulated:

- STEP I.1: Code inter-comparison for scenarios with an UK source term (Report NRPB-M152, 1988) and German meteorology as suggested by the Czech side with the following computer codes: COSYMA (Czech Republic and Austria), RTARC and ESTE (Czech Republic)
- STEP I.2: Code inter-comparison for scenarios with a source term prepared by the ARCS Seibersdorf research (ARCS) for WWER 1000 with simple deterministic calculations for a range of meteorological and release scenarios with the computer codes COSYMA (Czech Republic and Austria), RTARC and ESTE (Czech Republic)

- STEP I.3: Comparison of existing dispersion calculations which were made for the licensing of Temelín NPP by the models HERALD and HAVAR for one or more emission scenarios and different meteorological conditions used in the Temelín Safety Analysis Report with calculations performed by COSYMA.
- STEP I.4: Comparison of “worst case” meteorological conditions

STEP II – “Real-time Meteorological Long-distance Modelling” was divided in two main activities:

- STEP II.a – Comparison of Real-time Meteorological Long-distance Modelling:
- Comparisons of dispersion calculations performed with the operative models of the meteorological services of both countries, the Czech Hydrometeorological Institute (CHMI) and the Austrian Central Institute for Meteorology and Geophysics (ZAMG), was planned. This exercise replaced the originally envisaged STEP II.a, to join the ENSEMBLE exercises within the 5th Research Framework Programme of the EC.
- STEP II.b – Realistic Case Studies (real-time and/or a-posteriori): Comparison of results of calculations used codes: ESTE, PTM, TAMOS, FLEXPART, OECOSYS for two selected weather situations, which would transport radionuclides from a hypothetical release at Temelín NPP into the Czech Republic and into Austria. Calculations of volume concentration, deposition, food stuff contamination, doses (partly including ingestion) and averted doses were planned. Not all models had to produce all endpoints, but concentrations and depositions were the minimal requirements for all models.

In STEP III – “Food Chain – Case Studies” – a comparison of the codes routinely used by Czech and Austrian sides for calculations of food chain contamination and discussion of criteria for counter measures implementation, especially for long-term counter measures, was planned.

2.8.5 WG Meeting in Prague, September 10-11th, 2002

A comparison of calculations performed in the framework of STEP I.1 and STEP I.2 was presented and differences in the results were analysed. Information on parameters and definitions used by ESTE and RTARC was supplied by the Czech side. Extensive comparisons of the models HERALD (older code) and HAVAR (newer code) as used for design and licensing purposes with PC-COSYMA according to STEP I.3 were presented by the Czech side. Additional background publications on these models were made available.

Apart from the discussion of dose factors, which had been deferred to STEP III, all tasks of STEPs I.1, I.2 and I.3 were finalised.

Concerning STEP II.a, CHMI and ZAMG presented information on comparisons of dispersion calculations with their operative models – an exercise which replaced the envisaged STEP II.a, as the CHMI model domain does not permit participation in the ENSEMBLE exercise. The representative of CHMI indicated, however, that they consider participating in any ENSEMBLE exercises which have source sites within the domain covered by their dispersion model.

The Austrian side presented "worst case" scenarios regarding meteorological conditions (STEP I.4). The practicality of the use of "worst case" conditions for calculations was discussed. It was agreed that the Austrian side would continue with these calculations and put the results on the CIRCA information platform. Additionally, it was agreed that the Austrian side might come back to this item at an appropriate moment, depending on the results of other “Road Map“ events.

Regarding the realistic case studies of STEP II.b, it was agreed to choose a source term from the RODOS library and to use the weather situations of STEP II.a. It was planned to fix all basic assumptions, boundary conditions and intended results, and make them available via CIRCA information platform before the inter-comparison exercise. The following models participated in the exercise: TAMOS, OECOSYS, FLEXPART, PC COSYMA, RTARC/PTM, RODOS/MATCH, HAVAR, ESTE.

The WG took note of the presentations of the Czech and Austrian participants on emergency management. Taking these presentations into account, it was agreed that in STEP III – "Food Chain" – sub-group 3 will focus on the activities of comparison with dose codes routinely used by both sides.

On November 8, 2002, an unscheduled meeting was held in Prague. At the meeting, a more detailed programme of STEP II.b activities was developed, and subsequently in December 2002, the Source Term 2 of scenario 2 from the RODOS library was approved by both sides as the input for Realistic Case Studies performed within STEP II.b

2.8.6 WG Meeting in Vienna, April 28-29th, 2003

The discussion of dose-risk factors related to STEP I.3 was addressed in the item “Food Chain" of the agenda of this WG meeting. The Austrian participants presented results of the "worst case" calculations as agreed in STEP I.4 via the CIRCA information platform. It was agreed that the Austrian side might come back to this item at an appropriate moment depending on the results of other “Road Map“ events. The WG considered STEP I to be closed.

Final results of the comparison of real-time emergency response models with two case studies in the framework of the co-operation of ZAMG and CHMI were presented according to STEP II.a.

In the framework of STEP II.b – "Realistic Case Studies" – different codes performed dispersion and dose calculations based on realistic meteorological cases with historical input data (prognostic or diagnostic data). The results of the calculations were presented and a comparison was made by both sides. Geographical information and several model parameters were exchanged and also agreed upon prior to the workshop.

The results of TAMOS and FLEXPART calculations and a comparison of FLEXPART and PC-COSYMA calculations were presented by the Austrian participants. The Czech representatives compared the long-range models RODOS/MATCH and RTARC/PTM, and the Austrian side used the PC-COSYMA code for comparison, too.

To sum up, in-depth discussion of the findings of the calculation comparisons within STEP II.b lead to a principal understanding of the differences of the Austrian and the Czech results. However, the results both sides obtained with PC COSYMA are in very good agreement. Apart from a joint summary note of conclusions of the STEP II.b exercise after the workshop, the WG considered STEP II to be closed.

Within STEP-III food chain aspects and counter measures were discussed. The Austrian side presented parameters and assumptions of the OECOSYS code for food chain calculations and the Czech side of the HAVAR code. The results for the ingestion dose calculated at the points of comparison (according to STEP II.b) and suggested counter measures on the basis of the results of STEP II.b dose calculation were summarised and discussed by the WG. In addition, the regulatory basis for urgent protective measures and precautionary protective measures was briefly summarised.

As a result of this workshop, the Austrian side was convinced to implement a computer code taking into account local weather conditions – beside the long- range computer code (TAMOS) already in use – for improving emergency management in Austria. Therefore, Austria asked the Czech Republic to supply Austria with the weather data from the NPP site and to transmit to Austria preliminary estimates of the release data based on the ESTE system. It was agreed to address this issue in the framework of the bilateral agreement. It was further agreed to test this new arrangement in the framework of joint exercises.

Finally, it was agreed to elaborate a joint summary of the entire item 7a attaching a full documentation of all important contributions and presentations after closing STEP III.

2.8.7 Joint Presentation at the International Symposium on Off-Site Nuclear Emergency Management, Salzburg, 29th September – 3rd October 2003

As agreed in the WG meeting in Vienna, April 28-29th, 2003, a joint presentation of the main results of the "Road Map" 7a activities was prepared and presented at the International Symposium on Off-Site Nuclear Emergency Management, Salzburg, 29th September – 3rd October 2003. The conference paper will be published in the proceedings of the Salzburg Symposium in a special volume on "Radiation Protection Dosimetry" in 2004.

2.8.8 WG Meeting in Prague, October 9, 2003

In a common review of the process, both sides underlined the fruitful co-operation of the Working Group, both during the presentations and discussions of the results at the workshop and in the phase of performing calculations and preparing results for comparison before the workshop. The Czech side appreciated the installation of a common information platform, CIRCA, provided by Austria in June 2002. Both sides considered this platform a very fruitful and effective tool and therefore intended to use it for future co-operation and exchange of views. Both sides agreed on a table of contents for a Joint Summary Report and a time schedule for the finalisation of this report.

Within the framework of STEP-III, food chain aspects and counter-measures were discussed. Both sides presented elaborate calculations based on an agreed working programme for comparison of calculated doses and suggested protective counter-measures. The WG considered its activities within STEPs I-III to be closed successfully.

The Czech representatives presented information on the development of new tools for SÚJB for decisions regarding counter-measures. Both sides exchanged information on the current status and further developments of their Radiation Monitoring Networks.

Regarding future co-operation, both sides agreed that in terms of a planned Bilateral Arrangement on data and information exchange in case of a radiation accident, the following data are expected to be exchanged:

- Actual weather conditions at the point of radionuclide release,
- Radionuclide air concentration and deposition forecasts based on weather models obtained by both parties,
- Forecasts of the course of the accident and its potential radiological consequences based on actual weather data and calculations from ESTE, HAVAR and other codes used by the Czech competent authority (in the future to be transmitted to the Austrian competent authority),
- Forecasts of radiological consequences based on prognostic weather predictions and calculations from TAMOS, OECOSYS and other codes used by the Austrian competent authority (in the future to be transmitted to the Czech competent authority),
- Territory and food chain monitoring results obtained by the Radiation Monitoring Networks of both parties.

According to the presentation and discussion at the Panel Session of the International Symposium on "Off-site Nuclear Emergency Management" held in Salzburg, 29th September – 3rd October 2003, the Czech-Austrian bilateral co-operation together with the bilateral co-operation with other countries could be the basis for a regional co-operation in emergency preparedness in Central Europe. The EURANOS project of the EU 6th Research Framework Programme provides a pragmatic opportunity to find out how such co-operation would function. It is assumed that the RODOS system will gradually become a quasi-standard used to assess the potential radiological consequences, and to inform the decision-making process. During the EURANOS project, therefore, the various mechanisms for the data exchange can be tested and evaluated. Based on these regional activities both sides proposed to intensify regional co-operation demonstrating its feasibility by using RODOS as an infrastructure.

2.8.9 Annual Bilateral Meetings on Issues of Common Interest in the Field of Nuclear Safety and Radiation Protection, 2002 and 2003

During both bilateral meetings under the Agreement between the Government of the Republic of Austria and the Government of the Czech Republic on issues of common interest in the field of nuclear safety and radiation protection, 2002 and 2003, an overview on the activities of the "Road Map" 7a) Working Group on comparison of calculations regarding the radiological consequences of BDBA was presented.

2.8.10 Concluding Statement

Summarising the outcome of the Working Group on comparison of calculations regarding the radiological consequences of BDBA established with a view to harmonising the basis for emergency preparedness in accordance with Item No.7, "Severe Accidents Related Issues – a)" of ANNEX I of the "Brussels Protocol", both partners conclude that the co-operation has been very successful and that within the last two years, 2002 and 2003, a large number of activities have been performed.

At the first meeting in Vienna, May 2002, a Working Group was set up and a work programme was agreed upon. Detailed comparison calculations in the field of assessing the radiological consequences were made and discussed in three additional Working Group meetings. The introduction of a common information platform, CIRCA, provided by the Austrian side in June 2002, allowed a quick and prompt exchange of information and results in the meantime.

The codes and models used in both countries in case of nuclear or radiological accidents and in the field of emergency preparedness were compared in different exercises. The assumptions and model parameters were discussed in detail and background information on the models and codes was exchanged. The emergency procedures in both countries were presented and the criteria for implementing different precautionary and protective (short- and long-term) measures were compared.

A basis for mutual understanding of procedures and codes used in emergency situations was created by the WG activities and the intensive information exchange has already had a very positive impact on the emergency preparedness in both countries. Furthermore, the results and the experience gained could be a basis for further harmonisation in the field of emergency management in both countries. Based on the results and conclusions of discussions, both sides consider activities within STEPs I-III to be brought to a successful close.

The result of the Working Group on comparison of calculations regarding the radiological consequences of BDBA are presented in detail in the comprehensive "Joint Summary Report".

As one of the main outcomes of the WG activities, a programme for future bilateral and regional co-operation in the field of emergency preparedness and emergency management is being developed by SÚJB and BMLFUW. These common future activities include an intensified data and information exchange and co-operation between both emergency centres. In terms of a bilateral agreement and mainly under the newly signed Arrangement, the following data are expected to be exchanged:

- Actual weather conditions at the point of radionuclide release,
- Meteorological prognoses for dispersion calculations (extracted from TAMOS),
- Radionuclide air concentration and deposition forecasts based on weather models obtained by both parties,

Since the publication of the "Joint Summary Report" in October 2004 this exchange of data has been more precisely specified:

- Forecasts of the course of the accident and its possible radiological consequences based on the actual weather data and calculations of ESTE codes,
- Forecasts of the possible radiological consequences based on prognostic weather predictions and calculations from TAMOS, OECOSYS,

Furthermore, it is envisaged that both countries will co-operate regarding relevant topics included in the European Union's 6th Research Framework Programme. The last but not least field of co-operation shall be the exchange of emergency planning experts in the Crisis Centres of both countries.

2.9 Item No. 7 – Severe Accidents Related Issues – b)

Technical Project Management	ENCONET Consulting (Austria) Institute of Risk Research, University of Vienna (Austria) ARCS Seibersdorf Research (Austria)
Technical Support from	Dipartimento di Ingegneria Meccanica, Nucleare e della Produzione (DIMNP), (University of Pisa – Italy) Dycoda LLC (United States of America) ENPRO-CONSULT Ltd. (Bulgaria) Fortum Nuclear Services (Finland) Institut für Kern- und Energietechnik (IKET), (Forschungszentrum Karlsruhe – Germany) A. Madonna (Consultant – Italy) H. Karwat (Consultant, Germany) V. B. Morozov (Consultant, Russian Federation) NRG, an ECN KEMA Company (The Netherlands) Nuclear Services Corporation, (Leiden – The Netherlands)
External Scientific Advisor to Umweltbundesamt	Helmut Hirsch (Consultant – Austria/Germany)

2.9.1 Basis and the background for the project

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” achivements 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”).

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 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) with the general management of the implementation of the “Roadmap”. Each entry to the “Roadmap” corresponds to a specific technical project [see ANNEX C of the FMR for Item 7b].

The objective of the Roadmap process covered by the item 7 as stated in ANNEX I of the “Brussels Agreement” is: *"Effective prevention and mitigation of consequences of beyond design basis accidents (severe accidents).”*

ANNEX I provides the following statements regarding the *“Present Status and specific Actions Planned”:*

“A set of preventive and mitigative measures is, at present, applied in NPP Temelín with respect to beyond design basis accidents. These include software and hardware measures, among others, e.g. Symptom Based Emergency Operating Procedures, Technical Support Centre, Post Accident Monitoring System, Emergency Preparedness.

For the purpose of emergency preparedness, the PSA was employed with the aim to identify and group events with different initiating occurrences, but with similar end-effects. On the basis of this assessment the relative risk was estimated for specific events in order to select those, which will serve for the determination of emergency response activities (pre-planned, reactive).

Severe Accidents Management Guidelines (SAMG) as a state-of-the-art tool will complete the whole system of mitigation measures with respect to the beyond design basis accident management. The project for SAMG development is scheduled to be finished by end 2002 to be followed by validation.

To foster mutual understanding two lines of activities will be followed within the framework of the bilateral agreement:

a) A Working Group on comparison of calculations regarding the radiological consequences of BDBA with a view to harmonise the basis for emergency preparedness will be established.

b) The exchange of information related to SAMG will include discussion on the analytical basis as well as on corresponding software and hardware measures."

The issue (a) has been covered in a separate project PN1 [see ANNEX C of the FMR for Item 7b], the issue (b) is covered by this project.

Refering to Chapter IV of the “Brussels Agreement” and the principles of the “Roadmap”, a number of issues identified in the “trialogue” of the Melk Process are found suitable to be followed-up in the framework of the Bilateral Agreement. The following seven issues are closely related to the topic of item No. 7 (b) and are therefore also covered in this project:

- Issue No. 1 Containment bypass and priminary-to-secondary (PRISE) leak accidents
- Issue No. 4 Containment Design and Arrangement
- Issue No. 5 Probabilistic Safety Assessment and Severe Accidents
- Issue No. 6 Emergency Operating Procedures EOPs & Severe Accident Management Guidelines (SAMGs)
- Issue No. 16 Hydrogen Control
- Issue No. 26 Beyond Design Bases Accident Analysis
- Issue No. 29 Technical Basis for Temelín Emergency Planning Zones (EPZs)

The Roadmap specified that the related Specialists’ Workshop would be held in the 1st half of 2003 to discuss this issue.This Specialists’ Workshop on the “Roadmap” item No. 7b was conducted in Prague on 17 and 18 June 2003 according to Article 7(4) of the Bilateral Agreement of the Exchange of Information on Nuclear Safety. This workshop was the key element in the monitoring process. The analysis of information made available there played a significant role in the development of the basis for the Final Monitoring Report.

An Austrian Experts' Team composed of international experts was committed by the Umweltbundesamt (Federal Environment Agency) on behalf of the Austrian Government to provide technical support for the monitoring on the technical level of the implementation of the SAMGs 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 PN7 comprising altogether seven predefined "project milestones" (PMs).

Consideration of beyond design basis accidents (BDBAs) of the NPP is an essential component of the defence in depth approach used in nuclear safety. BDBAs have low likelihood, but may have significant consequences resulting from the degradation of nuclear fuel. It is worth noting that accidents of low likelihood, but more severe than those taken into account in the design basis (i.e. BDBAs), have not been explicitly considered in the design of nuclear power plants, which are currently under operation. However, the possibility of severe accidents has been recognized later as an important safety issue and addressed in comprehensive and systematic way for most of the operating plants.

In accordance with the current safety philosophy the consideration of severe accidents in NPPs usually includes the following elements:

- Identification of event sequences that lead to severe accidents;
- Consideration of existing plant capabilities, including the possible use of some systems beyond their originally intended function, to return the plant to a controlled state and to mitigate the consequences of the severe accident;
- Identification of the permissible degree of non-uniformities in the hydrogen distribution in the atmosphere,
- Evaluation of potential design changes, which could either reduce the likelihood of these events or mitigate the consequences;
- Establishing accident management procedures, based on representative and dominant severe accidents.

The set of actions taken during the evolution of an event sequence towards a design basis accident (DBA) is known as Emergency Management and once the sequence enters any BDBA sequence – Accident Management (AM). Accident management is intended to prevent the escalation of the event into a severe accident, to mitigate the consequences of a severe accident, to re-establish critical safety functions and to return the plant to a controllable safe state. Accident Management Programmes (AMP) based on this concept were adopted in many nuclear plants starting from early 1980s. AMPs comprise plans and actions undertaken to ensure that personnel with responsibilities for AM are adequately prepared to take effective on-site actions to prevent or to mitigate the consequences of a severe accident and, when deemed necessary, to plan and implement plant functional modifications.

The Temelín Nuclear Power Plant (NPP), being of an original Soviet design, which was later upgraded with equipment following western philosophy, addressed severe accident management (SAM) in the later construction phase. Considering that the process of SAM implementation was not completed and information on the approach taken at the Temelín NPP was insufficient the "Severe accident related issues" remained as one of the items to be addressed during the follow up to the Melk process.

2.9.2 The objectives of the PN7 project

Enconet and IRR-ARCS, entrusted with the Technical Management of the Austrian Experts' Team, defined the following additional objectives in order to implement this overall objective:

- The **principal objective of the project** is to provide technical support and the expertise to assess the adequacy of the development and implementation of SAMGs at the Temelín NPP, as well as the overall approach to the issue of severe accidents at Temelín (see also the list of issues to be tackled according to the "Brussels agreement" (ANNEX I).
- The **specific objective** of the **horizontal segment** is to assure that all issues that need to be addressed within the evaluation of Severe Accident Management for Temelín are highlighted to allow for an evaluation considering state-of-the-art requirements and criteria as applied in European Union (EU) and/or the United States (USA).
- The s**pecific objective** of the **vertical segment** is to assure that specific contributors to early containment failure (such as hydrogen combustion) are included within the evaluation of SAM for Temelín.

2.9.3 Main tasks accomplished within PN7 project

2.9.3.1 Identification of severe accidents issues and scenarios

The issues, which are of relevance for understanding the phenomenology of severe accidents have been identified and relevant information collected. This includes all the accident phenomena, which have been identified (and for which specific reactors were analyzed) in the western countries and for Soviet designed reactors. Also issues, which are being discussed in research fora in Europe and in the USA have been added to the list.

After the issues were identified, their applicability for a WWER 1000 was investigated. This work resulted in a comprehensive list of issues, which are of relevance for a WWER 1000 and Temelín in particular. This issue list has served as a basis for the further investigation of Severe Accident issues important for Temelín.

2.9.3.2 Identification of approaches to prevention and mitigation of severe accidents

In addition to the identification of scenarios, the issues of prevention of severe accidents and approaches to their mitigation have been investigated using western practice as well as the findings of severe accident analyses of WWER 1000 units.

2.9.3.3 Review of applicability of Severe Accident issues and prevention/mitigation to Temelín

The specific applicability of severe accident issues to Temelín has been investigated to evaluate, which of the issues are of relevance and of interest for further studies. For this purpose information was drawn from other WWERs 1000 plants and considering Temelín specific upgrades, which are of relevance.

From the list of issues, which are applicable to Temelín, those, which are open issues or potentially problem issues in Temelín have been selected.

The review of regulatory approaches included the position of US Nuclear Regulatory Commission (US-NRC) on PWRs with large dry containments of US design, of licensing authorities within the EU such as the French IRSN, the German Reaktorsicherheitskommission (RSK) and of Western European technical support organizations (TSO) such as French-German consortium GRS/Riskaudit.

The US-NRC for their ruling has determined that dry containments offer such large safety margins that for the existing US plants, which implement WOG (Westinghouse Owners Group) SAMGs, the hydrogen combustion and direct containment heating issues can be considered resolved.

Licensing authorities within the EU apply various approaches in their respective countries. Detailed findings are presented in ANNEX A of the FMR for Item 7b.

The analysis of the actual situation in Temelín NPP showed that the plant is provided with a large dry containment, with comparable features to those in use with US pressurised water reactors (PWRs), but differing in some geometrical aspects, in particular in the shape of steam generator boxes, which are horizontal and not vertical as in the PWRs. This can result in slower dispersal or propagation of hydrogen released during not only the in-vessel accident phase and in possible increase of its local concentration to the values higher than in typical PWR containments. On the other hand, compared to the US plants, Temelín has the advantage of the installed passive hydrogen recombiners, which deplete hydrogen by combining it with oxygen to water over long-term operation. Detailed findings are presented in the report and summarized in Section 4.3 of the FMR for Item 7b.

2.9.3.4 Code calculations for assessment of selected sequences

The initial activity in this step was identification and selection of accident sequences leading to an immediate threat to the integrity of the containment either due to Molten Core Concrete Interaction (MCCI) failure or due to hydrogen formation leading to a detonable gas mixture within the containment. Both these cases were analysed using MELCOR, a computer code suitable to analyse to the detail required severe accidents and determine consequences. The MELCOR analyses have been done within both the horizontal segment and the vertical segment of PN7. The WWER 1000 MELCOR input deck available for Kozloduy NPP (KNPP) plant has been modified taking into consideration specifics of Temelín insofar as they were known. The results have been assessed to verify, which of the problem issues need to be specifically addressed for the development of SAMGs.

The calculations made in PN7 covered more than twelve scenarios with some variants aimed at checking sensitivity of results to the assumptions adopted in calculations. Several points in, which no sufficient data were available to judge Temelín statements have been identified, but generally the agreement of PN7 calculations results with those of TACIS programme for WWER 1000 NPPs and with Czech results for Temelín was reasonable.

As it was recognized that besides general review there is a need for in-depth analysis of the topics connected with hydrogen hazards, the problems of hydrogen generation and transient local distributions were addressed in MELCOR analyses of three scenarios plus a special 3-dimensional GASFLOW analysis for a specific scenario, providing insights into non-uniformities of hydrogen distribution during the phase of most intensive hydrogen release and the related hazards.

2.9.3.5 Identification of relevant steps in the development of SAMGs

With consideration of the severe accident sequences, their outcomes, probabilities, and possible mitigation measures, the steps relevant to the development of SAMGs have been established.

Based on experience of the project team in evaluation and validation of Severe Accident Management Guidelines (SAMG)s, the specifics to be investigated in this area have been identified.

The issues have been listed, which need to be addressed in relation to the adaptation of SAMGs and training of plant staff in the use of SAMGs.

The Severe Accident Management requirements have been analysed as indicated by international practice and formulated in the Westinghouse Owners Group (WOG) SAMGs. The available information on the Temelín approach and the SAMG development status was reviewed (The SAMGs as such were not available for review). The result showed that the SAMGs development and implementation by Temelín was said to have followed the WOG approach, taking into account WWER-1000 specific requirements and behaviour, it therefore can be assumed to correspond to good international practice and after completion the SAMGs in Temelín NPP should be equivalent to those in other plants using the WOG approach. However, it could not be reconfirmed by checking relevant documents during the monitoring process, that these are the facts, therefore some points needing further attention have been found as identified below.

2.9.3.6 Verifiable line items

The objective of this task was to break down the overall subject into the line items, which could then be verified for completeness and compliance with the accepted international practice. This task was the “road map” for the whole project. On the basis of all the analyses,, which are discussed above, the project team has identified all necessary elements, which are of interest in developing and implementing an acceptable severe accident management program including its verification. The list of Verifiable Line Items (VLIs) covering more than 240 questions in 40 topical areas has been developed, covering both SAMG development and accident sequences in the plant. It was the basis for consolidation of the information achieved during the joint Specialists’ Workshop with representatives of the Safety Authority and the Temelín NPP operator, which took place in June 2003 in Prague. There, the 240 questions addressing aspects of accident analyses and intended to examine correspondence of the accident analyses and SAMGs to internationally recognized practice could not be all posed at the Specialists’ Workshop due to intrinsic limitations of the procedure.

2.9.3.7 Specialists Workshop

The preparatory activities for the workshop included the development of briefing material and a briefing session for the Austrian delegation, and proposing experts to participate in the workshop as well as participation in the workshop. The compliance and differences with the state-of-the-art practices have been identified and commented on regarding their safety significance.

A list of documents was prepared (the Specific Information Request) that was considered to contain that kind of information required to provide profound answers to the VLIs.

In the Specialists’ Workshop the Czech side presented a set of twelve papers, which together with the discussion sessions made it possible to determine answers to sets of VLIs, as shown in the report. A number of methodological aspects have been left unanswered due to the limitations of time available and the complex nature of the phenomena involved in severe accidents analysis. Nevertheless, the information accumulated in the preparation of the Specialists’ Workshop and obtained during the Specialists’ Workshop is sufficient to formulate a coarse picture of the Temelín NPPs preparation to cope with severe accidents (given the fact that Sections 3.1.4, 3.1.5, 3.2.3, 3.2.4, 3.3.1, 3.3.2, 3.3.3, 3.3.4, 3.3.5, 3.3.6, 3.4.3, 3.6.2, and 3.6.5 of the main report of the FMR for Item 7b discuss areas where the information presented was evaluated as insufficient; in addition, see Section 1.4 of the main report of FMR for Item 7b for an explanation of the assessment framework). In some cases the Austrian delegation requested further written information and the Czech side provided it after the workshop. This information was subsequently used to repeat a selection of the calculations performed within PN7 project with updated characteristics of basemat concrete and hydrogen recombiners in the Temelín NPP. The final conclusions in the report are based on those updated calculations.

2.9.4 Main findings

2.9.4.1 Regulatory approach and practice

The Czech Nuclear Regulatory Authority (SUJB) has required the plant to prepare and accomplish a program to deal with BDBAs, including estimation of plant vulnerabilities, proposed accident management procedures and the schedule of their implementation. The maximum incident rates set by SUJB for severe core damage frequency and for large off-site releases are 10^{-4} and 10^{-5} events per reactor year, respectively, which is consistent with the INSAG targets for existing NPPs.

The responsibility for development of SAMGs is left to the utility. The regulatory body defines acceptance criteria and provides guidance to Temelín NPP, leaving enough flexibility for potential candidate actions to address specific challenges.

2.9.4.2 Temelín programme of severe accident management

The overall concept and approach to development/implementation of the SAMG package was found to reflect the current good practice in the SAM area. The selection of plant specific SAM strategies has been based on the well-established generic approach developed by Westinghouse Owners Group. These generic strategies have been adapted to Temelín plant conditions based on a systematic process that has been presented as the current state-of-the-art in this area.

The development and implementation of Temelín SAM programme has not been finalized, however it has been stated that it is well advanced. On several occasions the Austrian Experts' Team stated that the detail of information about accident sequences provided and the associated countermeasures is not sufficient to allow for a final evaluation, because the related analyses were declared as not fully completed yet.

The SAM programme is supported by severe accident analysis and plant specific probabilistic safety assessment (PSA). It should be noted that in addition some SAM strategies, apparently the most recent, are not well supported by severe accident (SA) analysis. For this reason, there were some instances, when the existing results of SA analysis were also not properly incorporated into the PSA. The interface between the PSA team and thermal hydraulic analysis team needs to be improved.

The PSA study includes Level 1 and 2. The first version of the PSA has been reviewed during an IAEA mission and the resulting recommendations are reported being incorporated into the upgraded study. The upgraded PSA was still not finalized at the time of the Workshop. Generally, the 1996 PSA study was developed in compliance with the current state-of-the-art, and the updated analysis was intended to address IAEA comments and the as-built design of the plant. The PN7 Austrian Experts' Team has observed some deficiencies, but they are not expected to have significant impact on the final conclusions with regard to SAM strategies. The existing results have been used in the development of SAMG strategies and setting up priorities in the execution of strategies.

The calculation tools used for SA analysis are similar to those used worldwide for the purpose of SAM. The existing analyses provide a reasonable basis for understanding plant specific vulnerabilities to severe accidents and the identification of AM strategies. However, the risks resulting from containment behaviour during severe accidents have not been assessed sufficiently, since some of the existing analyses are old and do not necessarily reflect the current plant status and state-of-the-art in the area of SA codes, modelling and simulation, in particular with respect to hydrogen distribution within the containment and with respect to the discharge of molten core material in case of a pressure vessel defect. The plant is planning to improve these analyses using more current codes and improved modelling concepts.

Westinghouse in close co-operation with plant staff has developed a plant specific SAMG package. The contents, structure, and format of plant specific SAMG, which were shown at the Specialists' Workshop, have been found to reflect the current state-of-the-art practice. This package was under internal review and translation into Czech language ongoing at the time of the Workshop.

Organizational arrangements related to SAMG had not been finalized at the time of the Specialists' Workshop. Although the upgraded ERP (Emergency Response Plan) had been submitted to SUJB for approval, the updated version of the Emergency Operating Procedures including transition points to SAMGs still needed to be developed and implemented. Some concerns can be raised in the definition of responsibilities/authorities for determination and approval of an intentional release of radioactive material during a SA. The items to be discussed also include TSC status and changes with respect to the availability of qualified staff to provide AM functions required in response to the sequences expected to dominate the risk. Interface functions and timeliness for decision making and of information distribution are of particular importance in this context.

It is recommended to address these aspects further on the technical level.

The plant has properly considered all further steps of SAMG implementation including validation and training, and plans for their execution are being developed. Based on the available knowledge all the related plant arrangements are considered adequate. Little is known about the training and refreshing courses of SAM staff and the related schedules for implementation. Therefore, it would be welcome if the related activities would be subjected to further treatmentin the framework of the pertinent bilateral Agreement between Austria and the Czech Republic.

It should be noted that proper evaluation of the SAMG package including the supporting analyses would require detailed investigations that involve specialized expertise and considerable effort. Such an evaluation was beyond the scope of PN7 project. Therefore, it would be very desirable to have detailed aspects of SAM development and implementation addressed by qualified independent external reviewers. It is known that the plant management and SUJB seriously consider having an independent review of SAM (i.e. a IAEA RAMP Mission).

2.9.4.3 Technical measures available in Temelín for SA management

One of the main areas of hazards due to severe accidents is that of primary to secondary circuit leaks, since such leaks involve loss of primary coolant accidents with the leak point situated outside the containment. In case of such an accident all four barriers preventing radioactivity release to the environment can be lost simultaneously. Both contemporary regulatory guidance and industrial practice stress the necessity to avoid large PRISE events. In Temelín the hazards involved in primary to secondary leak (PRISE) accidents are well recognized, the appropriate strategies developed and the technical means are provided to cope with PRISE events.

Another potential hazard is connected with long term complete loss of electric power (station blackout), both from outside sources and from emergency diesel generators installed at the NPP. In such a case the means of heat removal from the reactor are lost, except for gradual evaporation of water, first in the secondary, then in the primary coolant circuit. If this situation persists for several hours, the coolant in the core evaporates, the core dries out, and will be damaged.

The preventive measures at Temelín NPP address the issue of station blackout. The most important measure for mitigation of the effects of blackout and other transients involving loss of electric power consists in early forced depressurization of the primary circuit. While not comprehensive, summary presentations of calculations carried out by the Czech experts as well as calculations performed within the PN7 project indicate that the capability for depressurization in Temelín is comparable with that in other plants of similar vintage and is sufficient for timely depressurization of RCS.

The WOG SAM strategies being implemented at the plant recognize the importance of depressurization and the EGRS, although of limited capacity, can serve as an additional means of depressurization in the unlikely case of a severe accident with PORV failure.

The ejection of molten corium under high pressure involves the hazards of molten corium attack against the containment liner and possibly against other surfaces involved in providing containment leak tightness.

Information about the development of depressurization measures in this context was provided. An in-depth analysis of the implementation was not performed in the frame of this monitoring process.

The measures taken to prevent a blackout – important as an initiating event – seem to be satisfactory. In view of the long delays of core damage in case of blackout, the limited capacity of batteries in Temelín seems to be inappropriate. According to the design, the period of time that the batteries deliver power sufficient for plant control is shorter than the time that would pass before severe damage of the core occurs. Thus the potential advantages of good thermal hydraulic properties of Temelín could not be used due to battery limitations. Temelín EOPs and SAM strategies include measures to extend battery power supply time by restructuring the load profile much beyond the design period of 1 hour. Nevertheless, it would be desirable to exchange batteries or include into the system additional power sources providing electric power for instrumentation & control during station blackout.

An important safety advantage of Temelín NPP is the fact that it is provided with a large dry containment. This reduces considerably the challenges to containment integrity during severe accidents. For similar NPPs with large dry containments, the hazards of early containment failure due to direct containment heating (DCH) have been evaluated as rather low and the strategy of reactor coolant system (RCS) early depressurization included in SAM in Temelín will further reduce such hazards, provided it is initiated early enough and takes place sufficiently fast.

The long-term pressurization hazards are reduced by the fact that the basemat concrete in place in Temelín practically does not contain any carbon, so there is no build-up of carbon monoxide and carbon dioxide due to molten corium-concrete interaction. This keeps low the long-term quantities of non-condensable and burnable gases generated inside the containment. The calculations with the MELCOR code showed that the containment integrity is not threatened by long-term increases of pressure due to gas generation. Rather, the calculations show that basemat failure occurs long before overpressure failure would become an issue.

In case that the depressurizing strategy would fail due to unlikely reasons (opening of one PORV is sufficient to depressurize effectively the primary circuit) then the accumulation of molten corium at the RPV bottom heating the reactor pressure vessel wall under high pressure conditions would result in RPV failure under pressure.

The corium would be expelled then from the disintegrated RPV into the cavity, driven by still significantly high pressure, leading to a massive local pressure build up transient, in case that the door of the cavity cannot be opened before the failure of the RPV.

As a consequence the structures in the lower part of the containment as well as the containment liner could be mechanically damaged. An intact containment liner is pre-requisite for containment leak-tightness – in case of damage – strongly elevated leakage from the containment would have to be expected.

However, in view of the information on PORVs' failure rates and qualifications as presented during the Prague Specialists' Workshop, the hazard of high pressure path can be considered as unlikely.

Hydrogen hazards in NPPs with large dry containment are considered to be unimportant by US NRC and some regulatory bodies in EU countries, but most EU regulatory bodies require technical means for hydrogen depletion.

In Temelín the release rates of hydrogen during the in-vessel phase of the accident are comparable with those in PWRs, and the volume of the containment is similar. The geometry of the steam generator boxes and the ducts in Temelion NPP is different from that in PWRs and makes hydrogen mixing less effective, which in case of small break loss-of-coolant accidents (SB LOCA) can lead to local formation of sensitive clouds of hydrogen during the in-vessel accident phase.

The predictions presented for the Temelín NPP concerning hydrogen distribution in the containment in the course of various severe accidents are not sufficient. Indications from an exemplary GASFLOW simulation suggest, that temporary high local hydrogen concentrations can lead to powerful deflagrations, eventually even to detonations.

In the long term the installed hydrogen recombination system of Passive Autocatalytic Recombiners (PARS) – (designed for DBA conditions, but since passive, operating also under severe conditions) – will contribute to containment inerting by reducing the hydrogen and oxygen content. However, this process is slow, and these PARS are insufficient to cope with temporary deflagrative and detonative hydrogen-oxygen-steam mixtures in case of core melt accidents. Therefore for severe accidents it would be advantageous to have properly located PARS of higher capacity.

The means for deliberately initiating local hydrogen burns are not installed therefore an intentional initiation cannot be performed with the current provisions at the plant.

The frequency of hydrogen explosion causing containment failure in severe accident sequences has preliminarily been estimated by Austrian experts of the IRR to be $1{,}7\times10^{-7}$ per year of operation.

Most likely this sequence results directly in containment failure with a large source term – large quantities of radioactive substances are released unhindered to the environment. In this context it should be noted that the product of the mean severe accident frequency and the mean accident radiologic consequences to be assumed would represent the approximate contribution of these accident scenarios to the overall risk [derived from the respective accident sequences] to the public per year of operation.

In the ex-vessel phase the presence of a large dry containment and early inerting of the containment by steam contribute to prevention of hydrogen hazards:

The Czech strategy is supposed to consist of:

a) early intentional hydrogen deflagration (through planned actuation of equipment to try to initiate a deflagration), which should help reduce formation of sensitive clouds during in-vessel phase (currently not installed);
b) reliance on the hydrogen recombiners (PARs) to gradually reduce the hydrogen source in the containment (Design Basis Accidents' capacity only);
c) long term inerting of containment with steam during the ex-vessel phase with procedural controls on spray actuation to prevent deinerting burns (under development); and
d) as necessary, venting the containment through a high pressure venting line through filters to the plant stack to release hydrogen from the containment (under development).

Both Czech and PN7 calculations showed that in the case of unplanned actuation of the containment spray system at the moment when the contents of hydrogen is the highest the containment integrity could be lost, and Czech materials provide an evaluation of radiological consequences of such a scenario. However, the SAM strategy proposed for Temelín addresses the issue of reduction of the hazards of late confinement failure due to hydrogen deflagration in line with the Westinghouse SAMG approach.

In the case of ultimate necessity, Temelín can reduce the pressure in the containment through partial release of the containment atmosphere via the containment pressure test depressurization line and/or reduce also the hydrogen content.

This strategy is still under development. The heating due to fission product collection in filters can result in rising filter temperatures (with loss of filter efficiency) or in the worst case initiate fire at the filter.

For the time being, the method to be used for gas releases from the containment to reduce pressure has not been confirmed. Thefore the issue of introducing filtered venting in Temelín should stay on the agenda of future bilateral information exchange.

The main severe accident hazard consists in the possibility of <u>containment basemat penetration</u>.

The measures planned be implemented in Temelín in case of RPV failure at low pressure assure slowing down of the molten corium concrete interaction (MCCI) process. While these measures go in the right direction, it cannot be proved that they assure protection of the basemat against penetration by molten corium if RPV failure occurs. The likelihood of reactor pressure vessel (RPV) failure is small, as shown by recent analysis, but it exists e.g. due to possible embrittlement. According to the statements of Czech specialists, the measures planned in Temelín include corium spreading and water-cooling, which together with the planned remote opening of the cavity door should enable to stop the corium progression.

The calculations performed within PN7 project confirmed that corium spreading slows down the process and provides additional time margins. The effectiveness of water-cooling was not studied in PN7 due to the lack of access to the latest experimental OECD data. Recent information about the results of large scale tests on concrete penetration by molten corium conducted within OECD programme on “The Melt Coolability and Concrete Interaction“ indicates that in large scale test in the US enhanced cooling was obtained due to long term water cooling of the molten corium mass. Other experimental studies in Germany in this matter indicate some limitations for the reduction of the core melt attack by top cooling of released core melt with water. The Czech Republic participates actively in some programmes and has the actual information available on the OECD MCCI program.

As of now, the stopping of the corium erosion progress cannot be clearly demonstrated. Therefore, the Temelín staff considers additional measures aimed at improving leak-tightness of rooms below the containment basemat. The hazards due to radioactive releases in case of basemat melt-through are much smaller than in the case of an early containment-failure. As shown elsewhere, for releases due to basemat failure, the mass of radioactive aerosols still suspended in the containment atmosphere is dramatically reduced (orders of magnitude) compared with early containment failure. Not considering re-volatilisation and emanation of deposited contaminants during late containment failure, the offsite radiological hazards are correspondingly reduced.

During the Specialists’ Workshop in Prague, in response to questions the Czech specialists discussed the environment in the reactor building after melt-through of the containment basemat. The Czech experts discussed an evolving strategy of attempting to prevent revolatilization of fission products that have already been deposited on surfaces in the containment; this could result from violent air turbulence in case the containment would depressurize when the basemat melts through. The evolving strategy also includes prevention of hydrogen combustion in the reactor building after basemat melt-through. The reason for this is to preserve reactor building integrity to allow both for natural aerosol attenuation mechanisms to lower the source term, and to allow the release from the reactor building via the plant stack (via the reactor building ventilation system) to achieve greater dispersion and lower radiation doses offsite.

The strategy would involve depressurization of the containment – before basemat melt-through – via the venting system (high pressure duct work to the plant stack). This would also reduce the hydrogen concentration in the containment. During the Specialists' Workshop Prague Czech specialists mentioned these issues, but no detailed information was obtained on the approach being followed.

The measures and strategies to reduce fission product releases will be in line with the international practice once they are introduced as outlined at the Specialists' Workshop. The open issues are mostly connected with the reduction of radiological releases in the case of basemat penetration by molten corium. Czech specialists consider it a problem for future consideration, while they see as the most urgent tasks those, which are related to prevention of the basemat melt-through.

2.9.5 Recommendations for Future Bilateral Information Exchange

The monitoring process conducted so far within the framework of the "Brussels Agreement" (ANNEX I) in the area of severe accidents helped to clarify a number of relevant issues. It was demonstrated that a comprehensive process directed towards accomplishing the comprehensive SAM and mitigation of SA consequences is in place at Temelín NPP.

However, this process is still ongoing and the Austrian Experts' Team at the present can only follow a number of views and expectations on the SAMs final implementation as expressed by the Czech side: The Austrian Experts' Team must assume from the information available, that adaptations of the plant, like the additional means for an early pressure reduction in the primary system, the mechanism to remotely open the cavity door, the installation of load resistive spoilers against unhindered spreading of the corium entrainment into the containments lower part and eventually draining out through the base-plate, as well as passive recombiners with increased capability have not been installed up to now.

Control of the containment atmosphere during a Severe Accident remains a challenge. Establishing and maintaining an inert containment atmosphere relies on appropriate multiple operators' actions.

For these facts the Austrian Experts' Team would recommend revisiting the findings in the framework of the pertinent bilateral Agreement between Austria and the Czech Republic.

The following areas were identified as of interest:

- The supporting severe accident analysis and PSA as well as their use in the verification of SAM strategies and the related procedures,
- SAMG implementation activities including procedural framework, SAMG validation, and SAM-related staff training,
- Identification of the permissible degree of non-uniformities in the hydrogen distribution in the atmosphere
- Implementation of plant changes to enhance the technical measures for SAM (e.g. in spite of the importance of the cavity door opening during severe accident sequences, before corium enters the reactor cavity – the appropriate provisions have not been implemented by end of March 2005.

The Austrian Experts' Team recommends revisiting the calculations which have been announced to be made by Temelín NPP using MELCOR 1.8.5 and other code systems, and recommends making the results – as compared to previous calculations – subject of bilateral expert discussions:

More details regarding proposed areas are provided below.

- The capabilities of PORV, together with the effectiveness of the planned primary coolant system depressurization procedure,
- The regulatory framework for and effectiveness of hydrogen control, and/or additional use of filtered venting for mitigation of radioactive releases,
- Operational capabilities of the emergency gas removal system in SA conditions,
- Analyses of basemat meltthrough failure.

The Austrian Experts' Team also recommends revisiting the SAMG implementation activities at Temelín in order to confirm that the remaining steps of the implementation process are successfully completed. Important items that need further monitoring/verification include the revised procedural framework, SAMG validation, and staff training process. At the same time the recommendations from any independent review of SAM and their resolution should be paid due attention.

Technical measures needed for prevention and mitigation of risk significant scenarios should be monitored to demonstrate that appropriate plant arrangements are in place (both procedures and hardware measures). Due attention should be given to SA situations that are most relevant from safety point of view such as basemat penetration in case of molten corium release from the RPV and station blackout. Aspects, worth to be mentioned in this context include the measures for timely opening of the reactor cavity door before the RPV failure, protection of containment penetrations and the containment liner against MCCI, and increasing the capacity of batteries. Further analytical work conducted by the plant and the TSO staff on the MCCI hazards and mitigation of the related radiological consequences should also be included into the further exchange of information.

2.10 Chapter V – Environmental Impact Assessment

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The Republic of Austria and the Czech Republic, using the good offices of Commissioner Verheugen, reached an accord on the "Conclusions of the Melk Process and Follow-up" on 29 November 2001 ("Brussels Agreement"). In order to enable an effective use of the "Melk Process" achievements in the area of nuclear safety, 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 four-member Commission on the Assessment of Environmental Impact of the Temelín NPP – set up on the basis of 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).

It has to be recalled, that with the 'Melk Protocol' a comprehensive and full-scope environmental impact assessment of the Temelín NPP guided by the Council Directive on the assessment of the effects of certain public and private projects on the environment (Council Directive 85/337/EEC as amended by Council Directive 97/11/EC), in particular with regard to the participation of neighbouring countries has been agreed.

The signatories of the "Conclusions of the Melk Process and Follow-up" agreed that the implementation of the said measures would also be regularly monitored jointly by Czech and Austrian experts within the pertinent Czech-Austrian Bilateral Agreement.

A "Roadmap" for the monitoring on a technical level in the framework of the pertinent Czech-Austrian Bilateral Agreement as foreseen in the "Brussels Agreement" was 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.

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

Furthermore, the Federal Ministry of Agriculture, Forestry, Environment and Water Management commissioned the Umweltbundesamt to give technical support for monitoring the implementation of the measures referred to in Chapter V of the Conclusions. This specific project is referred to as project PN5. Therein, special attention was paid to the implementation of the measures which are of particular interest to Austria.

Following the information exchange at the annual meetings organised under the pertinent Czech-Austrian Bilateral Agreement in 2002, 2003 and 2004, and at an additional meeting of the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management and the Umweltbundesamt with representatives of SÚJB and the EIA commission in February 2005, the current status can be summarized as follows:

- An overview has been given by the EIA commission and SÚJB on the status of implementation of the said measures, their scope and the organisations in charge.
- Most of the activities for the implementation of the said measures are still under way, some for the whole service life time of the NPP Temelín.
- The pertinent Czech-Austrian Bilateral Agreement is considered to be the appropriate framework for further joint monitoring of the ongoing process of the implementation of the measures.
- It is of particular interest how the implementation of the measures for which corresponding research projects come to an end in the near future will be continued and how they will be integrated into standard programmes of the corresponding authorities.
- Furthermore, if there are any changes in the functionality of the EIA commission web-page as an information platform, continued provision of information to the general public needs further attention in the further bilateral information exchange.

3 ABBREVIATIONS

AM	accident management
AMP	accident management programme
ASME	American Society of Mechanical Engineers
BDBA	beyond design basis accident
BMLFUW	Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management
BRU-A	main steam relief valve
ČEZ	electrical utility, owner of Temelín NPP
CSCR	comprehensive safety case revisit
DBA	design basis accident
DEGB	double-ended guillotine break
ECT	eddy current testing
EIA	environmental impact assessment
EQ	equipment qualification
ERP	emergency response plan
ETE	Elektrarna Temelín (power plant Temelín)
FEM	finite element method
FMR	Final Monitoring Report
GIS	Geographic Information System
HEL	high energy line
HELB	high energy line break
IAEA	International Atomic Energy Agency
ISI	in-service-inspection
KTA	Kerntechnischer Ausschuss (German rulemaking body)
MCE	maximum credible earthquake
MFW	main feedwater
MHPGA	maximum horizontal peak ground acceleration
MS	main steam
MSK	macroseismic intensity scale according to Medvedev Sponheuer Karnik
MSSV	main steam safety valve
ND	nominal diameter
NDT	non-destructive testing
NPP	nuclear power plant
OBE	operating basis earthquake
PM	Project Milestone

PN	Project Number
PMR	Preliminary Monitoring Report
PORV	Power Operated Relief Valve
PSA	probabilistic safety assessment
PTS	pressurized thermal shock
PWR	pressurized water reactor
PTSA	pressurized thermal shock analysis
QB	Qualification Body
RPV	reactor pressure vessel
RPVI	reactor pressure vessel integrity
RAMP	Review of Accident Management Programmes (IAEA mission)
SAM	severe accident management
SAMG	severe accident management guidelines
SGSV	steam generator safety valve
SIF	stress intensity factor
SIR	specific information request
SL1	safety level 1, corresponding to the operating basis earthquake (OBE)
SL2	safety level 2, corresponding to the safe shutdown earthquake (SSE)
SMR	Summary Monitoring Report
SONS	see SÙJB
SPSA	seismic probabilistic safety assessment
SSE	safe shutdown earthquake
SSS	Safety Status Series (published by IAEA)
SÚJB	Czech State Office for Nuclear Safety
TH	thermo-hydraulics
TSC	technical support center
TSO	technical support organisation
US NRC	US Nuclear Regulatory Commission
VLI	Verifiable Line Items
WG	working group
WOG	Westinghous Owners' Groug
WWER	Water-Water-Energy-Reactor, reactor type developed in the Soviet Union
WPS	warm pre-stress (effect)

4 UNITS

°C	Celsius (degrees) (temperature): 0 [°C] = 273,6 [K]
°C/h	Celsius per hour (temperature change with time) 1 [K/h] ≡ 1 [°C/h]
1/a	Events per year (frequency of events per year (of reactor operation))
Bar	Bar (pressure difference) 1 [Bar] = 10E5 [Pa] (in excess of environmental)
Bar_{abs}	Bar absolute (pressure absolute) 1 [Bar] = 10E5 [Pa]
cm	Centimeter (length)
cm/h	Centimetres per hour (speed (here speed of ablation))
d	Day (time)
g	Gram (weight)
K	Kelvin (degrees) temperature or temperature difference
K/h	Kelvin per hour (temperature change with time) 1 [°C/h] ≡ 1 [K/h]
kg/s	Kilogram per second (mass-flow)
kJ/mol	Kilo-Joule/Mol (work per Mol – chemical reaction work)
km	Kilometer (distance, length)
kPa	Kilo-Pascal
m	Meter (length)
m^2/MW_{th}	Specific surface for heat transfer
m^3	Cubic meter (volume)
mm	Millimeter (length)
MPa	Mega-Pascal
MPa_{abs}	Mega-Pascal absolute (pressure)
MW_e	Electrical power output/demand
Pa	Pascal (pressure) 1 [Pa] = 1[N/m²]
s	Second (time)
Sv	Sievert (effective dose (received by humans from radioactive radiation))
Sv/a	Sievert per year (of operation) Risk to the public resulting for one year of operation
t	Ton (weight)
t/h	Tons per hour (mass flow)
vol.%	Fraction of volume (gas)
wt.%	Fraction of weight (solids, liquids) or also denoted as %
y	Year (time)

ANNEX A

"CONCLUSION OF THE MELK PROCESS AND FOLLOW-UP"

CONCLUDING STATEMENT

ON THE NEGOTIATIONS HELD ON 29 NOVEMBER 2001
BETWEEN THE CZECH AND AUSTRIAN GOVERNMENTS
LED BY PRIME MINISTER ZEMAN AND FEDERAL CHANCELLOR SCHÜSSEL
WITH THE PARTICIPATION OF COMMISSIONER VERHEUGEN
ON THE

"CONCLUSION OF THE MELK PROCESS AND FOLLOW-UP"

The Republic of Austria and the Czech Republic have, using the good offices of Commissioner Verheugen, reached an accord on the annexed "Conclusions of the Melk Process and Follow-up". They have agreed to communicate this agreement, in an appropriate form, to the Accession Conference.

Prime Minister Milos ZEMAN **Federal Chancellor Wolfgang SCHÜSSEL**

Commissioner Günter VERHEUGEN

Conclusions of the Melk Process and Follow-up

Preamble

With the aim of further developing good-neighbourly relations between the Czech Republic and the Republic of Austria, a "Protocol on the Negotiations between the Czech and the Austrian Governments, led by Prime Minister Zeman and Federal Chancellor Schüssel with the Participation of Commissioner Verheugen" was signed in Melk on 12 December 2000, further referred to as the 'Melk Protocol'.

The signatories of the 'Melk Protocol' found it appropriate to meet in Brussels on 29 November 2001 to define a follow-up to the process set forth in the Protocol mentioned above.

The signatories agree that the process started in Melk has led to an improvement in the exchange of information on the Temelín Nuclear Power Plant thus creating prerequisites for more confidence between the Czech Republic and Austria within an intensive dialogue on nuclear energy.

The signatories agree on the usefulness to open expert talks on amending the existing bilateral Agreement on the Exchange of Information on Nuclear Safety, concluded between the two states in 1989 so as to correspond to the achieved level of confidence and the needs of the signatories, including a reliable Info-Hotline.

Respecting the sovereign right to select their own energy policy, the two countries share their interest in a high level of nuclear safety of nuclear installations. The Czech side recognises the specific interest of the Republic of Austria as a neighbouring state in a high level of safety of Czech nuclear power plants.

The Czech Republic is exclusively committed to the provisions of Vienna Convention on Civil Liability for Nuclear Damage and Joint Protocol to the application of the Vienna Convention and the Paris Convention. The Republic of Austria is fully committed to the Austrian Nuclear Liability Act of 1999.

Chapter I - Info-Hotline

The Info-Hotline was installed immediately after the negotiations in Melk and its functionality is positively assessed by the signatories.

The Czech side has been providing information also on putting into operation the non-nuclear part of the first unit as well as information on the second unit of the Temelín NPP.

The Czech Republic and Austria agree that the Info-Hotline constitutes a useful measure, also with regard to nuclear and non-nuclear testing of both units, that its functionality will be regularly assessed within the bilateral Agreement on Information Exchange and that, if needed, measures will be taken to increase its effectiveness.

Chapter II - Early Warning System

An automatic monitoring device in `Ceské Budìjovice provided by Austria was installed on April 24, 2001 and the supply of data on radiation levels from the monitoring network continues without any problem.

The signatories agree that this measure fully meets its purpose and will remain in operation.

With a view to establishing a regional network in the long-term, which could be included into ECURIE, the possibilities of exchanging data with other national monitoring networks will be explored.

Chapter III - Energy Partnership

The Czech Energy Agency has been co-operating with the Austrian Energy Agency in the fields of energy efficiency and reconstruction of tenement houses, exploitation of renewable energy sources and the use of co-generation units. The signatories will make further efforts to intensify this co-operation.

Chapter IV - Safety Issues

The Czech and the Austrian side appreciate the role played by the European Commission in establishing and facilitating a "trialogue", launched to find a better mutual understanding on the issue of the Temelin NPP related to nuclear safety.

During the process, twenty-nine issues of Austrian concern have been identified. All of them were documented and addressed. The expert mission under the Melk Protocol regarded nine issues as closed, meeting the purpose of the Melk process. Due to the nature of the respective topics, the expert mission found another ten issues suitable to be followed-up in the framework of the pertinent Czech-Austrian Bilateral Agreement. Finally, the Melk process helped to narrow gaps in the understanding of remaining ten issues.

Even if it was not possible to reach an agreement on all the technical issues at stake, all participants agreed that the aim foreseen in Melk, namely to facilitate the dialogue between the Czech and Austrian governments, has been achieved.

In order to enable an effective use of the Melk process achievements in the area of nuclear safety, the Annex I to this Protocol contains details on:

- Process and documentation of the "trialogue"
- Specific actions to be taken as a follow-up to the „trialogue“ in the framework of pertinent Czech-Austrian Bilateral Agreement.

The signatories are fully aware of the AQG/WPNS Report on Nuclear Safety in the Context of Enlargement, in particular the recommendations pertaining to the NPP Temelín contained therein. The signatories agree that the peer review procedure foreseen by the EU to monitor the implementation of the recommendations should serve as another important tool to handle remaining nuclear safety issues.

Furthermore, the Czech Republic and Austria agree to intensify bilateral co-operation on emergency preparedness.

Chapter V - Environmental Impact Assessment

With the ‘Melk Protocol’ the signatories agreed on a comprehensive and full-scope environmental impact assessment of the Temelín NPP guided by the Council Directive on the assessment of the effects of certain public and private projects on the environment (Council Directive 85/337/EEC as amended by Council Directive 97/11/EC), in particular with regard to the participation of neighbouring countries.

To this end, a four-member Commission on the Assessment of Environmental Impact of the Temelín NPP was set up on the basis of a resolution of the Government of the Czech Republic.

The Commission on the Assessment of Environmental Impact of the Temelín NPP presented a report and recommended in its Position the implementation of twenty-one concrete measures (Annex II).

The signatories agree that the implementation of the said measures will be regularly monitored jointly by Czech and Austrian experts within the bilateral Agreement on the Exchange of Information.

Furthermore, the Czech Republic and Austria agree to intensify bilateral co-operation on emergency preparedness.

Chapter VI - Commercial Operation

Unit 1 and 2 of the Temelín NPP will only be put into commercial operation following the successful termination of commissioning and trial run. During these stages all tests prescribed by the programmes approved by the State Office for Nuclear Safety and required by the Czech legislation have to be performed and all relevant criteria corresponding to the state-of-the-art safety criteria prevailing in the Member States of the European Union have to be fulfilled, including this Protocol. In any case the implementation of those safety measures enumerated in Annex I, which are conditional for the safe operation of the NPP Temelín in line with Czech legislation, is a prerequisite of commercial operation.

Chapter VII - Free Movement of Goods and Publicity in the Media

The signatories positively assess the efforts to maintain and respect free movement of goods and persons. The signatories agree also in this respect to continue to honour their pertinent commitment of the “Melk Protocol”.

Chapter VIII – Enlargement

Based on the understanding that the Czech Republic will inform the Accession Conference comprehensively of the technical and procedural substance as well as of the binding character of this document and based on the understanding that the common position of the EU on the Energy Chapter will adequately reflect the information to the Accession Conference mentioned above, the Republic of Austria will agree to contribute constructively to start the next steps for the Energy Chapter as foreseen in the “road map” of Nice in order to start the implementation of the Protocol.

Closing provisions

The signatories shall – irrespective of the ownership of the NPP Temelín – guarantee the implementation of the conclusions of this Protocol in accordance with domestic legal regulations of the Czech Republic and international agreements.

The signatories state that the implementation of specific steps of this "Conclusions of the Melk Process and follow-up" will be monitored 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.

A "road map" regarding the monitoring on technical level in the framework of the pertinent Czech-Austrian Bilateral Agreement as foreseen in this Protocol will be 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 by 10 December 2001 at the latest.

In accordance with the importance attached by the EU to nuclear safety, as underlined by the European Council in Cologne and Helsinki, both sides will actively support and promote a high level of nuclear safety in the enlarged EU.

Austria and the Czech Republic agree on the common objective to include the bilateral obligations contained in these "Conclusions" in a Protocol to the Accession Act.

Brussels, 29 November 2001

Annex I

According to the Chapter IV of the Protocol, the parties established „an expert mission with trilateral participation“ which was dispatched first to Vienna, on 2 February 2001, to identify the Austrian main issues of concern. During a subsequent mission to Prague and the Temelin NPP, on 15 and 16 March 2001, the same expert mission heard the explanations given by representatives of the Czech Republic on these issues of concern. Five issues of major concern to Austria were selected and discussed in depth. Two additional workshops were organised by the Czech side in February and in April to accommodate specific technical issues. An IAEA Operational Safety Review Team mission lasting for three weeks in February 2001 reviewed the operational safety of the plant. The conclusions were presented to the trilateral expert mission. A final joint meeting took place in Brussels, on 14 and 15 May 2001, in order to find solutions to the identified problems, on the basis of the state-of-the art relevant in the Member States of the European Union. A final discussion between heads of delegation took place in Brussels on 30 May 2001, at the request of the Austrian side.

This process is documented in a Working Paper Summarising the outcome of the Expert Mission with Trilateral Participation Established Under the Melk Protocol (July 2001). It has been drafted under the sole responsibility of European Commission experts involved in the process. It summarises the work of the tripartite mission. For each of the twenty-nine issues of concerns identified, this paper provides a summary of the discussions that have taken place. To limit the size of this paper recording the positions of the parties, these have been summarised. The summaries therefore do not always present the full scope of the concerns expressed or the details of the information provided.

To enable an effective ”trialogue” follow-up in the framework of pertinent Czech-Austrian Bilateral Agreement, a seven-item structure given below will be 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 SUJB respectively.

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

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 side understand that the first two items below in particular would be subject to this peer review procedure.

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

Objective:

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.

Present Status and Specific Actions Planned:

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.

Item No.2 Qualification of Valves
(AQG/WPNS country specific recommendation)

Objective:

Demonstration of reliable function of key steam safety and relief valves under dynamic load with mixed steam-water flow.

Present Status and Specific Actions Planned:

Demonstration of reliable function of key steam safety and relief valves is included in original 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 qualification documentation in order to re-evaluate validity of Temelin key steam safety valves qualification. The result of these efforts will be made available to the Regulatory Authority till the June 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 Regulatory Authority and if needed included into the above - mentioned regulatory decision in order to meet the objective of this item.

Item No.3 Reactor Pressure Vessel Integrity and Pressurised Thermal Shock

Objective:

The reactor pressure vessel (RPV) integrity under pressurised thermal shock (PTS) conditions shall be maintained with a sufficient safety margin against brittle fracture throughout the NPPs service life.

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

Present Status and Specific Actions Planned:

The NPP Temelin is commissioned and operated respecting pressure-thermal (PT) curves calculations developed according to Westinghouse methodology. These calculations will be expanded with set of the further PTS analysis for both units using a step by step approach with full respect of the IAEA Guidelines for the PTS analysis. The PTS analysis will be finished in accordance with approved project work plan for this item.

Item No. 4 Integrity of Primary Loop Components – Non Destructive Testing (NDT)

Objective:

Selected safety classified primary circuit components shall be inspected using certified NDT methods to maintain their safety function.

Present Status and Specific Actions Planned:

The NDT qualification programme is being applied in accordance with the European Network for Inspection Qualification (ENIQ), recommendations from the European regulators (document EUR 16802) and IAEA principles. The qualification of inspection procedures using test blocs will be conducted not later than its first application within the in-service inspection programme.

Item No. 5 Qualification of Safety Classified Components

Objective:

All safety systems shall be qualified for their dedicated safety function.

Present Status and Specific Actions Planned:

The seismic qualification is completed. The EMC (Electro Magnetic Compatibility) qualification is completed. Respective documentation is completed and filed. In the case of environmental qualification, all processes (tests and/or analyses) required by licensing procedure have been performed. Qualification of I&C and electrical supplies, which represent the majority of the equipment relevant for qualification, is documented and filed in a standard format. In a limited number of the cases (where the equipment was procured in the beginning of the nineties), regulatory authority requested a transfer of qualification documentation to standard format till the end of 2001. This submittal will be a subject to regulatory review and approval taking into account requirements for accessibility of documentation according to state-of-the-art standards.

Item No. 6 Site Seismicity

Objective:

Siting of the installation shall take into account seismic as one of the possible external hazards.

Present Status and Specific Actions Planned:

The NPP Temelin underwent a thorough siting procedure in relation to possible seismic hazards. The Czech standard for this procedure is based on IAEA recommendations. A set of written documentation was released prior and in course of the “trialogue” giving evidence of this process. Due to the complexity of this issue and in order to foster mutual understanding, a topical workshop will be organised in the frame of the bilateral co-operation.

Item No. 7 Severe Accidents Related Issues

Objective:

Effective prevention and mitigation of consequences of beyond design basis accidents (severe accidents).

Present Status and specific Actions Planned:

A set of preventive and mitigative measures is, at present, applied in NPP Temelin with respect to beyond design basis accidents. These include software and hardware measures, among others, e.g. Symptom Based Emergency Operating Procedures, Technical Support Centre, Post Accident Monitoring System, Emergency Preparedness.

For the purpose of emergency preparedness, the PSA was employed with the aim to identify and group events with different initiating occurrences, but with similar end-effects. On the basis of this assessment the relative risk was estimated for specific events in order to select those which will serve for the determination of emergency response activities (pre-planned, reactive).

Severe Accidents Management Guidelines (SAMG) as a state-of the-art tool will complete the whole system of mitigation measures with respect to the beyond design basis accident management. The project for SAMG development is scheduled to be finished by end 2002 to be followed by validation.

To foster mutual understanding two lines of activities will be followed within the framework of the bilateral agreement:

a) A Working Group on comparison of calculations regarding the radiological consequences of BDBA with a view to harmonise the basis for emergency preparedness will be established.

b) The exchange of information related to SAMG will include discussion on the analytical basis as well as on corresponding software and hardware measures.

Annex II

With the target to minimise stress feelings mainly of the Austrian public, the Commission recommends (besides standard monitoring of the Temelín NPP Radiation Inspection Laboratory, standard monitoring within the national grid of the Czech Hydrometeorological Institute, respectively others) to ensure independent super-standard monitoring of the nuclear power plant operation wastes.

The optimal solution for super-standard measures is implementation of research task financed from the funds for science and research within the framework of the Czech Republic Governmental Council.

1. To establish a system for continuous informing of wide public both on current values of the factors affecting the environment as a consequence of the Temelín NPP operation (on-line outlets) and on development of time sequence of selected parameters of the environmental impacts monitoring (continuously updated diagrams, photos of the Earth remote examination, bio-monitoring results, and so on) as well as on other important facts (for instance earthquake in Alps indicated on seismological stations in South Bohemia, ...). All of these data would be shown on the Internet pages of the Temelín NPP, on publicly available monitors in Týn nad Vltavou and in Èeské Bud jovice, and in the Temelín NPP information centre.
2. To ensure continuous measurement of gaseous radioactive outlets within the framework of the operating network of the investor of the Temelín NPP.
3. To continuously improve and modernise the existing radiation monitoring network operated by the state authorities of the Czech Republic.
4. To regularly inform the public in the Czech Republic, Austria and the Federative Republic of Germany on all measurements.
5. To permanently monitor the impacts of the Temelín NPP cooling towers on climate even in wider region (through the existing meteorological stations network of the Czech Hydrometeorological Institute).
6. To ensure independent and continuous monitoring of the Temelín NPP operation impacts in the following fields:
   - Assurance of supply and quality of drinking water from the point of view of the nuclear power plant as well as nuclear power plant impacts on the water resources in the Temelín NPP surroundings;
   - Assurance of supply and quality of technological water from the point of view of the nuclear power plant;
   - Impacts of emissions on water system and risk of radioactive pollution of the recipient as a consequence of tritium water and other water effluents, including assessment of temperature impacts, accumulation and synergic impacts of harmful substances (including eutrofisation) in Orlík water reservoir;
   - Impacts of emissions on atmosphere, verification of thermal pollution and evaporation of water on cooling towers;
   - Impacts on agricultural activities and forest economy.

7. To order elaboration of soil map of the nuclear power plant surroundings in a digital form for surface generalisation of the impacts on pedosphere (soil sphere) from the point of view of further dynamic development.
8. To ensure conditions for seismic monitoring (including establishment of the monitoring centre located within the Temelín NPP area, eventually in the Information Centre). The basic objective of this centre will be to inform the public, state organisational units and local municipal governments on earthquake impacts on the locality and on the surroundings of the Temelín NPP.
9. To guarantee continuous maintenance and restoration of all technical equipment and devices of the nuclear power plant in such a way to correspond with the up-to-date status of the technique development as well as with the knowledge in the field of seismic engineering.
10. To ensure determination of radioactive substances in surface water, underground water and drinking water resources as well as in the food basket elements within the programme of the Radiation Monitoring Network of the Czech Republic.
11. To create conditions for implementation of the health condition monitoring study of about 30,000 of inhabitants in the surroundings of the Temelín NPP by means of epidemiological and radiobiological methods (for instance using chromosome analysis).
12. To establish a concept of continuous sociological examination of the population within wider surroundings of the Temelín NPP, to create conditions for implementation of the proposed programmes and related measures in the field of informatics and cultural - educational activities.
13. To discuss revitalisation of the area abound the Temelín NPP as a compensation for impacts on the Temelín NPP area surroundings during its construction, to discuss reverse revitalisation in damaged sectors of river basin including initiation of discussion on revitalisation system in the effected area of Stropnice river basin.
14. To ensure maintenance (mitigation of undesirable succession) on sub-xerophythe locations of the former military area of Litoradlice and on areas of valuable marshes around new retention reservoir in Strouha river basin.
15. To ensure monitoring of radionuclide accumulation in biological materials - bryophyte, forest soil and pine bark and to maintain monitoring of radionuclides in fish.
16. To monitor impacts of waste and rain waters by means of separate chemical and biological monitoring
    - In Býšov in Strouha river basin;
    - Monitoring of oxygen and temperature of selected sectors of Vltava;
    - Season occurrence of plankton in Hnìvkovice, Koøensko and Orlík reservoirs, and in selected model pond reservoirs in the surroundings of the Temelin NPP, while maintaining, eventually extending monitoring of changes in chlorophyll concentration in Orlík water reservoir with emphasise on plankton share assessment with one sampling point under Koøensko;
    - To extend monitoring of changes in water ecosystems by monitoring of changes in zooplankton composition because of its sensitiveness on changes in water temperature and subsequent changes in water ecosystem trophic structure.

17. To establish long-term monitoring (even retrospective) of changes in landscape character by means of multispectral satellite data analysis, especially suitable for monitoring of humidity and temperature changes of landscape related to changes in vegetation structure and functions. We recommend annual assessment of satellite data and related creation of ground key for satellite data including definition of key biotopes comprising forests on satellite photos and to ensure regular generalisation in this context in five-year intervals. With respect to the range of individual photos it is possible to ensure objective assessment of changes, which could exceed the borders with Austria and the Federative Republic of Germany.
18. To create conditions for financial security of care for residuals of preserved intangible cultural values in the surroundings of the Temelín NPP (including prospects for about 65 cultural monuments) from the side of the Temelín NPP operator as a compensation for affection of the landscape historical structure during construction.
19. To decide on further use of spent fuel or to ensure definite storage in permanent underground storage within 65 years in accordance with the concept on spent fuel disposal approved by the Czech Republic Government.
20. To eliminate high conservativeness of design accident calculations and to transfer to assessment of best estimate type; to compare inland calculation diagrams with the foreign ones.
21. To improve eventual accident occurrence indication system including its assessment; to train emergency preparedness for this purpose and eventually to update emergency plans (conditions for fast information, ability to perform actions and coordination of emergency measures).

ANNEX B

ROADMAP FOR THE IMPLEMENTATION OF ANNEX I AND ANNEX II OF THE CONCLUSIONS OF THE MELK PROCESS AND FOLLOW-UP

Roadmap for the implementation of Annex I and Annex II of the Conclusions of the Melk process and follow-up

The „Closing provisions“ of the „Conclusions of the Melk process and follow-up“ - further referred to as the „Conclusions“ - call for a “road map” regarding the monitoring on technical level in the framework of the pertinent Czech-Austrian Bilateral Agreement to be 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. This „road map“ is based on the following principles:

Principles

- The implementation of activities enumerated in Annex I and II of the Conclusions 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 side 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 below.

First half of the year 2002

Item No. 7 Severe Accidents Related Issues - a)

This topical meeting will serve to establish a Working Group on comparison of calculations regarding the radiological consequences of BDBA (Beyond Design Basis Accidents) with a view to harmonise the basis for emergency preparedness.

Second half of the year 2002

Regular bilateral Meeting

As specified as a general rule, this meeting will serve, inter alia, to monitor the implementation of those measures referred to in Chapter V of the Conclusions and to address those issues which have been found suitable to be followed-up in the framework of this Bilateral Agreement.

Item No.1 High Energy Pipe Lines at the 28.8 m Level
Item No.2 Qualification of Valves (AQG/WPNS country specific recommendation)

This specialists' workshop will address these issues based on the outcome of the AGQ/WPNS Peer Review as well as based on the pertinent Regulatory Authority decisions.

Item No. 5 Qualification of Safety Classified Components

This topical meeting will serve to address regulatory review and approval of environmental qualification documentation taking into account requirements for accessibility of documentation according to state-of-the-art standards

First half of the year 2003

Item No. 7 Severe Accidents Related Issues - b)

This specialists' workshop will be focused on the exchange of information related to SAMGs (Severe Accident Management Guidelines), including discussion on the analytical basis as well as corresponding software and hardware measures.

Item No. 6 Site Seismicity

This specialists' workshop will be organised by March 2003 to address seismic issues. The information provided by Czech side will aim to clarify that siting of the installation took into account seismic as one of the possible external hazards.

Second half of the year 2003

Regular bilateral Meeting

As specified as a general rule, this meeting will serve, inter alia, to monitor the implementation of those measures referred to in Chapter V of the Conclusions and to address those issues which have been found suitable to be followed-up in the framework of this Bilateral Agreement.

In addition, this meeting will include a presentation and discussion of the results of the Working Group on comparison of calculations regarding the radiological consequences of BDBA (Item 7a) as well as a general discussion on the progress achieved in monitoring on technical level regarding the implementation of Annex I and II of the "Conclusions".

First half of the year 2004

Item No.3 Reactor Pressure Vessel Integrity and Pressurised Thermal Shock

This topical meeting will serve to address the status of the PTS (Pressurized Thermal Shock) analysis.

Second half of the year 2004

Item No. 4 Integrity of Primary Loop Components – Non Destructive Testing (NDT)

This topical meeting will serve to address the status of NDT (Non-Destructive Testing) inspection procedures, including qualification.

Regular bilateral Meeting

As specified as a general rule, this meeting will serve, inter alia, to monitor the implementation of those measures referred to in Chapter V of the Conclusions and to address those issues which have been found suitable to be followed-up in the framework of this Bilateral Agreement.

In addition, this meeting will include a summary discussion related to monitoring on technical level as said in the "Conclusions"

ANNEX C

LIST OF AUSTRIAN PROJECTS

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	Chapter V – Environmental Impact Assessment	
PN 6	Site Seismicity	[Item No. 6]*
PN 7	Severe Accidents Related Issues	[Item No. 7b]*
PN 8	Seismic Design	
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]*

** The Items are related to ANNEX I of the “Conclusions of the Melk Process and Follow-up”*

ANNEX D

ASSOCIATED ISSUES LIST

Referring to Chapter IV of the “Brussels Agreement” and the principles of the “Roadmap” – identified in the “trialogue” of the “Melk Process”

Assosciated Issues List

Referring to Chapter IV of the "Brussels Agreement" and the principles of the "Roadmap", a number of issues identified in the "trialogue" of the "Melk Process" were found suitable to be followed-up in the framework of the Bilateral Agreement.

Those issues, where appropriate, were also covered by the corresponding technical projects as listed here:

- **PN2 High Energy Pipe Lines at the 28,8 m Level (AQG/WPNS country specific recommendation) [Item No.1]**

  Issue No. 23 –Leak Before Break (LBB)

  (only aspects of applicability for high energy line breaks, for primary piping applicability aspects see Project No. 10)

- **PN4 Qualification of Safety Classified Components [Item No. 5]**

  Issue No. 19 – Environmental and Seismic Qualification of Equipment

- **PN6 Site Seismicity [Item No. 6]**

  Issue No. 7 – Seismic Design and Seismic Hazard Assessment

  (only aspects of Seismic Hazard Assessment, for aspects of Seismic Design Assessment see Project No. 8)

- **PN7 Severe Accidents Related Issues – (b) [Item No. 7]**

  Issue No. 1 – Containment bypass and preliminary-to-secondary (PRISE) leak accidents

  Issue No. 4 – Containment Design and Arrangement

  Issue No. 5 – Probabilistic Safety Assessment and Severe Accidents

  Issue No. 6 – Emergency Operating Procedures EOPs & Severe Accident Management Guidelines (SAMGs)

  Issue No. 16 – Hydrogen Control

  Issue No. 26 – Beyond Design Bases Accident Analysis

  Issue No. 29 – Technical Basis for Temelín Emergency Planning Zones (EPZs)

- **PN8 Seismic Design**

  Issue No. 7 – Seismic Design and Seismic Hazard Assessment (only aspects of Seismic Design Assessment, for aspects of Seismic Hazard Assessment see Project No. 6)

- **PN10 Integrity of Primary Loop Components – Non Destructive Testing (NDT) [Item No. 4]**

  Issue No. 23 – Leak Before Break (LBB)

  (only primary piping applicability aspects, for aspects of applicability for high energy line breaks see Project No. 2)